DANCE MEDICINE & SCIENCE GUIDE

FROM THE BRAZIL-UNITED KINGDOM DMS NETWORK

Editors

Adriano Bittar
Matthew Wyon
Valéria Figueiredo
Derrick Brown
Aline Haas

DANCE MEDICINE & SCIENCE GUIDE

FROM THE BRAZIL-UNITED KINGDOM DMS NETWORK

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EDITORA KELPS
Rua 19 nº 100 – St. Marechal Rondon
CEP 74.560-460 – Goiânia-GO
Fone: (62) 3211-1616
E-mail: kelps@kelps.com.br
homepage: www.kelps.com.br

GUEST EDITOR CHAPTER 7
PhD Karen Wood

TRANSLATION ENGLISH-PORTUGUESE
AND PORTUGUESE-ENGLISH
Adriano Bittar

REFERENCES EDITING
Vitória Gomes

VISUAL PROGRAMMING
Victor Marques

CIP – Brasil – Catalogação na Fonte
Dartony Diocen T. Santos CRB-1 (1º Região)3294

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Avisos

Guest Collaborators (in alphabetical order)

1. Ana Carolina Quireze Rosa - guest author

Certified Nutritionist and former Ballet Dancer, specialist in Enteral and Parenteral Clinical Nutrition (GANEP), International Society for the Advancement of Kinanthropometry -ISAK level 1. Works for Quasar Cia de Dança (2006-), at the Gastroenterology Institute of Goiânia (2006-), at Solo Espaço Pilates (2015-) and at the Liver and Bile Duct Clinic (2019-), in Brazil.

2. Emma Redding - guest author

PhD, Head of Dance Science at Trinity Laban Conservatoire of Music and Dance, in the UK. Trained originally as a Contemporary Dancer. Wrote the first Master's degree in Dance Science, playing a key role in developing Dance Science as a recognised field of study. Founding partner of the National Institute for Dance Medicine and Science and member of the Board of Directors and Past President of the International Association for Dance Medicine and Science.

3. Helen Laws - guest author

BA (Hons) Dance, Diploma Arts Management from Roehampton University. Experienced dance manager, instrumental in shaping One Dance UK's Healthier Dancer Programme and in bringing together UK leaders for the formation of the National Institute of Dance Medicine and Science in 2012, establishing the first

National Health Service (NHS) dance injury clinics, for which she was recognised in the 2014 Evening Standard's 1000 most influential Londoners. Author of "Fit to Dance 2 - The report of the second national inquiry into dancers' health and injury in the UK". Served as a member of the International Association for Dance Medicine and Science board, 2005-2013.

4. Fernando Zikan - guest author
PhD Public Health (Federal University of Rio de Janeiro - *UFRJ*), Physiotherapist, specialised in Traumatology-Orthopaedics and Osteopathy. Adjunct Professor of the Department of Physiotherapy/Faculty of Medicine/*UFRJ*. Guest lecturer of the Dance School at the Municipal Theatre of Rio de Janeiro (*TMRJ*). *TMRJ* Physiotherapist from 2005-2010, acting as a guest PT since then. Head of Education of the Brazilian Association of Physiotherapy in Traumatology-Orthopaedics (*ABRAFITO*). Guest professor of Postgraduate courses and of workshops in Brazilian Dance Festivals.

5. Karen Wood - guest editor
PhD, Dance practitioner/researcher/educator, Research Associate at the Centre for Dance Research at Coventry University. Worked on two large funded projects - AHRC Invisible Difference: Dance, Disability and Law and EU Horizon 2020 Wholodance: Whole-Body Interaction for Dance Learning and Education. Karen's research focusses on phenomenology, particularly perception and embodiment, digital technology, screendance and choreographic practice. Karen is passionate about working with artists to expand professional practice. She sees the value in artist-led initiatives and how they can create opportunity

and encourage risk taking for dance making practices. Recently, her research explores using embodied research methods for understanding issues in post-conflict societies.

6. Nico Kolokythas - guest author
PhD Dance Science, experienced accredited coach (UKSCA) working in the athletic development of the adolescent in elite performance in a variety of sports (Judo, Netball, Basketball, Football, Taekwondo, Tennis). Strength and conditioning coach for professional martial artists in Muay Thai and Mixed Martial Arts. Based at Elmhurst Ballet School, UK, also works as a consultant for Birmingham Royal Ballet. Developed an injury prevention intervention called "11+Dance". Visiting lecturer at the University of Wolverhampton, in Science in Coaching, Motor Learning & Control and in the MSc in Dance Science.

Collaborators (in alphabetical order)

1. Adriano Bittar - editor, author, coordinator Brazil-United Kingdom Dance Medicine & Science Network
PhD Art, Physiotherapist, Craniosacral Therapist, Contemporary Dancer and Pilates teacher. Adjunct Professor at the State University of Goiás/School of Physical Education and Physiotherapy, coordinator Post-graduate course in Pilates at CEAFI Faculty, Fletcher Faculty and representative Fletcher Pilates in Brazil. Worked at Quasar Cia de Dança (2000-2016) and currently at Basileu França (2015-). Researcher, frequent international speaker on events about Pilates and Dance Medicine, owner and Physiotherapist of Studio Adriano Bittar.

2. Aline Haas - editor, author, member Brazil-United Kingdom Dance Medicine & Science Network
PhD Sports Science, BA Physical Education. Dance and Pilates practitioner/researcher and educator. Associate Professor at the School of Physical Education, Physiotherapy and Dance and the Postgraduate Programme in Movement Science, at the Federal University of Rio Grande do Sul (*UFRGS*), in Brazil. Postdoctoral research in Dance Science at the University of Wolverhampton, UK. Member of the Research Committee at the International Association for Dance Medicine and Science (IADMS); leader of the "Research Group in Arts, Body and Education" (*GRACE*). Aline's research focusses on Dance Science, Dance and Health and Pilates.

3. Andreja Paley Picon - author, member Brazil-United Kingdom Dance Medicine & Science Network
PhD Sciences, BSc Biological Sciences and Physical Education. Post-doctorate in Biomedical Engineering, and Biomechanics. Coordinator of the Physical Education Course, UNINOVE, in Brazil. Associate Professor and advisor, Postgraduate Program in Rehabilitation Sciences, Faculty of Medicine, University of São Paulo. Registered teacher at the Royal Academy of Dance. Coordinated a line of research in dance biomechanics at the Laboratory of Biomechanics of Movement and Human Posture - University of São Paulo.

4. Bárbara Pessali Marques - author, member Brazil-United Kingdom Dance Medicine & Science Network
PhD Exercise and Sport Science (emphasis in Dance), Manchester Metropolitan University, UK, Diploma Arts/Dance, BSc (Hons) Physical Education. Dance practitioner/researcher/educator, Director of Multiart Ltd and founder/president of Organisation

for Arts and Sport - ONG ComCiencia, Coordinator of Espaço Viverde and Director of Bastidores - Dance, Research & Training, in Brazil. Developed and patented “Best Performance and Movement” a training method specific for dancers as well as specialised equipment for measuring and training flexibility in dancers. Guest researcher in the research group Sports Psychology at the State University of Minas Gerais (*UEMG*) Ibirité and in the Group of Conceptions in Contemporary Dances at the Federal University of Minas Gerais (*UFMG*), both in Brazil.

5. Cláudia Daronch - author, member Brazil-United Kingdom Dance Medicine & Science Network

MSc Human Movement Sciences, BA and Licensed in Dance, Specialist in Kinesiology. Dance practitioner/researcher/educator graduated from the classical dance school of Teatro Guaíra, and Pilates Teacher. Assistant Professor of the Dance Course, Federal University of Rio Grande do Sul (*UFRGS*). Former ballet master and/or rehearsal director of Ballet Teatro Guaíra, Cia de Danças de Minas Gerais and Quasar Cia de Dança. Choreographer, Teacher of classical and contemporary dance workshops in Brazil and abroad, in addition to workshops on body conditioning for dancers. She is currently pursuing a PhD in Neuroscience at *UFRGS*, investigating the influence of the differentiated use of emotion in dance.

6. Debora Cantergi - author, member Brazil-United Kingdom Dance Medicine & Science Network

PhD in Human Movement Sciences from the Federal University of Rio Grande do Sul (*UFRGS*) and Coventry University (UK), BSc Physical Education. Assistant Professor at the Faculty of Education and Technology Iracema, in Brazil. Post-doctorate at the Laboratory of Movement and Human Posture Biomechanics at the University of São Paulo (*USP*). She has experience in Physical Education, with an emphasis on Biomechanics and focuses on dance and Pilates, acting mainly on the following themes: loads, spine, model, and inverse dynamics.

7. Derrick Brown - editor, member Brazil-United Kingdom Dance Medicine & Science Network

MSc Dance Science (Hons - Uni of Wolverhampton), Certified Sport/Performance Nutritionist (CISSN). Co-program Manager and Lecturer in Dance Science at the University of Bern, Institute for Sport Science, in Switzerland. Research fellow at the National Centre for the Performing Arts, Guest Lecturer in health at ArtEZ University of the Arts and the Coronel Institute of Occupational Health, People and Work - Academic Medical Center Amsterdam, both in the Netherlands. Peer reviewer for several international journals, currently an editorial board member for the Journal of Dance Medicine & Science. Co-author of numerous peer-reviewed articles, book chapters and books on dance education and performance. Former Dancer, Teacher and Rehearsal Director, having danced and taught ballet for classical and contemporary dancers in numerous dance companies and universities in Europe.

8. Diego Pizarro - author, member Brazil-United Kingdom Dance Medicine & Science Network

MA Contemporary Art (University of Brasília), Assistant Professor at the Dance Course of the Federal Institute of Brasília (*IFB*). Dance practitioner/researcher/educator/choreographer, trained in Modern Theatre Dance at Amsterdam University of The Arts. Registered Somatic Movement Educator (ISMETA) certified as

Teacher of Body-Mind Centering®, Practitioner of Articulation and Muscle Chains Method GDS®, Gyrotonic® and Gyrokinesis® trainer. Director *Coletivo de Estudos em Dança, Educação Somática e Improvisação*/Group of Studies in Dance, Somatic Education and Improvisation - CEDA-SI. One of the main organizers and creators of the International Encounter of Somatic Practices and Dance, held in Brasília, Brazil. Editorial and Advisory board member of Journal of Dance and Somatic Practices. Doctoral candidate in Performing Arts at the Federal University of Bahia (*UFBa*).

9. Erin Sanchez - author, member Brazil-United Kingdom Dance Medicine & Science Network

MSc Dance Science, BA (Hons) in Dance and Sociology, and qualified in Safe and Effective Dance Practice. She is an advocate, educator, and researcher supporting dancers' physical and mental health. Manager of Dancers' Health, Wellbeing, and Performance, at One Dance UK, Manager of the National Institute of Dance Medicine and Science (NIDMS). Member of the International Association for Dance Medicine & Science. Pursuing her PhD from the University of Edinburgh.

10. Flora Pitta - author, member Brazil-United Kingdom Dance Medicine & Science Network

Master in Rehabilitation Sciences from the Faculty of Medicine at the University of São Paulo (*USP*, Physiotherapy, Speech Therapy and Occupational Therapy Department), BSc in Physiotherapy. Dance practitioner/researcher/educator, specialist in Rehabilitation Applied to Sport. Member of the International Association for Dance Medicine & Science and Associate Researcher of the National Association of Dance Researchers. Physiotherapist and Researcher at Adam Center - Cia. Alvin Ailey, NY/USA.

11. Frances Clarke - author, member Brazil-United Kingdom Dance Medicine & Science Network

MSc, is Dean of the Faculty of Dance at Trinity Laban Conservatoire of Music and Dance, in the UK. Previously, she was Artistic Director for Springs Dance Company prior to leadership roles in Further and Higher Education, including programme leading three degree courses at the University of Wolverhampton. Her field of research is in Dance Science and she is completing her PhD on balance and dance performance. She regularly publishes academic papers, presents at international conferences and is Chair of the International Association for Dance Medicine & Science (IADMS) Publications Committee. She is Chair of Rosie Kay Dance Company, a Board member of DanceHE, UK, and an advisor for a dance scholarship at Cambridge University.

12. Izabela Lucchese Gavioli - author, member Brazil-United Kingdom Dance Medicine & Science Network

PhD Performing Arts from the Federal University of Rio Grande do Sul (*UFRGS*), BSc Medicine, Specialist in Internal Medicine, Rheumatology and Sports Medicine. Dance practitioner/researcher/educator, Assistant Professor at the Dance Course of *UFRGS*, also teaching Dance Medicine in the Dance Specialization Course at Pontifical Catholic University. Member of the International Association for Dance Medicine and Science (IADMS).

13. Janine Bryant - author, member Brazil-United Kingdom Dance Medicine & Science Network

Dance Educator in Higher Education, Dance practitioner/researcher. Former Senior Lecturer, Faculty of Performing Arts, University of Wolverhampton. Former Chair of Dance and Theater, Director of Dance Programs and Assistant Professor of Dance and Kinesiology at Eastern University, St. Davids, PA. Specialties include classical ballet, pointe and variations, Graham-based modern dance technique, dance anatomy and kinesiology, and conditioning for dancers. PhD Candidate, Wolverhampton University, UK, researching aging and range of motion.

14. Luciana Ribeiro - author, member Brazil-United Kingdom Dance Medicine & Science Network

PhD History, BA and Licensed in Physical Education. Dance practitioner/researcher/educator and activist. Adjunct Professor of the Dance Course at the Federal Institute of Education, Science and Technology of Goiás (*IFG*), Aparecida de Goiânia Campus. Author of the book "Breves Danças à Margem: aesthetic explosions of dance in the 1980s in the city of Goiânia".

15. Lucie Clements - author, member Brazil-United Kingdom Dance Medicine & Science Network

PhD Dance Science from the Trinity Laban Conservatoire of Music and Dance, in the UK, Chartered Psychologist of the British Psychological Society. Senior Lecturer in Psychology at the University of Chichester. Author of a number of publications in the area of dance psychology, focusing on the psychosocial underpinnings of optimal performance, including the training environment and significant individuals (such as the teachers/ parents) in nurturing healthy dance engagement, and on creativity in the life of a dancer. She also delivers dance psychology workshops to dancers, teachers and parents.

16. Matthew Wyon - editor, author, coordinator Brazil-United Kingdom Dance Medicine & Science Network

PhD, Professor in Dance Science at the University of Wolverhampton, in the UK. Course leader for the MSc in Dance Science and Director of Studies for a number of Dance Science and Medicine doctoral candidates. Founding partner of the National Institute of Dance Medicine and Science, UK, and former President of the International Association for Dance Medicine & Science between 2015-17. Applied physiologist in numerous dance companies. Published extensively on injury epidemiology and performance enhancement.

17. Moira McCormack - author, member Brazil-United Kingdom Dance Medicine & Science Network

MSc, BSc Physiotherapy, specialised in Dance. Physiotherapist for the Royal Ballet Company. Former professional dancer, trained at the Royal Ballet School and danced with the Royal Ballet Company, National Ballet of Canada and London Festival Ballet. Qualified ballet teacher with an interest in the relationship of physique, technique and injury prevention. Assessment of joint laxity and the control required by the hypermobile physique is a driving interest and one that she feels warrants further research and dissemination of knowledge in professional dance. Currently, she is concluding her PhD thesis at University College London.

18. Ross Armstrong - author, member Brazil-United Kingdom Dance Medicine & Science Network

PhD Musculoskeletal Screening at Edge Hill University, UK, Qualified Chartered Physiotherapist, BSc (Hons) Sports Science and Physiology at the University of Leeds. University Senior Lecturer and author of several publications in the area of Dance Medicine and considerable clinical experience working in the National Health Service, private practice, with the military and in professional sport and dance.

19. Sarah Needham-Beck - author, member Brazil-United Kingdom Dance Medicine & Science Network

PhD Dance Science from Trinity Laban Conservatoire of Music and Dance, in the UK, BSc (Hons) in Exercise and Sport Sciences. Research Fellow with the Occupational Performance Research Group at the University of Chichester. Former researcher, guest lecturer, and manager of the Healthier Dancer Programme at One Dance UK. Her research focusses on the cardiorespiratory demands of contemporary dance training and performance and appropriate methods for documenting this. Sarah currently serves on the Promotion Committee for the International Association for Dance Medicine and Science (IADMS).

20. Valéria Maria Chaves de Figueiredo - editor, author, member Brazil- United Kingdom Dance Medicine & Science Network

PhD Education from the Faculty of Education at Unicamp, in Brazil, BA Physical Education from Gama Filho University, Diploma in Contemporary Dance and Somatic Education from the current Faculty Angel Vianna, in Rio de Janeiro. Associate Professor at the Dance Course of the Federal University of Goiás (*UFG*). Founding member of the Goiás Dance Forum, editor of "Revista Pensar a Prática" (*UFG*). Coordinator of dance internships, scholarships and pedagogical residency in the *UFG* Dance Course. Coordinator of *LAPIAC* - Interdisciplinary Research Laboratory in Performing Arts. Operates in graduate and postgraduate courses in Dance and Theater. Develops extension and research projects that link educational processes to student and community creation processes in formal and non-formal spaces.

FORWARD

As a dance practitioner, educator and researcher, I was honoured to be asked to write the Foreword for this book. I have known Matthew Wyon for more than 20 years and I remember our shared conversations about the need for more research into the science of dance. Back then, we couldn't have imagined how quickly the field was to develop as we spoke, on the cusp of something substantial and significant. I have a great deal of respect for the editors and all of the contributing authors of this book, many of whom I consider both colleagues and friends.

When I met Adriano Bittar a few years back, I knew immediately that he was someone with drive, passion and an unwavering commitment to the field. He explained his ambition to fly a group of researchers from the UK to Brazil for a week-long residency of discussion and debate and I realise now, how significant that trip really was. The visit served to establish the Brazil-United Kingdom Dance Medicine & Science Network and this was a turning point.

Dance medicine and science is a field that has been taking shape over the last 30 or so years. It incorporates expertise and inquiry through a set of common objectives and methodologies. It is multi-disciplinary and inter-disciplinary, driven by passionate and curious people from dance, therapy, medicine, science, research and education.

Teaching methods in dance have typically evolved through experience, intuition and practitioner wisdom rather than from movement and exercise sciences. Perhaps this is why so many dancers sustain a debilitating injury at some point in their careers. Dancers tend to view themselves as artists not athletes even though their highly trained physical skills through which they express their ideas in choreographic work have much in common with athletes. Fortunately, there has been a shift in thinking in recent years as a result of the growing influence of sport and exercise science and its application to dance.

However, the years of having to rely solely on the advice of sport and exercise science are over. While we have witnessed a growing number of dance medicine and science articles published in reputable journals, we now have textbooks!

To me, the emergence of textbooks in dance medicine and science, demonstrates wholeheartedly, that the field of dance medicine and science is sufficiently mature to support programmes of study in Higher Education and is one that is here to stay.

The book begins with an informative account of the history of dance medicine and science and a focus on the important early milestones in the UK and Brazil acknowledging some of the key pioneers - trailblazers who bravely suggested a new way of thinking. There are excellent chapters detailing the physiological and biomechanical demands of dance and capacities of dancers calling into question, the extent to which current dance training is fit for purpose. We then learn of the relevance of assessment techniques and standardisation with helpful protocols and instructions for testing dancers. The authors tackle the pitfalls of various assessments as well as the lab versus field test conundrum. The chapter on supplementary training explains the how and why to apply principles of training and periodisation to create a well-designed safe and effective programme. This section concludes with an informative chapter on Pilates and Somatics to underpin the proposition that dancers benefit from engaging with specific motor-sensory integrative work to re-align, re-pattern and encourage subtle attention from within onself. Section III of the book provides robust writing on dance injuries and offers a comprehensive review of previous research including rates and risk factors. This is followed by an insightful chapter on medical care and the importance of considering the whole dancer when diagnosing and treating injury. The role of physiotherapy and psychological factors in ensuring dancer health and well-being is discussed in the following chapter highlighting not only related published research but offering helpful recommendations for applying many of the ideas discussed.

Collating writings from a collection of authors is hard even when the authors are from the same country. This bilingual Portuguese-English book draws together 23 of the most well-known researchers from across the globe. It celebrates and communicates the collaborative work arising from the Brazil-UK Dance Medicine and Science Network. And I suspect there is more to come!

What I appreciate most about this book is that it integrates disciplines that are often dealt with on their own. It combines theory with practice, research with opinion and provides context and practical suggestions.

I am vouching for the importance of this book for dance practitioners, therapists and teachers, for the integrity of this book for dance medicine and science lecturers and researchers and for the value of this book to the wider academy.

It's interestingly difficult to predict the way in which this field will grow. However, this book goes some way to furthering the importance of its multi-disciplinarily nature. Dance medicine and science is a collaborative endeavour and this book exemplifies this statement beautifully.

Professor Emma Redding, PhD
Head of Dance Science
Trinity Laban Conservatoire of Music and Dance, London UK
President (2011-13), International Association for Dance Medicine and Science

PREFACE

Adriano Bittar / Valéria Figueiredo
Aline Haas / Matthew Wyon

"Only when we are instructed by reality can we change it."
Bertolt Brecht

The inaugural actions of the Brazil-United Kingdom Dance Medicine & Science Network (BRUK NET) emerged through the organisation of the workshop "The Potential and Challenges of Research in Dance Medicine & Science: building collaborations between the United Kingdom and Brazil", held in Goiânia/ Goiás, Brazil, from 27 to 31 of August, 2016. The BRUK NET was conceived and initially organized by Adriano Bittar, adjunct teacher at the State University of Goiás/Faculty of Physical Education and Physiotherapy of Goiás (*UEG/ ESEFFEGO*), that invited Professor Matthew Wyon to coordinate this Network along his side.

This event was co-financed by the British Council, through the Newton Fund, and by the Research Support Foundation of the State of Goiás (*FAPEG*). It was held by *UEG/ESEFFEGO*/ Coordination of Projects (*PRE*), University of Wolverhampton and National Institute of Dance Medicine and Science (NIDMS) which is a consortium of the University of Wolverhampton, University of Birmingham, Trinity Laban Conservatoire of Music and Dance, One Dance UK, Royal National Orthopedic Hospital, Royal Ballet and Birmingham Royal Ballet. Partners of this event were the Dance Courses from the Federal University of Goiás (*UFG*)/Faculty of Physical Education and Dance (*FEFD*), and from the Federal Institute of Goiás (*IFG*)/Câmpus Aparecida de Goiânia. The *UFG* Cultural Center/Coordination of Projects and Culture (*PROEC*), where the event was held, participated as an institutional supporter. The cultural supporters were: Quasar Cia de Dança, Dança Basileu França, Casa Corpo (por quá grupo de dança, e Vida Seca); Quadrilha Arraiá Chapéu do Vovô and singer Grace Carvalho.

In order to have this workshop organized, different leading researchers from this field of study were contacted in Brazil and the United Kingdom, such as Professor Matthew Wyon, from the University of Wolverhampton, Valéria Figueiredo, from *UFG/FEFD*, Luciana Ribeiro, from *IFG*, Aline Haas, from the Federal University of Rio Grande do Sul (*UFRGS*)/Faculty of Physical Education, Physiotherapy and Dance (*FEFID*), Prof. Márcia Strazzacappa, from the State University of Campinas (*UNICAMP*)/Faculty of Education, Andreja Picon, from the University of São Paulo (*USP*)/Faculty of Medicine (*FM*) and Prof. Isabel Sacco, also from *USP*/*FM*. This collective of researchers with different experiences in the area of DMS and with the same desire to develop innovative collaborations, exchanged several ideas about the creation of this Network and refined them to really be able to collaborate, in face of the enormous potential available and so many challenges.

Since the inaugural event in 2016, and through the progress of sharing that took more than four years of intense e-mail exchanges, face-to-face or online meetings, and a lot of dedication, this bilingual publication was born, with the perspective of presenting our efforts for growth and consolidation of DMS, expanding the possibility of democratizing the knowledge produced. This publication is a small sample of an extensive work performed by several research groups and a presentation of a trajectory built together. The expectation is that this book approaches current and complex issues in DMS that indicate the ethical and scientific growth this field of study has endured in the past years, whether in Brazil or in the United Kingdom.

Each of the 6 editors, 23 authors, and many contributers who participated of the writings of this book shared their effort, their concern and their reflection, which we are grateful for.

Therefore, the book is presented in four versions: two physical variants, one in Portuguese and another in English; and two online editions in the same languages. All versions are composed of texts produced by authors who are scholars and whose contributions were organized along three axes: Part I - Introducing Dance Medicine and Science and the BRUK NET, which focuses on presenting DMS to the reader and parts of its history, moving between the particularities of England and Brazil; Part II - Dance Science, presents in four texts written by experienced researchers, which lay out specific knowledge about the physiological and biomechanical responses of pre-professional and professional dancers, also developing topics such as dance assessments, supplementary training for dancers, and notes on Somatics and Pilates in dance; and, finally, Part III - Treating Dancers, consists of texts that address injuries in dance, medical treatment, physiotherapy and psychological well-being.

The idea behind this book is that it builds constructs around DMS, from where visibility, access and sustainability could develop. The desire for an interinstitutional, interdisciplinary, collective and supportive cooperation has enabled us to create a book of cross-cutting contexts and diverse views. The demand for DMS services and knowledge is growing. It requires that professionals from different backgrounds; dance, health, education, and many others, ethically reflect and debate over the breadth and rigor necessary for the growth and valorization of this field of study.

TABLE OF CONTENTS

SECTION I – INTRODUCING DANCE MEDICINE & SCIENCE AND THE BRAZIL-UNITED KINGDOM DANCE MEDICINE & SCIENCE NETWORK

1 – What is Dance Medicine & Science and the Brazil-United Kingdom Dance Medicine & Science Network? 33

Valéria Figueiredo / Matthew Wyon

Introduction 33
1. What is Dance Medicine & Science? 33
2. Brazil-United Kingdom Dance Medicine & Science Network 38
Conclusion 42
References 43

2 – The History Of Dance Medicine And Science In The United Kingdom: Research, Education And Practice 45

Erin Sanchez, Helen Laws

Introduction 45
1 Milestones And Trailblazers: Research, Education and Applied Practice in Dance Medicine and Science in the Uk 46
2 Theme 1: A United But Diverse Voice to Advocate for Dancers' Health 48
3. Theme 2: The Value Of Evidence Informed Approaches............... 71
4 Theme 3: A Shared Responsibility For Dancers' Health................ 89
Conclusion 99
References 100

3 – Historical Aspects of Dance Medicine & Science in Brazil ... 103

Adriano Bittar / Valéria Figueiredo / Luciana Ribeiro

Introduction 103
1 Dance Medicine & Science in Brazil 104
2. Theme 1: Constitutions and Traces of DMS in Brazil.................. 106
3 Theme 2: DMS in Brazilian Universities 121

4 Theme 3: Further Development and Growth................................ 129
5. Conclusions 139
Additional Notes - Timeline 140
References.. 142

SECTION II – DANCE SCIENCE

4 – Dance Medicine and Science: Physiological and Biomechanical Aspects... 147

Matthew Wyon / Andreja Picon / Debora Cantergi / Sarah Needham-Beck

Introduction 147
1. PHYSIOLOGICAL ASPECTS OF DANCE 148
 1.1 Body Composition 151
 1.2 Muscle Strength 152
 1.3 Cardiorespiratory Capacity 153
 1.4 Flexibility 162
 1.5 Supplemental Training 163
 1.6 Vitamin D 164
2. Biomechanical Aspects of Dance.. 165
 2.1 *Turnout* Kinematics... 166
 2.2 Joint moments in *elevé* and *sauté* 173
 2.3 Dance shoes.. 175
 2.4 Flooring 178
Conclusions.. 181
References.. 182

5 – Assessing Dancers in Applied and Research Settings............ 189

Bárbara Pessali-Marques / Frances Clarke / Moira McCormack
Adriano Bittar / Matthew Wyon / Nico Kolokythas

Introduction 189
1. Assessing Dancers... 191
 1.1 Assessment Protocols... 192
 1.2 Physical Activity Readiness.. 193
 1.3 Anthropometric Assessments 193

1.3.1 Body Segmentation 194
1.3.2 Body Mass 195
1.3.3 Caliper Testing 196
1.4 Muscle Assessments 201
1.5 Flexibility Assessments 205
1.6 Aerobic And Anaerobic Assessments 211
1.7 Functional Assessments 213
1.7.1 Static Postural Assessment 214
1.7.2 Dynamic Postural, Movement-Based and Technique Assessments 217
2. The Reality of Dance Assessment in Brazil and the United Kingdom 224
References 227

6 – Supplemental Training for Dancers 243

Matthew Wyon / Adriano Bittar / Janine Bryant

Introduction 243
1 Conditioning 245
2. Supplemental Training Concepts for Dancers 247
2.1 Principles of Individuality, Specificity, Progressive Overload and Periodization 247
2.2 Cardiorespiratory Training 250
2.3 Muscular Training 252
2.4 Core Training 255
2.5 Range of Motion and Flexibility Trainings 258
Conclusions 261
References 262

7 – Related Topics: Somatics and Pilates in Dance 267

Adriano Bittar / Aline Haas / Janine Bryant / Diego Pizarro / Cláudia Daronch

Guest Editor: Karen Wood

Introduction 267
1. Somatics and Dance 269
2 Pilates for Dancers 278
2.1 Powerhouse or whole-body training? 280
2.2 Scientific data 282
Conclusions: Is it Time to Rethink Dance Training? 286
References 292

SECTION III – TREATING DANCERS

8 – Injuries in Dance: Definitions, Severity, Rates, Prevalence, Types and Risk Factors ... 305

Ross Armstrong / Adriano Bittar

Introduction ... 305
1 Injury Definitions And Severity ... 306
2. Injury Rates, Prevalence And Types ... 309
3 Injury Risk Factors ... 313
Conclusions ... 315
References ... 316

9 – Medical Care, Screening and Medication in Dance ... 323

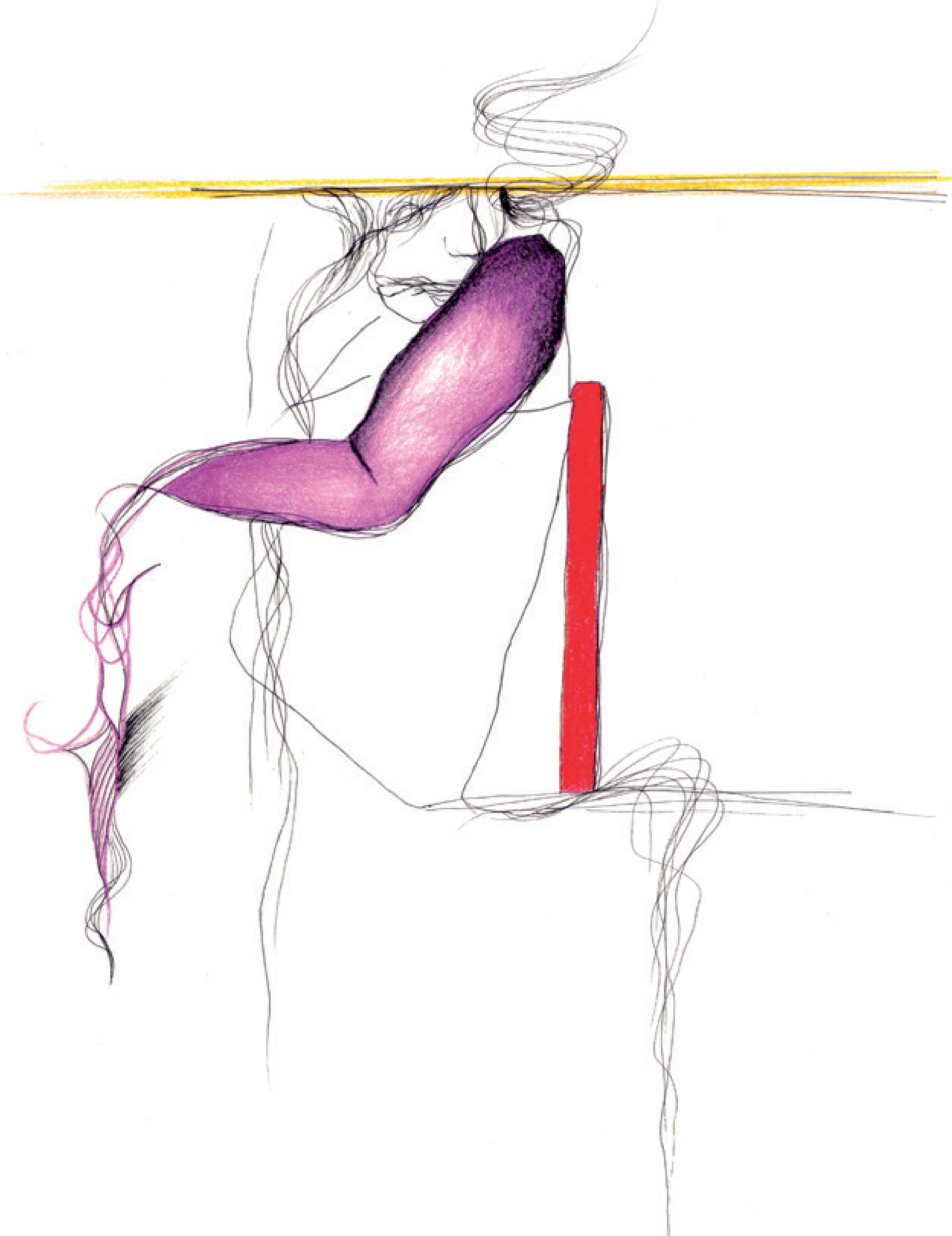
Izabela Gavioli / Adriano Bittar

Introduction ... 323
1 Medical Care, Screening and Medication in Dance ... 324
1.1 Medical Care for Dancers in Brazil and United Kingdom ... 332
Conclusions ... 334
References ... 334

10 – Physiotherapy And Psychological Well-Being In Dance ... 339

Adriano Bittar / Ana Carolina Quireze Rosa / Lucie Clements
Moira McCormack / Ross Armstrong / Flora Pitta / Fernando Zikan

Introduction ... 339
1 Physiotherapy in Dance ... 341
1.1 An Overview of the Brazilian and British Physiotherapy in Dance ... 347
2 Psychological Well-Being in Dance ... 358
Conclusions ... 360
References ... 362



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SECTION I

INTRODUCING DANCE MEDICINE & SCIENCE AND THE BRAZIL-UNITED KINGDOM DANCE MEDICINE & SCIENCE NETWORK

CHAPTER 1

WHAT IS DANCE MEDICINE & SCIENCE AND THE BRAZIL-UNITED KINGDOM DANCE MEDICINE & SCIENCE NETWORK?

Valéria Figueiredo / Matthew Wyon

INTRODUCTION

This chapter's objective is to make Dance Medicine & Science (DMS) known as a complex established interdisciplinary field of study. Furthermore, it also aims to present the Brazil-United Kingdom DMS Network (BRUK DMS NET) to the reader. Since its inception, in 2016, it has been instrumental to remarkable achievements.

1. WHAT IS DANCE MEDICINE & SCIENCE?

Dance Medicine & Science (DMS) can be defined as the art of preventing or alleviating diseases that affect dancers. As a discipline, it investigates the causes of dance injuries, promotes their care, prevention and post-rehabilitation, following through until the dancer fully returns to dancing. It also looks at how dance performance can be enhanced, through improvements in physical fitness, psychological and motor skills. To do so, it investigates how dancers can best dance, reflecting on the biomechanical, physiological, neuromotor, psychic, pedagogical and educational aspects as they relate to nutrition, physical conditioning, body therapies and Somatics (International Association of Dance Medicine & Science [IADMS], 2015).

DMS has also been extended to what has been described "dance for health", encompassing the study of the effects of dance in different populations, from children with special needs to the elderly, etc. Dance for health will not be discussed in extension on this book, as this is meant to be a book about DMS based on the researches and practices of the BRUK NET members, which, until the publication of this book, have devoted themselves more to understanding aspects related to pre-professional or professional dancing.

The DMS field was created between the 1970s and 1980s, arising from the integration of disciplines and the needs that emerged with the discovery of demands of the movement's own practice. One of the most poignant was the realization that dance performance, exhaustive and/or poorly applied, could cause serious and numerous injuries. This was particularly seen in classical ballet schools and companies (Ryan, 1997).

Juan Bosco Calvo (2000), a Spanish medical doctor (MD) and one of the pioneers in this field, suggested that the connection between Dance and Medicine was very ancient, dating back to before Christ, when healing rituals were performed to the rhythmic movement of the bodies, or even later in Dance Movement Therapy, that can help people with special needs, for example, and many others.

In addition to Ryan (1997) and Calvo (2000), according to Izabela Gavioli, a Brazilian MD, dancer, DMS researcher and BRUK NET member:

> […] the subspecialty Dance Medicine, although not yet with this name, began in 1960, through the professionalization of Eastern Europe dance companies. In them, it was designated an exclusive medical doctor to take care of the cast, so that this health professional could get to know the "dance code", understand its peculiarities and give the bodies of dancers a differentiated attention. (Gavioli, 2016, p. 184)

In this way, this hybrid field guided by Human Movement Science involves areas that study dance in an integrative and complimentary way: Anthropology, Health, Physical Education, Biomechanics, Nutrition, Somatic, Physiotherapy, Dance, Philosophy, Anthropometry, Poetics, Psychology, and Exercise Science, just to name a few. In recent years, the therapeutic and educational aspects of various dance styles have started to be discussed as well: tango being used with Parkinson's (Lötzke, Ostermann, & Büssing, 2015), ballroom dancing in the elderly (Lazarou et al., 2017) and belly dancing in adult women (Hernandes, 2018). Research on poetry and creativity (Clements & Weber, 2018), and in neuroscience and biology, has grown in recent decades (Koch & Fischman, 2011). On the other hand, the history and epistemology of DMS must advance, to report, question and serve as a critical base for this field of study.

Historically, DMS-related areas began to formalize their findings around the eighteenth century. Occupational Health, for example, first recorded injuries to bodily practices around 1713 in Bernardino Ramazzini's book "Diseases of the Workers". Already in the nineteenth century, the diseases of athletes began to be widely described, and in 1928 the term Sports Medicine was firstly used in the second Olympic Winter Games, in Switzerland.

Also, that same year, the first international congress of Sports Medicine was held in Amsterdam (Ryan, 1997).

In 1948, the first injuries identified with dance were officially reported in Francesco Ronchese's "Occupational Marks and Other Physical Signs", and other articles dealing with this subject were published mainly by French, Russian and Belgian investigators (Calvo, 2000). In 1979, the term Dance Medicine was used at the first International Symposium on Medical and Orthopedic Aspects of Dance, held in New York, and in 1982 two important medical symposia on Dance were held in Paris.

With respect to the education and organisation of professionals in specialised courses or a category association, it was only in 1985 that the first course in Dance Medicine was created in Alicante, Spain, coordinated by Dr. Juan Bosco Calvo. This course strengthened the area and promoted the formation of the Spanish Dance Medicine Association (ASAMEDA) (Calvo, 2000), which in 1990, together with other professionals from the area - dancers, dance medicine professionals, dance teachers, dance scientists - from the United States of America (USA), Spain, England and Belgium, formed the International Association for Dance Medicine & Science (IADMS[1]) (Figures 1 and 2). Other class associations, such as the American Performing Arts Medicine Association (PAMA[2]), also came to be around the same time.

1 More information about the International Association for Dance Medicine & Science at: www.iadms.org

2 Details on the Performing Arts Medicine Association, at: www.artsmed.org

Figure 1 - Aline Haas, BRUK NET member, and Juan Bosco Calvo, at the IADMS Conference, in Helsinki, Finland [Digital media]. (2018). Helsinki, Finland: Aline Haas' personal archives, printed with permission.

Figure 2 - At the reception of the IADMS Conference in New York [Digital media]. (2008). New York, USA: Adriano Bittar's personal archives, printed with permission. (From L to R: Rosa Pasarin, Adriano Bittar (BRUK DMS member), Marilyn Mardini, Juan Bosco Calvo and Giu Bergamo).

Dance Medicine & Science as an academic discipline has made great strides in countries such as the UK and the USA, as well as Australia, Japan, China, Canada, Germany and Switzerland (IADMS, 2015). In 2001, Trinity Laban Conservatoire of Music and Dance, in London, was the first dance education institution in the world to offer a Masters in Dance Science. The University of Wolverhampton, in the north of England, has a Bachelor of Science (BSc) degree, a Masters and doctoral programs in Dance Science, and in the USA, Texas A & M University and the University of Oregon accommodate undergraduate or graduate studies focusing on DMS.

In practice, dance scientists work in companies and dance schools, universities (in graduate courses such as dance, physiotherapy and physical education, or in postgraduate courses in DMS, etc.), in companies that develop dance floors and shoes, in hospitals, private clinics, and community dance centers, among others (One Dance UK, 2017).

2. BRAZIL-UNITED KINGDOM DANCE MEDICINE & SCIENCE NETWORK

A collective effort in 2016 proved to be promising for the expansion of DMS in BR and the UK. It all started as a contact established between research professors from the State University of Goiás (*UEG*), in BR, and the University of Wolverhampton, in England. From this contact, a joint proposal for the formation of the BRUK NET[3] was agreed upon, with the objective of developing research and collaborative services over a period of 15 years.

From this agreement and already as an initial action of the BRUK NET (Figure 3; Cabral, 2016), a dialogue was initiated

3 BRUK DMS NET information at: www.brukdms.blogspot.com.br

between some UK institutions, including the University of Wolverhampton and other participants of the National Institute of Dance Medicine and Science (NIDMS[4]), such as Birmingham Royal Ballet, University of Birmingham, One Dance UK, Royal Ballet and Royal National Orthopaedic Hospital; and from BR, *UEG* - Câmpus Goiânia, State University of Campinas (*UNICAMP*), Federal Institute of Goiás (*IFG*), Federal Institute of Brasília (*IFB*), University of São Paulo (*USP*), *Universidade Salgado de Oliveira* (*UNIVERSO*), Federal University of Goiás (*UFG*) and Federal University of Rio Grande do Sul (*UFRGS*), to promote cooperation among these institutions, as well as other private sector stakeholders and individuals.

Figure 3 - Cabral, U. (Artist). (2016). BRUK DMS NET logos in English and Portuguese [Digital images]. Goiânia, Brazil: BRUK DMS NET, printed with permission.

The first opening action of this Network was an inaugural international symposium in August 2016, which took place at the *UFG* Cultural Center (*CCUFG*) in Goiânia, Goiás, BR (Figures 4, 5 and 6). This event was co-financed by the British Council, through the Newton Fund, and the Foundation for Research Support of the State of Goiás (*FAPEG*), and carried out by *UEG*, University of Wolverhampton and NIDMS. Through an open call, which was intended to invite early-career DMS PhDs and other senior professors from the area to attend the

4 For National Institute of DMS, please see: www.nidms.com.uk

conference in Brazil and to be part of the BRUK NET, 15 Britons and 21 Brazilians were selected. The different profiles of those who arrived in BR and the Brazilians who participated in the creation of the Network in 2016 clearly highlight the diversity and breadth of the area, being these professionals from diverse backgrounds: Dance, Physical Education, Medicine, Psychology, Physiotherapy, Biology, Exercise Physiology, Somatic and Education (Figueiredo, Bittar & Ferreira, 2017). From BR, most of them were residents from Goiânia, Porto Alegre or São Paulo. The British, so called because they have lived in Britain for some time while studying or working with Professor Matthew Wyon, member of the BRUK NET, were from different locations in the world, including the USA, Holland and Great Britain.

Figure 4 - Abreu, Audinã. (Photographer). (2016). BRUK NET members at the workshop in Goiânia. [Digital image]. (Back row, L to R: Ross Armstrong, Derrick Brown, Matthew Wyon and Cláudia Daronch; front row, L to R: Clara Fischer-Gam and Aline Haas). Goiânia, Brazil: BRUK DMS NET, printed with permission.

Figures 5 and 6 - Abreu, Audinã. (Photographer). (2016). BRUK DMS NET workshop and Erin Sanchez at the workshop in Goiânia. [Digital images]. Goiânia, Brazil: BRUK DMS NET, printed with permission.

Following the creation of the BRUK NET, the perception is that it fostered a discussion in the regions involved, regarding the promotion of activities, plans and strategies derived from interdisciplinary initiatives aimed at the well-being of dancers and on Dance and Science, contributing to more than the medical aspects in dance (Bittar & Wyon, 2017). This was only possible by organizing new research groups between BR and the UK to consolidate knowledge production, publication of results and the creation of services in this area.

In 15 years from 2016, the intentions are to: create effective partnerships between related groups; request funding for student exchanges, for multi-center thematic research, purchase of equipment and materials; create an effective calendar of events/workshops/conferences and congresses; define educational by-products; publicize educational actions and promote courses and training; promote social inclusion actions for people in social vulnerability; promote functional metric evaluations and formalize the periodization of descriptive reports of the Network actions (Figure 7).

Figure 7 - Abreu, Audinã. (Photographer). (2016). BRUK DMS NET members. [Digital image]. (Top to bottom, L to R: Row 1 - Andreja Picon, Christine Bergeron and Julia Ziviani; Row 2 - Lucie Clements, Sarah Needham-Beck, Moira McCormack, Debora Cantergi, Isabel Sacco, Marcia Strazzacappa, Prof. Matthew Wyon (coordinator), Ross Armstrong, Clara Fischer, Cláudia Daronch and Tassiana Stacciarini (guest); Row 3 - Nefeli Tsiouti, Liliana Araújo, Aline Haas, Rina Magnani (guest), Ana de Pellegrin and Fernanda Nora (guest); Row 4 - Janine Bryant, Derrick Brown, Flora Pitta, Maria Eugênia Ghizellini, Bárbara Pessali-Marques, Janete Hernandes and Frances Clarke; Row 5 - Izabela Gavioli, Erin Sanchez, Luciana Ribeiro (mentor), Alexandre Ferreira, Adriano Bittar (coordinator), Valéria Figueiredo (mentor), Cibelle Formiga, Flavia Gervasio, Tânia Hamu and Diego Pizarro). Goiânia, Brazil: BRUK DMS NET, printed with permission.

CONCLUSION

Dance Medicine & Science is a dynamically developing field of study, that deals with all the complexity involved in the health of dancers. In general, the ideas put forth by the BRUK DMS NET satisfies the participants, since this organisational system is able to bring together individuals and institutions around related causes, in a democratic, flexible and participative way, sustained by the will and affinity of its members (Figueiredo, Maia, & Strazzacappa, 2013). Since its inception, the BRUK NET seems to have fostered organisation of its members through the exercise of citizenship, having the opportunity to make them stronger and more cohesive (Olivieri, 2003).

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CHAPTER 2

THE HISTORY OF DANCE MEDICINE AND SCIENCE IN THE UNITED KINGDOM: RESEARCH, EDUCATION AND PRACTICE

Erin Sanchez / Helen Laws

INTRODUCTION

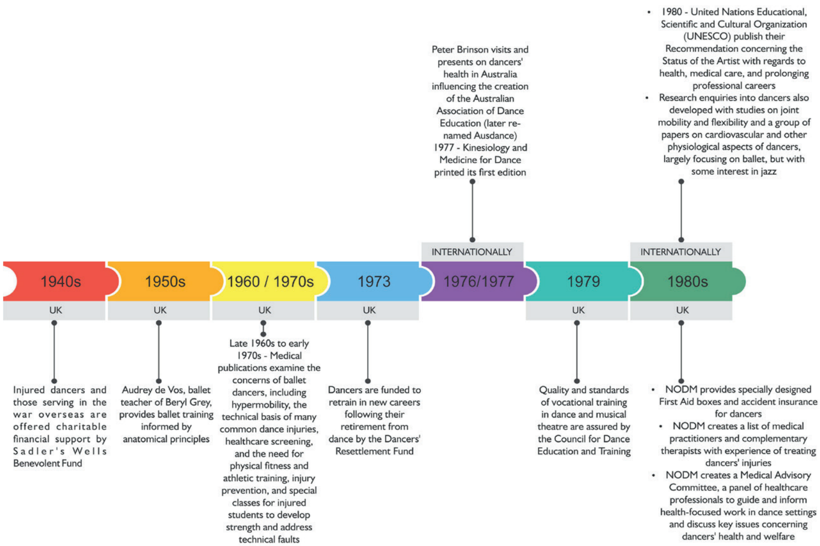
The development of Dance Medicine & Science (DMS) in the United Kingdom (UK) is a history of mentorship, partnership, and interdisciplinary and international collaboration. This chapter will focus on the key milestones of change in this field in the UK and the unique leaders and visionaries who made these developments possible.

What is included in this chapter is, by necessity of space, an annotated history largely focused on applied practices and drawing examples from the 1940s through to the present day[5]. Examples show the development of healthcare and research into dancers' performance and wellbeing and its dissemination in studios and onstage. Key to the development of dancers' health initiatives and DMS in the UK are three overarching themes: 1) a united but diverse voice to advocate for dancers' health, 2) the value of evidence informed approaches, and 3) a shared responsibility for dancers' health.

5 A more comprehensive history is being written collaboratively for later publication on One Dance UK's website: onedanceuk.org

1 MILESTONES AND TRAILBLAZERS: RESEARCH, EDUCATION AND APPLIED PRACTICE IN DANCE MEDICINE AND SCIENCE IN THE UK

KEY MILESTONES IN THE UK AND INTERNATIONALLY



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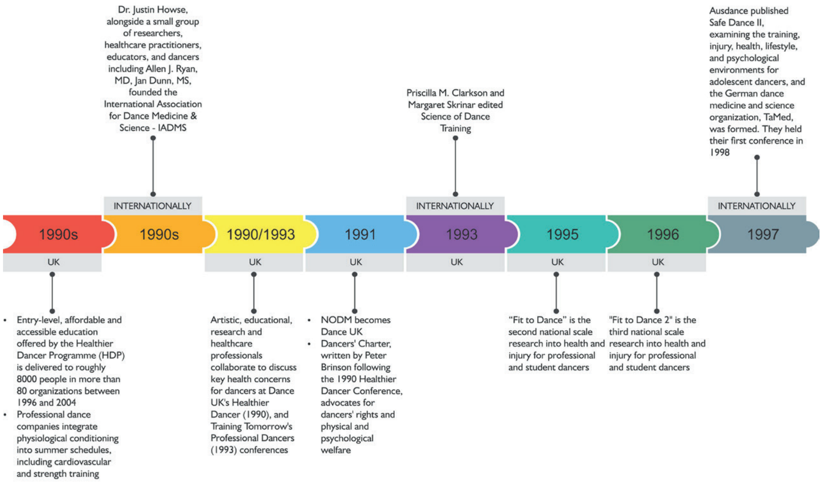

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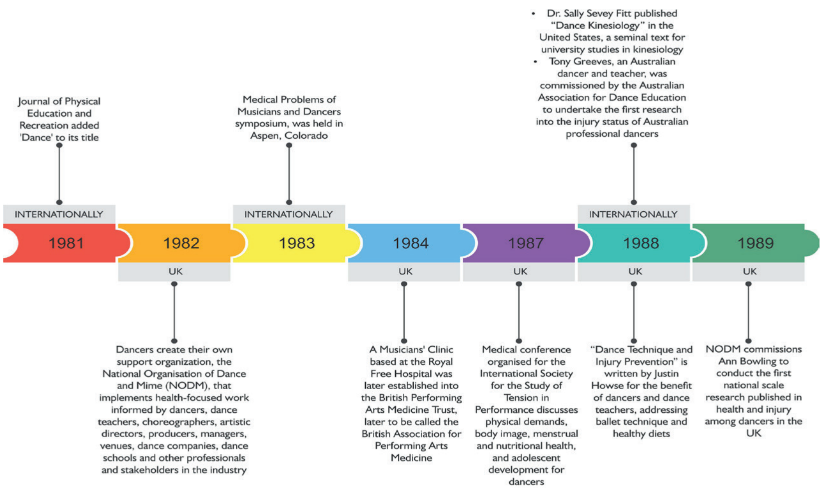

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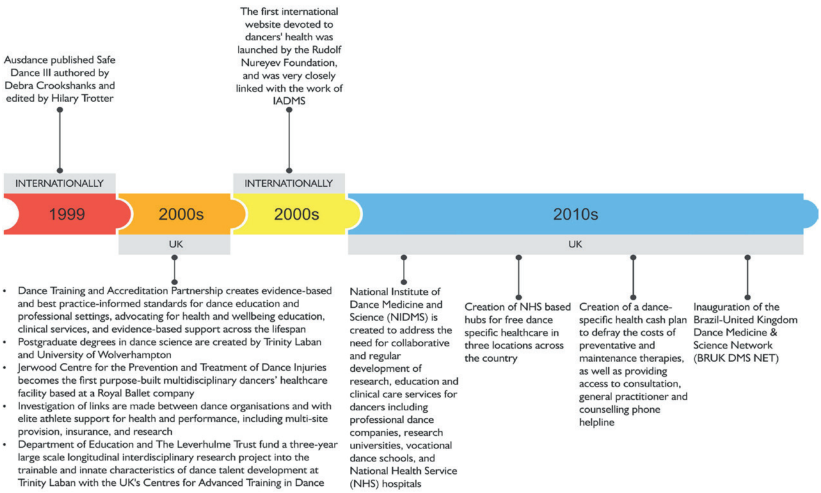

2 THEME 1: A UNITED BUT DIVERSE VOICE TO ADVOCATE FOR DANCERS' HEALTH

The UK's approach to DMS has, from its beginning, been informed by many diverse voices. Voices in this field came from supportive organisations, healthcare professionals and academics, and dancers themselves.

Activities to support dancers' health in the 1940s included support from charitable organisations such as the Vic Wells Ballet Fund, founded in 1936 by Dame Ninette de Valois[6], Sir Donald

6 Dame Ninette de Valois (1898-2001) was an Irish dancer, choreographer and entrepreneur, who created a small company and school, the Vic-Wells Ballet. It was firstly based at The Old Vic Theatre, and in 1931 it moved to the Sadler's Wells Theatre in North London, remaining there until 1939, when they left on a tour for a year in Europe, performing for the Allied troops. In February 1946, they transferred to the Royal Opera House, to reopen Covent Garden as a lyric theatre after its war-time closure. In 1956, to mark its 25th anniversary, a Royal Charter granted this company its current name: The Royal Ballet (Royal Opera House [ROH], 2019).

Albery and Arnold Haskell, CBE[7]. Although its first purpose was to support the production of ballets for the company of the same name, in the early 1940s the re-named Sadler's Wells Benevolent Fund began granting funding to dancers serving in the World War II overseas, and, in 1943, for the first time to a dancer in the Sadler's Wells Ballet who couldn't work following a knee injury (Dance Professionals Fund, 2018).

In 1973, the Dancers' Resettlement Fund (later renamed Dancers' Career Development) was founded by dance critic Peter Williams to support and fund professional dancers in government funded dance companies to retrain in new careers in the first three years following their retirement from dance. Over the course of their development, they expanded services to encompass support for all professional dancers regardless of the stage of their career (Dancers Career Development [DCD], 2018).

Records suggest that by the 1960s medical professionals were involved with the care of professional and vocational student dancers who suffered injuries. When Dr. Justin Howse took over from Mr. Ivor Robertson in 1966 to become the orthopaedic consultant to the Royal Ballet and the Royal Ballet School (International Association of Dance Medicine & Science [IADMS], 2017), he joined an existing interdisciplinary team of physiotherapists and dance teachers. Moira McCormack, one of Howse's patients as a dance student and professional dancer, and a protégé when she later became a physiotherapist for dancers, commented:

> (Dr. Howse) felt that dancers needed specialist knowledge and treatment, and was the first in this country to attempt to provide it. […] He felt that prevention of injury was

7 CBE - Commander of the Order of the British Empire.

> paramount and firmly supported the contribution that physiotherapists could make to this (Stafford, 2013)

Dr. Howse's influence extended beyond the UK not only based on his direct treatment of many dancers, but also on his interactions and mentorship of many healthcare professionals, including surgeons David Weiss, Donald Rose and Boni Reitveld. He also began publishing on dancers' medical support needs in 1972 with the article, "Orthopaedists Aid Ballet". Following on from a short article entitled "Ballet Injuries" written by Mr. Ivor Robertson in 1967, Howse sets out an impressive and concise explanation of the need for physical fitness and athletic training, injury prevention, special classes for injured students to develop strength and address technical faults, healthcare screening, and a listing of common dance injuries (Howse, 1972). Howse's articles are still both applicable and insightful today, discussing the need for periodization, and recommendations for regular training to build and maintain fitness to prolong performing careers. Perhaps the most prominent legacy he contributed to dancers' health was his commitment to the prevention of injuries through correct dance technique and dance teachers' knowledge of the human body:

> The importance of physical fitness and athletic training cannot be overemphasized […] after their month's annual holiday, dancers of the Royal Ballet company need a full month of rehearsal before they are fit to perform. All injuries in the physically trained dancers are a result of faulty dance techniques […] unless interfered with by some object outside the dancers' control. Technical deficits may be the result of an anatomic inability […] a result of poor or inadequate teaching, or failure to use

> the correct technique at some particular moment […] The failure to use a correct, fully acquired technique, may occur when dancers have had to give a series of performances in rapid succession, especially when much travelling is necessary. […] Once an injury has occurred, especially if it is minor enough to allow the dancer to continue working, further injuries may follow. This is because the discomfort of the initial injury often leads to an alteration in accurate technique to avoid strain on the injured part, […] (which) in itself predisposes to further injuries. Even though the dancer may be well trained technically, […] poor habits often creep in unnoticed, especially among those dancers who have improperly supervised warm-ups or who rarely attend class. In an effort to prevent injuries, all ballet teachers should have a simple basic knowledge of anatomy to enable them to understand more fully and appreciate an individual student's difficulties. It will also help the teacher to guide the student in exercises and ways of overcoming technical problems. Perhaps even more important, it will deter the teacher from asking the student to carry out maneuvers which, for that student at that particular stage of training, may be impossible […] Choreographers, like teachers, should know the basic limitations of the human body so that their physical demands are within reason. (Howse, 1972, p. 53)

This representation of the technical aspects of ballet dancers' careers and training within academic publications gave insights into a traditional form with which many healthcare practitioners would not have had direct experience.

The interrelationship between medical, scientific and artistic perspectives in the health and wellbeing of dancers also began to become more evident in dance pedagogy and injury rehabilitation. A very early example of such work is dance teacher Audrey de Vos (1900-1983), who coached and influenced an entire generation of ballet dancers and teachers including Royal Ballet dancers Beryl Grey and Maggie Black, and brought in-depth anatomical knowledge through slow conditioning work with a focus on awareness and memory. Some of the key concepts of this teaching were in:

> [...] working from within, […] being grounded, […] release of tension for more economical use of the body, […] flow of movement that formed a bridge between more stationary physiotherapy rehab exercises into more dynamic movements and then into fuller ballet technique. (Grinstead, 2010)

She claimed that this method achieved a: "[...] greater sensitivity and awareness to alignment [...] blending conditioning work into ballet class [...]. Linking conditioning exercises into barre work and [...] building a strong link with ballet technique." (Grinstead, 2010). The integration of kinesiological studies with neuromuscular education and internal perception (Somatics) as a focus was common in USA dance education through the American Dance Festival and Martha Myers[8].

Publications at this time also addressed teaching practice, medical care, and implications for injury. In 1980, the United Nations Educational, Scientific and Cultural Organization (UNESCO) published Recommendation concerning the Status of the Artist:

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8 An excellent history of the integration of Somatics in dance has been created by Glenna Batson for the International Association for Dance Medicine and Science called "Somatic Studies and Dance", 2009.

> […] (b) in order to preserve the health and prolong the professional activity of certain categories of artists (for example ballet dancers, dancers, vocalists) Member States are invited to provide them with adequate medical care not only in the event of incapacity for work but also for the purpose of preventing illness, and to consider the possibility of research into the health problems peculiar to artistic professions. (UNESCO, 1980)

In 1988, Dr. Justin Howse and physiotherapist Shirley Hancock published the book "Dance Technique and Injury Prevention" which was written for the benefit of dancers and dance teachers.

In 1982, The National Organisation of Dance and Mime (NODM, re-named Dance UK in 1990) was born out of an initial meeting of existing dance organisations of the day, expressing the need for support and industry representation. Its first director, Jane Attenborough, and founding chair, Bob Lockyer, aimed to give dancers guidance and support through training and careers' development. Bob Lockyer remembers the sector was a disparate group of professionals, and that much of the early work of Dance UK was to unite that group and unify their voice:

> *NODM was to widen the perception both politically and socially of dance [….] before it happened, it was all company based, […] lots of little islands. What NODM was trying to do was to build a great continent and bring the profession together. […] I think we broadened and widened the profession in a sense. It spreads the idea of the community of dance. When NODM started, it wasn't. It was a very small, fragmented group of people. […] I think there was a bit of fear about what was going to happen. We*

> *had to make sure we were going to be an open organisation […] that brought the profession and everybody into it and talked about it.* (Lockyer, personal communication, 2018)

NODM needed to convince dancers that the organisation could do something for them. NODM's earliest health work came directly from dancers' own experiences and the vision of the people within the organisation. In 1985, NODM created the Medical Register, a listing of medical practitioners and complementary therapists with experience of treating dancers' injuries, directly followed in 1986 by a Medical Advisory Panel to discuss key issues concerning dancers' health and welfare, including Prof. Craig Sharp, Yiannis Koutedakis, and Dr. Roger Wolman. Here, the medical profession was directly interacting with the dance sector, but further interaction was required to address dancers' needs.

In 1990, the first Healthier Dancer Conference was organised at the Royal Opera House by the newly renamed Dance UK; the 130 delegates composed of dancers, teachers, ballet masters, rehearsal directors, artistic directors, choreographers, administrators and managers, notators, researchers, higher education lecturers, community artists, dance company doctors, physiotherapists, and funding bodies. The conference provided an introduction to a key topic of concern for dancers at the time, the issue of health. Discussion groups provided a list of ideas and recommendations: "Here, we felt, is the authentic voice of Britain's professional dancers on matters of supreme concern to their profession […]. Since the reports also showed a consensus over a range of subjects, a sort of dancers' charter emerged." (Brinson, 1990, p. 51).

The subjects of the charter ranged from thoughts about standards of practice during training, guidelines for key knowledge among teachers, considerations for choreographers and managers around promoting health and reducing injury and illness, issues around injury risk, treatment and management, and standards for working environments. “Medical Views”, formed another significant aspect of the conference, or the health and injury of the dancer from the perspectives of physiology, physiotherapy, nutrition, biomechanics, and eating disorders. The conference also featured a review of dancers’ health interventions from across the world (Brinson, 1990).

Many valuable strengths emerged from the 1990 conference including a focus on improving working conditions and support, developing resources and encouraging debate among professionals. In 1992, Dance UK collaborated with Peter Brinson, Dance Umbrella and Dance/USA to launch an official publication of the “Dancers’ Charter” advocating for dancers’ rights and physical and psychological welfare (in 2005, Dance UK’s Industry Standards were published online, stemming from the Dancers’ Charter, providing clear updated guidelines on the standards of practice for which the dance industry was striving). Dance UK created new resources and guidance, including a list of healthcare professionals experienced in treating dancers’ injuries, providing specially designed First Aid boxes and accident insurance for dancers. Finally, the 1990 Healthier Dancer Conference set a precedent in dancers’ health in the UK encouraging debate and discussion from a multitude of viewpoints in a safe space. Educators, dancers, healthcare professionals, researchers, artistic staff, choreographers, managers and students worked together, in active cooperation.

The impact of this shared dialogue can also be seen in more recent developments. Often, in the history of DMS in the UK, there have been passionate debates about issues concerning both health and artistry, and one of these consistent concerns is that of training excellent dancers. In 1993, during the Dance UK conference, "Training Tomorrow's Professional Dancers", a concern was voiced about the lack of British ballet dancers in the upper ranks of leading ballet companies in the UK. Comments following the conference confirmed the need for discussion:

> "I FEAR for the future of British dance if we can't start producing the quality that classical ballet demands.", thus spoke the director of the English National Ballet, Derek Deane, after hiring only one of the 100 dancers he had auditioned at the weekend. "There has been a general concern about training standards in ballet for some time. Last autumn, Dance UK, the body that represents professional dance companies in this country, held a three-day conference on the subject, which was attended by leading directors, dancers and trainers. It emerged, however, that the main problem was the high rate of injury sustained by professional dancers rather than the standard of training itself.". (De Marigny, 1994)

Dr. Peter G. Skew, doctor to the English National Ballet, stated:

> I thoroughly agree […] that dancers' training is poor [...]. Only yesterday I saw a young ballet dancer, just coming up to exams, who is physically totally unsuited to ballet. She had no natural turnout at the hips and, as foot placing was demanded by the teacher, she had to compensate from the knees down. The result is stretched tendons and ligaments around the ankles, causing severely pronated feet which her mother can no longer find shoes to fit. A simple examination would have excluded her from ballet training at the outset. If there is no control in who goes

> into the schools, and not enough control of the teaching, is it any wonder that the results of professional auditions are unsatisfactory? (Skew, 1994)

It is evident from these comments, that the ballet world shared both understanding and rapport with medical professionals, though from different viewpoints.

Another example of this interdisciplinary discussion was in 2015, at Dance UK's conference "The Future – New ideas new inspirations". Three critically acclaimed choreographers jointly released a press statement just before the launch of the conference, asserting that some contemporary dance conservatoires produced dancers who "[...] lack rigour, technique and performance skills" (Anderson, 2015). Their comments touched off an industry wide debate about contemporary dance training in the UK, much of which centred on defining the demands of a professional's career in contemporary dance – namely, that career pathways were diverse and successful training of graduates cannot only be measured on performance quality alone, as writes Judith Mackrell, dance critic, for The Guardian:

> If we're going to debate whether our training institutions are fit for purpose, we have to consider exactly what that purpose is. […] life for conservatoire graduates is desperately precarious. Most, given that the supply of contemporary dancers far outstrips demand, will have portfolio careers. At different times, they might find themselves performing, choreographing, producing, publicising, teaching, writing about dance or involved in dance therapy. […] So, while Theo van Rompay, deputy director of PARTS, acknowledges that it is essentially a school for those who "decide their place is on the stage", and while Juilliard hand-picks its annual intake of 24 students

> from an already highly trained group of applicants, the philosophy of the UK's top institutions is that the dance industry is about far more than performance. (The Guardian, 2015)

Although it may seem strange to include the debate about career success in the history of dancers' health in the UK, similar to the debates about ballet that occurred following the 1993 Training Tomorrow's Dancers conference, the question of whether dancers were strong or fit enough for the demands of a professional career had been the focus of dance science research for some time, including research into cardiovascular demands of contemporary dance, reducing injury rates among dance students, and implementing periodization in dance training. Interdisciplinary discussion was leading to changes in practice. A part of the industry discussion also focused on working towards better training and the challenge of "fitting everything in" including technique, fitness training, and exposure to a variety of current choreographic demands. By 2012, ArtEZ Conservatoire in the Netherlands had established applied research with Professor Matthew Wyon to implement periodised training phases, monitored and adjusted training loads, and applied science from training in sport to dance (Nvao, 2012).

To support and continue such discussion, the Healthier Dancer conference became an annual event in 2011 (see Table 1 for a list of conferences and themes). These regular conferences began discussion and activity on a range of topics to make sure that there was an open and safe space for discussion and debate between artistic, healthcare, and academic professionals.

Table 1 – *Healthier Dancer Conferences, 1990-2019*

Year and Conference Title	Key Speakers and Topics
15-16 September **1990** **The Healthier Dancer Conference** Royal Opera House, London	**Injuries to dancers and their response** Christopher Bannerman, Dr. Ann Bowling, Monica Mason, and Patricia Sohl. **Medical Views** Physiology – Craig Sharp. Physiotherapy – Moira McCormack. Orthopaedic surgery - Justin Howse. Body control - Dreas Reneyke. Amenorrhoea - Dr. Roger Wolman. Eating disorders - Dr. Robert Lefever and Julia Buckroyd. Nutrition - Jasmine Challis. General Illness - Dr. John Creightmore.
3-5 September **1993** **Training Tomorrow's Professional Dancers** Royal Opera House, London	**Training of dancers** Fitness for Dance – Prof. Yiannis Koutedakis. An overview of dance teaching – Peter Brinson. Training or Taming – Tony Geeves. Sports Psychology – Virginia Gallagher. Beyond Technique – Christopher Bannerman. **Classical and contemporary training** Richard Alston, Maria Fay, Monica Mason, Deborah Bull, and Lauren Potter. **Training for cultural diversity** Siobhan O'Neill, Beverley Glean, and Shobana Jeyasingh.

October **2000** **Moving Matters** Royal Opera House, London	**Forty-one speakers discussed dancers' health and wellbeing, addressing physiology, cultural, nutritional, and supplementary techniques.** **'Your Body, Your Risk':** A review of disordered eating, amenorrhoea and osteoporosis. Perspectives from specialists working with dancers in psychological, nutritional, psychiatric, endocrine, and bone health. Alan Currie, Linda Edwards, Nicola Keay, Jasmine Challis, Elizabeth Nabarro, and Julia Buckroyd. **'New Ideas and Research':** Sections on bullying in the dance profession, injury prevention in the West End, dance auditions and injury management. Enhancing the art of teaching dance as well as physiological cost of dance class and performance. Roger Wolman, Tony Geeves, Helge Hoel, Elizabeth Sharp, Warrick McNeill, Matthew Wyon, Emma Redding, and S. Craig Phillips. **'Focusing the mind and body':** Discussions and workshops regarding strength and flexibility conditioning, Skinner Releasing Technique, Yoga for concentration and focus. Gill Clarke, Eric Franklin, Kirsty Alexander, and Ann-Marie Zulkahari. **'Psychology of optimal performance'** Imagery for elite performers, how we think and feel affects performance, confidence and self-assertion. Prof David Collins, Britt Tajet-Foxell, and Sue Coryndon. **I'm injured where do I go for help?** Includes the dancer's perspective, self-help following injury and Pilates for injury recovery. The role of physiotherapists, remedial teaching, and podiatrist. Finally, how to get the best out of the NHS. Cathy Barrett, Gill Clarke, Moira McCormack, Alan Herdman, Marion Tait, Simon Costain and Robert Marston. **Closing the gap: From the reality we have, to the future we want –** Richard Ralph.

4 February **2005** **Healthier Dance Companies: Optimising performance, making the most of artistic and financial resources** Royal Festival Hall, Chelsfield Room	**Keynote speaker: Alistair Spalding.** Gap in knowledge about dance when dancers were using NHS services - setting up education for dance and sport. **Optimising Support in Dance Performance: Misha Botting.** Results of his research and the importance of learning from sports what drives change, funding, nature of communication and uses of sport psychology for performance. **Panel discussion: Performance, health and financial benefits of injury prevention. Richard Alston, Derek Purnell, Janet Smith. Moderator: Matthew Wyon.** Incorporating the ideas of sport science into the artistry of dance. In-house-care provided for major NY dance companies led to increased speed of treatment, and reduction in injury, time taken off and financial costs. Support available across the company not just for dancers. **Optimising Performance: Lifestyle management for elite performers: David Collins.** The issue of daily hassles affecting your life balance. Reinforcement structure or a way of rewarding yourself, acknowledge your good days. The dangers of monotony both for individuals and organisations. **Unexplained Underperformance Syndrome: Dr. Richard Budgett.** Overtraining syndrome, burnout, staleness, sports fatigue syndrome. Some are depressed. Periodisation discussed – long & short cycles of training. **Leap of Faith – the next steps towards healthier dance companies. Feedback from group discussions, Moderator: Matthew Wyon.** Healthier dancers do make better dancers (after a period of rehabilitation).

10th October **2006** **In the Balance: Achieving excellence through effective and healthy dance training** Elmhurst School of Dance, Birmingham	**Working smarter, not just harder – depth versus diversity in dance training.** **Helen Laws** (chair). **Rachel Rist, Maggie Morris & Matthew Wyon** (panel). Aspects going into dance training, funding body requirements. Neuroscience perspective of training and motor learning Physiological aspects. **Shaping the dancer.** **Sara Matthews** (chair). **Emma Redding, Jann Parry, Wayne Eagling & Laetitia Lo Sardo** (panel). Is there a required physique for dance (physically/aesthetically)? Who decides? Finding a balance between aesthetic/fitness & health. **Sustaining motivation – fostering excellence.** **Sarah Wilson** (chair). **Toby Norman-Wright, Joan Duda, Angela Pickard** (panel). Nurturing the individual. Encouraging independent learning in a group training environment. **Open forum.** Exploring issues discussed earlier in the day, particularly working environments and best ways forward.
27th November **2006** **Optimising and evaluating performance** Trinity Laban Conservatoire of Music and Dance, London	**Keynote – Gill Clarke.** **Talent Identification. Emma Redding, Greg Whyte & Joan Duda.** What makes a dancer? **Injury prevention and health screening. Katherine Watkins.** Practical demonstration, why screen & what are the benefits? **Injury monitoring & training diaries. Naomi Siddall & Margot Rijven.** Keeping track of dancers' injuries, fitness, health and performance. **Understanding & applying the medical scientific information. Odette Hughes & Andy Rolls.** Case studies. **Evaluating success, measuring dance performance. Matt Wyon.** Measures have one goal in mind – great dance performances. How can we test if these measures are having the desired beneficial effect on performance & health?

20 April **2009** **Hypermobility and the Female Triad** Royal Society of Medicine, London	**What is expected from dancers? -** Wayne McGregor. **The dancer's perspective -** Rachel Peppin. **Female athlete triad –** Dr. Roger Wolman. Importance of screening menstrual history, changes in cycle, weight loss, BMI and recurring injuries. **Modifying Training –** Prof. Matthew Wyon. Emphasis of quality rather than quantity of training. **Psychological Aspects –** Dr. Johnathan Katz. Eating disorder profile, important to separate person from their behaviour as well as investing in personal and process goals. **A global approach to management –** Heather Walker & Kim Pedrick. Encourage discussion, lead by example, consistent health and performance related education as well as an open-door policy. **Developmental aspects of hereditary and acquired problems –** Dr. Richard Hull. Hypermobility syndrome common presentations. **When is hypermobility counterproductive to a dancer? –** Moira McCormack. **Management of hypermobility –** Elizabeth Sharp. **A joined-up approach to dance medicine and science research and practice –** Helen Laws. Healthcare for 100 independent dancers pilot scheme.

4 April **2011** **From injury to performance - lessons to share between dance and sport** Royal Society of Medicine, London	**A dancer's perspectives on injuries –** Angela Towler, Rambert Dance Company. **An athlete's perspective on injuries –** Denise Lewis OBE, Olympic Gold Medallist. **Risk management and injury epidemiology -** Dr. Colin Fuller, Associate Professor and Course Director of the MSc in Sports and Exercise Medicine, The University of Nottingham. **How injury surveillance examples from rugby can help dance in the future –** Dr. John Brooks. **Prevention and management of injury: Psychologist's perspective –** Ms. Britt Tajet-Foxell, **How important is nutrition? –** Mr. Nathan Lewis, Senior performance nutritionist for the English Institute of Sport (EIS). **Ankle sprains:** **The physio's perspective –** Ms. Rachele Quested. **The Pilates practitioner's perspectives –** Ms. Jane Paris. **The surgeon's perspective -** Mr. James Calder, Consultant Orthopaedic Surgeon Specialist in Foot and Ankle Surgery, Imperial College London. **Chondral defects:** **The surgeon's perspective –** Prof. Fares Haddad, Consultant Orthopaedic Surgeon, University College London Hospitals NHS Trust. **The physio's perspective –** Miss Anna Brodrick, Head Physiotherapist, Central School of Ballet and English National Ballet School. **The strength and conditioning coach's perspective –** Raphael Brandon, MSc Head of Strength and Conditioning, English Institute of Sport. **Sports and dance injuries of the knee: An overview** Dr. Chinmay Gupte, Consultant Orthopaedic Surgeon/Senior Lecturer, Imperial College London (St Mary's and Charing Cross Hospitals). **Dance and sports: The Olympic legacy -** Dr. Richard Budgett, Chief Medical Officer, 2012 Summer Olympic Games.

30 April **2012** **Nutrition and disordered eating in dance: Artistry, athleticism and the role of the multidisciplinary support team** Royal Society of Medicine, London	**Keynote –** Kenneth Tharp on the complex context of eating disorders and the pressures for dancers to conform to a physical stereotype. **Perspectives from artistic directors on the aesthetic and physical requirements, and implications on dancers' health.** Alistair Spalding, Richard Alston, Dame Monica Mason, David Bintley, David Nixon, and Ann Sholem. **The dancers' perspective on performance demands education and support.** Matthew Lawrence, Ben Duke, Lauren Cuthbertson, Zenaida Yanowsky, Gemma Nixon, Teneisha Bonner, and Archana Ballal. **Prevention and early intervention of disordered eating and eating disorders.** Rachel Peppin, Dr. Huw Goodwin, Louise Dunne, and Prof. Joan Duda. **Creating and utilising a multidisciplinary teach which is the foundation for success.** Nicola Stephens, Nick Allen, Martin Collins, Dr. Alison Joy, Tracey Lee, Elizabeth Nabarro, and Heather Walker.
29 Nov **2013** **Beyond the body: Psychological tools for performance enhancement and wellbeing in dance** Birmingham Hippodrome, Birmingham	**Dance psychology: Perceptions and history –** Prof. Joan Duda & Sue Glasser. **Psychological challenges of dance training and careers:** **Perfectionism –** Howard Hall. **Eating disorders –** Jon Arcelus. **Injury career transitions and identity.** Lana Ashton, Jennifer Curry & Isabel Mortimer. **Psychological tools to improve wellbeing and performance in training and careers.** An introduction to the research in talent development and passion; and workshops on helpful psychological tools such as mental skills training, positive psychology and positive motivational climates in education. Dave Collins, Imogen Aujla, Eleanor Quested, Charlotte Woodcock and Elsa Urmston.

April **2014** **Aesthetic athletes and dancers: Training and optimising performance** Royal Society of Medicine, London	Speakers encompassed of professionals working within rhythmic and artistic gymnastics, ice-skating, synchronised swimming, dance and diving. **Aesthetics – judging and performance.** Dan Edwardes, Founder of Parkour UK; Vicki Hawkins, High Performance Coach and Brevet Judge, International Rhythmic Gymnastics. **Optimising body composition.** Physiological demands of the aesthetic art form, nutrition as well as optimal strength and conditioning. Prof. Matthew Wyon, University of Wolverhampton; Mhairi Keil, Performance Nutritionist, British Gymnastics at English Institute of Sport; Ruddi Farquharson, Strength and Conditioning Coach, British Gymnastics, English Institute of Sport. **Performance optimisation and injury prevention.** Profiling for rehabilitation specialists, core stability in aesthetic performers and hypermobility. Lauren Bradshaw, Sports Physiotherapist, Ex Great Britain Ice Dancer; Gareth Ziyambi, Specialist Sport and Performance Physiotherapist, British Diving; Nick Allen, Clinical Director, Birmingham Royal Ballet's Jarwood Centre. **Problematic dieting within aesthetic art forms.** Regulating weight in synchronised swimming, the role of the coach/teacher in eating disorders and energy availability and impact on bone health. Biz Price, High Performance Director, British Synchronised Swimming; Prof. Jon Arcelus, Consultant Psychiatrist; Dr. Roger Wolman, Consultant in Rheumatology and Sports.

April **2015** **The Future – New ideas, New inspirations** Trinity Laban Conservatoire of Music and Dance, London	**Day 1: Dance in the Wider World.** Tamara Rojo – Welcome. **The Future of Dance** – discussions from Jonzi D, Siobhan Davis, Emma Gladstone and Robbie Synge. **"TED-style" talks** on Disability in dance, public health and the art of digital. **Future funding for dance** chaired by John Nicholls. **Captivating Young audiences** chaired by Alice McGrath. **Day 2: Invest, Create, Innovate.** Caroline Miller – Introduction. **Dancers Need Rest –** Glenna Batson. **The Dilemma – Risk Taking in Choreography** featured contributions from Moira McCormack, followed by a panel discussion on **Choreographic Demands in Dance and Risk, Injury and Boundary Breaking,** chaired by Farooq Chaudhry with panellists Kim Brandstrup, Deirdre Chapman, and Didy Veldman. **Bone Health in Dancers –** Dr. Roger Wolman. **Protein for Dancers –** Prof. Kevin Tipton. **Periodisation in Dance looked at the integration of periodastion into ArtEz, a training college for dancer makers in the Netherlands –** Joost Van Megan and Prof. Matthew Wyon. **Psychology Bitesized** – Dr. Peter Lovatt. **Psychology of injury –** Dr. Natalie Walker. **The future of dancers' health –** Daniel Watson, Dr. Emma Redding, Prof. Matthew Wyon, Helen Laws and Mark Rasmussen. **Injury in the classroom: Adapting class** – Nicola Stephens and Helen Steggles. **The hypermobile student** – Nicky Ellis. **Physiological preparation for the demands of choreography –** delivered by Dr. Emma Redding, Edel Quin and the physiological challenges of Wayne McGregor's choreography live while wearing a gas analyser to measure cardiovascular demand.

October **2015** **Strength and conditioning in dance: Power, performance and rehabilitation** Elmhurst Ballet School, Birmingham	**Keynote speakers on perspectives, context and theory:** **Dancer's perspective –** Khyle Eccles, Johannes Hattunen, Brian Maloney and Glenn Wilkinson. **Dance application, uses and training** – Greg Retter. **Introduction to theory -** Prof. Matthew Wyon. **Practical strength and conditioning** included dance classes, stretching for recovery, physical conditioning in strength, power and plyometric, cardiovascular training, and Pilates training. **Rest and recovery: Integrating recovery into training –** Dr. Benjamin Rosenblatt.
May **2017** **Mind the gap: Train smart, improve performance** Stratford Circus Arts Centre, London	**'World-café' discussions** – all delegates to address key questions about injury, training and resources needed. **Conference Route:** **Introduction to healthcare and research in hip hop-** Erin Sanchez and Dr. Sarah Needham-Beck. **Clinical care of hip hop dancers-** Dr. Roger Wolman and Caroline Jubb. **Research presentations** by Nefeli Tsiouti, Prof. Matthew Wyon, Dr. Keir Philip and Sonja Cimelli. **Workshop Route:** **Alternative hip hop –** Luther Dyer. **Project Breakalign –** Nefeli Tsiouti. **Acrobatics with Mimbre –** Silvia Fratelli. **Injury Management –** Stephanie De'Ath, Olivia Daniell & Lauren Filer. **Nutrition –** Zerlina Mastin & Miroslav Sekula. **Krump Fitness-** Theo Oloyade. **Breaking Fitness –** Emmanuel Adelekun & Anthony Jackson. **Locking and popping fitness –** Frederick Folkes.

May **2017** **A Healthier Dancer Day on The Adolescent Dancer** IADMS Regional Meeting, DanceEast, Ipswich	**Training the adolescent dancer: physiological and psychological perspectives –** Siobhan Mitchell. **Pointework Readiness –** Katy Chambers. Or **Resilience and Mental Health –** Stella Howard. **Dance Floors –** Mark Rasmussen, Harlequin Dance Floors. **How do we support adolescent dancers to dance –** Chaired by Rachel Trist, panellists Sujata Banerjee, Hakeem Onibudo, Sarah Lewis and Tracy Witney. **Nutrition for the young dancer –** Zerlina Mastin. Or **The widening role of the dance teacher –** Tom Hobden.
November **2017** **One Dance UK conference season: Healthier Dancer Programme strand** Trinity Laban Conservatoire of Music and Dance, London	**Keynote "Gender division in decision making roles within creative industries" –** Dr. Gorkan Ahmetoglu **Mental health within dance: Self-care and healthcare –** Interactive dialogue by One Dance UK Dance Science expert panel Dr. Irina Roncaglia, Dr. Nicoletta Lekka, Fiona Macbeth and Georgia Cooper **Mental health and issue-based work** examining the creation of work using psychological material and safeguarding the artistic process – Stuart Waters **Resilience/mental agility: Preparing for the profession –** Dr. Irina Roncaglia **What happens when you are in pain? Brain, body, emotion –** Dr. Roger Wolman **Are your dancers physically prepared? –** Charlotte Tomlinson and Fiona Smith **Managing rehearsals to get the most form your dancers-** Claire Cunningham, Anusha Subramanyam, Kate Flatt and Christine Cartwright. **Injury rehab in the studio: Biopsychosocial concerns –** Georgia Cooper **Self-criticism: Opportunities for reflection and self-growth –** Fiona Macbeth Dance teachers and leaders also took part in **Empowering Dance©,** a 3-hour workshop for dance leaders and choreographers based on the work of Prof. Joan Duda at the University of Birmingham

March **2018** **Preparing to fly** Dance Base, Edinburgh	**Three-hour event on:** **Components of fitness for aerialists and acrobats.** Including balance, cardiovascular fitness, flexibility, strength, endurance and rest. **Structuring training effectively.** **Hypermobility.** **Warm-up and cool down.** **Practical workshop –** embody taught content and consolidate strategies to ensure future practice had a reduced risk of injury. This day was led by Erin Sanchez and Claire Farmer, in collaboration with Jennifer Paterson, All or Nothing Aerial Dance Theatre.
November 2018 **One Dance UK Conference Season – Healthier Dancer strand: Leading the way in dance medicine and science** Leeds College of Music, Yorkshire Dance and Leeds Beckett University	**Keynote** Steve Ingham – Performance Scientist and Founder of Supporting Champions. **Addressing Barriers to Mental Health in Training and Performance -** Phaedra Petsilas, Rambert School. **Taking the Lead in Your Career – Building Resilience as an Independent Artist -** Sarah Lewis. **Pregnant Pause? Maintaining and Progressing a Dance Career Through Pregnancy and Parenthood -** Lucy McCrudden, Steve Ingham and Anna Ehnold-Danailov (Parents in Performing Arts). **Leading the Way in Dance Healthcare Management – the Science Behind the Arts -** Emma Redding, Karen Sheriff, Chris Powney, Greg Retter and Nick Allen. **Safe in Dance International: Warm up and Cool Down (open class) -** Charlotte Tomlinson. **Toolkit: Smartabase Workshop -** Smartabase and Adam Mattiussi**.** **Provocation: What makes a strong dancer? -** Sharon Watson. **The art of scheduling in dance training and performance -** Gaby Allard, Matt Wyon, Derrick Brown, Martin Hargreaves and Phil Mosley. **Toolkit: Fitness for Performance – the application of strength and conditioning to dance training -** Nico Kolokythas, Seema Chopra and Nicola Stephens, MSc, MCSP, MMACP. **Supporting potential at audition (and beyond) – physical, nutritional and psychological assessment -** Kim Hutt and Karen Sheriff.

Note: this Table was created and organized by Anastasia Paschali.

3. THEME 2: THE VALUE OF EVIDENCE INFORMED APPROACHES

Although the development of DMS required broad discussion and debate, it also demanded evidence to support interventions and drive forward changes in practice. Injury care is an excellent example of the regular integration of research into practice within the UK context. At the end of the 1980s, research into dancers' injuries increased exponentially. From the late 1980s, Dance UK conducted multiple national scale studies into health and injury of dancers. These studies progressed understanding of the concerns of dancers and dance students on a national scale and increased both awareness and action to improve dancers' health, reduce the chances of injury, and support injury care.

In 1988, NODM commissioned Ann Bowling to undertake research into the incidence of injury among dancers, as well dancers' perceptions of the causes of injury, preventative measures, and availability and use of healthcare services. Approximately 46% of all dancers in employment in Britain were surveyed with questions developed by the NODM Medical Advisory Panel, including 141 professional ballet and modern dancers from seven companies in the UK. 47% of dancers experienced chronic injury, and 42% were injured in the previous six months, affecting their dancing. Perceived causes of injury included overworking, strain and pressure (38%), unsuitable flooring (25%), cold environments or insufficient warm-up (14%), difficult choreography (12%), repetition of difficult movements (7%), and 39% mentioned reasons including "*[...] inadequate diets, falls due to partnering difficulties, and forced turn out from the hips.*". Most injuries were found in the back or neck (29% chronic and 26% in previous six months, respectively), followed by the lower limb including ankle (20% and 19%), knee (17% and 12%) and thigh or leg (16% and 10%). 54% of dancers reported no rest after sustaining injuries. However, all those with injuries in the past six months sought a health professional's advice, and 63% sought help from more than one; 76% from a physiotherapist, and 46% from a general practitioner or specialist, 79% from another practitioner such as masseuse, osteopath, acupuncturist or other. Based on these findings, Bowling suggested:

> The dancers were aware of preventive procedures, and it seems that practical remedies could be undertaken: sprung and even floors and warmer studios should be provided; teachers and choreographers should be more aware of a dancer's limitations and of dancers' needs to rest as soon as injuries occur; and dancers need immediate access to adequate treatment. The profession of dance is believed to be fairly conservative in responding to recommended changes. The current climate within the profession, however, is ripe for initiating discussions about preventing injuries to dancers, given the awareness of dancers of the high rates of injury and the increasing interest in the potential of sports and dance medicine. (Bowling, 1989, p. 733)

Bowling offered several insights to the perceptions of dancers' health through her research. The findings shed light on the status of professional dancers' health through a retrospective study and focused on the experiences of dancers, rather than the professional diagnosis and recommendation of medical professionals. Her research was also guided by and visible to those studying and working in dance[9]. Bowling was commissioned to undertake her research by NODM, on behalf of the dancers they represented, and her research questions were informed by this collaboration. In 1990, Bowling presented findings as a part of the Healthier Dancer Conference, giving a platform for dissemination and discussion with both participants and stakeholders. As discussed in the previous section, this conference initiated work on industry standards, resources, and a programme of work to support dancers' health. Research informed practice and provided a rationale for activities to address injury concerns.

Subsequent national studies built on initial findings and extended research into dance training. In 1992, Peter Brinson[10] was selected for a Digital Premier Award, a sum of £30,000 pounds to contribute to a cause of his choice, with which he chose to fund an inquiry into dancers' injuries, health and welfare with Dance UK's Healthier Dancer Programme, thus named after the 1990 conference. The research was overseen by an Editorial Board including respected dance professionals, artistic directors, dance medics, researchers in sports science, physiology and

9 In 1988, the Australian Association for Dance Education (later renamed Ausdance) commissioned Tony Greeves to undertake the first research into the injury status of Australian professional dancers, Safe Dance, which was published in 1990. Bowling and Greeves' research was heavily mutually informed. The Safe Dance report also featured informational appendices including "Care of the Instrument", and "The Metamorphosis of a Dancer" which were later shared with Dance UK to become information sheets for dancers in the UK.

10 Peter Brinson was an academic, intellectual, educator, but above all, an advocate for dance in all its forms. Educated at Oxford, he began as a film scriptwriter and research director, but after seeing the Sadler's Wells Ballet and approaching Dame Peggy van Praagh to learn "[…] what it felt like to be a dancer […]" (Nugent, 1996, p. 126) he changed his life path. In the foreword of the Australian Safe Dance report (1999), van Praagh is mentioned as an 'inspiration and guide' to the Australian Association for Dance Educators as "[…] care for the well-being of dancers was high on her list of priorities.". This attention to the welfare of dancers perhaps was part of the genesis of Peter Brinson's philosophy (her student in the 1950s), as well. Peter also studied ballet with Audrey de Vos, an early pioneer of anatomically informed dance pedagogy in the UK. Peter Brinson's impact on dance and dancers goes beyond the scope of this chapter, however, he was undoubtedly one of the fathers of dance research, advocacy, and education in the UK.

psychology, and dance educators, and research was undertaken by a team (Figure 1) including Brinson, Fiona Dick, Dr. Yiannis Koutedakis, Dr. Paul Pacy, Magita Khalouha, Angelica Herold MacArthur, and Matthew Wyon (Brinson & Dick, 1996).

Research included a survey of professional dancers and pre-professional dance students, talking to dance/sports medics to inform recommendations from the survey, visits to dance companies and dancers, separate research into fitness and nutrition and psychological variables with 50 volunteer dancers in London and in Wolverhampton, and an enquiry into existing medical and dancers' health provision. The results of the dancers' survey showed that of the 658 ballet, contemporary, jazz, south Asian, tap, afro-Caribbean, and other professional dancers and dance students responding, 83-84% had sustained at least one injury in the preceding 12 months. Muscular injuries and injuries to the lower back were most common across both professionals and students, and perceived causes of injury included fatigue/overwork, ignoring early warning signs, repetitive movements, and unsuitable floor. Most dancers reported warming-up, but far fewer reported cooling down. Key psychological problems reported included general anxiety, tension with people, and external stress. Results from nutritional research with volunteer dancers indicated average energy consumption at 2650 calories for males and 1980 for females, and dancers with not enough vitamin C, D and E experienced higher rates of musculoskeletal injury than counterparts with normal levels. Recommendations were included for the dance world on improving physical fitness, lifestyle issues, working conditions, injury management, psychological issues, and training (Brinson & Dick, 1996) (Selected findings are reported in Tables 2 & 3).

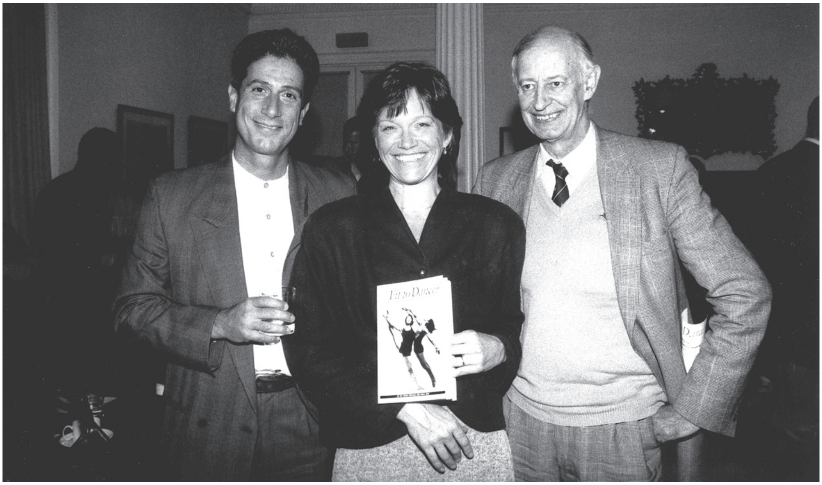


Figure 1 – Fit to Dance launch. (1996). Dr. Yiannis Koutedakis, Angelica Herold McArthur, and Professor Craig Sharp at the launch of Fit to Dance research publication. [Digital image]. London, England: Healthier Dancer Programme and One Dance UK, printed with permission.

As the researchers analysed the data, it became clear that further action needed to be taken to support both professionals and those in training. Yiannis Koutedakis began to offer lectures and implement interventions for fitness enhancements in dance companies and schools, including London Contemporary Dance School, the Northern School of Contemporary Dance and Phoenix Dance Company (Leeds) and the Birmingham Royal Ballet; and the outcomes of this work were published in 1996 (Koutedakis, Cross & Sharp, 1996). According to Koutedakis, as a result of this paper, Sir Peter Wright (the former artistic director at the British Royal Ballet) was inspired to set up the UK's first strength training facility in a professional ballet company. The recommendations that came out of the original research also dictated the focus and work of the educational extension of the Healthier Dancer Programme (HDP); including educating dancers and raising awareness about reducing injury risk factors, managing injury, and the costs and loss of wages injury could potentially cause.

A full time HDP Manager role was created to carry out the growing work in dancers' health, dedicated to education in both vocational schools and dance companies. Healthier Dancer Roadshows funded by the Foundation for Sport and the Arts and the Macintosh Foundation, began in 1995 and helped bring information to dance schools and companies around the UK, guided by the expertise of the Medical Advisory Committee and Physiotherapy Advisory Group. English National Ballet, Birmingham Royal Ballet, and Rambert invited the HDP into their companies for days or weeks of educational talks for dancers during August, much of which was led by physiotherapist Caroline Marsh (Figure 2). The Physiotherapy Advisory Group provided professional networking to discuss treatment methods, injury rates and causes (Laws, 2004). The HDP also supported and advocated for the development of knowledge among dance teachers about the importance of warm-up, fitness, healthy diets, and the psychological impact of some teaching methods (Laws, 2001). A poster series on diet, health and treating injury was published by Dance UK. In 1997, a video of a warm-up for African and Caribbean dancers, called "Oya k'Ajo - Come on, let's dance", was launched.

Figure 2 – Healthier Dancer Roadshows. (1998). English National Ballet dancers during a fitness training session run by the Healthier Dancer Programme. [Digital media]. London, England: Healthier Dancer Programme and One Dance UK, printed with permission.

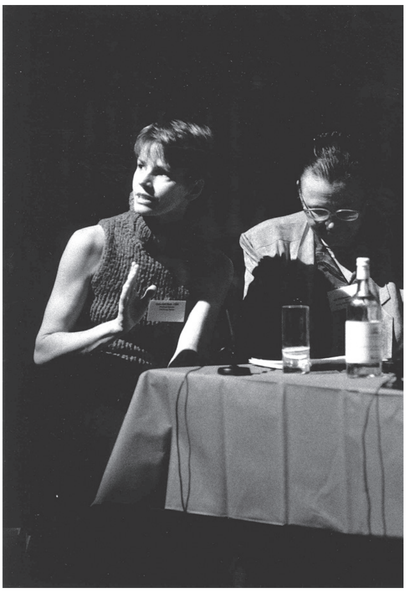
The impact of increased collaboration between dancers and scientists was being noticed, even among the most famous UK dancers of the time, such as then Royal Ballet principal dancer Deborah Bull who not only highlights the integration of physiological research into performance enhancement for dancers, but goes on to describe a diverse variety of scientific elements integral to performance and injury prevention:

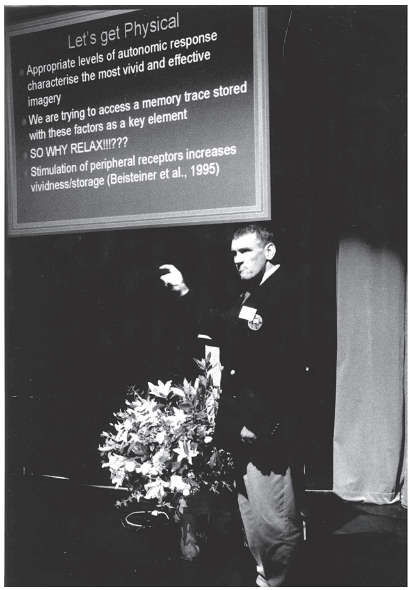
> It wasn't until relatively recently that I discovered that the magical qualities 'energy' and 'stamina' were elements that could be worked on in the same way as

> *pirouettes* or *entrechats* […]. A couple of years ago, I met a physiotherapist who checked my heart rate at the end of the Black Swan *pas de deux* and found it to be over 200 beats per minute. I was intrigued as to why he was so interested in it. How was this relevant to me and my work? It was the beginning of a long learning curve for me. For the first time in all my years someone introduced the idea that perhaps dancers are not utilising the most efficient ways to achieve optimal performance, and that by improving fitness and nutrition, I could achieve better results in performance and at the same time, guard against injury. […] consequently, my working practices have radically altered, with noticeable benefits […]. My increased fitness has meant that in performance I can focus on technique and artistry and not on staving off total collapse. That in itself has made dancing a more satisfying experience. The knowledge that I have gained is a kind of support system, both physical and psychological. Knowing that I can contribute in such a positive way to my work acts for me as an antidote to pre-performance nerves. There is always luck involved when you go on the stage, but I feel that now I am not quite so dependent upon it. (Bull, 1996, as cited in Brinson & Dick, 1996, p. 65)

Outcomes of the Fit to Dance research continued with expanded education, resources for dancers, and improved clinical services embedded in ballet companies, an expansion of the educational programme and roadshows, the "Healthier Dancer Introductory Talks", which had previously been more focused on companies, into vocational colleges and schools. Events were held at a variety of dance organisations on a regular basis, providing information on warm-up and cool down, injury prevention and management, nutrition and hydration, safe dance practice, fitness training, performance psychology, imagery, self-esteem, motivation, assertiveness, the adolescent dancer, and the importance of language in teaching. The roadshows reached more than 4700 people in more than 45 organisations between 1996 and 2004. Shorter talks embedded in vocational colleges and schools reached 4600 people in 36 organisations between 1998 and 2003. Talks and events were delivered by professionals including Caroline Marsh, Jasmine Challis, Kim Pedrick, Fiona Winter, Rachel Rist, Dave Collins, and Matthew Wyon. In 1999, Dance UK published "The Dancers' Survival Guide" in collaboration with the Foundation for Community Dance and The Place Dance Services and a new information sheet on Core Stability, written by Warrick McNeill was also published. The Dance UK website was launched in 2000, and Dance UK also published "A Dancer's Guide to Warm-Up and Cool Down" posters and a new information sheet answering common physiotherapy questions. In 1999, Jackie Pelly joined the English National Ballet as physiotherapist, and shortly thereafter, joined Dance UK's Medical Advisory Committee.

The second major Healthier Dancer Conference, "Moving Matters", took place over two days in October 2000 at the Royal Opera House, bringing together the dance, sports and health communities (Figures 3 and 4). 41 speakers addressed dancers' health and well-being in terms of physiological, cultural, nutritional, and complementary techniques. 374 delegates attended representing academic, artistic, healthcare, and educational perspectives. The morning of the conference was devoted to sessions entitled, "Your Body, Your Risk" which included perspectives from professionals working with dancers in psychological, nutritional, psychiatric, endocrine, and bone health specialisms. The second part of the day had concurrent sessions on new research as well as supplementary practices for holistic training methods including Franklin and Alexander Techniques, and Yoga. Day two began with discussion of psychological aspects of excellent performance, followed by an address from Secretary of State for Culture, Media, and Sport, Chris Smith (Member of Parliament - MP). Afternoon sessions focused on seeking help for injury, with insight from physiotherapy, Pilates, orthopaedic surgery, and sports medicine, as well as perspectives from a ballet mistress and an independent dance artist. The day finished with a discussion on the interrelationships of responsibility, and the challenges of reaching a healthier future.





Figures 3 and 4 – Deborah Bull, principal dancer of the Royal Ballet, speaking on a panel, and Prof. David Collins lecturing on effective imagery for elite performers at the Moving Matters Healthier Dancer Conference. (2000). [Digital images]. London, England, Healthier Dancer Programme and One Dance UK, printed with permission.

The 10 years since the first conference brought some change, but the conference highlighted further needs. Bob Lockyer commented:

> For me, it was wonderful to listen to so many united voices at the Linbury Theatre at the Moving Matters Conference in October. Performers, teachers, doctors, academics, all seemed to be on the same wavelength. The problems of eating disorders were faced and discussed openly. There was no intake of breath like there was at the first (HDP) conference (in 1990) when the subject was raised. Have we in the dance world really faced it? When I go to school and company canteens, I still see too many sweet drinks and chocolate bars and not enough pasta and fresh fruit. I had another look at "The Dancers' Charter", our "little red book" which was written by Peter Brinson all those years ago after the first conference. Please look at it again. So many of the points raised still need to be addressed by everyone in the dance world. I suppose that and conference only preaches to the converted. The people – dancers, teachers, choreographers, companies, funders – who need to change most don't attend such events. Is there a way around that? I always said in the early days that you could change attitudes in five years if you go to the students and teach them good practice. That is why it is so exciting about Dance UK and The Healthier Dancer Programme [...] They have proved that it works. [...] We have come a long way, and we can by looking behind us to check how far we have come. But the climb ahead is even steeper. Come on, look how far we have climbed, we are more united than ever as a family […] dance does speak with one voice. So, let's use it. (Lockyer, 2000, p. 1)

Following the conference, and the call for greater attention to dancers' health, two key developments occurred for education in dance science: the Laban Centre began the first MSc in Dance Science in 2001, followed by the University of Wolverhampton in 2002, and dancers' health education for all dance teachers became a subject of wider discussion. MSc programmes in Dance Science aimed:

> [...] to give the same rigor to the analysis of dance training as has been applied to sports. Attempts to address the physical aspects of dance training on the body have relied on knowledge developed in sports science. However, dance is unique in the sense that it requires the body to be taken to unusual extremes and the dancer is required to be both athlete and artist. It seemed necessary and appropriate to initiate a dance science course that developed dance specific ways of measuring and improving dance training and performance. (Redding, 2002, p. 20)

In 2003, conversations between the Council for Dance Education and Training and the dance awarding bodies aimed at teaching qualifications included not only robust aspects of technique, but also pedagogy and safe practice. As many organisations modernized their teacher training syllabi, the Healthier Dancer Programme was often consulted for advice and to read drafts of new courses and modules on dancers' social, emotional, physical, and psychological safe practice considerations. Dance UK's Medical Advisory Committee and Physiotherapy Advisory Group provided support to create guidance for awarding bodies on the content and progression of this information through teacher training. In 2005, The HDP collaborated with the Council for Dance Education and Training to design a a series of workshops on safe dance practice and health and safety that could be used by teachers completing training with these awarding bodies. Due to the differing requirements between awarding bodies for hours of required Continuous Professional Development (CPD) in different areas, these didn't go ahead as initially envisioned. They did however, inspire continued discussion about the potential for a standalone safe practice module that could be accessed by all dance teachers.

As education became more widespread and scientists and healthcare practitioners had more interaction with dance environments, it was pertinent to reassess the situation of dancers' health through research. In 2005, the results of the second national inquiry into dancers' health and injury in the UK were published. "Fit to Dance 2" (Laws, 2005) results indicated some changes in injury incidence and use of preventative practices, but also revealed psychological, nutritional, and social challenges dancers faced. As in the 1996 study, 80% of dancers sustained an injury each year in 2005, but between 1996 and 2005, significantly fewer dancers reported lower back injuries (31% versus 44%) (Laws, 2005, p.18), and fewer ballet and contemporary dancers reported sustaining injuries due to unsuitable floors and cold environments. About 80% of dancers reported warming-up, but only 30% reported cooling down after performance. However overall, more dancers reported cooling down in 2005 than in 1996, and in 2005 results indicated a significant correlation between cooling down after rehearsal and decreased injury risk.

Psychological concerns reported by dancers were even more prevalent than injuries, with 92% of dancers reporting at least one psychological issue, and 85% reporting more than one. Concerns included "tension with people", "constant tiredness", "low self-confidence", and "general anxiety". There was a reduction in reports of eating problems from 21% in 1996 to 16% in 2005 (Brinson & Dick, 1996; Laws, 2005). Student dancers were more likely than professionals to report eating problems (19% versus 7%), low self-confidence (58% versus 40%), and constant tiredness (60% versus 43%). Weight reducing diets increased to 23% in 2005 from 15% in 1996. In 2005, 25% of dancers reported eating problem in past, 36% female dancers reported having had irregular periods, and 17% female dancers reported their periods stopped for 6 months. Ballet professionals also reported increased alcohol/drug overuse, difficulty concentrating, external stress, and performance anxiety in 2005. Smoking reduced among both males (28% from 40%) and females (19% from 36%) in 2005 (Tables 2 and 3).

Table 2 – *Anatomical Sites of Injury*

<table>
<tr><th></th><th>*Injuries within past 12 months (Laws, 2005, p. 19)</th><th>*Injuries within past 12 months (Brinson & Dick, 1996, p. 45)</th><th>*Injuries within past 6 months (Bowling, 1989, p.732)</th></tr>
<tr><td>Shoulders</td><td>12%</td><td>14%</td><td rowspan="2">5%</td></tr>
<tr><td>Arms/Hands</td><td>4%</td><td>7%</td></tr>
<tr><td>Neck</td><td>13%</td><td>19%</td><td rowspan="3">26%</td></tr>
<tr><td>Upper back</td><td>10%</td><td>12%</td></tr>
<tr><td>Lower back</td><td>31%</td><td>44%</td></tr>
<tr><td>Ribs</td><td>2%</td><td>4%</td><td rowspan="4">12%</td></tr>
<tr><td>Pelvis</td><td>2%</td><td rowspan="3">16%</td></tr>
<tr><td>Groin</td><td>13%</td></tr>
<tr><td>Hip</td><td>10%</td></tr>
<tr><td>Thighs</td><td>14%</td><td>15%</td><td rowspan="2">10%</td></tr>
<tr><td>Lower legs</td><td>15%</td><td>21%</td></tr>
<tr><td>Knees</td><td>23%</td><td>34%</td><td>12%</td></tr>
<tr><td>Ankles</td><td>24%</td><td>32%</td><td>19%</td></tr>
<tr><td>Feet</td><td>16%</td><td>22%</td><td>16%</td></tr>
</table>

Table 3 – *Perceived Causes for Injury Among Dancers*

	Ballet		Contemporary		Ballet and Contemporary
	Laws, 2005	*Brinson & Dick, 1996*	*Laws, 2005*	*Brinson & Dick, 1996*	*Bowling, 1989*
Fatigue	38%	57%	37%	60%	38%
Overwork	37%		31%		
Repetitive movements	33%	38%	38%	45%	7%
Recurrent injury	34%		37%		
Floors	28%	47%	20%	37%	25%
Cold environment	15%	37%	16%	36%	14%
Ignoring early warning signs	25%	23%	9%	34%	
Difficult choreography					12%

Recommendations from the research included the following:

- dancers should be physically fitter;
- dancers should warm-up and cool down;
- dancers should eat and drink properly;
- dancers should not smoke;
- safe environments for dancing should be provided;
- dancers should get immediate treatment for injury;
- education about the body is needed for both dancers and teachers;
- special consideration should be given to the menstrual status of female dancers;

- dancers should know how to rest, pace themselves and combat staleness;
- dancers' psychological needs should always be considered alongside their physical ones.

As the findings for "Fit to Dance 2" were being disseminated and discussed, a new focus emerged. HDP Manager Helen Laws began to look at how to offer dance-specialist and affordable injury care for all dancers. The "Fit to Dance 2" findings made it clear that many dancers still needed access to healthcare, and money was a formidable barrier to accessing treatment and advice. Industry research was undertaken through a gathering of dance managers and artistic directors, exploring how such services were provided to Olympic athletes with Dr. Richard Budget from the Olympic Medical Institute and Dr. Rod Jaques of the English Institute of Sport, and a great deal of industry discussion. In 2007, a plan was developed for multidisciplinary hubs where dancers could access advice and information, health screens, supplementary training programmes, treatment and rehabilitation for injury. The Scheme responded to the main issues facing the dance profession and the development of DMS in the UK: 1) the need to improve the availability of affordable, comprehensive, dance specific healthcare provision and dance science support services to all dancers, not just those well-funded ballet companies; and 2) the need for more detailed research into the mechanisms, prevention and rehabilitation of injury to effectively shape healthcare provision.

Considering the urgency and scale of this new vision and as it became more common for schools and companies to provide their own education in dancers' health, a shift in priorities occurred to support fundraising for this project within the HDP. The "Healthier Dancer Roadshows" were paused, and a “Healthier Dancer Programme Speakers List” was added to the Dance UK website to signpost to expert speakers. Through 2008, the HDP continued to develop resources to disseminate key knowledge in dancers’ health to a growing audience, including adding recipes vetted by accredited Sports Dietician and HDP advisor Jasmine Challis to the Dance UK website, and working with Foundations for Excellence[11] to produce new information sheets on dance psychology.

The HDP was profiled on BBC television’s “The One Show” and was also a part of the steering committee to create the new Certificate in Safe and Effective Dance Practice offered by Trinity College London. Conversations about dance teaching qualifications and formal recognition of the expertise of independent and community dance artists led to the creation of the Dance Training and Accreditation Partnership which grew to include a diverse group of organisations representing dance training, qualifications, and quality assurance bodies in a variety of settings. Quarterly meetings to evolve the partnership through funding from the Arts Council allowed for discussion on creating occupational standards for teachers that would recognize the skills and core competencies teachers should embody in their work. Concurrently, the standalone training for dancers’ health which had been in discussion, titled the “Safe and Effective Dance Practice Qualification” was developed with support and planning from Rachel Rist, Emma Redding, Matthew Wyon, and Helen Laws alongside other IADMS members. The training gained accreditation from Trinity College London, where Maggie Morris supported its development by internally advocating for the value of such a qualification.

11 Foundations for Excellence existed to share research, resources and best practice for the support and development of talented young musicians, singers and dancers. This was achieved through the online resource hub, the commission of new information sheets on a variety of specific topics and a biennial conference.

Alongside innovative approaches to healthcare and dancers' health education, in 2009, the Department of Education and The Leverhulme Trust funded a three-year large scale longitudinal interdisciplinary research project into the trainable and innate characteristics of talent development. This research, conducted by Trinity Laban Conservatoire of Music and Dance, enhanced understanding of student dancers' physical and mental health and examined how it changed over time at eight government-funded Centres for Advanced Training (CATs) in dance with over 800 dancers aged 11-18. The research questions were heavily informed by consultation with teachers within the CAT programmes and examined the physiological, anthropometric, psychological, injury, adherence, and creativity characteristics of the young dancers, through both quantitative and qualitative methodologies (Redding, Nordin-Bates & Walker, 2011). This project was followed by a second project commissioned by Dance4 and funded by the Department for Education, exploring the talent identification, progression pathways, and barriers to training provision for young dancers with disabilities.

Pertinent certainly to the development of research informed practice was collaboration with international partners, including the International Association for Dance Medicine & Science, colleagues in Europe and Australia, and in 2016, a partnership was set up through the Newton Fund and the Foundation for Research Development of the State of Goiás (*Fundação de Amparo à Pesquisa do Estado de Goiás - FAPEG*) between Brazil and the UK to develop links in DMS (Brazil-United Kingdom Dance Medicine & Science Network - BRUK DMS NET). The foci were on the challenges and potential of DMS in the UK and Brazil, allowing the development of pieces of research and books, exchange of post-graduate students, creation of services, and researchers to attend conferences in the participating countries.

National scale research into health and injury of professional and student dancers, longitudinal research into talent development and training, and international collaboration guided and enriched practices in dance education and healthcare, and provided iterative opportunities for DMS to grow in the UK.

4 THEME 3: A SHARED RESPONSIBILITY FOR DANCERS' HEALTH

Alongside the opportunities for open debate and research to inform practice, there is also the necessity in DMS to work in an interdisciplinary way to embed contributions from science and healthcare into artistic environments. Interdisciplinary collaboration in the UK has come in the form of shared working environments, partnerships towards ambitious goals, and projects bringing multiple strengths together. One of the key partnerships in the UK's DMS work, and the primary focus of this section, is the National Institute of Dance Medicine and Science - NIDMS, an innovative and unique service to provide healthcare, education, and dance science support services to dancers.

Before NIDMS, in 2001, The Birmingham Royal Ballet received a £200,000 grant from the Jerwood Foundation, enabling them to both refurbish and extend their building to house a state of the art centre for dance medicine, The Jerwood Centre for the Prevention and Treatment of Dance Injuries, in April 2002 (Figure 5). Facilities available to dancers included a Pilates studio, physiotherapy and strength and conditioning room, and a variable level, jet-streamed pool; with the aim of not only treating injuries but focusing on the reduction of injury through early intervention and research (Jerwood Foundation, 2002).

Figure 5 – Ross, Andrew. (Photographer). (2011). Nick Allen (Clinical Director) at Birmingham Royal Ballet's Jerwood Centre for the Prevention and Treatment of Dance Injuries. [Digital image]. Birmingham, England: Birmingham Royal Ballet, printed with permission from NIDMS.

In 2007, Dance UK, Trinity Laban Conservatoire for Music and Dance, the University of Wolverhampton, Birmingham Royal Ballet and Royal National Orthopaedic Hospital gathered to develop the Dancer's Health Pilot Scheme (Figure 6) - later to become the National Institute of Dance Medicine and Science (NIDMS). This allowed dancers to join the British Olympic Association's Athlete Medical Scheme. The Scheme aimed to test the vision of multi-site provision on a smaller scale with three of the potential hub-sites: Trinity Laban in London; The Jerwood Centre at Birmingham Royal Ballet; and the Olympic Medical Institute in Northwick Park Hospital, Harrow; with Wolverhampton University adding further research expertise. Nick Fellows, Head of the Olympic Medical Institute described the value of these diverse partners coming together to offer support for dancers and athletes, including access to comprehensive injury care and expert advice and support:

> The pilot scheme proposed by Dance UK is vital to the long-term health of dancers. There are many parallels between dancers and athletes, not least of which is the physical nature of their work. As with any top-level performer, fitness and conditioning are crucial elements of their preparation and, unfortunately, injuries are a common side effect of pushing the body to its limits. [...] In sport we have been fortunate to be able to offer athletes a comprehensive medical insurance scheme for a number of years and access to expert support for more than 20 years. Doctors, physiotherapists, sports scientists, nutritionists, psychologists and more are now available to athletes within high performance programmes, free at the point of use, to ensure that injuries are dealt with promptly and effectively, often in a multidisciplinary environment. Further work is being done on injury prevention and the education of support providers and coaches is continually improving to heighten their understanding of what causes, and how to treat, injuries. The Olympic Medical Institute (OMI) provides the only dedicated intensive rehabilitation centre for sport in the UK and offers specialist services including a bone health clinic, cardiac screening service and psychological support to overcome the mental effects of injury. A number of the specialist practitioners at the OMI also work in dance and our partnership with Dance UK seems an ideal way to begin to offer dancers the kind of support that athletes have been able to enjoy for a number of

> years. Not only can we help the dance world to avoid many of the potential problems involved in setting up a new service, but I believe that a parallel system, with overlapping aims, will represent a great legacy from the initiatives being undertaken by both sport and the arts in respect of the London Olympic Games. (Fellows, 2007, as cited in Laws, 2007, p. 15)

However, fundraising for this ambitious project was challenging following the recent financial crisis and recession and Dance UK was still a way off from the goal to raise £500,000 to deliver a comprehensive multidisciplinary service, to support research into dancers' injuries and their causes, and to test what was needed to sustain a nationwide service for the future. In 2012, NIDMS was officially launched at the Healthier Dancer Conference with founding partners Dance UK, Birmingham Royal Ballet, Trinity Laban Conservatoire of Music and Dance, Royal National Orthopaedic Hospital (RNOH), and the University of Wolverhampton and University of Birmingham. To make the most effective use of the funds raised to date, the partners planned to work together to provide a specialist dance injury service embedded within the NHS and subsequently the first NHS dance injury clinic was launched at the RNOH, led by Dr. Roger Wolman, Consultant in Rheumatology and Sports and Exercise Medicine (SEM). The new clinic was established within the sports injury clinics also run by Dr. Wolman and offered a dedicated dance specialist physiotherapist, seed-funded by NIDMS. This new clinic allowed dancers in London who had been unable to afford private medical care to have access to injury diagnosis and treatment by specialist practitioners, free at the point of use.

Figure 6 – Burrows, Helen. (Photographer). (2007). Dancers' Health Pilot Scheme launch. L to R: William Trevitt, Bonnie Langford, Nick Allen, Roanne Dods, Nick Fellows, Helen Laws, Emma Redding, and Matthew Wyon. [Digital image]. London, England: Healthier Dancer Programme and One Dance UK, printed with permission.

This collaboration proved highly successful at providing injury support to dancers within an existing dedicated team, and over the following year, NIDMS' London NHS clinic treated 100 dancers. After a successful first year, the dance physiotherapist became embedded in the NHS as the post was effectively self-funding through the normal NHS routes being utilized to capacity by dancers referred from around the country., A second clinic at the Queen Elizabeth Hospital Birmingham, headed by Dr. Kim Gregory, opened with a further £10,000 support from Harlequin Floors. The clinic was launched in 2013 with dancers from the West End and Birmingham Royal Ballet praising the work of NIDMS, and Harlequin presented NIDMS with a cheque for £10,000 (Figure 7). 2013 also saw investment in and development of the Royal Ballet's healthcare services for dancers.

By 2014, NIDMS' London NHS clinic had treated its 300th dancer and, in partnership with the Dance Again Foundation, opened a third dance injury service at the Royal United Hospital Bath. The Birmingham NHS dance injury clinic was also able to successfully develop the clinic to include dance specialist physiotherapy. While the NIDMS clinics were a welcome and sustainable way of providing injury diagnosis and treatment, this alone didn't fulfil the work for NIDMS to provide fast, affordable access to healthcare for independent dancers. Thus, Dance UK and NIDMS launched the new Performance Optimisation Package, a health package to provide independent dancers with an affordable way to access a multidisciplinary team providing dance science support, and preventative services similar to ones available in large companies.

Figure 7 – Senley, Rick. (Photographer). (2013). Launch of the National Institute of Dance Medicine and Science (NIDMS) Birmingham dance injury clinic, supported by generous donation of £10,000 from Harlequin Floors and offering free treatment to dancers through the National Health Service (NHS). L to R: Prof. Joan Duda, Helen Laws, Dr. Roger Wolman, Khyle Eccles, Sinead Long, Tom Rogers, Prof. Matthew Wyon, Nick Allen, Mark Rasmussen, Eleanor Quested PhD, and Emma Redding PhD. [Digital image]. Birmingham, England: Healthier Dancer Programme and One Dance UK, printed with permission.

Another collaboration of dance organisations further united the dance profession. In 2016, Dance UK, the National Dance Teachers Association, Youth Dance England and the Association of Dance for the African Diaspora joined together to create One Dance UK, a unified national support body for the dance sector, subject association for dance in schools, and support body for those who engage in dance. This important step forward reduced administrative costs and enhanced collaborative working within the areas of dance teaching, the dance profession, children and young people dancing in and outside of school, DMS, and dancers working in diasporic forms. As a part of the new organisation, a new membership category specifically serving healthcare practitioners and dance scientists was created.

The strength of the collaboration within NIDMS between academic, clinical, educational, and artistic partners provided several key developments as it continued. By 2016, NIDMS had raised £180,000 for dancers' health, treated 1200 dancers in the three free specialist dance injury clinics, published more than 50 peer reviewed articles, and delivered 200 conference presentations. NIDMS partner University of Wolverhampton, began hosting an annual two-day DMS research workshop to provide a forum for researchers to share work and discuss together. In January 2017, The Royal Ballet became a partner of NIDMS. The Performance Optimisation Package offered by One Dance UK was enhanced to include a tiered system allowing dancers to select three options for levels of services and support based on their needs, including benefits of reclaim 75% cost of physiotherapy, osteopathy, chiropractic treatment, homeopathy, and chiropody, heath screen up to £250, private diagnostic consultation up to £100, discounted gym membership, private prescription service, access to a 24 hour help line including counselling services, General Practitioner (GP) and legal advice. Additional 1:1 musculoskeletal and fitness screening with a dance-specialist exercise physiologist and physiotherapist in London and Birmingham with a report and training advice, maximal volume of oxygen (VO_2max) and analysis of current dance projects, and a second 1:1 session to implement training plans could also be added. In 2017, NIDMS clinic data on 800 dancers was presented at the International Association for Dance Medicine and Science conference in Houston, Texas.

NIDMS also capitalised on diverse strengths of its partners to enhance engagement with DMS through a variety of initiatives, including; providing consultations to dance companies regarding their dancer health and wellbeing policies, researching how to develop stronger ties with general practitioners to raise awareness of the NHS dance injury clinics and promote referrals for dancers, holding focus groups with West End musical theatre dancers to learn more about the support they needed in terms of health, increasing uptake of the Performance Optimisation Package; launching a weekly blog and enhanced engagement on social media to reach dancers; and offering bi-annual networking events for healthcare practitioners, researchers, and educators. International collaboration and sharing continued with Helen Laws presenting at the Korean Dancers Career Development Center's symposium. In November 2018, NIDMS raised £3400 from the Big Give Christmas Challenge to aid the further development of NHS dance injury clinics across the UK and additional provision for psychological care.

In 2018, the growth and development of NIDMS continued, with aspirations for new clinics, increased awareness across movement forms, and improved technologies to support dancers' healthcare. Discussions began to establish NHS clinics for dancers in Wales, Scotland and the north of England. Support of dancers' mental health increased with a section of resources on the NIDMS website. Research into collaborations with the NHS mental health services began with presentations to the Royal Society of Psychiatrists Sport and Exercise Special Interest Group, and social media campaigns for Eating Disorders Awareness Week and World Mental Health Day were carried out. NIDMS also began partnerships with practitioners in circus, attending the European Aerial Dance Festival to assist with a round table discussion on health issues arising in aerial arts to inform the programme for the first Health symposium in aerial dance presented by NIDMS and Gravity and Levity. Finally, NIDMS partner The Royal Ballet presented workshops at the Royal Opera House as well as the One Dance UK conference in Leeds about Smartabase, an injury surveillance software to be used during the planned NIDMS epidemiology study, for healthcare leaders in dance schools and companies.

In 2019, clinical services advanced in the spring with a new NHS-based emergency service was opened in London's Mile End Hospital for dancers who sustained serious injury in the last 72 hours that requires immediate attention, urgent medical diagnosis or treatment. Additionally, dancers with RED-S (Relative Energy Deficiency in Sport/Dance) were able to be treated both in London and Birmingham NIDMS clinics.

However, in the summer of 2019, an event occurred that emphasized the extreme value of the collaboration that NIDMS had created since 2012. The NHS decided to remove the Sports and Exercise Medicine Clinic at the Royal National Orthopaedic Hospital, thereby also removing the dance injury clinic led by Dr. Wolman. This decision was made as part of a high level

NHS 'service consolidation' exercise without consultation with NIDMS or patients, and displaced and delayed dancers already using, and intending to seek support for injuries. To give voice to the concerns of dancers, NIDMS began a social media campaign, #dancersmatter allowing dancers to sign a petition to highlight the importance of dance specialist healthcare and the lifeline this provides for professional and non-professional dancers. The campaign received more than 7,600 signatures, and hundreds of messages:

> NIDMS has helped me recover from an injury both mentally and physically during my intense dance training at university. Normal physiotherapists are unable to tackle the injuries in the same way a dance physiotherapist can. If it wasn't for NIDMS I would not have been able to finish my degree and have a career in a subject I adore (Lily Wilson, personal communication, 2019)
>
> I have received amazing dance-specific care and treatment tailored to me from the clinic at RNOH, which has undoubtedly prolonged my career. (A Hanauer, personal communication, 2019)
>
> As a performer, it is vital to be able to get specialist healthcare and often very difficult to find. Without physiotherapy in the case of injury, dancers are unable to work or seek future employment. This sort of specialist treatment is often difficult to find and very expensive and this clinic is incredibly important to the community. (Stephen Dole, personal communication, 2019)

Thankfully, NIDMS managers and partners worked together to quickly move the service to another hospital, the London clinic at Mile End Hospital which had been providing emergency dance injury services, thus continuing the vital service.

Without active, regular collaboration between researchers, clinicians, educators, and artists towards the shared goal of improving dancers' performance and health, innovations such as NHS-based clinics, financial support for performance enhancement and injury rehabilitation, and hubs for independent dancers to access screening services would never have been possible, and certainly cannot be maintained.

CONCLUSION

The diversity of voices and debate, discussion and a multitude of viewpoints in regular conferences has allowed for the development of a shared community of dance, research, and medical professionals and the sense of shared responsibility for dancers' health. Discussion, camaraderie and bringing people along have all been key factors in the development of DMS in the UK. This interdisciplinary community is regularly informed by international scale research and evidence-based education. Research also informs the process of raising awareness both within and outside the dance sector about the physical, psychological and social demands of dance careers and the need for research, education and clinical care for dancers. Collaboration and shared responsibility for the performance, health, and welfare of dancers have led to advances in services for dancers.

An aspiration is to continue to develop a shared understanding and responsibility across artistic, managerial and healthcare staff, dancers, rehearsal directors and teachers, of the importance of honest and open communication during the creative process, about the physical and psychological impact of the emerging work, in order to push artistic boundaries and create exciting work that the dancers can sustain in performance; and to empower dancers to find a strong and intelligent voice for their health and wellbeing in every context.

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CHAPTER 3

HISTORICAL ASPECTS OF DANCE MEDICINE & SCIENCE IN BRAZIL

Adriano Bittar / Valéria Figueiredo / Luciana Ribeiro

INTRODUCTION

The goal of this chapter is to reflect on the history of the Dance Medicine & Science (DMS) field of study and practice in Brazil (BR). The research focus is in the facts, documents and narratives that unveil life paths and experiences of important personalities in the Brazilian DMS field over the last decades. They indicate constructions of identities, bringing visibility to actions (Clandinin & Connelly, 1994; 2015) that transformed DMS in this country. Through a historical analysis, case studies mainly of some of the prominent agents of DMS in BR, and of the Brazil-United Kingdom DMS Network (BRUK DMS NET), are discussed, showing the potential and scope of this field of study, while pointing out the challenges faced.

From the testimonies collected, several characteristics that reveal important aspects of the DMS field in BR have been identified and further divided into three overarching themes: 1) constitutions and traces of DMS in Brazil; 2) DMS in Brazilian universities; and 3) further development and growth. DMS can be considered as an aggregator field, multidisciplinary and instigating for professionals who work with the human movement. In BR, its initial state of development is clear, despite the existence of quality research and services.

1 DANCE MEDICINE & SCIENCE IN BRAZIL[12]

12 Notes about the Timeline are added to the end of this Chapter.

KEY MILESTONES IN BRAZIL

2000s

BR

- Andreja Picon and Isabel Sacco create the dance research line of the Laboratory of Biomechanics of Movement and Human Posture (LABIMPH), at Universidade de São Paulo (USP)
- Aline Haas develops research in DMS at Pontifícia Universidade Católica do Rio Grande do Sul (PUCRGS)
- Adriano Bittar and Cláudia Daronch create a DMS service at Quasar Cia de Dança, in Goiânia, Goiás, with support from Universidade Estadual de Goiás (UEG); and Adriano starts developing research on dance training, injury prevention, and the use of Pilates and manual therapies in contemporary dancers
- Fernando Zikan takes over the physiotherapy service at the TMRJ, and starts assessing dancers from three important ballet schools in Brazil: Escola Estadual de Dança Maria Olenewa (TMRJ), Escola do Teatro Bolshoi no Brasil, in Joinville, Paraná, and Centro de Dança Rio, a private dance school in Rio; he also starts teaching DMS to students at the Physiotherapy School of Universidade Federal do Rio de Janeiro (UFRJ)

2010s

BR

- Aline Haas develops research in DMS at Universidade Federal do Rio Grande do Sul (UFRGS)
- Izabela Gavioli brings to Brazil perceptions about dance and Somatics after studying with Sylvie Fortin, in Canada; she starts writing a bi-monthly article to the column "Dance and Health" of the Brazilian dance site Dança em Pauta
- Bárbara Pessali-Marques creates Bastidores, in Belo Horizonte, Minas Gerais, a fitness studio and education centre specialized in training dancers and DMS professionals, and starts dialoguing about DMS with the Federal University of Minas Gerais (UFMG); she takes her doctorate in DMS at the Manchester Metropolitan University, in England
- Clara Fischer Gam finishes her graduation studies with Angel Vianna, takes her masters in Dance Sciences at Trinity Laban Conservatoire, in England, co-funds Corpos Aptos, Gestos Livres, a project for training dancers, developed at Ateliê Corporal, in Rio de Janeiro, and creates Ciência da Dança Brasil, the first Brazilian DMS social media group on Facebook
- Adriano Bittar creates the DMS service at Instituto Tecnológico de Goiás em Artes (ITEGO) Basileu França, one of the biggest state vocational dance schools in Latin America, in Goiânia, with support from UEG; being joined later by the physiotherapists Marcus Bastos and Patrícia Rocha
- BRUK DMS NET is created, with partnerships between BRUK institutions and stakeholders
- Debora Cantergi establishes research collaborations with USP and James Shippen (Coventry University, England) in dance biomechanics and Pilates
- Andreja Picon is invited by Adriano Bittar and Flávia Gervásio to teach the first Brazilian "Dance Biomechanics" workshop in the Centro-Oeste Congress of Biomechanics
- Cibelle Formiga and Adriano Bittar create DMS research line in the master's program of Science Products Applied to Health (UEG)
- DMS BRUK NET establishes partnership with the Brazilian Council of Dance (CBDD) in order to introduce DMS as a field of study to a wider audience in BR

KEY MILESTONES IN BRAZIL

2010s

BR

- Adriano Bittar and Patrícia Rocha work as Physiotherapists for the South American selection of the Prix de Lausanne, in Goiânia
- Janete Hernandes studies belly dancing, body image and quality of life in her doctorate at Universidade Federal de Goiás (UFG)
- Cláudia Daronch and Izabela Gavioli dedicate themselves to their doctorates in dance neuroscience
- Flora Pitta develops research in epidemiology, kinetic-functional evaluation and taxonomy in dance at LABIMPH - USP
- Diego Pizarro organizes the 1st International Dance and Somatic Meeting at Instituto Federal de Brasília (IFB), and takes his doctorate from the Federal University of Bahia (UFBa), researching Somatics applied to dance performance
- Aline Haas finishes her post-doctoral studies at the University of Wolverhampton, supervised by Prof. Yannis Koutedakis and Prof. Matthew Wyon, developing research on Parkinson's Disease and dance, and dance biomechanics
- Adriano Bittar and Andreja Picon teach the workshop "Truths and Myths related to Classical Ballet and Contemporary Dance" and Adriano teaches Fletcher Pilates® classes at the Youth America Grand Prix (YAGP) Brasil, in São Paulo
- Clara Fisher-Gam wins the 2019's Student Research Award from IADMS, presenting a poster, systematic review and meta-analysis on "The Effects of Supplementary Fitness Training on Muscle Power for Vocational and Professional Dancers"
- BRUK DMS NET book is released

2020s

...

2. THEME 1: CONSTITUTIONS AND TRACES OF DMS IN BRAZIL

According to the testimony of Iracity Cardoso[13], a great name of the Brazilian scenic dance, DMS began in BR in the same manner as around the world: in an unstable way in schools and established classical ballet companies. Therefore, an initial demand for DMS was noticeable with the creation of the Brazilian *Escolas de Bailado*, by Russian Maria Olenewa[14], in 1927, in Rio de Janeiro; of the *Ballet do Theatro Municipal do Rio de Janeiro* (*TMRJ*), in 1936; and the subsequent developments of the *Escola de Dança do Theatro Municipal de São Paulo* (*TMSP*), and other vocational schools alike, from 1940 to the middle of the 1960s. *TMRJ* and *TMSP* were the earliest official sites for the learning of classical ballet in BR, lodging the first ballet companies in this country:

> *I started dancing in the early 1960s, more or less. I was graduating from the Escola de Bailados (of the TMSP), and there were medical exams and other things like that for the children, who were very ordinary… nothing special, only the assessment of muscle reflexes, something like this. Over time, more specialized people began to appear, but this was*

13 Iracity Cardoso began to dance at the *Escola Municipal de Bailados* of the *Theatro Municipal de São Paulo (TMSP)*, current Escola de Dança de São Paulo (theatromunicipal.org.br/pt-br/escola-de-danca-de-sao-paulo/), becoming a professional dancer at the age of 14. She acted as a ballet dancer and teacher of the *Ballet Stagium* (stagium.com.br) and in the Dance Corps of the *TMSP*, currently *Balé da Cidade de São Paulo* (theatromunicipal.org.br/pt-br/bale-da-cidade-de-sao-paulo/). In Europe, she was a dancer and assistant director of the Ballet du Grand Théâtre de Genève, in Switzerland, becoming one of the directors of the company, and directed the Gulbenkian Ballet. She also created the Dance Center Umberto da Silva of the *Galeria Olido* (facebook.com/DancaGaleriaOlido/posts/355340151215522/), and was one of the founders of the *São Paulo Cia de Dança* (spcd.com.br).

14 Maria Olenewa (1896-1965) was a dancer, choreographer and teacher of Russian ballet who, after dancing in Pavlov and Massine's company, immigrated to Brazil. In 1927, she founded important schools of classical ballet and the *Escola de Danças Clássicas* of the *Theatro Municipal do Rio de Janeiro (TMRJ)*, the first vocational ballet school in the country. In 1943, she was invited to direct the *Escola Municipal de Bailados* of the *TMSP*.

> *not the concern by then, as it is nowadays [...] there was a masseur, who wrapped up our feet when we sprained our ankles, with arnica, salt and a kind of a solution of water and anti-inflammatory. Mainly "household" treatments, right?* (Cardoso, personal communication[15], 2018)

Eliana Caminada[16] (Figure 1), ballet teacher and dance critic, recalls that when she was dancing at the *TMRJ*, in the 1960s, there were two medical doctors (MDs) that treated dancers at a small clinic located at the ground floor of this theatre. They were pioneers that showed great enthusiasm and dedication to DMS, even though dance science was not their specialty:

> *The first time I had an injury ... that brought consequences to my life... because I came back (to Brazil) from a work contract with the Munich State Opera [...], I was 25 years. As I wanted so much to dance, I didn't even want to consider the possibility of missing that opportunity. I had been waiting so long to dance that paus de deux from Le Corsaire that at the time was coming up with Nureyev. [...] But I started to have tendonitis [...] and then I went to the Municipal Theater MD [...] there was a medical*

15 This citation was taken from interviews conducted in 2018 and 2019 with important personas from the Brazilian scenic dance and/or DMS field, including Iracity Cardoso, Eliana Caminada, Elaine de Markondes and Fernando Zikan. Questions were sent via WhatsApp to the interviewees and they responded back, via voice recording, or written messages. Questions presented: 1 - Do you know DMS? Comment about your own stories and/or trajectory within this field. 2 - How were health and body conditioning dealt with since you started dancing? What about nowadays? And in your professional experience as a dancer (if applicable)? 3 - Do you think that services related to DMS have increased in number and quality in Brazil? How is it so? Could you please cite specific names and venues, if possible? 4 - Please comment on the importance of DMS as a field for dancers.

16 Eliana Caminada started dancing professionally in the 1960s, when she joined the Municipal Theater of Rio de Janeiro ballet company. She also danced at *Balé do Teatro Guaíra* (teatroguaira.pr.gov.br/Bale), *Companhia Brasileira de Ballet* (wikidanca.net/wiki/index.php/Companhia_Brasileira_de_Ballet), *Grupo Raízes* and *Companhia de Dança Rio*. Caminada also works as a choreographer, ballet teacher and researcher. She was taught classical ballet mainly by Maria Olenewa.

> *office [...] it was a better equipped theater, incredible as it may seem [...] this medical service [...] helped a lot of us, because a MD was always an expensive thing, right? I went there to learn how to dance with that thing bothering me. He gave me an injection into the tendon sheath (calcaneal), a local xylocaine injection with cortisone, and I thought it was great, the pain went away. From then on, I think that whenever I had a problem, I would immediately appeal to cortisone [...].* (Caminada, personal communication[17], 2019)

Not surprisingly, Caminada ended up with a chronic injury that led her to visit different and specialised sports MDs, such as the ones hired by the Brazilian Football[18] team, in search of a cure. This was a common scenario, as there was a lack of health care provision in DMS:

> *Until one day I felt the injection hurt […] I started classes again, all seemed good, [...] but the pain came back. It was time for me to travel to Munich, and I spoke to Lídio Toledo, a well-known MD [...]. I said: "I'm not healed, I've done all kinds of warm-ups and treatments, but the fact is, I'm not getting well.". And he told me: "You don't look good either, because you never stop; you stop, but you keep doing some exercises [...], testing your foot, seeing if it's good, if it's not good. […] didn't you say you will get there and everyone will be on vacation? [...] Therefore, you have no obligation to arrive fit from your vacation.". It was not quite what I would like, but I accepted, there was no other way [...]. That's how I went to Munich, with my unhealed tendon.* (Caminada, personal communication[19], 2019)

17 This citation was also taken from an interview, as the one conducted with Cardoso (see footnote 03).
18 Football is the British correlate to the American soccer, and the Brazilian futebol.
19 Same as footnote 03.

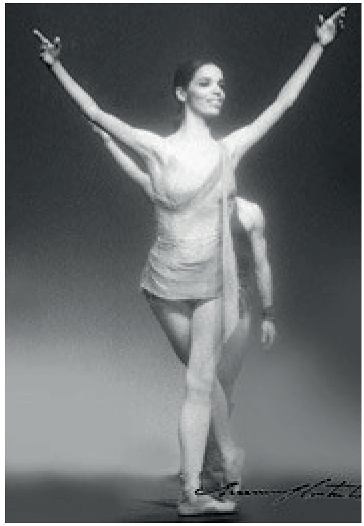

Figure 1 - Renato, Cláudio (Photographer). (1982). Eliana Caminada dancing Spartacus, Teatro Municipal Carlos Gomes, Rio de Janeiro. [Digital media]. twitter.com/elianacaminada1/status/832794014361415681, printed with permission.

Caminada also points out that in face of the dancers' lack of knowledge in DMS and the competitive atmosphere they faced in the time she danced, any sign of physical harm, even pain, would be neglected. When injuries got worse and pain unbearable, they would seek help. In this state, injuries were much harder to diagnose and took longer to heal:

> *[...] I was in pain... but I said, no, this is already a little psychological, this is anxiety too [...]. But as soon as I started working harder, I started to feel it again and it was no longer just a pain. My tendon was locking my foot and I couldn't run [...] I went to an orthopaedist and you know what he did to me? Gave me more cortisone, I took several cortisone shots that evidently didn't make me feel better [...]. I arrived here (in Brazil) [...] and one day, Aldo Lotufo, a colleague at the ballet company, asked if his brother, a MD, could take a look at my foot. [...] He said: "[...] I suspect you had a lump due to the injection into the tendon sheath [...]. If it is calcified, you will have to open your foot and*

take it off. If not, you can do a home treatment… but a very long treatment [...] you have to put your foot in hot and cold water [...]. As soon as it's over, you put your leg on Eric's lap (my husband) and he will massage it, [...] going up in the tendon sheath [...]". Gradually, it started disappearing, until I was completely good indeed [...]. But I ended my career without any injury […]. So, all I had was simple, but hard to diagnose, to treat. (Caminada, personal communication[20], 2019)

However, a true change of course on the history of the Brazilian DMS takes place from the middle of 1960 onwards, with the work of Klauss Vianna, dancer, teacher, researcher and strength coach. He created his own dance conditioning and injury prevention method, focused on increasing body awareness and expressiveness, and with his wife, Angel Vianna (Figure 2), and son, Rainer, established it in Minas Gerais, Bahia, São Paulo and Rio de Janeiro. Their method aims at the preparation of actors and dancers, integral education of dancers and of therapists who stimulate health in others by the differentiated use of dance.

Figure 2 - Feijó, Márcia (Photographer). (2015). Angel Vianna and Karla Relvas at Faculdade Angel Vianna. [Digital media]. Rio de Janeiro, Brazil: Karla Relva's archives, printed with permission.

20 Same as footnote 03.

Vianna's method questions ballet as a hard and indispensable technique for dancers, while bringing all the versatility of the Brazilian's body to the fore, with its open expressiveness and endless improvisational ability. Angel, in an interview conducted by Karla Relvas[21], talks about her family's method and the experiences she went through to create it. She starts recalling her sabbatical in New York (United States of America - USA), in 1974, when she stablished an intense relationship with Romana Kryzanowska[22], a first-generation Pilates teacher:

> *I told her that I would like to follow through and take a Pilates education course until the end; that I was there trying to understand what it was. But I thought: [...] hey, this is hard, very tiring for me, that business of Pilates; but I understood everything in my body. But it was hard work. I would get it all into my body quickly. I stayed there for a whole month, [...] because we had to see everything about dance in New York [...] the great (dance) masters, we saw them all. [...] She (Romana) said: "You were an excellent student [...]. I want to invite you; I want you to work with me, could you stay here?". Then I said: "I'm sorry, I have a school.". But she offered me that opportunity because she was alone.* (Vianna, personal communication[23], 2019)

21 Karla Relvas conducted an interview with Angel Vianna in 2019 at the request of the organizers of this chapter. She was one of the first students of the technical course in Psychomotor Reeducation through Dance, created and offered by Angel Vianna in the late 1980s. Currently, Karla works with Fletcher Pilates and Alexander technique, at Karla Relvas Studio, in Niterói, Brazil. Karla followed the same questions and methods used in other interviews on this chapter, recording the answers via WhatsApp.

22 Romana Kryzanowska was a direct disciple and one of the protégés of Joseph Pilates, creator of Pilates. She took over his studio in New York, in the early 1970s, after his passing.

23 This citation was also taken from the interview applied by Karla Relvas, as explained on footnote 08.

Back in BR, it was clear that in the dance conditioning method Angel developed with Klauss, knowledge of human anatomy of the body in motion was key. They managed to compile in their method specificities that had been identified through their own bodily experiences. The couple's preoccupation with the long-term health of dancers stands out, making themselves truly DMS innovators in BR:

> *Klauss and I had, in the companies we directed, almost no dancers injured, because we cared a lot. For instance, [...] when learning from dance teachers, they asked for a specific ballet step and I would ask: "Well, teacher, how could that be achieved?". And they could not explain it. One day I said: "Teacher, how can I perform 10 pirouettes? I can just do one, and my colleagues, only one or two?". He could not explain, he did not know about pedagogy. At that time, nobody understood anatomy (in BR) [...]. When we took anatomy lessons at the dentistry school of a university, the anatomy teacher told me: "Why do you want to get involved in what you do not know?". And I said: "[...] I came here to learn where a bone is, a muscle [...] how the body is, I need to understand it [...] I will understand it not only dancing, I need to study, my dear!" [...]. Klauss was the first to drop the bar and unfold (roll up and down) the spine [...]. I said: "Will you roll it, Klauss? You did very well, wonderful!". Then, we understood what our bodies could do, even though the spine in ballet had to keep stable, and not move too much.* (Vianna, personal communication[24], 2019)

24 Same as footnote 08.

It is noticeable that from the 1970s onwards, dancers, choreographers and teachers all over the world were influenced by European and American movement techniques that were interested in the care of dancers. Iracity says that these techniques have transformed Brazilian dance practice and teaching in official companies. They started off a new paradigm, in which dancer's health was taken into consideration, and an awareness of self was further explored. Caution and care were added to the dancer's toolkit and dance practice was questioned. Such a shift in the dance world might have been driven by dancers' needs to seek professional help, treatment and training alternatives, since they could not carry on with strenuous practices without adequate support:

> *I was very young, at 15 or 16 years of age, and the dancer's body was not so beaten down as it is today; the requirement of a vigorous physicality was not so high; and only later did I feel it, when I first went to Europe at the age of 20. In 1965, I worked in France and Germany, and there were no specialized physiotherapists, but there were other techniques people used to train dancers with. But it was still all precarious and there were not all of these techniques like Pilates, Rolfing, or others that have greatly helped dancers.* (Cardoso, personal communication[25], 2018)

Further along, massage therapists and new heating machines were also very useful, as Iracity reports:

25 Same as footnote 03.

> *In 1970, in the renovation of the Balé da Cidade de São Paulo, we hired two massage therapists who worked with the dancers, and they used Bier ovens[26], because they did not have machines as modern as today.* (Cardoso, personal communication[27], 2018)

After 1980, with the creation of DMS international class associations[28] and with dance incorporating some aspects of medicine and therapy, this area evolved rapidly, and more specialised techniques of exercise were created. At that time, with the growth of scenic dance around the world, there was a greater need for specific treatments. In BR, the dancers who had started dancing in the *Escolas de Bailado* also presented themselves with degenerative injuries due to their practice, as Iracity points out: "*I started to treat myself, because already at 35, my body was not that young anymore, and I started to familiarize myself with these more modern techniques.*" (Cardoso, personal communication[29], 2018).

Another pioneer in the Brazilian DMS is Elaine de Markondes, a physician, physiotherapist, dancer and Pilates teacher, that reaffirms that in the early history of the Brazilian DMS, knowledge of the area had to be gained in Europe or the USA: "*In 1984-85 I lived in New York; I went there to dance. I was a classical dancer and a medical doctor, and I had the privilege of understanding myself and of knowing the area of Dance Science, where I immersed myself.*" (Markondes, personal communication[30], 2018) (Figures 3 and 4).

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26 Bier ovens are metal half barrel shape-like devices that irradiate infra-red light. This light raises the temperature of the body part it gets in touch with, helping with relaxation, decreasing tension and spasm.

27 Same as footnote 03.

28 Refer to Chapter 1 to learn about the international DMS class associations.

29 Same as footnote 03.

30 This citation was also taken from an interview, as the one conducted with Cardoso (see footnote 03).


Figures 3 and 4 - Elaine de Markondes and partner dancing tango; Elaine at the Pilates Reformer in DeMarkondes Pilates Studio. [Digital images]. Curitiba, Brazil: Elaine de Markondes and *Núcleo do Corpo*'s archives, printed with permission.

Elaine got curious about Dance Science not just because she had an urgency to go beyond, being motivated by a need for technical improvement and injury recovery, but also due to a search for a specialization, or a new professional field of action:

> *[…] it was wonderful, because DMS gave me this theoretical support, which I missed in my dance practices, and created a synthesis in the sense of linking theory and practice. [..] I was able to understand the breadth and scope of this area in every way, including the dancer's health, longevity and autonomy. And the multiplication of potential as a profession. So, I understood that DMS extended the dancer's ability to continue working after having stopped performing. This justified my practice and research, and I was further reassured about which path to follow.* (Markondes, personal communication[31], 2018)

31 Same as footnote 03.

The influences of the Vianna family method kept growing in the Brazilian DMS scenario, as reports Valéria Figueiredo, a professor from the Federal University of Goiás Dance School, about the experience she had with the Vianna family, in the late 1980s:

> *I realize the trip I made to Rio de Janeiro, in 1986, was as a milestone in the beginning of my career, when I worked as a professional dancer. There, I graduated in Physical Education at the Universidade Gama Filho, trained in contemporary dance and specialized in Psychomotor Rehabilitation Through Dance at the Escola Angel Vianna. We were one of the first groups of students of this course, and nowadays it is called somatic education. It is worth reaffirming that Angel and Klauss Vianna are pioneers and visionaries in the Brazilian contemporary dance, both in their artistic dimension and in education. However, I think that especially Angel Vianna devotes all her efforts to offer young dancers the possibility of an extended formation; she has been, through many years, concerned and dedicated to the issues of formal and non-formal education. I think she added to dance the perspective of humanity, inclusion, diversity, and the possibility of a meaningful, inventive, non-exclusionary and supportive learning. In fact, they created a revolution for the Brazilian dance.* (Figueiredo, personal communication[32], 2018)

Another important figure in the Brazilian DMS is Ruth Rachou, one of the pioneers of modern dance and Pilates in Brazil. In the late 1960s and early 1970s, Rachou studied modern

32 This citation was taken from a survey sent to all Brazilian participants of the BRUK DMS NET before the workshop in Goiânia, in 2016 (for more information, please refer to Chapter 1). The organisation distributed an online questionnaire with just one question, inquiring what their careers in DMS had been like from the beginning, until then. Responses from nine participants were received, including those of: Adriano Bittar, Aline Haas, Andreja Picon, Bárbara Pessali-Marques, Clara Fisher-Gam, Cláudia Daronch, Flora Pitta, Isabel Sacco and Valéria Figueiredo.

dance with Martha Graham, Merce Cunningham and José Limón in New York, also taking Pilates classes with Robert Fitzgerald. She arrived back in São Paulo and opened the Ruth Rachou Dance School, aiming to educate dancers to allow them to work in performance and also education. In addition to Rachou, Alice Becker, a dancer and Pilates instructor that established herself in Salvador, Bahia, was also one of the pioneers in using the Pilates method in Brazil, teaching at the *Balé do Teatro Castro Alves* (http://www.tca.ba.gov.br/btca), one of the greatest contemporary/modern dance companies in BR. In the 1990's, Alice arrived in Brazil after having finished a master's degree in choreography from the CalArts/USA with the first Pilates Reformer of this country, started to teach this method to other colleagues and opened new opportunities for dancers to use Pilates as a tool for different populations.

In order to broaden the debate about the place of DMS in Brazil, it is reaffirming to look at Figueiredo's work and see that she also applied what she had learned with Angel Vianna to people with special needs, helping with the foundation of the Brazilian Society of Adapted Motor Activity (SOBAMA), concerned with the inclusion of dance as a possibility for different populations:

> *In 1997, already in Campinas, São Paulo, in the postgraduate program in Arts, I faced new challenges, working with dance and people with disabilities. At the Department of Adapted Motor Activity from the Faculty of Physical Education (FEF), in the State University of Campinas - UNICAMP, we developed studies with Professors Edison Duarte, José Júlio Gavião, and Maria da Consolação Tavares, my master's supervisor. I had the opportunity to include dance in the context of the projects and researches of this group, including the I Special Games*

> *and in the Artistic Activities at FEF, UNICAMP, and I accompanied and worked on the foundation of SOBAMA.* (Figueiredo, personal communication[33], 2016)

In line with Markondes' statements (2018), Gavioli, a MD, dancer and adjunct teacher of the Dance School at *UFRGS*, points out that Brazilian DMS grew by a need for knowledge production that could provide a basis for the actions of this area (Figure 5). She adds, in a curious way, that at the moment this growth still works as a marketing strategy created by dancers, to reassure the value of dance as a profession.

Figure 5: Abreu, Audinã. (Photographer). (2016). BR UK DMS NET member Izabela Gavioli at the BRUK DMS NET workshop. [Digital image]. Goiânia, Brazil: BRUK DMS NET, printed with permission.

According to Markondes, notwithstanding the evolution of Brazilian DMS, one of the most tangible problems in dance has always been undiminished: the never-ending search for a perfect body, and the distance created with a healthy body image. Elaine

33 This citation was also taken from the same survey sent to all Brazilian participants of the BRUK DMS NET, as cited on footnote 19.

suggests that a true understanding of the Brazilian body and of the adaptations of dance techniques necessary to keep it healthy are vital:

> *[…] there was always a very aesthetic relationship, related more to performance and form, than to content. Then, there was an ideal body, form, a certain language, and a pattern. […] I even think that health was not taken into account, in the health sense people understand today, related to the individual, their biography, context, options in life, in and out of dance. There was no such "democracy" of choosing what suited you best, which made the most sense to you. There was a pattern and we all pursued it, which did not always match ourselves, the link to the place of the world in which we lived. I participated and suffered much from this point of view, which was too delirious, aiming at physical forms and conditions that did not belong to the Brazilians, much less to me.* (Markondes, personal communication[34], 2018)

It may even be that the Brazilian DMS professionals are immersed in a scenario in which the concept and practice of health lie on a complex relationship of the somatic and physical conditioning aspects related to dance training that still cannot privilege both physiological and subjective aspects, as Elaine confirms:

> *[…] I began to know the softer, more organic world and approach to each individual, from where arose the true possibility of fostering longevity and autonomy for the dancer. […] It questions a pre-defined logic, leading to a more personal construction, even in the more formal languages, like classical ballet. […] I think that Brazil is*

34 Same as footnote 03.

moving towards making its own syntheses […]. Still, there are professionals who value the "performing" body or the most "somatic". I think that progressively we are moving towards abolishing this way of thinking. The body will be all the more potent in performance, regardless of the language it expresses, when it can synthesize these two paths: the body that performs from an understanding of itself. […] we really need these professionals to loosen up the ideas they hold on to, so that they promote their own synthesis, to contemplate all sides, because bodies have their own rhythms. So, good dancing cannot exist without repetition, training, maturation of the neuromuscular pathways and such. But you have to respect the individual. I think movement techniques are fundamental to maturing the sensory-motor experience in the body, the neuromuscular pathways, and this brings solidity to the body that dances. […] Techniques that can simultaneously propose sensorimotor re-education and mobilize the body progressively in assisted and resisted ways are fundamental to bring safety, precision, control of injuries, longevity and autonomy. […] one should not treat body issues in a purely musculoskeletal fashion, but understand that the dancer's health involves balance and the ability to self-regulate all systems, maintaining the immune system able to deal with the demands of training, repetition, perseverance, competition for roles and so on. […] Brazilian DMS needs to grow, because it still is mostly linked to a musculoskeletal approach. I believe we can develop and expand this field, and in order to do so, we need to have professionals available in all DMS areas, to create a culture of protection and respect for the body and the dancer. (Markondes, personal communication[35], 2018)

35 Same as on footnote 03.

Iracity's testimony complements what Markondes states about the current state of DMS in Brazil and the needs of dancers:

> *Of course, nowadays you have a myriad of techniques, articles and studies, because things have changed: total immobilization rarely happens; with two femoral prosthesis you can walk quite rapidly. So, orthopaedics and body mechanics, revitalizing techniques, psychology and relaxation, several things can help dancers a lot. Because dancers, besides being elite athletes, are artists. Then, there are two things that must be taken care of: they need to know the limits of their bodies, and develop a solid body awareness. If they do so, dance becomes much more interesting and rewarding, because dancers are not injuring themselves all the time, and thus, they can express everything inside and out, as artists.* (Cardoso, personal communication[36], 2018).

3 THEME 2: DMS IN BRAZILIAN UNIVERSITIES

Even though DMS is still relatively new in universities, its presence in the Brazilian academic field as a constituted knowledge area has begun from 2000 onwards. One of the pioneers in this field was Aline Haas (Figure 6), from the graduate Dance Course and the Postgraduate Programs in Human Movement Sciences and Pilates of *UFRGS*:

> *With regards to DMS, I started studying it in my graduation in Physical Education at UFRGS in 1992, and went on to do my PhD in Medicine & Surgery at the University of Cadiz, Spain, in 1999, where I studied with a leader in this area, Juan Bosco Calvo. Then, I specialized in Sports Sciences and developed a practice with dance and Romana's*

36 Same as on footnote 03.

Pilates Method. Since 2010, I have been a teacher of the UFRGS Dance Course. In 2015, I joined the Postgraduate Program in Human Movement Sciences as a teacher, aiming to contribute as an academic with the production in the area of DMS, specifically within the research lines "Physical Activity and Health" and "Physical Activity and Performance". (Haas, personal communication[37], 2016)

Figure 6 - Abreu, Audinã. (Photographer). (2016). BR UK DMS NET member Aline Haas at the BRUK DMS NET workshop. [Digital image]. Goiânia, Brazil: BRUK DMS NET, printed with permission.

At the same time, the University of São Paulo (*USP*) created an important research group devoted to studying healthier habits for dancers. Andreja Picon (Figure 7) was one of the leaders of this group, and coordinated the dance research line of the Laboratory of Biomechanics of Movement and Human Posture (*LABIMPH*), within the Faculty of Medicine, led by Professor Isabel Sacco. In 2008, Andreja became part of the research team of this laboratory, though she began her studies in DMS in 2000, when she developed her Master's Degree in Physical Education at the School of Physical Education and Sports of *USP*, under the

37 Same as on footnote 19.

guidance of Professor Paula Lobo da Costa. The theme of the first research developed by Andreja, which originated the dance line of research in *LABIMPH*, was the influence of the type of pointe shoe and of the musical progress in the forces and pressures in the feet of classical ballet dancers: "*This work originated two important and pioneering publications in DMS in Brazil.*" (Picon & Sacco[38], 2016).

Figure 7 - Abreu, Audinã. (Photographer). (2016). BR UK DMS NET member Andreja Picon at the BRUK DMS NET workshop. [Digital image]. Goiânia, Brazil: BRUK DMS NET, printed with permission.

Still bridging between the university and the various possibilities of the DMS field of study, we have the testimony of Adriano Bittar, physiotherapist, dancer, Pilates teacher and adjunct teacher at *UEG*, Superior School of Physical Education and Physiotherapy of Goiás (*ESEFFEGO*):

> *In 1994, after a career as a volleyball player, and graduated in Physiotherapy from the Pontifícia Universidade Católica de Campinas (PUCCAMP), I started teaching*

38 Same as on footnote 19.

at ESEFFEGO's Physical Therapy Course, and also taking classical ballet and contemporary dance classes at Quasar Companhia de Dança. Wanting to study dance medicine in greater depth, I went on a quest for DMS at Trinity Laban in London, where I entered the master's degree in Dance/Movement Therapy. Surprised by the focus of the course, which was not approaching the DMS I was glimpsing, I ended up getting to know Pilates and doing a postgraduate course in Craniosacral Therapy. Upon returning to Brazil, I started dancing in a small company called Grupo Solo that was created to prepare new talents to join Quasar Cia de Dança, and gradually started treating dancers, using Pilates and Craniosacral Therapy. In 2000, myself and Cláudia Daronch, maître from Quasar, created a healthier dance programme for Quasar. As a result of this project, we had a drop on injury prevalence of almost 60%. These experiences extended for long years, unfolding in my masters at the Federal University of Bahia (*UFBa*) *and my doctorate in Art at the Universidade de Brasilia* (*UnB*), *in 2015, where I developed a research on poetic preparation using Pilates and Craniosacral Therapy. I also created the observational internship in Physiotherapy for the Performing Arts at Instituto Tecnológico de Goiás* (*ITEGO*) *em Artes Basileu França. At Basileu, one of the biggest vocational schools in Latin America, we also develop studies on themes such as: anthropometry, biomechanics and Pilates, vitamin D and injuries in ballet, etc. In the year 2018, we also set up a physiotherapy service and attended the dancers of the South America's selective Lausanne Grand Prix, held in Goiânia. This was done thanks to a partnership of BRUK DMS NET with the Brazilian Council of Dance* (*CBDD*). (Bittar, personal communication[39], 2016)

39 Same as on footnote 19.

Still among the team of *UEG* researchers, are physiotherapists Cibelle Formiga, Tânia Hamú and Flávia Gervásio, who develop research in DMS, mainly focused on anthropometric data, motor learning, growth and maturation (DOS SANTOS, Bittar, Hamu, Picon, & Formiga, 2020), vitamin D and biomechanical investigations (Araújo et al., 2020) in children, adolescents and adults.

Worth mentioning is the work of Izabela Gavioli, that plays an important role as an adjunct teacher at the *UFRGS*' Dance Course. Gavioli started a master's in Performing Arts at *UFRGS* in 2012, in search of a broader insertion space for Dance Medicine. That year, she spent some time in an internship with researcher Sylvie Fortin at the *Département de Danse, Faculté des Arts, Université de Québec à Montréal* (*UQÀM*). In 2019, Gavioli finished her PhD in the Postgraduate Program in Performing Arts, at *UFRGS*, where she studied neuroscience and processes of creation in dance:

> *In Brazil, the relative lack of familiarity with the term "Dance Medicine" discourages its use in diverse scopes, including editorials and academics. Often, we have to replace it with "Dance and Health", which, more often than not, presupposes approaching the benefits of practicing dance to the general population or using dance as therapy. Dance Medicine covers all these aspects but it is definitely not limited to them. [...]. Fortin is a worldwide reference in Somatic Education, with hundreds of publications and communications in the field. I was able to follow her Feldenkrais sessions and dance-related activities for women with fibromyalgia. At the occasion (November 2013), I was also able to participate in the programming of the Semaine Société et Santé, where medicine and dance were closely related*

> *and discussed in roundtables such as "Dance in health care training" and workshops such as "Body and Somatic Education in Artistic Practice" and "Contributions of artists and therapists - practitioners and researchers - for the arts in health promotion". [...]. (In the Dance course at UFRGS) The contents covered (in the minors I teach) are: physio pathogenesis and the creation of methods of somatic education; risk limits and the genesis of dance injuries; pain threshold and joint proprioception; processes of creation in dance and dance injuries; somatotype, aesthetic arbitrariness and health in dance [...].* (Gavioli, personal communication[40], 2016a)

Debora Cantergi is another Brazilian DMS talent that works as a physical educator and lecturer at *Faculdade de Educação e Tecnologia Iracema*, in Tatuapé, São Paulo. She received her PhD in Human Movement Sciences - Biomechanics from *UFRGS* and part of this degree was conducted at Coventry University, in the UK. In 2015, she finished her post-doctorate at *USP*. She develops pieces of research in biomechanics, concerned specifically to ballet and Pilates.

Concerning the development of the DMS field specifically aimed at the care of ballet dancers, it is important to mention the works of Fernando Zikan, physiotherapist of the *TMRJ* Ballet Company for the last 15 years, and teacher of the Physiotherapy School of *Universidade Federal do Rio de Janeiro* (*UFRJ*). Zikan has developed studies about the TMRJ ballet dancers' health and the risk factors associated with the injuries they sustained. Furthermore, in 2006 he finished his dissertation at the *UFRJ*'s Collective Health Program, focusing on the occupational health and the physical, environmental and emotional conditions these

40 Same as on footnote 19.

same ballet dancers were exposed to. In 2012, he finished his PhD thesis, assessing the health, pain, mobility, flexibility, injury risk and body image of 100 young ballet dancers from main schools in Brazil, such as the *Escola Estadual de Dança Maria Olenewa* (*TMRJ*), *Escola do Teatro Bolshoi* in Brazil, based in Joinville, Paraná, and *Centro de Dança Rio*, a private ballet school. Since then, Zikan supervises students researching DMS at *UFRJ*, and his lectures on DMS in the major dance festivals around Brazil are very popular.

In another aspect, dancer, PhD student and adjunct teacher Diego Pizarro (Figure 8) from the *Instituto Federal de Brasília* (*IFB*) Dance Course, has been joining efforts to develop a research line on Somatics and performance. His extensive training in DMS and Somatics was carried out in several countries with a focus on studies in human physiology, muscle chains, and the experimental anatomy of Body Mind Centering (BMC), among others. In 2017, he organized the 1st International Somatic Practices and Dance Meeting, which included outstanding teachers such as Ciane Fernandes, Martha Eddie, Soraya Jorge, Silvia Mamana, Adriana Almeida Pees, and Wendy Hambidge, among others.

Valéria Figueiredo, with her teaching practice at the Dance Graduate Course and Postgraduate Theatre Program at *UFG*, shares affinities with Diego Pizarro, as she also introduces topics on Somatics and rehabilitation to students of those programs, teaching how they could apply them in schools, the community in general and performance.

Figure 8 - Abreu, Audinã. (Photographer). (2016). BR UK DMS NET member Diego Pizarro at the BRUK DMS NET workshop. [Digital image]. Goiânia, Brazil: BRUK DMS NET, printed with permission.

Furthermore, in *UFRGS*, research and projects run by Haas include: "*Dance and Parkinson's disease; dance in women's health and stroke; nutrition and cardiorespiratory endurance in contemporary dance; jazz: strength and flexibility; Pilates and turnout of ballet dancers.*" (Haas, personal communication[41], 2016). At *USP*, from 2000 to 2016 they developed research concerning the following themes: "*Kinematics, kinetics and intra and inter-limb coordination during the execution of ballet steps; the influence of different sneakers, movement techniques and teaching methodologies on these steps; and [...] aspects related to the dancer's health (of different dance genres) and somatic interventions in the preparation of this population […].*" (Picon & Sacco, personal communication[42], 2016).

This emphasizes the different and interesting ways DMS has developed in some Brazilian universities. Although some highly competent researchers and universities have developed studies, services and lines of research in DMS, such as *USP*, *UEG*,

41 Same as on footnote 19.
42 Same as on footnote 19.

IFG, *UFG* and *UFRGS*, this field is still segmented and not very accessible, being in its phase of growth in Brazil (Gam, 2016a; Bittar & Wyon, 2017).

4 THEME 3: FURTHER DEVELOPMENT AND GROWTH

One of the first outcomes of the BRUK NET was the emergence of partnerships fostering the relationships between the DMS groups in Brazil. Important spaces of cooperation with the British were opened up too, as states Adriano Bittar (Figure 9):

> *I had contact with a dispersed group of colleagues who worked in DMS, but I never thought it would be possible to create a network of collaboration with them. When I lived in London, in 1994, DMS was still very incipient; and in Brazil, even in 2016, there was no cohesion. But there was one item contemplated in the application for the Newton Fund award (British Council/FAPEG) which made me think there was an open possibility: neglected diseases. That was the focus. When looking for potential partners in the UK, I found Professor Wyon, one of the leaders in the field, and sent an e-mail to him, who responded promptly. With the unrestricted support of Professor Maria Zaira Turchi, from FAPEG, who secured the approval of the project, we organized the workshop "The Potential and Challenges of Research in DMS: building innovative collaborations between the UK and BR". Before the workshop happened, we went to the DMS Research Workshop at the University of Wolverhampton, from June 13-14, 2016, along with Clara Fischer, Bárbara Pessali-Marques and Aline Haas, to launch the idea of the workshop and share our research with British colleagues. Edel Quin also invited us to participate in the event "The fourth Dance Science student and graduate networking and careers day" at Trinity Laban on June 10, 2016.* (Bittar, personal communication[43], 2016)

43 Same as on footnote 19.

Figure 9 - Abreu, Audinã. (Photographer). (2016). BR UK DMS NET members and coordinators Matthew Wyon and Adriano Bittar at the BRUK DMS NET workshop. [Digital image]. Goiânia, Brazil: BRUK DMS NET, printed with permission.

The workshop in Goiânia, held diverse activities, including:

> *[...] round tables on "DMS around the world", "the aging dancer", "publishing and disseminating your work", "the potential of DMS in primary schools", and "career opportunities in DMS". Two lectures on "the potential and challenges of DMS in Brazil and UK" were delivered by the Network coordinators Prof. Wyon and myself. There have also been workshops on "fitness and health", based on the English program "Healthier Dancer" from One Dance UK, "How can poetics be measured?", "The role of dance in health and education institutions", "movement and dance in the creative process and human cognition"' and "supplementary training". The plenary sessions focused on "dance and biomechanics", "dance psychology", "what is the future of DMS?", "the British Council and the development of the BRUK NET", "how can innovative collaborations be born"' and "strategic action". Research presentations took*

> *a whole day. At the end of each of the five days of meeting, panoramas of the Goiânia's dance scene and the Brazilian culture were presented, with participations of Quasar, Basileu França and Quadrilha Arraiá Chapéu do Vovô.* (Bittar, personal communication[44], 2016)

In technical visits to key services in Brazil, the BRUK DMS NET expanded its reach, says Adriano:

> *Soon after the event, at the invitation of Aline Haas and Isabel Sacco, me, Professor Wyon and Erin Sanchez went to UFRGS, in Porto Alegre, for a day of visits, lectures and dissemination of the BRUK NET. The following day, we traveled to São Paulo to visit LABIMPH* (*USP*)*. These two visits were very important, as they provided other possibilities for cooperation sometime after this first meeting, such as the lectures given by Professors Wyon and Yiannis Koutedakis, in the Postgraduate Course in Movement Sciences at the invitation of Aline Haas and Jefferson Loss.* (Bittar, personal communication[45], 2016)

Subsequently, activities continued, with Andreja Picon being invited to teach the first "Dance Biomechanics" workshop of its kind in the Centro-Oeste Congress of Biomechanics, in 2016, following an invitation from Adriano Bittar and Flávia Gervásio, from *UEG*. Bittar also presented the results of the Network's actions at the IADMS International Conference in Houston, with new support from FAPEG in 2017, which allowed for another visibility, openness and possibilities for collaborations. The participation of Bittar and Patrícia Rocha in the South American round of the Prix de Lausanne,

44 Same as on footnote 19.
45 Same as on footnote 19.

organized by Gisela Vaz in Goiânia (2018), when they offered physiotherapy support to the dancers, made DMS gain a fresh impulse in Brazil. In this sense, Picon and Bittar, at the Youth America Grand Prix Brasil (YAGP), organized by Katty Houlis in São Paulo (2019), were also disseminators of DMS in this important competitive international event. They taught the workshop "Truths and Myths about Classical Ballet and Contemporary Dance" and Bittar taught Fletcher Pilates. Other achievements include major joint publications in congresses and journals, bilateral debates and mutual aides, and even the Aline Haas' postdoctoral fellowship (supervision of Professors Wyon and Koutedakis) at the University of Wolverhampton.

Currently in Brazil there are no specific training opportunities that allow specialization in DMS for those in human movement and dance. Moreover, DMS is limited to a few research lines, projects and development of services. This might reinforce the tangible tension that dance and medicine in BR are still undergoing in the present days:

> *Over the years, I continued to find a certain roughness between the two areas: medicine did not seem to have great appreciation for the study of dance, and dance feared that the insertion of science would harden its subjective dominion. For the medical community, having a dancer colleague could not be more than a "hobby". For the dance community, a dancer that was a medical doctor could not have chosen more than a "safe way to earn a living". Intersections, overlaps, and crossovers are still difficult to understand.* (Gavioli, personal communication[46], 2016)

46 Same as on footnote 19.

This might be the tip of the iceberg of a broader discussion, that involves the transdisciplinary within DMS. It reveals a complexity that affirms both a matrix identity and a challenge in deconstructing common sense and crystallized knowledge. Physiotherapy, Physical Education, Psychology, Biology, Medicine, Dance and the Performing Arts must all collaborate in DMS.

Some fields of study stand out in DMS within the Brazilian universities, such as Biomechanics, Somatics and also Neurology, as reports the researcher Cláudia Daronch, from *UFRGS*:

> *I remember one of my first teachers based the teaching of ballet on anatomy and correct biomechanics. I moved to Curitiba in 1987 to attend the classical ballet school at Teatro Guaíra. There, I discovered there existed the graduate course in dance at the Pontifícia Universidade Católica do Paraná* (*PUC-PR*)*, where I graduated. During my studies, I had Professor Elaine de Markondes as a teacher of kinesiology applied to dance. It was in this course that I had a more in-depth contact with contents related to anatomy, biomechanics and concepts of Ideokinesis, which made me grow fond of the preventive approach to teaching dance. I am currently an assistant teacher of the Dance Course at UFRGS. I try to highlight the importance of teaching dance within this scientific perspective, focusing on neuroscience applied to dance.* (Daronch, personal communication[47], 2016)

As for DMS as a profession in a clinical setting, we have the example of researcher Flora Pitta, MSc and ex-member of *LABIMPH* (*USP*), who, after having danced professionally and

47 This citation was also taken from the same survey sent to all Brazilian participants of the BRUK DMS NET, as cited on footnote 19.

graduated as a physiotherapist, had a desire to understand the dancer's body, how dance injuries occurred and how to avoid them. Thus, she worked for a year mainly treating dancers in an internship at *Centro Olímpico* and at *Constâncio Vaz Guimarães* (*Ginásio do Ibirapuera*), through the *Centro de Traumatologia do Esporte* (*CETE - USP*) - *Universidade Federal de São Paulo* (*UNIFESP*) - *Escola Paulista de Medicina* (*EPM*):

> *This was my first professional contact as a physiotherapist with dancers. Today, I provide individualized treatments that ranges from working with injuries, and preventing new injuries. I finished my masters in the postgraduate program in Rehabilitation Sciences at LABIMPH, developing a research about a kinetic-functional evaluation protocol based on physical abilities and motor skills.* (Pitta, personal communication[48], 2016)

With regards to DMS services in the private practice, it is worth mentioning Bárbara Pessali-Marques (Figure 10) and her studio *Bastidores*, in Belo Horizonte, Minas Gerais. Bárbara and her colleague Luciana Bruschi created an exclusive patented training method for dancers named "Best Performance and Movement/BPM", derived from their extensive practice and research on DMS. The BPM method focus on body conditioning (strength, aerobics, flexibility, etc), Pilates, Yoga, injury prevention, movement compensation and rehabilitation of children from 5-12 and of adults. Bárbara has recently finished her PhD at the Manchester Metropolitan University, in England, studying dance and flexibility.

48 Same as on footnote 19. Note that the information provided in the interview given was adapted due to the time lapse since 2016. At that time, Flora was still finishing her masters at *USP*.

Figure 10 - Abreu, Audinã. (Photographer). (2016). BR UK DMS NET members Liliana Araújo e Bárbara Pessali-Marques at the BRUK DMS NET workshop. [Digital image]. Goiânia, Brazil: BRUK DMS NET, printed with permission.

Clara Gam (Figure 11), a bachelor in Physical Education (IBMR/Laureate Universities) and Dance Education (*Escola Angel Vianna*), Master of Dance Science (Trinity Laban), also developed in 2015 a body conditioning program called *Corpos Aptos, Gestos Livres* at a private fitness studio:

> *This project was founded in 2015 in Rio de Janeiro, together with Weld Encarnação, director of Ateliê Corporal. It aims to promote the health and well-being of dancers through courses, workshops and consultancies directed to agents of the dance sector.* (Gam, personal communication[49], 2016)

49 Same as on footnote 19.

Figure 11 - Abreu, Audinã. (Photographer). (2016). Grace Carvalho (singer) and BR UK DMS NET member Clara Fisher-Gam (left) at the BRUK DMS NET workshop. [Digital image]. Goiânia, Brazil: BRUK DMS NET, printed with permission.

In 2015, Clara also founded the group *Ciência da Dança Brasil*[50], on Facebook, which became an important channel for the promotion of DMS in the country. She assertively points out that one of the main challenges DMS in BR faces is lack of access to information about Dance and Health. And this is key on raising awareness of DMS community to the problems of this sector (Gam, 2016b). She further reflects about the DMS state "below the tropics", the problems faced and political agendas of DMS in BR:

> […] it is not surprising that here the Brazilians are still building the field. In the country, we have about a dozen IADMS members. Because we are creating a field in its infancy, we face many challenges in achieving legitimacy and acceptance [...] the growing number of university (dance) courses being created in recent years seems to be

50 Visit https://www.facebook.com/groups/dancesciencebr/ for further information.

opening space for discussion on reforms in the traditional curriculum. […]. Although civil organizations have been campaigning for the rights of dance industry for a considerable time, laws on career regulation are still in the process of being approved. Therefore, information from the current body of knowledge in DMS could be used to legitimize and strengthen discourse about the relevance of such policies - possibly speeding up the implementation process. [...]. While promoting the health of the dancer, it is important to consider that this work needs to go hand in hand with the empowerment of the dance profession. (Gam, 2016a)

Fernando Zikan's observations should also clarify how DMS in BR could further develop into a stablished field of study. He points out that after 15 years of experience on this field, he perceives that many dance companies, differently from beforehand, tend to look after their dancers. But they lack financial provisions to sustain a dance health department, for instance. The most important companies in BR count on funds delivered by the government, so that a staff of health professionals is hired to take care of dancers. The others end up establishing partnerships with health care providers that cannot keep a close "*in loco*" contact with dancers, and this seems to be detrimental to all:

Specifically, in Rio de Janeiro, some physiotherapists, and few medical doctors, began offering care services to dancers in their clinics, creating a network of caregivers with a more attentive look to dancers. Just a few companies were able to keep professionals directly connected to them, such as: Theatro Municipal do Rio de Janeiro, Teatro

> *Municipal de Niterói*[51], *Deborah Colker Companhia de Dança*[52] *and Focus Cia. de Dança*[53], *in addition to the companies outside Rio de Janeiro […], such as Quasar Companhia de Dança, Grupo Corpo, Balé Teatro Guaíra, Balé da Cidade de São Paulo and temporary Musical Theater companies in seasons throughout the country, which maintained contracted physiotherapists for their casts.* (Zikan, personal communication[54], 2019)

When comparing dance and sports, Zikan emphasizes:

> *And what about dance? What would move the advancement of research, care, assistance, therapy? The universe of dance does not move the same amount of money (as of sports). Thus, the support and encouragement for the advancement of Dance Medicine occurs slowly, much more because of the dedication and love of some professionals for this area, than the support of institutions and companies, as occurs in sports. If it is already rare in developed countries, in developing countries such as ours, it becomes even more difficult. Even though in recent years more dancers recognize the need, advances, new technologies and knowledge produced by DMS, we know that it is not yet available to everyone.* (Zikan, personal communication[55], 2019)

Zikan has also devoted his time to develop tutorials on important themes in DMS that are normally streamed via Ana

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51 More information about *Companhia de Ballet da Cidade de Niterói:* balletcidadedeniteroi.com.br

52 More information about *Deborah Colker Companhia de Dança*: ciadeborahcolker.com.br/home-english

53 More information about *Focus Cia. de Dança*: wikidanca.net/wiki/index.php/Focus_Cia._de_Dança

54 This citation was also taken from an interview, as the one conducted with Cardoso (see footnote 03).

55 This citation was also taken from an interview, as the one conducted with Cardoso (see footnote 03).

Botafogo's YouTube channel[56], and to teach DMS in the most important dance festivals in BR, such as *Festival de Dança de Joinville*[57].

In addition to professional dancers, another part of the dance community is also assisted by DMS, as in the case of recreational belly dancers, who are led by psychologist and PhD Janete Hernandes, that works with their quality of life. Janete studied this subject in her doctorate in Sciences of Health at the Faculty of Medicine of *UFG*.

5. CONCLUSIONS

After all, taking up the challenge of writing the history of Brazilian DMS led to the understanding of some points of convergence and conflicts in the testimonies collected. Highlighted, below, are the ones that signal peculiar characteristics of the DMS trajectory in BR, which shows the challenging and full of potential place DMS is at this moment in time. Thus, DMS in BR could be considered as:

a. a new field of study attempting to encompass other fields such as Dance, Physical Education, Physiotherapy, Medicine, Nutrition, Psychology, Somatics, etc.;
b. a field of study in development, given the lack of specific training;
c. establishing connections, but at the same time a distinction, between Dance and Somatics;

56 Ana Botafogo is a Brazilian important ballet dancer and actress. She is a prima ballerina at Theatro Municipal do Rio de Janeiro, having been appointed as an ambassador of the city of Rio de Janeiro. More details at Ana Botafogo's YouTube channel: https://www.youtube.com/channel/UCNbp5kpsQNtXiesNgalarsQ

57 Visit http://festivaldedancadejoinville.com.br/2019/ for more information about *Festival de Dança de Joinville*.

d. a field in which professionals of Somatics and Physiotherapists have greater understanding of the issues of prevention and treatment of injuries caused by the practice of dance;
e. an area neglected or even unknown in dance schools, studios and companies;
f. an area of knowledge that has been approached timidly at the graduate dance schools in universities; where the curriculums lack a more specific direction in relation to the understanding of the healthiest practices of movement, distancing the knowledges of dance and health. Majors such as Anatomy, Biomechanics and Kinesiology end up not having the necessary scope and depth;
g. an area formed by professionals who mostly started early in dance, particularly with classical ballet, but during their path did not find so much specific subsidy and training in the DMS area;
h. a complex area that, although focused on the health of dancers, can cover the processes of creation, dance therapy, dance for health, etc.;
i. and finally, an area in which development is linked to the maturation of the dance artist, his/her insertion and social valorization, creation of specific policies for the concrete identification of dancers' needs and access to DMS in general.

ADDITIONAL NOTES - TIMELINE

1 To know more about the Vianna family, please visit: www.angelvianna.art.br

2 *Balé da Cidade de São Paulo* is one of the most important contemporary dance companies in BR. More details at: https://theatromunicipal.org.br/pt-br/bale-da-cidade-de-sao-paulo/

3 *Balé do Teatro Guaíra* is another important contemporary dance company in BR: http://www.teatroguaira.pr.gov.br/Bale

4 Learn more about SOBAMA at: http://www.sobama.org.br

5 *Balé do Teatro Castro Alves*, in Salvador, Bahia is one of the leading contemporary/modern dance companies in BR: http://www.tca.ba.gov.br/btca

6 Refer to Chapter 1 for more information about Juan Bosco Calvo.

7 Learn more about *LABIMPH* at: http://paineira.usp.br/labimph/

8 More about *Quasar Cia de Dança*, a leading contemporary dance company in BR at: http://www.quasarciadedanca.com.br

9 *Escola Estadual de Dança Maria Olenewa* is the first classical dance school in BR dedicated to the formation of classical ballet dancer, situated at the *Theatro Municipal do Rio de J*aneiro: http://www.theatromunicipal.rj.gov.br/escolas-de-formacao/escola-de-danca-maria-olenewa/

10 *Escola do Teatro Bolshoi no Brasil* is the only branch of the Bolshoi Theatre outside Russia. Created in 2000 and located in Joinville, Santa Catarina, it is aimed at the teaching of the Vaganova method to dance artists.

11 More about *Centro de Dança Rio* at: https://centrodedancario.com.br/sobre/

12 Get to know *Dança em Pauta* at: http://site.dancaempauta.com.br

13 Lear more about *Bastidores* at: https://bastidorestraining.com/equipe/

14 Learn more about *Ateliê Corporal* at: https://www.ateliecorporal.com.br

15 Visit *Ciência da Dança Brasil* at: https://www.facebook.com/groups/dancesciencebr/

16 Visit ITEGO Basileu França at: https://www.basileufranca.com.br/danca

17 Get to know more about the BRUK DMS NET at: www.brukdms.blogspot.com.br

18 Learn about CBDD at: https://www.facebook.com/cbddconselhobrasileirodadanca/

19 Learn more about YAGP *Brasil* at: <yagpbrasil.com>.

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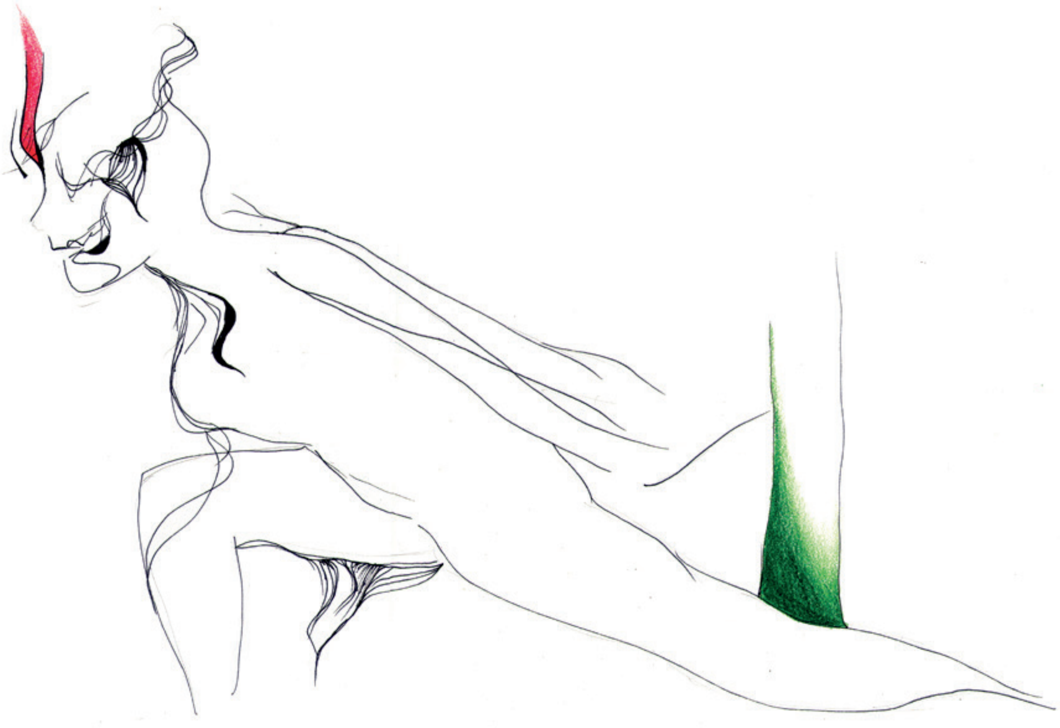

Célula Corporal MADAM. Autora: Anna Behatriz, 2012. Ilustração em papel Canson. 21x29,7cm.
Arquivos de Adriano Bittar, reproduzida com permissão.

SECTION II

DANCE SCIENCE

CHAPTER 4

DANCE MEDICINE AND SCIENCE: PHYSIOLOGICAL AND BIOMECHANICAL ASPECTS

Matthew Wyon / Andreja Picon
Debora Cantergi / Sarah Needham-Beck

INTRODUCTION

This chapter is mainly composed by Professor Matthew Wyon's transcribed lecture on dance physiology and biomechanics given in Porto Alegre, Brazil, in December 2016, at *Escola de Educação Física, Fisioterapia e Dança* (*ESEFID*) - *Universidade Federal do Rio Grande do Sul* (*UFRGS*). Due to that, the reader will find many parts written in the first person, singular or plural (I, my, we, our, etc.). In addition, pertinent dance physiology and biomechanics' excerpts of research developed by Brazil-United Kingdom Dance Medicine & Science Network (BRUK DMS NET) members Andreja Picon, Debora Cantergi and Sarah Needham-Beck are also included.

Professor Matthew Wyon will introduce various aspects of the physiology of dance, also reflecting on the biomechanical demands placed on a dancer's body, across different genres. Sarah Needham-Beck dedicates her writing to the aerobic capacity of dancers. *Turnout*, or the ability to externally rotate the lower limbs, an important feature for ballet dancers, the kinematics and moments presented in *elevés* and *sautés*, dance footwear and flooring will be further discussed also by Andreja Picon and/or Debora Cantergi. Furthermore, these authors suggest ways that dance practice and training could be adapted to improve well-being and physical performance.

1. PHYSIOLOGICAL ASPECTS OF DANCE[58]

In the United Kingdom (UK), Dance Science forms a sub-genre of Exercise Science. My interest[59] is mainly focused on how to improve a dancer's performance and within this how can injury incidence be reduced.

Dancers are technically very good, but their physical and mental abilities haven't been developed to the same level as their technique and are often overlooked within the training environment. Dancers have been classified as "artistic athletes", though their athletic ability doesn't influence performance outcomes to the same extent as sport. My supervisor Professor Craig Sharp coined the term "artistic athlete" to describe dancers (Koutedakis & Sharp, 1999). The aim is not to make dancers, athletes, but to support them so they can perform to the best of their abilities.

58 Following the BRUK NET workshop in Goiânia (more details in Chapter 1), Prof. Matthew Wyon was invited by Aline Haas to give a series of lectures at the Postgraduation in Movement Sciences, University of Rio Grande do Sul (*UFRGS*), Physical Education, Physiotherapy and Dance Superior Schools (*ESEFID*), in Porto Alegre, Brazil. This event was made possible due to the partnership of BRUK DMS NET, *UFRGS* and *Pontifícia Universidade Católica do Rio Grande do Sul* (*PUCRS*). Event's details: date - Dec 14th, 2016; venue: *PUCRS*; organization: Aline Haas; translation: Bárbara Spessato and Karla Vendramim. Transcription of the lecture: Adriano Bittar. Edition: Bittar and Debora Cantergi.

59 In this case, "My interest […]" is a statement made by Prof. Wyon.

Within the UK, major ballet companies have between 200-250 performances a year, whilst an elite soccer team would have 70. So, dancers have a much harder performance schedule, but their underlying physical foundation is less developed to cope with this demand and could account for some of the factors that contribute to the high injury incidence. In the UK and Europe, dancers' average retirement age is 34-35 years-old, which means dancers often spend more time in-training than they do as professional dancers. Interestingly, research has shown little age effect on dancers' physical capabilities, suggesting retirement might not be due to not keeping up with the younger dancers as is often the case in sport.

In the UK, dance courses were initially developed in Physical Education (PE) Colleges and it wasn't until the 1950s that they moved from the PE departments into the Arts in universities. Then, 50 years later, Dance Science emerges, and Dance departments see a potential threat that could lead to dance being put back into PE. Underlying this is the concept of athletes and artists. Dancers don't like to think of themselves as athletes, even though they use their bodies.

How hard is it to dance? Physically, it is not very strenuous compared to some sports: energy demands of a ballet class have been measured through calorimetry at 300 kilocalories per hour (kcal/h) for male and 200 kcal/h for female dancers (Cohen, Segal, Witriol, & Mcardle, 1982), and contemporary dance at 6.67 kilocalories/minute (kcl/min), 5.93 kcal/min and 9.49 kcal/min for class, rehearsal and performance for male, respectively; and at 4.73 kcal/min, 2.63 kcal/min and 6.67 kcal/min for class, rehearsal and performance for female dancers (Wyon, Abt, Redding, Head, & Sharp, 2004). But the technical demand is much greater. The high technical demand means that the intensity that you can exercise at is very low, hence sports that perform at greater intensities have a much lower technical element.

To give an example we have 3 people competing over 100 meters: the sprinter, the hurdler and a dancer. Who wins? The sprinter comes first, because there is comparatively little skill required, just that he/she runs fast. The hurdler comes in second as the skill level has increased, because he has to go over the hurdlers. And the dancer takes 4 hours because of the choreography. We can't really compare the dancer with sports people, because the goal of what they do is totally different.

Dance is very different from sport, where often the focus is on the development of one area, with the aim at becoming exceptional in it. If we use marathon runners as an example, a good female runner can run a marathon in 2 hours and 20 minutes, to 2 hours 30 minutes; that is averaging 18 kilometers per hour (km/h) for the whole marathon. But if you ask her to sprint 100 meters, she can't go much faster, maybe 19 km/h. This is because their training has developed specific energy systems to the detriment of others. A high jumper cannot become a javelin thrower. The training load a person is exposed to has a direct influence on their aerobic capacity.

Body composition, aerobic power, muscular power, muscular endurance, muscular strength, speed, agility and flexibility make up physical fitness, and all affect dance performance. In comparison, athletes from different sports have developed different attributes. For instance, marathon runners have good muscular endurance, body composition and aerobic power, but often poor flexibility and muscular strength;

whilst judokas have good agility, muscular strength and power. Therefore, the different dance genres need to be classified as to the demands that are placed onto the dancer. The diverse choreography within the genres could mean there is more variation within a genre than between the genres.

1.1 Body Composition

Do dancers have low body fat? Not necessarily. Published data suggests that some elite athletes have lower body fat percentages. Male ballet dancers are reported at 10% body fat, compared to runners at 7%, rugby players at 7%, and cyclists at 9% (Twitchett, Angioi, Metsios, Koutedakis & Wyon, 2008); whilst female dancers are between 17-20% compared to runners at 15% and gymnasts 13% (Koutedakis & Sharp, 1999). The light body mass of dancers shouldn't be confused with low body fat, but often a lack of equivalent muscle mass to athletes.

The difference is that outside of competition periods, athletes are usually slight heavier and carry more body fat; 6-8 weeks prior to competition they start to strip down to their competitive weight. Whether this is possible within a dance environment has not been examined. Twitchett et al. (2008), in a study analysing body composition and injury incidence, noted that dancers with higher percentages of body fat were more prone to injury, whilst those with low percentages took longer to recover from injury.

Studies compared body composition variables between ballet and DanceSport (competitive ballroom dance). Little difference was found between male participants of the two genres for body fat. Female ballet dancers have a lower mean body fat, but there is much greater variation (standard deviation) within the group than for the female DanceSport group (Liiv et al., 2013). There is little difference in bone mineral density (BMD) data for the two genres. At the femur and lower spine (L4-L5) there is very little difference between both groups, as these sites correlate to greater body activity and especially impact from jumps, etc. The area of concern for ballet is the radius, where the females are significantly lower. BMD has been shown to migrate to areas of need (impact). Female ballet dancers receive little if any impact through their arms and therefore it is deposited to areas of need (femur and lower spine). Other data has shown that this can be seen in male dancers but it increases when they start lifting (Amorim et al., 2017). The low BMD in the upper extremities needs to be rectified for long-term health, especially in women so they are protected from possible fall fractures in later life.

Some other studies are looking at more than body fat, they are concentrating on menstruation. If female dancers do not menstruate, they are unhealthy, as simple as that. But we also recognize that if they are doing an 8-week show, as they are now dancing “The Nutcracker”, they might lose their menstruation during the shows, but they have to menstruate again as soon as it is over. Most dancers stop menstruating when they are below body mass index (BMI) 17-18.5 kg/m^2.

1.2 Muscle Strength

Research indicates that increased muscle strength has a beneficial effect on injury incidence (Koutedakis, Frischknecht, & Murthy, 1997). In comparison with other athletic populations, dancers have significantly less muscular strength. Strength training is rarely part of dancers' supplemental training regimens, probably as it has been wrongly linked to big muscles. Using marathon runners as an example, strength training is an integral part of their training programmes without compromising body weight (muscle mass) and enhancing performance. Improved muscle strength allows dancers to dance at a lower percentage of their maximal capacity, helping delay the effect of fatigue. It provides a protection when technique and alignment fail. Presently injuries are more likely to occur towards the end of class, at the end of rehearsal and on the first week of performances, because of fatigue.

Dancers in many Western dance genres are often overtrained[60]. A study by Koutedakis & Sharp (1999) noted that dancers' muscle function actually improved during their summer holiday when they were resting, indicating they were overtrained. This is acerbated by their underlying poor physical fitness levels and demanding performance schedule that affects recovery.

1.3 Cardiorespiratory Capacity

Physiological research findings to date on the fitness profiles of dancers, the cardiorespiratory demands of dance activity, and adaptations to dance training and performance, as is the case with many areas of investigation in DMS, only scratch the surface of the complex physiological response to dance. There are many unexplored and unanswered questions, even at the basic level.

60 Overtraining occurs when there is pressure to performing always to one's best abilities. In such a case, dancers may complain of reduced physical performance for no apparent medical reason, suffer constant fatigue and show emotional and behavioral changes.

It can be proposed that the investigation of physiological aspects of dance and application of findings within training and performance practices aims at the development of physical capacity/fitness, which results in a reduction in the relative intensity of a set movement and, therefore, allows relative ease in both training and performance.

Research is continually conducted internationally to bridge these gaps in knowledge and develop a deeper understanding. Partners within the BRUK DMS NET contribute to this through their own individual research, as outlined here, and through active collaboration to further this research base and create services.

Untrained sedentary populations have aerobic capacities between 38-42 milliliters of oxygen per kilogram of body weight per minute ($ml.kg^{-1}.min^{-1}$), which is not too dissimilar to some reported data from ballet dancers (Koutedakis & Jamurtas, 2004), though more recent data has shown them to be similar to field sport athletes (Wyon et al., 2016a). Contemporary and DanceSport dancers have aerobic capacities similar to gymnasts and slightly higher than ballet dancers (Liiv et al., 2013). Improved aerobic conditioning has been linked to improved dance performance capabilities (Twitchett, Angioi, Koutedakis, & Wyon, 2011) and recommended targets should be in the low 50 $ml.kg^{-1}.min^{-1}$ for women and mid 60 $ml.kg^{-1}.min^{-1}$ for men. Too great a development of the aerobic system will have detrimental effects on the other energy systems as its primary function is to improve recovery rates between high intensity bouts during performance and rehearsals. We really have to look at female dancers at their low 50s and at men at their 60s, so that when they are dancing they are performing at their 80% maximum.

The average aerobic capacity of the general population is around 35ml.kg^{-1}.min^{-1}, marathon runners between 70-80 ml.kg^{-1}.min^{-1}, and field sports people 50-60 ml.kg^{-1}.min^{-1}. Dancers are between 35-50 ml.kg^{-1}.min^{-1} despite their long hours of training (Wyon, 2005).

Figure 1 is representative of the physiological demands of a contemporary dance class. Most of the class is at the same intensity as vacuuming and then towards the end, the *grand adagio* section, is characterised by short high intensity bouts and long rest periods (Wyon, Head, Sharp, & Redding, 2002).

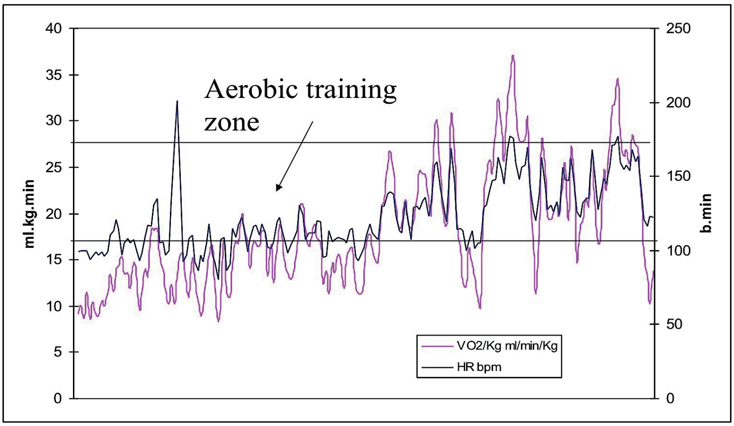

Figure 1[61]: Heart rate and oxygen consumption during a contemporary dance class.

Rehearsals are often long, but most of it is very low intensity as the focus is on skill acquisition, with short periods of higher intensity when the section is run at performance pace (Figure 2). As the focus is on learning new skills, the intensity is too low to cause physiological adaptation.

61 Figure 1 is part of the non-published personal archives of Professor Matthew Wyon, printed with permission.

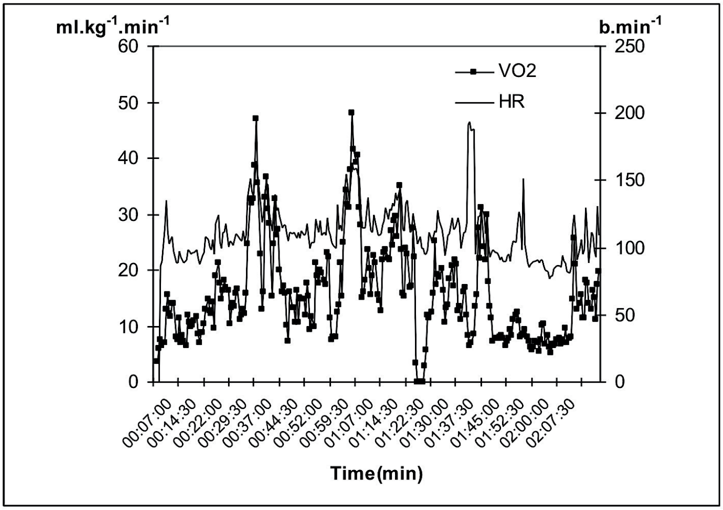

Figure 2[62]: Heart rate and oxygen consumption during a contemporary dance rehearsal.

Then, in a very short period the dancers need to cope with a great increase in the physical demand being placed on them. During a 30 minutes performance of a piece from UK-based Phoenix Dance Theatre (Figure 3), the physiological demand (oxygen consumption and resulting heart rate) is significantly higher than that seen during dance class and rehearsal (Wyon et al., 2004). When interviewed, most dancers felt it took two weeks of performing before they feel physically ready or can cope with the performance. During this period, when dancers are adapting to the physical demands of performing, there is also a spike in injury incidence potentially due to the increased levels of fatigue. As the performance season progresses, it has been seen that dancers get aerobically fitter (Wyon & Redding,

62 Figure 2 is part of the non-published personal archives of Professor Matthew Wyon, printed with permission.

2005), which is the opposite that has been reported in sport, especially field sports such as football (Casajús, 2001), called soccer in the United States. In football, the focus of the pre-season is to get the players much fitter than they need to be and as the season progresses there is a decline in fitness levels. It is their responsibility to be fit, so they can do their job. There are just a few dancers that have taken this responsibility for themselves. Most of them expect their companies to get them fit and believe that ballet classes, rehearsals and Pilates will get them fit to perform.

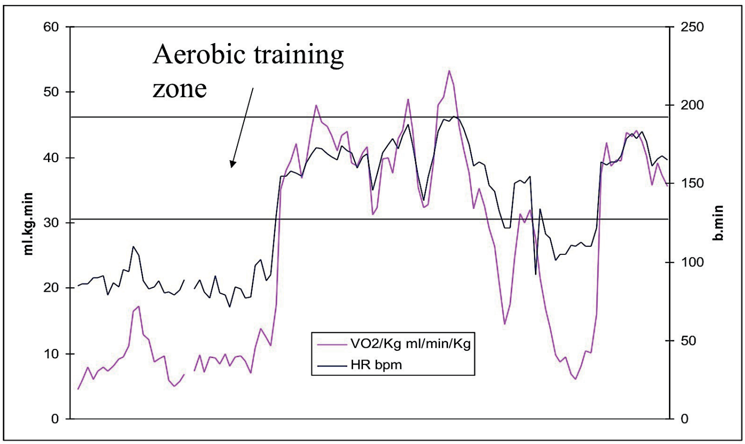

Figure 3[63]: Heart rate and oxygen consumption during a contemporary dance piece.

Recent research undertaken by Sarah Needham-Beck (2015, 2017, 2018) examined the relevance and importance of cardiorespiratory fitness in contemporary dance training and performance. A published systematic literature review

63 Figure 3 is part of the non-published personal archives of Professor Matthew Wyon, printed with permission.

surveyed the available literature concerning either the cardiorespiratory demand of dance activity or the effects of training or performance on the cardiorespiratory fitness of dancers, with a particular focus on critically appraising methods adopted in these studies (Needham-Beck, Redding & Wyon, 2015). Key findings highlighted that the degree of physiological strain placed on the body during dance class involves a complex interaction of the intermittent work and rest periods, and that the varying intensities of work depend upon specific movement vocabulary executed at different stages of the class. It was also highlighted that very few studies have examined dance rehearsal and amongst the data available, variation is too high to allow a generalized statement of the energetic demand. However, there is a suggested influence of rehearsal status on values, with full-run through intensity likely to closely mirror that of performance. Regarding performance, the high intensity nature of performance across dance genres is evident from data sets presented; however, more research is required to determine the variability of this both within and between dance genres. Lastly, there is a lack of documented positive physiological adaptation occurring through periods of dance training and rehearsal in contrast to that achieved through supplementary fitness training.

Aerobic fitness and energy cost of dance movement occurring throughout one year of vocational contemporary dance training were observed in student dancers from undergraduate (UG group) and postgraduate (PG group) dance degree programmes (Needham-Beck, Wyon, & Redding, 2018). Measurements of aerobic fitness (aerobic capacity - VO_2peak) and lactate threshold (LT), and cardiorespiratory response to a standardised four-minute dance sequence at the beginning (TP1), middle (TP2), and end (TP3) of an academic/ training year were undertaken. Results demonstrated that both groups displayed an overall decrease in mean VO_2peak throughout the year, despite a peak in fitness at TP2 in the PG students. These findings agreed with previous research stating that typical dance training does not improve aerobic fitness. Although, it is interesting to note that TP2 followed a rehearsal period for the PG group, suggesting that rehearsal may improve aerobic fitness levels, in contrast to previous research findings (Wyon & Redding, 2005). Future research could therefore further investigate the energy demand of rehearsal and cardiorespiratory adaptation during rehearsal periods. In contrast to the aerobic fitness findings, a significant reduction in the relative intensity of the dance sequence, particularly in relation to mean VO_2 ($ml.kg^{-1}.min^{-1}$) and %LT data, was observed over time in both groups; although, the degree of change was less in the UG group than the PG group.

This finding highlighted the potential importance of exercise economy in dance physiology research. Exercise economy refers to the oxygen uptake required at a given absolute exercise intensity, with a more economical individual theoretically requiring less oxygen to complete the same task. Given the low cardiorespiratory fitness levels often documented for dancers of varying levels across various dance genres, and the highly specific nature of dance training practices, it seems likely that dancers are highly economical in their movement, allowing them to complete required sequences at a lower relative intensity and with seeming ease. Dance, as highly dynamic movement in nature, with frequent changes in direction and pace, does not lend itself to accurate direct measurement of economy; however, this does seem a relevant concept for future research to explore.

Cardiorespiratory demands placed upon contemporary dancers during performance of specific repertoire was further researched by Needham-Beck, Wyon and Redding (2018). This study examined five pieces of repertoire performed by student and professional dancers. Results displayed an overall dance time of 50.31% (±12.98) for female student dancers and 41.60% (±5.73) for male student dancers, compared to 74.25% (±5.12) for male professionals. High variation was noted within and between all pieces although the majority of time was spent at either moderate or vigorous intensities across all pieces for the majority of participants.

This study also raised concerns regarding which variables and measurement techniques provide a sensitive, reliable, and valid representation of the cardiorespiratory demand faced during performance of dance repertoire. It is important for future research to continue to document the demands of a range of repertoire to help develop the understanding of the demands faced and therefore allow us to investigate ways to better prepare dancers to meet these.

With many questions relating to the physiological response to dance specific activity still unanswered, there are many avenues for future research to explore. Pertinently, the research needs to expand to examine more dance genres, due to the likely high variation both between and within genres, as outlined earlier in this chapter. Further description and detailed examination of training content and structure is also required, as is experimental research which tests the efficacy of various interventions designed to optimize physical preparation for performance.

Figures 4 and 5[64] provide an idea of breaking and street dance routines. The breaking routine had a lot of power moves, such as the *Windmill*[65]; whilst the street dance routine was closer to a pop video. New style or street dance comes from jazz and have a different origin than breaking, so even within what we call street dance, the genres are very different in how they developed and how they are manifested. Breaking has a foundation in improvisation, whilst street dance is highly choreographed. Research has started to examine other styles such as DanceSport and jazz, but there are still many genres not yet examined outside of aesthetic differences.

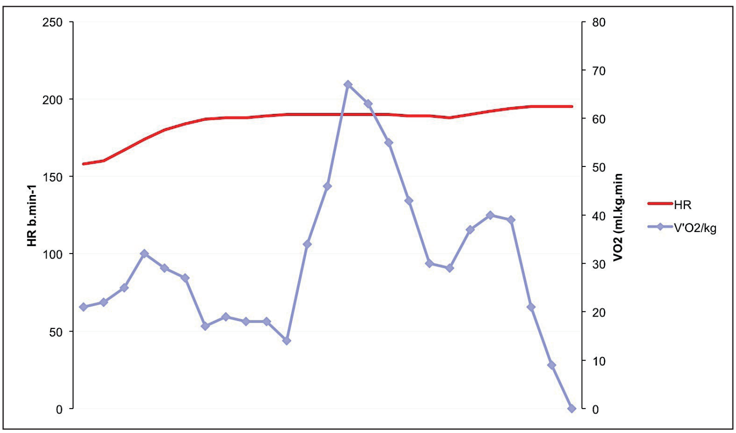

Figure 4: Heart rate and oxygen consumption during a breakdance routine.

64 Figures 4 and 5 are unpublished data from the archives of Prof. Matthew Wyon, printed with permission.

65 The Windmill is a popular breakdance move, where the breaker rolls his torso continuously in a circular path on the floor, across the upper chest/shoulders/back, while twirling his legs through the air.

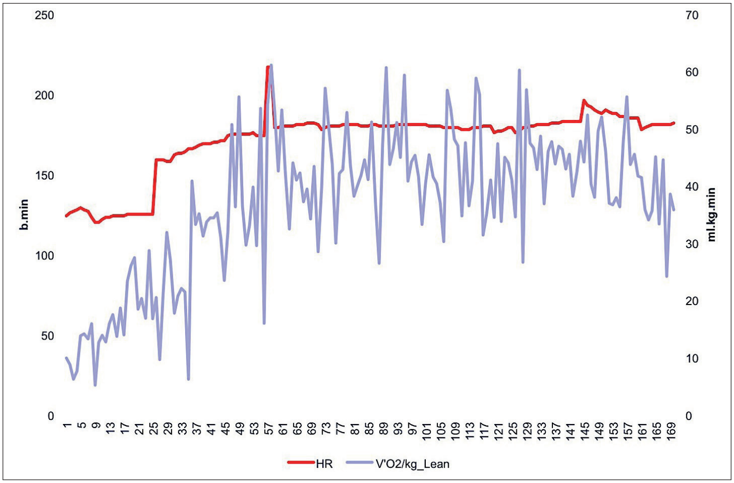

Figure 5: Heart rate and oxygen consumption during a street dance routine.

Dancers generate significantly less anaerobic power than gymnasts and footballers (males: 680 Watts - W) vs 852W vs 914W; females 410W vs 440W vs 600W, respectively), possibly because they are not aware of their bodies' maximum capabilities. Because their exercise is always highly technical, they rarely work maximumly. They stop before they ever reach maximum. Dancers do not know what their bodies are capable of, because when dancing, they are thinking of those intricate movements, and the position of their bodies, not "… how hard can I push myself?".

1.4 Flexibility

Dancers are renowned for their flexibility, but generally they only have greater ranges of movement (ROM) in their hips compared with other athletes. Joint ROM is activity specific, e.g. swimmers present large ROM in their shoulders. Increased ROM can be accompanied by increased instability, unless strength is also developed (Wyon, Felton, & Galloway, 2009). Dancers spend a lot of time stretching but they don't spend a lot of time strengthening those muscles to take that leg through the ROM. Therefore, it is useful to measure the difference between active and passive ROM, as clinical data suggests that the bigger the difference, the more they are prone to injuries. For instance, in ballet dancers the difference between passive and active hip flexion has been measured at 46 degrees in male and 29 degrees for female dancers (Redding & Wyon, 2004).

Dancers are also stretching too hard. Some studies show that the intensity of the stretch may cause more inflammation than necessary, damaging the muscles. By stretching to low intensity, between 30% to 60% of their maximum, dancers had better increased passive and active ROM than those who stretched 80% of their capacity. The ones that stretch hard also recover much slower from muscle damage. Thus, low intensity stretch could help them to recover from a full day of dance as well. The underlining reason why this is true is still not known, but it seems that a little bit of stress helps stimulate healing, but too much stress does the opposite. This fits to other healing mechanisms we see in terms of different tissues: a little stress helps healing, not a lot. Sometimes a small electric shock applied to muscles does this, helps healing, this is the same mechanism.

1.5 Supplemental Training

Technically, dancers are amazing; their movement and motor control are amazing; their ability to pick up new moves is amazing. But optimum performance is not just skill, earlier parts of this chapter have shown that dancers are working very close to their maximum, and intervention training is needed, so there is spare physical capacity.

Scheduling extra training into an already hectic timetable is difficult without increasing the risk of overtraining and injury. Evidence in sport has illustrated that training quality is more important than training quantity, which is something that needs to be adopted in dance.

There is not a huge amount of evidence to support supplemental training. A couple of studies done using supplemental training as an intervention (Angioi, Metsios, Twitchett, Koutedakis, & Wyon, 2012; Twitchett et al., 2011) showed that not much is needed to have a beneficial effect, as dancers are already doing a lot of exercise. These studies incorporated one to two 1-hour sessions a week for 6-10 weeks; the intervention group improved their fitness levels and dance experts perceived they danced better. Injury incidence also decreased in the intervention group. Presently few school or companies have supplemental training as part of their timetabled schedules, so if dancers want to incorporate this training it has to be in their own time. Some of the major ballet companies have invested in state of the art gyms, swimming pools and Pilates equipment but the dancers' contractual hours are all focused on dancing.

1.6 Vitamin D

Across the world there is this deficiency in vitamin D, even in "sunny" countries such as Australia and the Middle East. Vitamin D used to be solely linked to bone health, but it has now been shown to have a beneficial effect on a range of areas including respiratory illness, cancers, immunology and muscle function. At least two studies have examined vitamin D levels in classical dancers. The first study measured serum 25 hydroxyvitamin D, known as 25(OH)D, in winter and summer (Wolman et al., 2013). The majority of dancers had insufficient levels of vitamin D in the winter, which is normal, but, after summer holidays, only three had reached normal levels and two were still deficient. Interestingly, injury incidence was higher in the winter than in the summer, even though they were doing the same kind of performance.

The second study supplemented a group of dancers with 2000 international units a day (IU/day) vitamin D for four months with a group of volunteers acting as a control (Wyon, Koutedakis, Wolman, Nevill, & Allen, 2014). Muscular strength and power were measured pre and post intervention and injury incidence recorded over the whole period. The supplement group increased muscle strength, jump height and had a lower injury incidence.

A third study used judo players as participants. Experimental group received 150000 IU of vitamin D and a control group had placebo pills (Wyon et al., 2016b). After one week, there was a 12% increase in muscle strength by rectifying vitamin D deficiency. Research suggests that there are no benefits of increasing vitamin D beyond normal levels.

2. BIOMECHANICAL ASPECTS OF DANCE

Over four decades, injuries in dancers, that often occur when the load applied to a structure is higher than its capacity to regenerate (Bartlett, 1999), have been the focus of dance medicine studies (Miller, Schneider, Bronson, & McLain, 1975).

The high incidence of injuries in dance, occurring mainly in the lower limbs, is related, among other factors, to the repetitive characteristics of dance training and the expectation of performing in extreme ROMs.

Biomechanics, especially sports biomechanics, focus in injury prevention and performance enhancement. To enable injury prevention, it is necessary to understand its mechanism, starting with the forces occurring in dance movements. While questionnaires and goniometry are still some of the most popular methods in dance medicine and injury research, methodologies are becoming more sophisticated in the past years, using kinetics and kinematics.

2.1 *Turnout* Kinematics

The ability to externally rotate the lower limbs is known as *turnout* in classical ballet. Whilst other dance genres also use *turnout*, ballet dancers are expected to dance with feet extremely turned out, each in a 90° angle. In ballet, perfect *turnout* is thought to be achieved by an external rotation that happens at the hip, while maintaining a neutral pelvis[66], aligned centres of knees and second metatarsals, weight balanced in both feet and equally distributed within each foot between calcaneus, first metatarsal and fourth/fifth metatarsals (Gilbert, Gross & Klug, 1998; Gontijo, Candotti, Feijó, Ribeiro, & Loss, 2015).

However, the amount of external rotation in the hip joint is limited by each dancer's individual anatomy. Thus, the majority of dancers is not able to achieve 90° of external rotation at the hip, using external rotation from the knees and ankles to enhance the

66 Neutral pelvis refers to the alignment of the anterior superior iliac spine and the pubic bone in line with each other in the coronal or frontal plane.

angle between the feet, characterizing a forced *turnout* (Gilbert et al., 1998; Welsh, Rodriguez, Beare, Barton, & Judge, 2008). In forced *turnout*, the pelvis is often tilted anteriorly, the weight is shifted towards the medial edges of the feet and the knees are torqued, with the proximal tibias spiraling out, and distal femurs in, generating twisting forces at these joints (Krasnow, 2015). Authors that examined the improper use of *turnout* and the incidence of injuries in dancers agree that forced *turnout* contributes to the occurrence of injuries (Coplan, 2002; Negus, Hopper, & Briffa, 2005; Cimelli & Curran, 2012).

It is now recognized that dancers rarely achieve 180° *turnout* expected in ballet, and that the knees and ankles are often important in composing *turnout* (Gilbert et al, 1998; Krasnow, 2015). In a study by Cantergi et al., 2017, a group of eight dance major students from Coventry University performed series of *elevés* and *sautés* while kinematic data and ground reaction forces (GRF) were obtained for estimating joint angles and internal joint loads. Data from static feet *first position* showed dancers presented 45.5° ±*7.1*° of external rotation from the right hip and 49.1° ±*11.8*° from the left hip. No external rotation from the knees was present; only 2° ±*4.8*° and 3.4° ±*6.9*° of external rotation from the right and left ankle complex were found, respectively. During the *elevés*, hip external rotation ranged between 40-50°, with a decrease of about 7° when ankles were at their highest position. Knee external rotation was not present and ankles presented less than 3° of external rotation (Figure 6). During the *sautés*, external rotation at the hips and knees decreased in the aerial phase *(±10*°). At the ankles, external rotation decreased in 5° during the flight phase. Unlike *elevés*, at the contact phase of *sautés,* maximum hip and knees external rotations were higher than at static first position, probably because of the help of the friction forces between the feet and the floor.

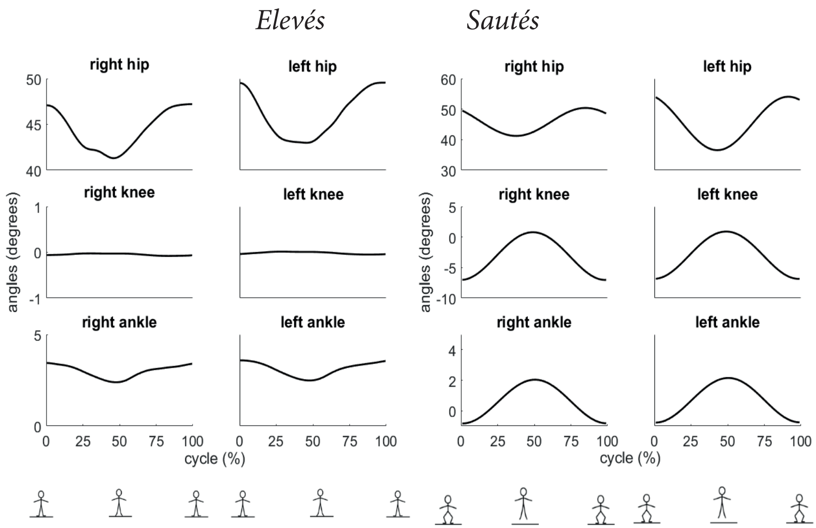

Figure 6[67]: Hip, knee and ankle joints rotation angles through the performance of the *elevés* (left) and *sautés* (right).

In a study by Picon and colleagues (2018) researchers compared the *turnout* of ballet students with different technical levels and training backgrounds. They evaluated 14 experienced Royal Academy of Dance (RAD) students (Royal Experienced Group - REG), 8 inexperienced RAD students (Royal Inexperienced Group - RIG), and 7 experienced students from other teaching methods (Mixed Experienced Group - MEG), such as French and Vaganova. Dancers performed two series of eight *sautés* in a specific rhythm, and rotation angles of the hip were acquired by six infra-red (IR) cameras (OptiTrack FLEX: V100, Natural Point, USA). Coefficients of variation (CV), minimal, maximal and mean hip/knees/ankles *turnout* values in the *sautés* were calculated. No differences were found between the REG x MEG or REG x RIG groups for the external knees and ankles rotations in the observed

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variables (ROM, mean or CV), despite the expressive participation of the hip/knees/ankles joints in the composition of total external rotation of the lower limbs (Table 1).

With regards to the mean qualitative pattern of the angular variation of the time series of *sautés* analyzed for the three joints of interest (hip, knees, and ankles), the greater angular variability was found in the inexperienced group (RIG). MEG dancers showed a larger mean hip external rotation in relation to REG, which contributed to a greater *turnout*. Although the passive lateral rotation angles were no different between experienced groups, in dynamic situations they changed. It can be hypothesized that this happened because of the acquisition of a better *turnout* control by MEG dancers, gained after years of training and experience in different methodologies.

Table 1[68] – *Mean (± standard deviation) of ROM, mean value (Mean) and, Coefficient of Variation (CV) of external rotation angles of hip, knee and ankle right joints (degrees) for the RAD Experienced Group (REG), Mixed Experienced Group (MEG) and RAD Inexperienced Group (RIG)*

External Rotation angle		REG (degrees)	MEG (degrees)	RIG (degrees)	p value ANOVA (<0.05)
HIP	ROM	13.1±3.4	12.6±2.2	13.4±2.3	0.872
	Mean ± sd	25.5±4.8	31.4±3.9*	22.2±6.5	0.02
	CV	8.5%	6.9%	13.3%*	0.000
KNEE	ROM	19.1±4.6	19.2±4.9	19.4±3.8	0.992
	Mean ± sd	19.7±6.4	16.2±9.1	15.5±4.7	0.354
	CV	21.7%	20.4%	23.1%	0.727
ANKLE	ROM	26.7±7.8	28.8±8.1	24.4±7.0	0.569
	Mean ± sd	6.8±6.2	5.9±3.5	2.1±5.0	0.176
	CV	20%	16%	16.3%	0.494

* Tuckey post hoc: HIP mean (p =0.012); Hip CV (p <0.001)

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Concerning the participation of other joints in *turnout*, more than 20º of external knee rotation was observed on the right lower limb. This external rotation corroborates the findings of Quanbeck, Russell, Handley, & Quanbeck (2017), who reported about 40º of external rotation between both right and left knees in the first position of feet using kinematic analysis. Thus, it was found that the knees contributed decisively to *turnout* composition, and not only the hip, as expected. One of the most common compensatory strategies observed in dancers is "twisting" the knees when in a closed chain; the dancer makes use of the friction forces between the feet and the floor to increase external rotation of the knees beyond the natural ROM, forcing hyper external rotation. Moreover, higher technical level seems to be linked to lower variability of hip external rotation while performing *sauté* in first position. Ballet training background also appears to influence the hip external rotation pattern regarding mean values and movement quality.

Furthermore, Picon and colleagues (2018) performed a detailed investigation of intra and intersegmental coordination of the lower limb joints in the *sautés* of those same ballet dancers. The idea was to understand the dynamic patterns of adjustment used during *sautés* to maintain the expected *turnout*. This investigation was based on the studies of Armour Smith, Siemienski, Popovich Jr, & Kulig (2012), that elucidated how trunk coordination occurs at different stages of a bipedal jump. This study supports the premise that variability in coordination may be a key success in movement organisation of skilled dancers. Additionally, Reeve, Hopper, Elliott, & Ackland (2013) observed through the technique of Vector Coding that experienced dancers did not increase the variability of movement execution on different floors, showing that they adapt easily. Jarvis, Smith, & Kulig (2014) also studied the coordination of trunk and lower limb segments in jumping, comparing dancers and non-dancers. They found out that lower inter-segmental coordination variability in expert dancers indicates a higher level of control.

Based on this information, Picon and colleagues (2018) compared the inter and intra-segment coordinating patterns in the transversal plane [hip-knee (HK), hip-ankle (HA) and knee-ankle (KA)] during *sautés* in beginners and expert~~s~~ ballet dancers with different training backgrounds. The joint coupling angles were calculated by the Vector Coding technique: through the phase portrait of each joint pair, the difference between each point in time that corresponds to the coupling angle is obtained, which represents an instantaneous spatial relationship of four patterns - proximal, in-phase, distal, and anti-phase (Chang, Emmerik, & Hamill, 2008). The values are expressed as a percentage in the cycle (Figure 7).

For the HK coordination, MEG (right = 36.14%; left = 26.34%) showed distal pattern predominance when compared to RIG and REG; MEG (just left side = 43.56%) also presented an in-phase pattern different from RIG (20.38%) and REG (37.49%). The HA coordination was no different between groups for the right limb. However, in the left side, RIG (47.89%) and MEG (40.56%) were different from REG (8.57%), showing an in-phase pattern. Finally, for the HA coordination, all groups were similar bilaterally, presenting an anti-phase pattern: RIG (right = 52.34%, left = 48.62%); MEG (right = 49.19%, left = 45.90%) and REG (right = 48.72%, left = 46.58%).

So far, it has been possible to perceive that the groups studied opted for different strategies and combinations of the articulated pairs when trying to maintain the external rotation of the lower limbs. These patterns may reflect the search of the ideal positioning and the way the learning process is conducted by each dancer.

		RIGHT (%)				LEFT (%)			
		PROXIMAL	IN PHASE	DISTAL	ANTIPHASE	PROXIMAL	IN PHASE	DISTAL	ANTIPHASE
HIP-KNEE PATTERN HK	RIG	25.56	24.27	19.05	32.65	33.24	20.38	14.29	32.05*
		± 11.38	± 15.05	± 8.75	± 17.98	± 17.18	± 8.92	± 7.55	± 9.92
	MEG	10.25*	21.85	**36.14***	31.72	15.26	**43.56***	**26.34***	14.8
		± 5.94	± 10.32	± 15.75	± 21.89	± 8.16	± 17.33	± 15.21	±16.48
	REG	22.9	22.29	19.67	15.35	30.72	37.49	18.27	13.11
		± 9.48	± 16.74	± 8.28	± 21.02	± 9.50	± 9.46	± 6.67	± 5.09

*ANOVA p<0.05

		RIGHT (%)				LEFT (%)			
		PROXIMAL	IN PHASE	DISTAL	ANTIPHASE	PROXIMAL	IN PHASE	DISTAL	ANTIPHASE
HIP-ANKLE PATTERN HA	RIG	12.45	24.69	31.53	31.29	15.5	**47.89**	22.07	14.5
		±7.46	± 16.41	± 14.54	± 22.77	± 4.76	± 14.25	± 6.87	± 9.77
	MEG	10.25	21.85	36.14	31.72	15.26	**40.56**	26.65	14.8
		± 5.94	± 10.32	± 15.15	± 21.89	± 8.16	± 17.33	± 15.82	± 16.48
	REG	13.82	24.65	32.88	28.8	17.25	8.57	23.93	50.57
		± 6.25	± 15.81	± 13.14	± 20.62	± 8.92	± 4.55	± 10.24	± 9.65

*ANOVA p<0.05

		RIGHT (%)				LEFT (%)			
		PROXIMAL	IN PHASE	DISTAL	ANTIPHASE	PROXIMAL	IN PHASE	DISTAL	ANTIPHASE
KNEE-ANKLE PATTERN KA	RIG	7.46	7.79	32.02	**52.34**	8.38	11.25	32.15	**48.62**
		± 4.36	± 3.66	± 6.10	± 6.89	± 4.86	± 5.34	± 7.20	± 5.67
	MEG	8.29	9.25	33.24	**49.19**	12.21	12.48	29.37	**45.90**
		± 4.32	± 5.64	± 6.10	± 5.12	± 8.86	± 6.40	± 6.80	± 4.90
	REG	10.14	8.32	32.77	**48.72**	11.27	11.11	30.38	**46.58**
		± 4.61	± 4.06	± 5.71	± 5.53	± 5.71	± 4.80	± 6.54	± 7.24

*ANOVA p<0.05

Figure 7[69]: Coordination patterns calculated by the Vector Coding technique.

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2.2 Joint moments in *elevé* and *sauté*

Cantergi and colleagues (2017) also observed, in a group of eight dance major students from Coventry University, that the joint moments in *elevé*, the turning effect produced by a force, calculated by multiplying the perpendicular force by the distance from the pivot (or axis of rotation), are mostly constant throughout the movement (Figure 8). At the hip, the abduction moment ranges between 70-90 Newton metre (Nm) and flexion and external rotation moments between 10-30 Nm. At the knees, flexion moment ranges between 40-60 Nm, the abduction moment is around 25 Nm and external rotation moment around 10 Nm. The knees flexion moment is probably occurring to keep the joint from flexing during the gesture, and the abduction moment at the hip occurs because of the rotated legs. Because the feet in contact to the floor form a closed kinetic chain, it is necessary that the legs move apart to accommodate the movement from the ankle joint complex.

Differently, during *sautés*, higher abduction moments at the hip and at the knees occur in the contact phase, when the knees are flexed (Figure 8). At the hip, the maximum abduction moments are about 150 Nm in the contact phase, shifting to adduction moments in the middle of the aerial phase. The hip highest external rotation moment is about 50 Nm during contact and close to zero in the aerial phase. The flexion/extension moments ranged from 50 Nm flexion moments in the contact phase and 50 Nm extension moment in the aerial phase. At the knees, an abduction moment of up to 75 Nm and an external rotation moment of up to 25 Nm occur in the contact phase. Flexion/extension moments range from about 20 Nm flexion and 10 Nm extension moments.

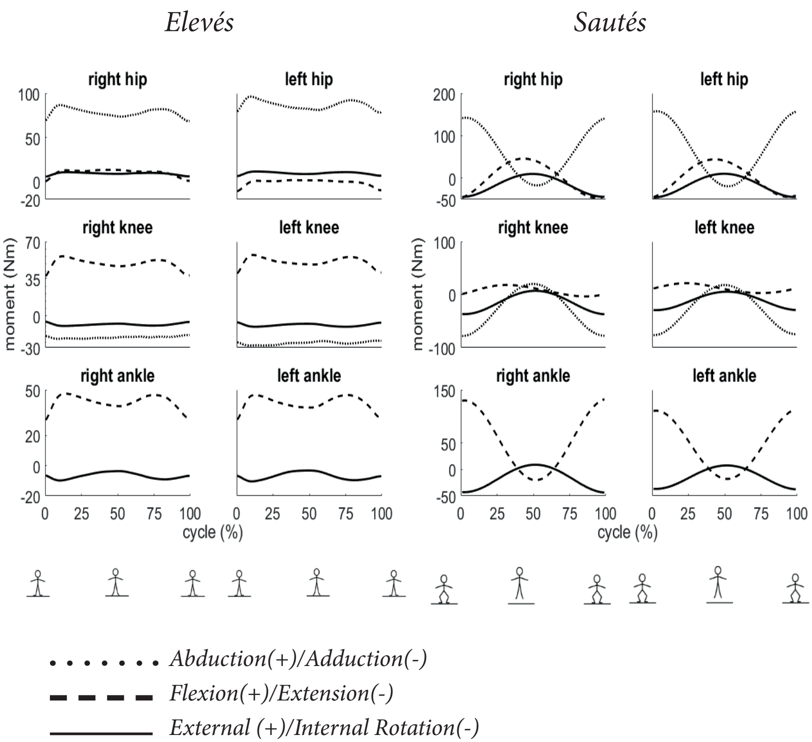

Figure 8[70]: Mean net joint moments during *elevés* (left) and *sautés* (right), representing the agonist muscle groups in action.

This study seems to be one of the first attempts to evaluate internal loads in dance. Describing the joint rotation angles and the joint loads during two simple ballet movements is a first step towards understanding how injuries in dancers occur and how to prevent them. There is a large field for biomechanics research in dance and a lot to be done with the available technology.

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2.3 Dance shoes

Dynamic stability in shoes is determined by a mixture of anterior/posterior, medial/lateral and vertical forces. The greater the heel height, the worst the stability. The thicker the sole, the more medial-lateral oscillation. In the particular case of ballet pointe shoes, many dancers or specialists spend hours modifying their shoes, so that they fit well.

Different models of pointe shoes, including traditional and thermoplastic models (Freed and Gaynor Minden, for example), were compared at their box, after breaking[71] them in and after 48 hours. Variables tested were balance, vertical ground reaction force (GRF), and loading rate on landing (both vertical and medio-lateral). Thermoplastic shoes were better in the balance test. Some of the traditional shoes presented better results for loading rate at landing, probably because of its stiffness. No difference was found in total display of action force. Thermoplastic were better on the horizontal loading rate at landing. After 48 hours of use the traditional shoes' internal structures were totally disintegrated. They were comfortable, but they weren't doing the job they were meant to do.

It is very common to see dancers going over their foot alignment when *in pointe*. And there are more and more dancers that think that getting over it is the right position. When they go over the right position, their feet are hanging by their ligaments and the muscles are switched off. The force that should be carried from the whole feet may be all collapsed.

71 Traditionally, ballet dancers are taught to customize their pointe shoes. One of the things they do is to break them in: they pry up the shank (reinforced sole), bend it back and forth where the heel becomes the arch, to make it more pliable when they rise up to *point*. To soften the platform at the front of the shoe that supports the toes (box), they gently step on it with the heel of your foot, to increase the comfort of wearing pointe shoes.

The usual 19-21 years of age dancer's feet look like 60-year-old women's (Figure 9). Maybe the pointe shoe needs to be re-manufactured, as it hasn't changed in 150 years: hessian and glue make up the box section; and leather, red board, cardboard - the shank; which is then all covered in canvas or satin (outer). All are handmade and this leads to discrepancies and to a high return rate (40%).

Figure 9[72]: When aesthetics comes first.

In a study conducted by Ghilardi (2017), the effects of different ballet shoes (ballet slippers - BS or pointe shoes - PS) and strategies (initiated from *piqué* or *relevé*) of *arabesque* performance were analysed. The *first arabesque* was the chosen gesture and measurements of the vertical GRF were used to

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verify the mechanical magnitudes that the dancers' bodies were exposed to (Ryman, 1997; Toledo, Akuthota, Drake, Nadler, & Chou, 2004). A total of 26 classical dancers from different ballet schools that presented the same technical level were chosen. A 10-minute self-warm-up preceded the four tasks: (1) *piqué arabesque on demi-pointe*; (2) *piqué arabesque on pointe*; (3) *relevé arabesque on demi-pointe* and (4) *relevé arabesque on pointe*. The order of movements and shoes was determined by a random numerical sequence. The dancer was instructed to position herself in classical pose and wait for the music to start each *arabesque*. The movement was initiated by the projection of the lower support member of the *arabesque* into the force plate (AMTI OR-6-1000, Watertown, USA), chosen according to the preference of the dancer, along with the movement of the upper limbs passing through the ballet arms' *first position* (Figure 10).

The highest values found during the *arabesque relevé* in relation to the *arabesque piqué* with both types of shoes, BS ($p < 0.001$) and PS ($p < 0.001$), evidenced a movement effect of $F = 236.497$. All values that showed significant increases were associated with *relevé*, evidencing that the movement has more influence in the GRF than the shoes. Analysis of the vertical component of GRF did not reinforce the hypothesis that ballerinas are submitted to high loads while performing movements wearing PS. Moreover, this study showed that classical ballet dancers use diverse strategies with significant mechanical differences to perform. Further research must be conducted in order to better understand them (Simmons, 2005; Lin, Su, & Wu, 2005; da Costa, Nora, Vieira, Bosch, & Rosenbaum, 2013; Picon, da Costa, Sousa, Sacco, & Amadio, 2002).

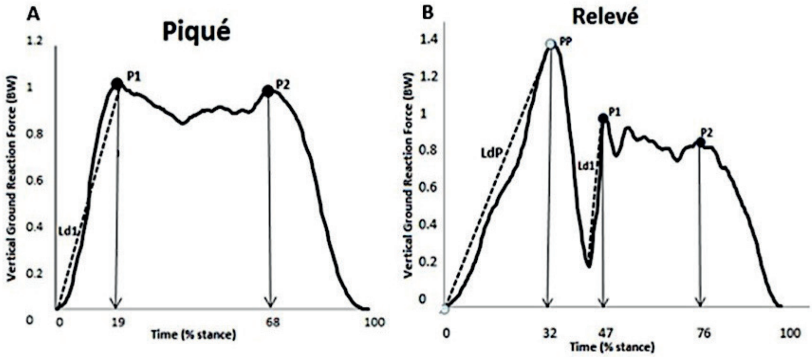

Figure 10[73]. Graphical representation of the vertical ground reaction force (GRF) variables X time (%stance) in mean curves of each movement, A: *Arabesque Piqué*; B: *Arabesque Relevé*, for both ballet shoes.

2.4 Flooring

Dancers can spend over 40 hours per week rehearsing or performing (Inge, McCrory, & Garden, 1993). The majority of dance movements are generated from a kinetic interaction with the floor surface (Kostrovitskaya, & Pisarev, 1978). Multiple stressors acting on the body below the acute injury threshold, including the GRF, may lead to a fatigue effect and subsequent injury (Bloomfield, Polman, & O'Donoghue, 2007). The high incidence of overuse injury to the lower limb observed in dancers may also be related to the interaction with the flooring (Bronner, Ojofeitimi, & Rose, 2003). So, how do the flooring mechanical properties influence injuries in dancers and can changes be made to dance environments to reduce injury risk without disturbing dance training?

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The mechanical properties of dance floor surfaces have been suggested to pose an injury risk for dancers (Bowling, 1989; Khan et al., 1995; Liederbach & Richardson, 2007). Human landing mechanics differ between known, unexpected or unknown surfaces and is highly adaptable to a known change in surface structure (Ferris, Liang, & Farley, 1999). For large volumes of time, dancers perform in a closed and controlled environment (Inge et al., 1993).

An international classical ballet company noted that injury incidence varied according to their tour venue. During one of the Birmingham Royal Ballet tours, the amount of injuries increased. The company had 55 dancers who were dancing six days/week with 5-7 performances each week. Dancers suffer an average of 4.1 injuries per 1000 hours, most of them occurring during rehearsal and class, rather than in performance. One of the variables that influence a touring company is the floor they encounter in each venue. For understanding how the floor may influence dancers, the mechanical properties of the surfaces used on tour were compared to the injury rate in each flooring that resulted in at least one day lost of work. Each floor presented different configurations and support structures (Figure 11). Mean days lost due to injury in each venue ranged from 0.14 to 1.41.

The main problem seems to be not the flooring itself, but not knowing the stiffness of what you are landing on because of the variability in stiffness due to the floors' substructures. When stepping on a new surface, the body responds straight away to it, so by the second step the body has already adapted its response to the floor's stiffness by either increasing or decreasing its own stiffness.

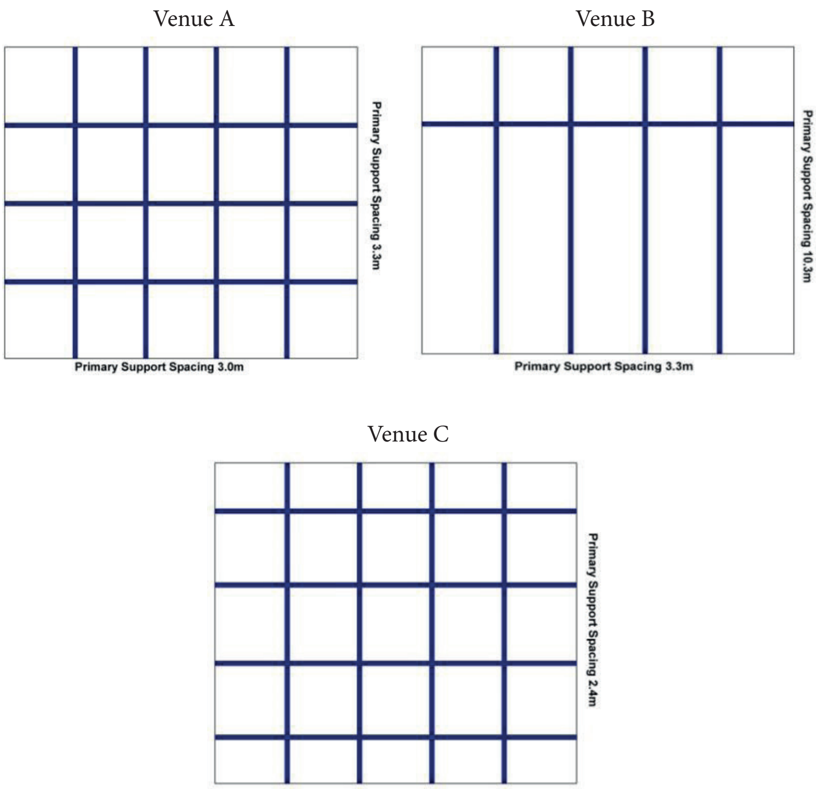
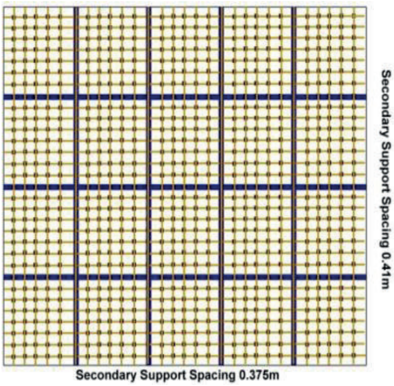


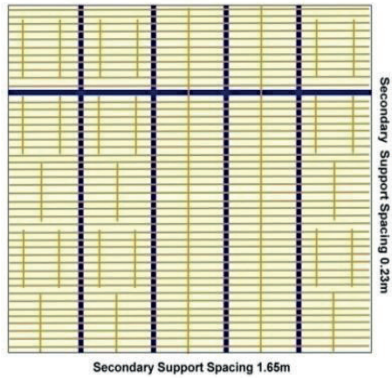
Figure 11[74]: Flooring configurations during Birmingham Royal Ballet tour. Venue A (above) = primary support spacing (pss) 3.0m (wide - w) x pss 3.30m (deep - d); Venue B (above) = pss 3.30m (w) x 10.30m (d); Venue C (above) = pss 2.4 (w) x 2.4 (d); Venue A (below) secondary support spacing (sss) 0.375m (w) x 0.41m (d); Venue B (below) = sss1.65m (w) x 0.23m (d); Venue C (below) = 0.6m (w) x 0.6m (d).

74 Figure 11 is part of the non-published personal archives of Dr Luke Hopper, printed with permission.

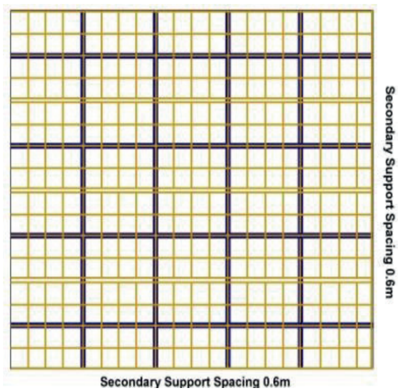
Venue A



Venue B



Venue C



CONCLUSIONS

This chapter provides an insight into some of the physiological and biomechanical research carried out within dance science. The evidence is still poor as there has been little replication of studies that would strengthen this. Physiological evidence suggests that dancers' physical fitness has not been developed to the same extent as their technical abilities. This has left them vulnerable to injury, but studies have shown that supplemental physical fitness training can reduce injury risk. Biomechanical research has highlighted potential areas of increased risk, such as dance floor and shoe construction; but has also examined how dancers move and the different strategies used to achieve the same movement. More research is of extreme necessity.

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CHAPTER 5

ASSESSING DANCERS IN APPLIED AND RESEARCH SETTINGS

Bárbara Pessali-Marques / Frances Clarke
Moira McCormack / Adriano Bittar
Matthew Wyon / Nico Kolokythas

INTRODUCTION

Dance is a challenging activity and professional dancers are expected to have both technical expertise and aesthetic competence (Koutedakis & Jamurtas, 2004; Koutedakis et al., 2007). In recent years, physical demands have increased due to the variety of choreographic styles and movement repertoires (Redding & Wyon, 2003; Twitchett, Angioi, Koutedakis, & Wyon, 2009; Wyon et al., 2011). Consequently, dancers are often asked to perform different dance genres that require distinct physical capabilities. For example, classical ballet and modern dance have been reported as intermittent types of exercise (Cohen, Segal, & McArdle, 1982; Wyon, 2005), belly dance (Abrão & Pedrão, 2005) and ballroom dance (Gonzáles, Sties, Mara, & de Carvalho, 2015) have been considered as aerobic types of exercise. As a result, not technical skills, but physiological and conditioning parameters are key factors in a dancer's training (Koutedakis & Jamurtas, 2004; Koutedakis et al., 2007; Angioi, Metsios, Koutedakis, &

Wyon, 2009). A growing trend in pre and professional dance endeavours is to apply a range of physiological, biomechanical, psychological and other types of assessments specifically developed for dancers. They can provide information that may be used to develop optimal performance and potentially prevent injury (Liederbach, 1997; Redding & Wyon, 2003; Wyon, 2007; Redding et al., 2009; Twitchett, Nevill, Angioi, Koutedakis, & Wyon, 2011; Tanner & Gore, 2012; Pessali-Marques, 2016; Picon et al., 2018).

Research across dance genres on the effect of supplementary training on dancers has shown some positive results (Koutedakis, Stavropoulos-Kalinoglou, & Metsios, 2005; Koutedakis et al., 2007; Wyon, Guinan, & Hawkey, 2010; Angioi, Metsios, Twitchett, Koutedakis, & Wyon, 2012; Watson et al., 2017). However, there has been little significant modification in physical fitness levels, suggesting that either dancers do not undertake sufficient supplementary training, or that the training may be ineffective in meeting the demands of stage performance (Wyon, Allen, Angioi, Nevill, & Twitchett, 2006; Redding et al., 2009; Rafferty, 2010). Thus, employing relevant and accurate physical fitness testing for dancers might be viewed as essential. Moreover, the practical reality of assessment in dance schools and companies is more challenging than simply applying the current theoretical approaches.

This chapter provides a topical overview of well used assessment procedures currently adopted in applied and clinical settings. The goal is to illustrate how those procedures are performed and how the information provided by some tests and questionnaires potentially lead specific strategies that improve the health of pre-professional and professional dancers. Caution should be taken by the reader, as many of the procedures described require extensive professional training in order to be applied. The reader must also be aware that some of these procedures, such as the Dual-Energy X-Ray Absorptiometry (DEXA scan) and Adams' Standing Forward Bend, must both be supervised by a health care professional. The chapter contents run as follows: Assessing Dancers, Assessment Protocols, Physical Activity Readiness, Anthropometric Assessments (Body Segmentation, Body Mass, Caliper Testing), Strength Assessments, Flexibility Assessments, Aerobic and Anaerobic Assessments, Functional Assessments (Static Postural, Dynamic Postural, Movement-Based and Technique: lower/upper limbs and spine), finishing with The Reality of Dance Assessment in Brazil (BR) and the United Kingdom (UK).

1. ASSESSING DANCERS

An evaluation process is performed, preferably, using specific validated tools to measure and document abilities or capacities, such as readiness, skill acquisition and learning. For example, to perform dance movements with skill, efficiency and reduced injury risks, dancers need to be able to physiologically support the load imposed to their bodies (Angioi et al., 2009; Bennell et al., 1999). Through dance-specific physical assessments, individual weaknesses and strengths are identified and specialised support offered. However, the "gold standard", expression that in science refers to tests and measurements that are highly sensitive and specific to the topic investigated, may not always be feasible due to equipment cost, lack of staff expertise, or time. Furthermore, assessment in field situations has been recommended to improve specificity and relevance (Redding et al., 2009; Tanner & Gore, 2012).

1.1 Assessment Protocols

Considering all the aforementioned factors and limitations, a discussion of the dancer's physical fitness assessment in applied and clinical settings is paramount. To gather data for this discussion, the assessment protocols used and/or indicated by some prominent researchers, strength and conditioning coaches, medical doctors, physical educators, physiotherapists, dance teachers and other practitioners from distinguished dance institutions and universities in BR and UK were analysed. The tables below (Tables 1, 2 and 3) show a summary of the tests, questionnaires and equipment most used for that purpose in the field or research settings. A physical activity readiness questionnaire is described in Table 1 (Physical Activity Readiness Questionnaire/PAR-Q). Also in Table 1, assessment protocols were divided in categories: anthropometric - body mass, stature/height, body mass index (BMI); circumferences; and skinfolds. Table 2 shows two categories: strength and range of motion (ROM - passive and active). The added screening techniques (Table 3) include: Dance Aerobic Fitness Test (DAFT) (Wyon, Redding, Abt, Head, & Sharp, 2003), Ballet DAFT (Twitchett et al., 2011), High Intensity Dance-Specific Fitness Test (Redding et al., 2009); Static Postural Evaluation (SPE); modified/random Star Excursion Balance Test (m/r SEBT); Topple Test, Airplane Test, Single Leg *Sauté* Test (Richardson, Liederbach, & Sandow, 2010); and Adams' Standing Test.

Regarding other assessments performed in research settings and laboratories, Dual-Energy X-Ray Absorptiometry (DEXA scan), pressure and force plates, isokinetic and static dynamometers, 3D-analyses/kinematics, inclinometers, gas analysis, electroneuromyography/ENMG, and electro goniometer, are briefly discussed.

1.2 Physical Activity Readiness

Screening for dance readiness might be performed by use of the Physical Activity Readiness Questionnaire (PAR-Q) (Thomas, Reading, & Shephard, 1992). PAR-Q is a simple general screening tool created by the British Columbia Ministry of Health and the Multidisciplinary Board on Exercise. Although not specific to dance, this self-applicable questionnaire is composed of questions that help uncover any potential health risk to exercising. Recently, an updated version of this questionnaire, the PAR-Q+, was created using the evidence-based AGREE process (Warburton, Jamnik, Bredin, & Gledhill, 2011). It covers not just cardiovascular, chronic and orthopaedic conditions, but also cancer, diabetes, mental problems, learning difficulties, respiratory diseases, spinal cord injuries and stroke.

1.3 Anthropometric Assessments

The study and measurement of the dimensions of human body is called anthropometry. It can be performed through analyses of variables such as body shape, size, mass and composition (Duren et al., 2008), to name a few. Anthropometric data can be used to predict general health status, disease risk and dietary adequacy, showing trends in growth and maturation over time.

There is no universal anthropometric measurements protocol required in dance populations; though some dance institutions and companies do use anthropometric data to predict body suitability for dance, or overall fitness. It is important, however, to standardise and define the method and to properly calibrate the equipment in use to allow comparisons within and between dancers. Expert examiners are normally trained and certified to perform measurements, following set rules defined by the International Society for the Advancement of Kinanthropometry - ISAK (Stewart, Marfell-Jones, Olds, & Ridder, 2011).

In dance medicine, anthropometric assessments normally include the analyses of body segments' lengths and circumferences, further discussed below under the subheading "Body Segmentation". Body mass and composition (fat and lean percentages), under "Body Mass" and "Caliper Testing", respectively, are also commonly evaluated.

1.3.1 Body Segmentation

Body segments' length and circumference, and body height/stature could be measured with a flexible steel or fiberglass tape measure, a stadiometer or height scale and headboard (Carter, 2002). These measurements should be recorded and repeated regularly, especially with children and adolescents (D'Hemecourt, 2009; Malina, Bouchard, & Bar-Or, 2004). In order to avoid technical errors of measurements, an anthropometry expert should deliver frequent training and participate of standardization sessions with involved staff. It is advised that the same person applies the same tests over a period of time, to help ensure reliability (Table 1).

Caution should be taken if any deviation from a human body ratio, such as an uneven gain of weight and height[75], is detected over a period of time. It could indicate that a dancer is not developing according to expectations. Circumference measurements might be used to predict muscle atrophy, an

75 Any deviations from a normal human ratio could be detected by use of the Center for Disease Control and Prevention (CDC) recommendations growth charts and gender stature-for-age and weight-for-age percentiles (CDC, 2000). They are not meant to be used as a sole diagnostic tool, but to help in the formation of a clinical impression.

underdevelopment of the muscle mass, or, on the other hand, asymmetrical hypertrophy. Diminished height and length of limbs might be related to delayed growth and maturation, commonly found in adolescent ballet dancers (Burckhardt, Wynn, Krieg, Bagutti, & Faouzi, 2011; Carl, Johnson, & Martin, 2017).

1.3.2 Body Mass

Body mass is also easily measured using a calibrated weighing scale. It is important to highlight that body mass may change according to hydration, fat or lean tissue percentages and circadian rhythm (Duren et al., 2008). Therefore, it should be measured in similar conditions (e.g. day time, clothes and menstrual cycle phase).

It is possible to calculate the body mass index (BMI) when the body mass is divided by the squared height (kg/m^2) (Duren et al., 2008) (Table 1). BMI criteria is used to screen for body mas categories in adult populations: underweight (BMI values < 18.5), normal or desirable weight (BMI values 18.5-24.9), overweight (BMI values 25.0-29.9), and obese (BMI values 30.0-above) (National Institutes of Health, 1998). Due to change in proportions of muscle and fat masses in some populations (e.g., athletes, dancers) caution is necessary when using the BMI percentiles (Duren et al., 2008). Therefore, the BMI is not a straightforward index for all populations; it is an additional variable utilised to overcome the lack of specificity of the isolated body mass and height measurements. Even so, extreme caution must be taken when dancers drop below 18 kg/m^2, as this state might expose them to injuries and other problems, absence of menstruation (amenorrhea), growth and maturation problems and osteoporosis (Simas, Macara, & Melo, 2019). If a professional dancer is below 18 kg/m^2 and a vocational dancer is below 16 kg/m^2 then referral to a medical practitioner should occur to make sure there are no other complications and medical doctors (MD) should determine dance engagement. In such a case, nutritionists and psychologists must teach dancers how to create a food plan and overcome the fear linked to gaining weight.

1.3.3 Caliper Testing

Measurement of skinfolds can be performed to verify the subcutaneous fat thickness distributed in specific regions of the body (Duren et al., 2008). Formulas using the sum of different skinfold sites can be found in the literature (Stewart et al., 2011), but often just using the total of the skinfolds and monitoring how they change over time is just as beneficial as converting the skinfolds into a percentage body fat (Table 1). One of the most used protocols records the sum total of seven skinfold sites: subscapular, suprailiac, abdominal, biceps, triceps, thigh and calf (Wyon, 2007). Changes in the total are then monitored over time and interventions implemented, if required. It must be noted that most interventions in dance are due to sudden decreases in the total amount of body fat, caused by increased training that has not been matched by added on energy intake. It is important to highlight that comparisons are only possible when the same tester and method are used.

The gold standard method of measuring body composition is Dual-Energy X-Ray Absorptiometry (DEXA scan[76]), which quantifies fat, lean and bone tissues. A scan takes approximately 10-20 minutes and exposes the participant to a very low dose of radiation to calculate body composition through mathematical

76 Please note DEXA-scans can only be performed with the assistance of health care professionals.

algorithms (Duren et al., 2008). The results are based on the levels of hydration, potassium content and tissue density (Kohrt, 1995). The use of Bio-Electrical Impedance Analyses is another viable option to measure body composition and for comparisons in between dancers (Duren et al., 2008). Participants need to be sufficiently hydrated, as otherwise the readings will prove erroneous.

It is important to highlight that anthropometric assessments that do not focus on training enhancement can be meaningless and may cause negative psychological effects on dancers, due to concerns regarding maintenance of low body mass (Wyon, 2007). This may happen in female ballet dancers, for instance, that might present 11% below the ideal weight average and 43% below the non-dancers group (Gupta et al., 2004; Bowling, 1989; Hamilton, Hamilton, Marshall, & Molnar, 1992). In addition, due to this concern in maintaining low body mass and to avoid the increase of the circumferences of the limbs, dancers may refuse to perform strength training, which is crucial for a healthy and long career (Aquino et al., 2010a).

Table 1 – *Anthropometric Assessment Protocols suggested to be used in Dance Settings*

Variables	Protocols
Physical Activity Readiness - PAR-Q or PAR-Q+	Ask dancers to fill the PAR-Q (Thomas et al., 1992) or PAR-Q+ (Warburton et al., 2011) to determine the safety or possible risk of exercising based on their health history, current symptoms and risk factors
Body mass*	Place a calibrated weighing scale on a firm, flat surface. Dancer wears the minimum amount of clothes and accessories and same clothes are used in all following measurements. Dancer stands in the middle of the scale's platform without support and with the body weight equally distributed on both feet. Weigh the participant in kilograms to the nearest tenth of a kg (Stewart et al., 2011)

Variables	Protocols
Stature*/Height	Use a stadiometer, or place a measuring tape to the wall. Make sure dancer's shoes are removed. Dancer should stand with feet and heels together, buttocks and upper part of back touching the scale, arms at sides, legs straight, and shoulders relaxed back facing the wall or equipment. Position dancer's head so that eyes are looking straight forward, without lifting chin (Frankfort plane), touching the scale. Instruct the subject to stretch upward and to take and hold a full breath. Lower the headboard until it firmly touches the vertex. Measure the height to the nearest 0.1 cm, at the end of the deep inward breath (Stewart et al., 2011)
BMI	Weight is divided by squared stature (kg/m^2) (Duren et al., 2008)
Arm relaxed circumference	Ask dancer to stand in a relaxed position, with the arm hanging by the side. Palpate along the spine of the scapula to the corner of the acromion. With the hand in a mid-prone position, find the most proximal part of the head of the radius. Find the midpoint and mark it with a pen. With the arm of the dancer hanging loosely by the side, abduct it slightly and measure the circumference around the midpoint using a tape measure pulled snug, but not tight (Stewart et al., 2011)
Chest circumference	Ask dancer to stand erect, arms hanging by the side and slightly abducted. Ask dancer to horizontally abduct arms and place the measuring tape around the torso in the middle of the sternum. Arms hang by the sides and dancer breaths normally; measurement is taken at the end of expiration (Stewart et al., 2011)
Waist* girth/ circumference	Ask dancer to stand relaxed, positioning arms folded across the thorax. Place the measuring tape around the narrowest part of the torso, or between 10th rib and iliac crest. With arms slightly abducted, subject breaths normally and measurement is taken at the end of normal expiration (Stewart et al., 2011)

Variables	Protocols
Abdominal circumference	Ask dancer to stand erect, with feet together and abdomen relaxed, and to lift arms, positioning them crossed with hands touching the shoulders. Place the measuring tape above the bellybutton and thus around the narrowest point between the 10th rib and the iliac crest. The subject lower his/her arms, breath normally and measurement is taken in the end of the exhale (Marfell-Jones, Olds, Stewart, & Carter, 2006)
Gluteal/Hip* circumference	Ask dancer to stand erect with arms folded across thorax, feet together and gluteal muscles relaxed. Weight should be evenly distributed on both feet. Place the measuring tape around the greatest protuberance of the buttocks (Stewart et al., 2011)
Thigh (1 cm) circumference	Ask dancer to stay in a relaxed standing position, with feet slightly separated, arms folded across thorax, mass evenly distributed between both feet. Place the measuring tape 1 cm below the level of the Gluteal fold site (Stewart et al., 2011)
Calf* circumference	Ask dancer to assume a relaxed standing position, arms hanging at sides, feet separated, mass evenly distributed. Place the measuring tape around the greatest circumference (Stewart et al., 2011)
**Skinfolds: Triceps*	At the level of the mid-point between the acromial (lateral edge of the acromion process, e.g. bony tip of shoulder) and the radial surfaces (proximal and lateral border of the radius bone, approximately to elbow joint), on the midline of the posterior (back) surface of the arm (over the most posterior part of triceps muscle) (Stewart et al., 2011)
Skinfolds: Biceps*	At the level of the mid-point between the acromial (lateral edge of the acromion process, e.g. bony tip of shoulder) and the radial surfaces (proximal and lateral border of the radius bone, approximately the elbow joint), on the midline of the anterior (front) surface of the arm (over the biceps muscle) (Stewart et al., 2011)

Variables	Protocols
Skinfolds: Subscapular*	The inferior angle of the scapula (bottom point of shoulder blade) (Stewart et al., 2011). If there is difficulty finding this landmark, get the dancer to reach behind his/her back with the right arm, while feeling for the movement of the scapula
Skinfolds: Iliac Crest*	Site near iliac crest, above mark drawn from the middle of the armpit to the most superior point of the iliac crest, taken near horizontally (Stewart et al., 2011)
Skinfolds: Abdominal*	A mark is made 5 cm adjacent to the umbilicus (belly-button), to the right hand-side (Stewart et al., 2011)
Skinfolds: Front Thigh*	Ask dancer to sit down at the front edge of a box, arms supporting hamstrings, legs extended and heel on the floor. Measure is taken at the mid-point of the anterior (front) surface of the thigh, midway between patella (knee cap) and inguinal fold (crease at top of thigh) (Stewart et al., 2011)
Skinfolds: Medial Calf*	Ask dancer to stand relaxed, with right foot placed on a box. Take the measurement at a point on the medial (inside) surface of the calf, at the level of the largest circumference (Stewart et al., 2011). A tape measure should be used to determine this point

* Circumferences - general recommendations: preferentially measure both sides for asymmetries comparisons. If only one side is being assessed, the right side should be evaluated. Muscles should be assessed relaxed. Mark the assessment locations with a pen making a cross. Use non-stretch, pliable tape measure and record the units in centimeters (Stewart et al., 2011).

** Skinfolds - general information: firmly grasp a fold of skin using the thumb and index finger and lift it up. The skinfold should include two thicknesses: one of skin and one of the subcutaneous fat, but no muscle or fascia. Place the contact surface of the caliper at a 90º angle to the surface of the skinfold, approximately 1cm below the fingers. Slightly release the pressure between the fingers but remain holding the skinfold so that a greater pressure is applied by the caliper. Only the right side is assessed. Record the measurements in millimeters (Marfell-Jones et al., 2006)[77].

77 Caution must be taken when measuring skinfolds, as dancers could feel intimidated by the results of measurements.

1.4 Muscle Assessments

Muscle function testing covers strength, power and endurance. Strength is defined as the skeletal muscles' capacity to generate tension against a certain resistance (Koutedakis et al., 2009); power is the ability to exert a maximal force over a short period of time; and endurance is the ability to sustain repeated contractions over an extended period of time.

Surprisingly, when the physical characteristics of classical dancers were compared to athletes, dancers were significantly weaker and less conditioned (Kirkendall & Calabrese, 1983; Kirkendall et al., 1984; Koutedakis & Sharp, 1999). A possible reason for the lack of strength faced by dancers is that the movements performed in some traditional dance classes are insufficient to stimulate the muscles to an overload that generates the desired adaptations (Koutedakis et al., 2007; Rafferty, 2010). Strength is increased only when there is sufficient tension applied to the muscle fibre and its contractile proteins (Koutedakis et al., 2009).

However, dancers can be reticent to perform strength training, due to the occurrence of hypertrophy, potentially damaging the perceived aesthetics of the dancer (Koutedakis & Sharp, 2004; Twitchett et al., 2009). Nevertheless, this view is unsupported if the strength training variables are manipulated to increase strength without necessarily resulting in hypertrophy (Koutedakis, Clarke, Wyon, Aways, & Owolabi, 2009). In addition, strength training does not limit flexibility (Aquino et al., 2010a). Therefore, proper strength assessment will provide important information for the adequate training load prescription.

In dance, bilateral differences in the lower limbs should be assessed, as research suggests that the characteristic repetitiveness of dance may be associated with imbalances between muscle groups (Aquino, Cardoso, Machado, Franklin, & Augusto, 2010b). Hamilton and colleagues (1992) found that muscular strength of male and female dancers varied greatly, mainly in the adductor and abductor muscles and internal and external rotators of the hip, with the latter being more developed in women. Gupta and colleagues (2004) found greater strength in the dancers' external rotators of the right hip, although dance is a bilateral activity. Also, according to Prati and Prati (2006), classical ballet aims to work the body bilaterally, but in practice, it is believed that there is more training on the choreography preference side (Kimmerle, 2010), which may characterise more unilateral practice increasing the chances of strength inequalities and even consequent postural deviations.

Field testing is an alternative for muscle assessment, although there is less evidence of accuracy and reliability for sensitive measurements and analysis. The 1 Repetition Maximum test (1 RM - the maximum amount of weight a dancer can move in one repetition of a designed movement), may also provide data about the dancer's strength. Another option is to use muscle endurance tests, that assess how long a dancer can endure through a specific exercise, such as sit-ups (Hall, Hetzler, Perrin, & Weltman, 1992; Snarr & Esco, 2014), push-ups (American College of Sports Medicine [ACSM], 2014) or heel raises (DeWolf, McPherson, Besong, Hiller, & Docherty, 2018) (Table 2).

Jumps in dance are dynamic human movements (Yoshioka, Nagano, Hay, & Fukashiro, 2010) with high upper and lower limb coordination (Markovic, Dizdar, Jukic, & Cardinale, 2004). They are an essential skill in dance performance (Wyon, 2006) and may provide important information regarding muscle power assessment. Jump height is crucial for dancers as they are expected to achieve exciting and dramatic elevations (Koutedakis et al., 2005). However, when compared to physically active control participants, dancers do not jump significantly higher (Harley et al., 2002); though specific supplemental training can increase it.

Jump or contact mats (Rogan, Radlinger, Imhasly, Kneubuehler, & Hilfiker, 2015) are considered reliable and inexpensive (Rogan et al., 2015; Garcia-Lopez et al., 2005; Leard et al., 2007), and can be used in field or outdoor research. The Just Jump mat (Proboctics, Huntsville, AL, USA) measures air time and calculates jump height. It has been used to assess dancers' vertical jump height (Wyon et al., 2007). An advantage of the jump mat is the immediate jump height and time contact floor provided by its attached hand-held computer, which records the flight time and determines the height of the jump (Rogan et al., 2015), while the results of the force plate need to be analysed after testing. On the other hand, the contact time and the jump height are the only measurements given by the jump mat. Contact mat systems use a basic kinematic equation to calculate jump height by flight time (Leard et al., 2007). The micro switches embedded in the mat time the interval between the participant's lift off from the mat and their landing.

Optojump photoelectric cells (Microgate, Bolzano, Italy) have been regarded as a more accurate tool for measuring vertical jump height than some other field tests. However, Glatthorn and colleagues (2011) suggest Optojump data should be used interchangeably with force plate data for best results, and Optojump is still regarded as inferior to force plates (Attia et al., 2017). Nonetheless, the Optojump system is more reliable than others, easy to transport and use, and should be considered for jump field tests. Accelerometers (Acceltec, Switzerland) are an alternative method of assessing power. They can be attached to the body in a functional test, such as a *grand jeté*, thus allowing assessment of more complex dance-specific movements (Wyon, Harris, Brown, & Clarke, 2013b).

Validation studies comparing different apparatus used for jump height assessment, including simple ones such as the jump and reach test (Table 2), reveal that all tests are reliable but cannot be used interchangeably (Muehlbaue, Pabst, Granacher, & Büsch, 2017). Therefore, improvised and simple measurements, such as jumping and reaching with chalk marks or dust in the walls, are a reasonable alternative to be used in field tests, even though there are limitations.

Assessment of impulse, maximal force and power produced by the lower limbs during jumps of any technique (such as squat jump, countermovement jump or plyometric jump), may be obtained directly on the force plate (Meylan, Nosaka, Green, & Cronin, 2010). Force plates are considered the gold standard in jump analyses and have been used in a number of dance studies, including the effects of foot positions (Chockley, 2008) and shoe conditions (Walter, Docherty, & Schrader, 2011; Wyon, Cloak, Lucas, & Clarke, 2013a) in jump landings.

In laboratory testing assessment, not just force plates, but pressure plates and dynamometers are some of the equipment also used to assess the strength of a body segment in research settings. Force plates measure the reaction forces according to the third Newton law. Pressure plates measure the amount of force per area applied. Manual and isokinetic dynamometers might assess individual muscles' strengths, depending on the protocol. Isokinetic dynamometry has been well considered in the assessment of dynamic muscle function in dancers (Koutedakis, Khaloula, Pacy, Murphy, & Dunbar, 1997; Koutedakis & Sharp, 2004; Wyon, 2007; Agopyan, 2018). Studies in research settings have focused in different aspects of muscle function, such as force-velocity and length-tension relationships of the thigh muscles (Gupta et al., 2004). Peak torque, or the single highest torque output of the joint when a determined muscle is activated as the leg moves through a range, for example, is considered as a determinant of leg isokinetic strength (Gleeson & Mercer, 1996). Although, these devices are considered valid for the strength assessment of any muscle, depending on the protocol in use, they are expensive and usually not affordable for dance companies and schools.

1.5 Flexibility Assessments

Flexibility is another physical attribute that is complex to assess. If flexibility is considered only as the range of motion (ROM) in a joint or group of joints (Magnusson, Simonsen, Aagaard, Sørensen, & Kjaer, 1996a; Alencar & Matias, 2010), simple goniometers may be used for ROM assessments (Table 2). The biggest limitations of the goniometer are the impossibility of measuring dynamic movements, such as jumps, and the reliability among examiners (Russell, Kruse, Neville, Koutedakis, & Wyon, 2010). More expensive devices, such as the electro goniometer, measures the electrical output signal issued by the rotation of the goniometer arms in relation to its axis, and it is used to record joint angle variations. This device, however, is not easily acquired by many institutions. The sit and reach test is a poor test for dancers as it was designed for the general population. This test has some limitations, such as the difficulty to guarantee the isolated hamstrings' flexibility measurement and the upper limb length contribution in the results, making difficult the comparison among individuals. The use of video analysis can also be of help to measure joint angles, this can be more ecologically valid as specific dance movements can be used (Table 2). Markers are placed on joints and then angles can be calculated afterwards through different software packages (Wyon, Felton, & Galloway, 2009; Wyon, Smith, & Koutedakis, 2013c).

Today, the assessment of ROM provides only information about the flexibility performance level and no information about the muscle-tendon unit behaviour after stretching. This additional information is necessary, as increasing ROM should not be the only aim in a dancer's physical training because uncontrolled excessive flexibility could prove to be detrimental. Regarding these multidimensional evaluations of flexibility, additional apparatus have been utilised to measure both the muscle tendon-unit sensory and biomechanical properties (Magnusson et al., 1996a; Magnusson et al., 1996b; Magnusson, 1998; Burke, Culligan, Holt, & Mackinnon, 2000; Blackburn, Padua, Riemann, & Guskiewicz, 2004; Chagas, Menzel, Bhering, & Bergamini, 2008; Cabido et al., 2014; Pessali-Marques, 2016). One limitation is that the majority of the equipment was built to measure the hamstring flexibility; therefore, an evaluation of the whole body is only possible using a simple goniometer.

One particular joint ROM that receives more attention in dance due to the performance requirements for those who aspire to be professional artists is the hip. Dancers who are generally flexible at the hips are found to be more apt to acquire the perfect *en dehors,* or *turnout*, a posture in which the dancer performs an external rotation of the lower limbs, ideally positioning the longitudinal axes of their feet in an angle of up to 180º (Bennel et al., 1999; Hamilton et al., 2006; Aquino et al., 2010a). It is usual for aspiring young classical ballet dancers to have it tested passively with a goniometer before starting their careers. If classical ballet training is uncompromising in the angle of *turnout* used, it is advised that external rotation of the hip meets the upper limits (60°). If training adapts the physique, the more restricted hip is acceptable.

Washington, Mayes, Ganderton, & Pizzari (2016) measured passive hip external rotation ROM in supine. This can also be measured in prone, but accuracy is important. Inter-rater reliability for either method has not been established yet (Malliaris, Hogan, Nawrocki, Crossley, & Schache, 2009), so, caution and precision are advised. Passive *turnout* indicates the potential available ROM. However, the angle at which the classical ballet dancer can control the turned-out position and maintain alignment of knee and foot is called functional or active *turnout*. Washington et al., (2016) and Picon et al. (2018) demonstrated precise anatomical markers for this measurement and the contribution from the knee, tibia (tibial torsion), ankle and foot during the functional *turnout*.

As the research by Foley and Bird (2013) and Chan, Hopper, Zhang, Pacey, & Nicholson (2018) demonstrate, there is, and will continue to be, a high incidence of Hypermobilty Syndrome/Ehlers-Danlos Syndrome - Hypermobility Type (JHS/EDS-HT) in professional dancers. Chan and colleagues (2018) advocate that if the nine point Beighton Scale is used in the dance population, the cut-off point should be increased to 6/9 or more, to avoid over estimation of generalised hypermobility. There is a new terminology as of 2017. Hypermobile EDS or hEDS has strict inclusion criteria. Those who do not meet the criteria, even being hypermobile are classified as Hypermobility Spectrum Disorder. Hypermobility can be seen as an asset in dance as long as it is correctly managed (Bird, 2016).

Table 2 – *Strength and Range of Motion Assessment Protocols suggested to be used in Dance Settings*

Variables	Protocols
*Power – Vertical Jump Test	Fix a measuring tape to the wall. Dancer stays sideways to the wall, preferred arm behind the back, and the other raised up, hand facing outwards, fingers extended. Standing reach is recorded with subject on his/her toes, chalk dust on the third finger. With the preferred side to the wall, dancer bends knees and jumps as high as possible, to touch the wall again (3 attempts)
Muscle endurance -Abdominal Sit Ups	Ask dancer to lie supine with knees bent, feet flat on the floor and arms folded across the chest. Hold their feet to the ground. Dancers should start each sit up with the back flat on the floor and raise until touch the elbows to the knees. Ask them to complete as many repetitions as they can in 30 seconds (Hall, Hetzler, Perrin, & Weltman, 1992; Snarr & Esco, 2014)
Muscle endurance – Rectus Abdominis, External Oblique, Erector Spinae	Ask dancer to lie prone with elbows and toes on the floor. They should raise their body to a plank, positioning shoulders and hip in the same height and hold for as long as possible while the time is recorded. Any misalignment is enough to stop the test (Snarr & Esco, 2014)
Muscle endurance – Unilateral Squat	Ask dancer to squat down to approximately 90° and mark the height. Participants should squat with only one leg and arms crossed around the chest to until they lightly touch the mark and immediately stand back up. They should repeat until they cannot reach the same angle, or the movement loses alignment (Bishop et al., 2019; Hopper, Sato, & Weidemann, 2016)
Muscle endurance – Push-up	Ask dancer to kneel and place the hands flat on the floor with hands shoulder-width apart and then lift the knees to a plank position. Ask male dancers to lower the body until the chin reaches the floor and return to the starting position with the arms fully extended. They should complete as many press-ups as possible with no rest and maintaining alignment. Women are asked to take this test with knees on the floor (ACSM, 2014). There is a grading system stating what is expected of each age group

Variables	Protocols
Muscle endurance – Heel Rise	Ask dancer to stand on one leg, the other held in a parallel *coupé*. They should perform as many *relevés* without *plié* as possible, to a set beat of 120 beats per minute, or 30 heel raises per minute. Test ends when dancer does not keep time with metronome or choses to stop. Right and left legs should be tested and result scores of each leg are added together (DeWolf, McPherson, Besong, Hiller, & Docherty, 2018)
Passive ROM - Hamstrings	Ask dancer to lay supine with hip and knees flexed and the soles of the feet on the floor. Add a support (e.g. cushion) in the lumbar to avoid movement of the hips. Ask dancer to flex the hip with the knee extended and pull it in the direction of the trunk (with the arms or a rope) up to the maximal ROM tolerated. Record the whole movement, making sure the camera is perpendicular to the participant. Calculate the angle between the trunk and the thigh (Kendall, McCreary, & Provance, 2005)
Passive ROM - Hip Adductors	Ask dancer to lie supine with hip and knees flexed at 90º and feet touching the wall. Add a support (e.g. cushion) in the lumbar to avoid movement of the hips. Ask dancer to open the legs to the maximal ROM tolerated. Record the whole movement making sure the camera is perpendicular to the participant. Calculate the angle between both legs (Kendall et al., 2005)
Passive ROM - Hip External and Internal Rotations	Ask dancer to lie prone with the knee flexed and the pelvis stabilized through strapping. Place goniometer with axis over the midpoint of the patella, stationary arm perpendicular to the floor, movable arm parallel to the anterior midline of tibia. Hold the dancer's leg (completely relaxed) and perform an external or internal rotation, to measure the angle between the initial and the final positions (Clarkson, 2005)

Variables	Protocols
Active ROM - Hip External Rotation	Dancer places feet over a set of rotational discs, aligning the second metatarsals and the centre of each heel with a line drawn in the centre of the two discs. With the help of a big paper sheet placed under the discs, dancers perform maximum external rotation, and evaluator demarcates on paper the final positions of the calcaneus centers and second metatarsals. Then, right and left demarcations should be joined by a straight line to measure the intersection angles between them with the use of a goniometer (Sherman, Mayall & Tasker, 2014)
Active ROM – *Developpés*	Position the camera perpendicular to the dancer, in centre, as he/she performs one *developpé devant,* one *à la seconde* and one *derrière en dehors,* sustaining the raised leg for as long as possible. Record the first and third movements facing dancer's sideways, and the second movement facing dancer's front. Use the software ImageJ to find the maximal ROM between two body segments (Wyon, 2007)
Passive/Active ROM - Spine Extension	Lying prone, ask dancer to push upper body as high as possible using the help of the arms, hands placed on the floor, while keeping hips on the floor. A photograph is taken at this point and ImageJ is used to measure extension ROM, or a tape measure is used to measure the distance between the clavicle notch and the floor. For active ROM, dancer does the same movement with the spine, but at this time does not use the help of the hands, and arms are kept by the sides. In both tests, an external object should not fix the legs (Wyon, 2007)
Hypermobility - Beighton Score	The dancer performs passive extensions of the thumbs and 5th fingers in an attempt to reach for the forearm; at the elbows and knees, active extensions aim to show if dancer reaches more than neutral position. While standing up, dancer is asked to bend his spine and reach his/her hands to the floor. Ranges of motion further than "normal" or neutral are scored as 1 in a 0-1 scale. Maximum score is 9 (Alter, 2004; Beighton, Grahame, & Bird, 2012)

* Strength – general information: try to book assessments in the same time of the day and after similar routine of warm-up. Assessment is made either by maximal number of repetitions, number of repetitions in a period or best score out of a designed number of repetitions. Make sure to not motivate the dancers, given that the instructor motivation may affect the test.

1.6 Aerobic And Anaerobic Assessments

Aerobic capacity is an important component of fitness for dancers (Koutedakis & Sharp, 1999), and there are a number methods of measuring this variable with different levels of detail and information. Laboratory tests provide very detailed information but require equipment not available to most schools and companies. Dance specific field tests have been developed as low-cost alternatives, but the level and accuracy of information are drastically reduced.

An incremental treadmill test using online gas analysis is considered the gold standard method for determining maximal or peak aerobic capacity (maximal oxygen uptake test - VO_2max) (Wyon et al., 2007; Needham-Beck, Redding, & Wyon, 2019). Other ergometers (cycle or rowing ergometers) can be used but the weight bearing and peripheral muscle use differs from dance activity. The starting speed of the test usually equates to 120 b.min^{-1} heart rate and the speed increases 1 km.h^{-1} per minute until a number of termination criteria are met: voluntary termination, Respiratory Exchanging Rate (RER) above 1.15, heart rate close to age predicted maximum, oxygen consumption does not increase with increased work load (speed) (Wyon et al., 2007). The data from this test provides an accurate peak maximum aerobic capacity but also training zones through the calculation of anaerobic thresholds.

A series of field tests have been developed to provide an easy to use option that can take place in the studio. The Dance Aerobic Fitness Test (DAFT) was developed by Wyon and colleagues (2003) as a studio-based field test, to assess aerobic capacity using dance-specific movements (Table 3). This test has shown to be a reliable and valid field test and is widely used in assessments of dancers in companies, vocational schools and universities. The DAFT consists of five continuous stages of increasing movement intensity that replicate the mean oxygen requirements of dance class and performance.

The DAFT can be adapted for different dance genres and Twitchett and colleagues (2011) developed a reliable and valid ballet-specific aerobic fitness test. A dancer's aerobic fitness can be assessed by recording heart rates in each stage and/or by their ability to maintain movement accuracy and complete the stages. Changes in a dancer's aerobic fitness may be assessed by recording a dancer's completion of higher stages or recording lower heart rates at each stage in a repeat test which may suggest improved aerobic power (Wyon et al., 2003). Heart rate monitors are relatively inexpensive, however, a free alternative for participants is to take their own pulse rate, including their resting heart rate, prior to the DAFT (or a similar test) and immediately at the end of each stage, but this is highly inaccurate. The DAFT, however, requires a dance or fitness studio or a hall which may not always be available given that the dance classes and rehearsals take priority. Other general tests include beep tests, step tests, and intermittent fitness tests developed for different sports and the general population.

Different genres of dance require dancers' use of both the aerobic and anaerobic energy systems. Consequently, Redding et al. (2009) developed a high intensity dance-specific fitness test (Table 3). This field test is more representative of stage performance and evaluates a dancer's ability to perform at higher intensities which uses the anaerobic energy systems. The test consists of four one-minute dance sequences at a tempo of 106 beats per minute (bpm), with a 2-minute rest between each sequence, and has been shown to be valid (Redding et al., 2009). Assessment can be undertaken by heart rate monitoring or observation of movement proficiency and completion of sequences (Redding et al., 2009). This fitness test could be adapted to a range of different dance genres.

1.7 Functional Assessments

Functionality in dance can be measured by observation of the various physical components and the postural adjustments a dancer uses on a daily basis, when performing or in class. Static postural, movement-based or technique assessments help identify malalignments of body segments, disrupted muscular synergies and faulty weight displacement, amongst other variables, so that specific interventions using refinement exercises can help change motor patterning (Potter, Galbraith, & Bass, 2011), enhance conditioning or technique and prevent injuries (Wyon, 2007; Santos, 2010; Richardson et al., 2010; Bronner & Ojofeitimi, 2011; Wilson & Batson, 2014; Gontijo, Candotti, Feijó, Ribeiro, & Loss, 2015; Picon et al., 2018).

In a literature review, Krasnow, Wilmerding, Stecyk, Wyon, & Koutedakis (2011) identified 89 studies, from 1970 to 2009, using different methods and instrumentation, such as electromyography, force plates, motion analyses using photography, cinematography, videography, video analyses and/or physics analyses, were performed to investigate different dance functional aspects: alignment (n = 8), *plié* (8), *relevé* (8), *passé* (3), *degagé* (3), développé (7), *rond de jamb* (3), *grand battement* (4), arm movements (1), turns (6), forward stepping (3), elevation work (28), falls (1) and dance specific motor strategies (6). Since then, many more studies have been developed, such as the inclusion of research on breakers (Tsiouti, Constantinou, Philip, Sanchez, & Paton, 2016), and the development of other alternative and open access motion analyses methods, as well as of field tests, that can prove to be invaluable and much more affordable options.

In the following section, static and dynamic postural assessments - lower and upper extremities, and the spine - are highlighted as key areas of functional assessment relevant for dancers.

1.7.1 Static Postural Assessment

Posture is defined as an equilibrium state between muscles and bones that protect the body from overload, leading to a minimum expenditure of energy and maximum efficiency (Magee, 2014). Posture reflects the living experiences of a person and can be assessed statically or dynamically. A static evaluation is normally performed with the dancer in an erect quiet stance, dressed appropriately: no shoes or socks, all jewellery removed, males with shorts and females with shorts and sports bra. Generally, it involves the use of a postural chart and a plumb line, for the observation and note taking of specific asymmetries in the anterior, posterior or lateral views (Krasnow, Monasterio, & Chatfield, 2001).

In such a case, when observing a dancer's posture in an anterior view, the plumb line should pass through the tip of the nose, centre of belly button, and fall in between the feet (Lippert, 2017). Then, consider overall muscle balance, comparing one side of the body to the other (trapezius, deltoids, pectoralis major, abdominals and quadriceps) and weight shift. Asymmetries between body sides are normal, but pay special attention to choreographies that place additional stress on already dominant muscles and muscle chains. Also observe: feet placement (facing front, lateral or medial; pronated or supinated); feet arches (normal, flat or pronounced); patella placement and height (elevated, centred, medial or lateral) and patella position relative to feet (straight line from patella to tibial tuberosity, ending between 2nd and 3rd toes); knees placement (knock-knees - genu valgus or bow-legs - genu varus); hips placement (Anterior Superior Iliac Spine - ASIS elevated, shifted laterally or rotated); waist line (Thales triangles

- shortened or lengthened); linea alba placement (aligned, shifted right or left); position of hands (thumbs forward or not); acromion processes and clavicles levels (shoulder levelled or elevated); and/or head level (centred, rotated, shifted or flexed laterally) (Kisner & Colby, 2012) (Table 3).

In a profile (side view), the plumb line should pass slightly posterior to the apex of the coronal suture, through external auditory meatus, through odontoid process of axis and bodies of most cervical vertebrae, midway through the shoulder, through bodies of lumbar vertebrae, through sacral promontory, slightly posterior to center of hip joint, slightly anterior to axis of knee joint and to lateral malleolus, and through calcaneocuboid joint (Kendall et al., 2005; Basmajian & De Luca, 1985). Observe: weight distribution on the anterior or posterior parts of the foot and the levels of the feet arches; positioning of knees (neutral, hyperextended or flexed); positioning of sacral kyphosis, lumbar lordosis, thoracic kyphosis and cervical lordosis (normal, increased or decreased); position of shoulder, neck and head (protruded or retruded). Please notice that both right and left sides of the body should be assessed (Kisner & Colby, 2012) (Table 3).

In a posterior view, the plumb line should pass through the middle of the occipital bone, spine and intergluteal cleft, ending in the middle of the feet (Kendall et al., 2005). Be aware of: feet and arches placements (as described on the anterior view), popliteal folds (centred, medially or laterally rotated); Posterior Superior Iliac Spines - PSIS levels (same as anterior view); waist line - Thales triangles (same as anterior view); spine placement (straight or curved; if curved, "C" or "S" shape; the locations and convex sides give the name to the scoliosis); distance between scapula medial borders and spine (equal between sides, retracted, protracted); scapular placement (normal or winging); and head position (same as anterior view) (Kisner & Colby, 2012) (Table 3).

While assessing the posture of dancers, it is advised that special attention is given to the way they hold their lower extremities while standing or sitting with knees in full extension. In professional ballet, hyperextended knees are considered as advantageous, for aesthetic reasons (Picon et al., 2018). However, a dancer with hypermobile knees could be more challenging to train, as this physical feature increases injury risk (Picon et al., 2018). Therefore, when hyperextended knees are observed in a postural assessment, measurement of passive hyperextension of the knee (Soper, Simmonds, Kaz Kaz, & Ninis, 2015) is important to add to the dancer's profile in order to understand his/her individual physique. Any laxity may be part of a generalised or selective hypermobility. Interventions and training will be guided by these results. It is also very common to observe abnormalities in female ballet dancers' spinal curves and pelvic placement (Iunes, Elias, Carvalho, & Dionísio, 2016).

On the other hand, photography, different softwares and motion analysis systems can also be of use for the assessment of a dancer's static posture. Woodhull, Clarkson, James, Watkin, & Barrett (1990) were pioneers in using photography to assess dancers' static postures. They photographed female college dancers from their side in *parallel first* (or *sixth*), and *turned out first, third* and *fifth positions*. Then, they measured distances between the ankle, knee, hip joint, pelvis, shoulder and ear. Best alignment was considered as the values coming closer to being in a straight line.

Although there are a range of other methods and softwares that have been used for alignment analyses in research and clinical settings, such as the Wickens-Kiphuth, that uses rods on the vertebrae spinal processes and take photos on a side view, in order to draw connecting lines on the photos (Fairweather & Sidaway, 1993), photogrammetry (Iunes et al., 2016) and the Postural Assessment Software - PAS (Meereis, Favretto, Bernardi, Peroni, & Mota, 2011), it is recognised that assessment of static alignment in the field setting is mostly done by simple observation of the subject himself/herself in quiet stance (Krasnow et al., 2001). However, there is no evidence of what posture is ideal for a dancer, and maybe even different styles should require different postures. Moreover, there is poor scientific evidence that a variation from a perceived ideal posture has a negative effect on performance/health.

1.7.2 Dynamic Postural, Movement-Based and Technique Assessments

Dynamic postural, movement-based and technique assessments, though, will focus on how the dancer keeps organised within his/her body while performing daily (sit to stand, walking, climbing stairs, etc.), and professional activities. It involves the analysis of ongoing processes of neuromuscular postural responses that happen automatically.

a. Lower Limbs

Concerning field tests, common functional evaluative tests for dancers used in various dance schools during the final year, in auditions and in companies of different styles, may include: execution of *demi-plié*, parallel; *grand plié*, turned-out; 2nd position *plié*; weight shift into *passé retiré*; and unilateral hops with opposite foot in *coup-de-pied* (Liederbach, 1997). Wilson and Batson (2014) have developed a preseason assessment tool, the modified/random Star Excursion Balance Test - m/r SEBT, based in the original SEBT (Olmsted, Carcia, Hertel, & Shultz, 2002; Gribble & Hertel, 2003), to make it a more dance-specific dynamic test of balance (Table 3). Despite lacking sensitivity and results being nonsignificant for dancers' balance, the research may provide qualitative criteria to help teachers and clinicians stratify technical levels and spot injury risk (Wilson & Batson, 2014).

Hopper et al. (2016) have examined the single leg squat in turned out positions. This constitutes an excellent alternative functional assessment for dancers, as it predicts leg alignment during various movements. The single leg squat is frequently used to assess lower limb function particularly in athletic populations. Poor performance may suggest weakness or altered motor control (Chen, McKay, Baldwin, Burns, & Simic, 2016).

Additionally, for biomechanical reasons and in all dance genres, plantarflexion should allow a line of weight bearing that runs from the knees through ankles and midfeet, to the end of the 2nd toes. Dickson, Hollman, Ojofeitimi, & Bronner (2012) state that aesthetics of dance dictates that a pointed foot should be aligned parallel to the tibial crest, whether in open or closed chain. They recommend measurement of plantarflexion with an inclinometer to assess talar position relative to the tibia. In such a case, both Dickson and colleagues (2012) and Russell et al. (2010) found goniometric measurement to be less accurate. On the other hand, dorsiflexion can be measured quickly in a clinic or field test with the dorsiflexion Weight-Bearing Lunge Test. This is a specific test and any normative data should be gathered with an inclinometer (Dickson et al., 2012). Moreover, both ballet and contemporary dancers require freedom of extension in the first metatarsophalangeal joint (MTPJ) to allow ideally 90° of extension to perform the ¾ pointe position. Dorsiflexion of the 1st MTPJ is measured with a goniometer.

When assessing pointe readiness, it is important to consider not just plantarflexion ROM, but also chronological age, years of dance training, lower extremity strength, neuromuscular control, and skill acquisition (Richardson et al., 2010). Point work is usually introduced to 9-15 year-old dancers, when they are undergoing rapid growth changes that influence motor control and psychological state. Richardson et al. (2010) noted that in this specific period of time, some objective functional tests, such as Topple Test, Airplane Test and Single Leg *Sauté* Test, could help determine a student's readiness for pointe training (Table 3). According to these researchers, *Sauté* test was the strongest predictor of pointe-readiness classification overall.

Kinematic analysis can evaluate functional performance under normal and abnormal conditions (An, 1984). Motion analysis systems for kinematic analysis assess movement angles, speed, order of joint recruitment, forces and movement dynamics. A range of cameras is positioned around the dancer and reflexive, infrared-emitting markers or sensors fixed in strategic anatomical points analyse their displacement. Some commercial systems such as Vicon (Oxford Metrics Ltd, Oxford, UK), Ariel Performance Analysis System/APAS (Ariel Dynamics Inc, CA, USA), Optotrak (Northern Digital Inc, Ontario, Canada) and Elite-Plus (Nacsport, Las Palmas, Spain) have high automatic tracking capabilities and are quite accurate. However, these systems are expensive to purchase and update and they may even fail under uncontrolled measurement conditions (Campos, 2010).

Santos (2010) used the Vicon system and force plates to analyse ballet dancers' gaits. Bronner and Ojofeitini (2011) also used Vicon motion capture system to analyse dancers executing *grand battements devan*t, à la second and *derrière* while at the ballet barre. They used a FIR filter with C3d editing software (Motion Lab Systems Inc., Baton Rouge, LA) to reconstruct and filter data. Picon and colleagues (2018) used Optitrack infrared cameras (FLEX: V100, Natural Point, USA) to obtain kinematic and kinetic data of ballet dancers' *sauté* jumps in *first position*. Additionally, they used the AMASS software (ADTech Motion Analysis Software System, C-motion, Ontario, Canada), and one force plate (AMTI OR-6-1000, EUA). Alternatively, Gontijo and colleagues (2015) evaluated experienced ballet dancers' lower limbs alignment using Dvideow (UNICAMP, Campinas, Brazil; Figueroa, Leite & Barros, 2003) for scanning and 3D kinematic reconstruction of dancers executing a *plié*. Metrics and angular variations of anatomical landmarks were analysed by MATLAB® (7.9, Natick, MA, USA).

When not using kinematic analyses of dancers' lower limbs, electromyographic (EMG) analysis can be an interesting option. Trepman and colleagues (1994) used EMG parallel bar active surface electrodes (NeuroMuscular Research Center, Boston University, MA) in eight lower limbs muscles to analise *demi-plié* in ballet and modern dancers. Electrodes were connected to an EMG preamplifier (NeuroMuscular Research Center, Boston University, MA) placed around the waist, connected via a cable to an EMG interface box, from which EMG signal was delivered to an analog/digital unit (Watscope, Northern Digital Inc, Waterloo, Ontario) and amplifier (Tektronic, Inc., Beaverton, OR). A video was also used to record *demi-pliés* in antero-posterior, lateral and oblique views, and ROM was measured from the videotape, by goniometry.

b. Upper Limbs

Proper arms' placement is another attribute highly valued in all dance styles, although not many studies have devoted themselves to studying this feature. In terms of functional tests for the upper limbs, Liederbach (1997) indicates the observational qualitative assessment of *port-de-bras* (*en* bas to *5*th*; en* bas to *2*nd) as important for dance educators and clinicians.

Innovatively, Tsiouti and colleagues (2016) evaluated the relationship between fatigue, pressure and weight distribution on the upper limb in breakers. Each volunteer performed a warm-up and 3 breaking movements (*baby freeze, air baby, bronco*) before and after a specific fatigue protocol. This protocol was repeated before the second measurement until breakers reached a rate of perceived exertion (RPE) of maximal exertion (20 - Borg scale). Dancers kept their dominant hand in each movement in contact with the pressure plate (RS Scan International, 7.7 second edition, Belgium), used with a 500 Hertz (Hz) sampling rate, 100 frames per second for 10 seconds, while performing the 3 designed steps. They found out that fatigue plays a negative impact on the stability of those breaking movements, reducing the force with which breakers perform them.

c. Spine

Spinal ROM is difficult to measure without specific equipment. No reliable tests have been validated. The more important range for ballet technique is that of extension. In clinic, for the purposes of profiling, simple positions can be used to demonstrate the end range. The cobra position or prone push up (a passive position), where the dancer uses his/her arms to push the spine into extension, can reveal hypomobility or hypermobility (Table 3). The distribution of mobility throughout the lumbar and thoracic spines, without hinging at any level, is ideal. It is also important to check if there is any deviation of the spine on the sagittal plane. Scoliosis are better observed in the Adams' Standing Forward Bend Test[78], where a dancer bends his/her spine forward in different angles and the observer looks from behind if there might be asymmetries (Table 3). In a 45º forward flexion, 6th thoracic vertebra (T6) convexities should be observed; in 60º, 12th thoracic vertebra to 1st lumbar (T-12-L1); and in 90º, 3rd lumbar vertebra to 4th lumbar (L3-4) (Liederbach, 1997). However, this should only be done by a qualified health care professional, as it stands out to be a clinical assessment.

Campos, (Campos, de Paula, Depra, & Brenzikofer, 2015; Campos, Figueiredo, Ferreira, & Bittar, 2016) created an instrument for the evaluation of the behaviour of vertebral curvatures in dance movements, in walking or running on a treadmill, with the goal of establishing parameters for dance teaching in schools that respect the characteristics of each child. In order to do so, he developed a module for automatic tracking of retroreflective markers, the Dynamic Posture kinematics system (Campos, 2010), an open system that measures posture of the spine statically or dynamically. So far, assessments of ballet dancers performing a *développé à la second* showed decreased geometric curvatures and a tendency to rectification in the lumbar and thoracic regions of the spine in more experienced dancers (Rangel & Campos, 2013).

78 Adams' Standing Forward Bend should be done by a health care professional.

Table 3 – *Specific Tests suggested to be used in Dance Settings*

Variables	Protocols
Aerobic Capacity - DAFT	The dancer performs five continuous stages of increasing intensity dance movements that replicate the mean oxygen requirements of dance class and performance. Heart rate is monitored normally by a chest strap and a wrist unit (Wyon et al., 2003)
Anaerobic Capacity - High Intensity Dance-Specific Fitness Test	The dancer performs 4 x 1-minute dance sequences (tempo = 106 beats per minute) with a 2-minute rest between each sequence. Heart rate is monitored normally by a chest strap and a wrist unit (Redding et al., 2009)
*SPE Anterior view	Observe head, shoulder, hips and knees alignments; Thales triangle and knees positioning (Kisner & Colby, 2012)
SPE Lateral view	Observe protrusion or retrusion of the head and shoulders; hypercurvature or rectification of cervical, thoracic and lumbar spines; ante-version or retroversion of the hips; knees genu recurvatum or flexed (Kisner & Colby, 2012)
SPE Posterior view	Observe hinged or retracted scapula, scoliosis in “S” or “C”, and inclination of the feet (Kisner & Colby, 2012)
m/r Star Excursion Balance Test	In the original SEBT test, a large star-shaped figure is taped to the floor, and the subject stands in the middle of it, trying to reach his/her leg for the furthest point along each of the 8 spokes of the star, coming back to centre on both feet after targeting each spoke. The distance reached by each dancer and malalignments are recorded. Wilson & Batson (2014) modified the test by asking the dancer not to restore bilateral weight bearing until the 8 spokes have been touched in clockwise and counterclockwise directions. Subtests related to timing (fastest and safest as possible), inclusion of cognitive challenges during testing and of a foam surface or closed eyes were also conducted. In the random SEBT, dancers target each spoke as soon as it is called, and after a brief rest, they repeat the test with the same limb gesturing *en l’air* at 45º

Variables	Protocols
Modified Topple Test	Dancer performs a single *pirouette en dehors* from 4th *position*, with the gesture leg in full *retiré*, supporting leg fully extended, and vertical trunk, showing a controlled decelerated landing. It was developed based on the research of Lopez-Ortiz (1994) that discovered skilled dancers could better control the acceleration, head movement, body sway and present at the same time a longer landing phase
Airplane Test	Dancer is in standing parallel and pitches trunk forward, while the non-support leg extends to the back, pelvis keeps square to the ground and arms are opened horizontally. Dancer should perform 5 *pliés* and bring the arms close together, touching the fingertips to the ground. Pass criteria: 4 out of 5 *pliés* maintaining overall good alignment (Liederbach, 2007)
Single Leg Sauté Test	Dancer executes 16 consecutive single-leg *sauté* jumps. Pass criteria: 8 out of 16 *sautés* should be properly executed, with neutral pelvic position, stable trunk, good lower extremity alignment, toe-heel landing, fully extended knee and pointed foot while in the air (Richardson et al., 2010)
Scoliosis - Adams' Standing	Starting standing, dancer bends forward as far as possible. Stay behind dancer. Look for one side of the rib cage, and check if it is higher than the other, next to the vertebral column. The convex side is the one with the rib hump. William Adams described the Forward Bending Test for scoliosis in 1865 (Fairbank, 2004)

* Standing Postural Evaluation/SPE: dancer should stand comfortably. The ideal clothing for the assessment is swimwear (Kisner & Colby, 2012).

2. THE REALITY OF DANCE ASSESSMENT IN BRAZIL AND THE UNITED KINGDOM

In BR, it is not common to have a medical department in dance institutions (Diniz, Pessali-Marques, & Rocha, 2017). Only a few funded and private companies can make such a financial investment. Thus, other private research and training centres, such as Bastidores – Dance, Research and Training, in Belo Horizonte, and dance companies, such as Quasar Cia de Dança, in Goiânia, have pioneered and implemented specialised assessment and body conditioning for dancers (Pessali-Marques, Lapas, Marques, Costa, & Lisboa, 2018; Bittar, 2004).

Bastidores' team is composed of Sport Scientists, Physiotherapists and Psychologists that work in partnership with Dance Teachers from dance schools around the country. However, in 2018 only three dance schools were hiring Bastidores' team, while the other students/clients were most commonly dancers interested to strength and conditioning due to fear old injuries' recurrence. Unfortunately, professional Brazilian dancers who train to improve their conditioning or to reduce the risk of injuries are scarce. This might be due to the lack of a specific insurance financially viable for dancers (Pessali-Marques et al., 2018).

In the UK a number of dance institutions have invested in medical departments beyond a sole practitioner. These often consist of a core of Physiotherapists supported by Medical Doctors, Surgeons, Psychologists, Nutritionists, Strength and Conditioning Coaches, Podiatrists and Physiologists. Even within these environments, it is hard to screen all the dancers as adequate time is rarely available in the timetable/rehearsal schedules. Training interventions are usually done in the dancers' own time (non-contractual) which reduces compliance.

Although DMS implementation has been in the UK for over 30 years, assessing dancers comprehensively is still not easy. Both BR and the UK (and probably many others) share the challenge of educating the dance population about the importance of assessment and further training. Even in countries that value and invest in dance, tight budgets mean there is little money for body conditioning; often the service is reactive rather than preventative. Reduced budgets and/or lack of information about the importance of supplementary training have been creating barriers for assessment in dance.

Unfortunately, assessment even in excellence centres is only implemented during the school audition, raising the question of the role of talent recognition that frequently dismisses talented people based on physical aspects that could have been improved later with adequate training. Gaining a thorough profile of a dancer is important not only to audition vocational school dancers, but also to monitor progress and growth, to assess current condition and inform on deficit and direct intervention, or to pre-hire in professional companies.

The functional practicalities of assessment are a little bit easier in professional dance companies, where the importance of maintenance of healthy dancers is of corporate interest. An injured dancer is more expensive for the company than a healthy one, given that the company needs to support the dancers on leave in addition to contracting a replacement for them. Therefore, the largest dance companies in UK invested in medical departments and gold standard equipment to assess and train the dancers, such as swimming pools for recovery and rehabilitation, force plates for jump and lower limb strength assessments, bio-impedance for body composition, Pilates and Gyrotonic equipment, free weights, treadmills and bicycles. Still, the number of dancers in the companies that attend the clinics for preventive physiotherapy and body conditioning is below expectations.

As stated previously, dancers often resist supplemental training programmes as fear of hypertrophy or loss of flexibility are commonly reported and disseminated in the field of dance, though scientifically unfounded. A second limitation is the fact that the screening and training are not part of the dancers' contracts, and therefore, not compulsory. The culture of dance needs to be changed so the supplementary training is seen as a tool for improving performance and decreasing injury risks contributing for a longer career instead of a burdensome, unwanted obligation.

The manipulation of training loads is only possible after proper assessments are performed. Choosing the correct assessment, however, is a challenge for Body Conditioning Instructors, Physiotherapists and Physiologists who work with dancers, due to the variety of dance styles and their distinct physical capacities requiremens (Wyon et al., 2011). It is also important to highlight that tests used in dance companies and schools need to be economical in time and expense, functional, and applicable, in order to assess accurately and inform training interventions.

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CHAPTER 6

SUPPLEMENTAL TRAINING FOR DANCERS

Matthew Wyon / Adriano Bittar / Janine Bryant

INTRODUCTION

Understanding dancers as "performing athletes" (Koutedakis & Sharp, 1999) begins in three key event locations in a dancer's life: class, rehearsal and performance. Whether the ritual dance class begins at the ballet barre, standing or sitting in the center of the studio, the dancers-athletes subject their body to countless hours of classes, repeating over and over the basic movements that are the foundation of every dancer's training. This repetition, generally categorised in classical ballet and contemporary/modern dance as a high-intensity intermittent form of exercise that utilizes all the energy systems (Koutedakis & Jamurtas, 2004), ultimately creates a highly skilled artist who performs effortlessly on stage, leaving audiences stunned at the height of jumps, the incredible control of a single *relevé* or the seemingly inhuman degree of range of motion (ROM) of a *penché*, which moves "effortlessly" to a position that dancers call "six o'clock", or a full 180-degree posterior extension of the gesture leg.

This aesthetic, however, is achieved at a price, as the dance technique classes are unable to provide enough physiological stimulus to generate adaptation. While regular class is essential to excel in a specific dance technique, it bypasses certain muscle groups and it does not raise the heart rate sufficiently (Krasnow & Chatfield, 1996; Wyon, 2005; Rafferty, Redding, Irvine, & Quin, 2007; Hamilton, 2008). An individualized cross-training program can help improve areas of weakness and increase physical fitness levels such as strength, flexibility or cardiorespiratory capacity, therefore decreasing risk for injury.

Wyon, Redding, Head, & Sharp (2004) and Wyon (2005) noted that class and rehearsals didn't prepare dancers for the cardiorespiratory demands of performance. Supplemental physical fitness training, outside of the class/rehearsal (Krasnow & Chatfield, 1996), is required to bridge the gap and prepare the dancer for these increased demands on their bodies. It is therefore important to minimize the difference between the dancers' individual physical abilities and their performance requirements, so that they can become the best dancers possible (Wyon et al., 2004; Koutedakis, 2005). Due to poor physical conditioning, dancers have an increased risk of chronic and acute injuries that, if not addressed, can delay progress, lead to compensatory injuries or even end careers (Liederbach, Hagins, Gamboa, & Welsh, 2012; Kenny, Whittaker, & Emery, 2016; Jacobs, Hincapié, & Cassidy, 2012; Jacobs et al., 2017).

This chapter provides a general perspective of the available relevant research in dance conditioning. The aim is to inform which supplemental training concepts should be applied to dancers, pertaining principles such as of Individuality, Specificity, Progressive Overload and Periodization; and physical training interventions just as Cardiorespiratory, Muscular Function, ROM and Flexibility. It must be advised that caution should be taken by the reader, as many of the procedures described require extensive professional training in order to be applied.

1 CONDITIONING

Physical conditioning concerns elements of fitness such as aerobic and anaerobic capacity, strength, power, endurance, flexibility, agility, and personal/psychological development (Koutedakis & Jamurtas, 2004; Rafferty, 2010; Wyon, 2018). Sometimes the same dance genre requires different elements of fitness, due to choreographic specificities. Although, many dance genres are considered as art almost complete forms of exercise, the truth is that dancers frequently need to consider all the components of fitness, investing on a balance between all required elements to be able to present adequate body composition and the stamina necessary for artistic performance.

In recent studies, professional dancers that have included a physical conditioning program to their weekly schedules have perceived positive physiological adaptations such as: reductions in fatigue, improvement in general energy levels and an improved capacity in their dance classes to sustain technique and jumping ability (Irvine, Redding, & Rafferty, 2015). Further, strength training has been found to reduce dance injuries without interfering with artistic or aesthetic requirements (Koutedakis, Stavropoulos-Kalinoglou, & Metsios, 2005). A number of studies on ballet and contemporary/modern dancers have shown artistic, and physical fitness benefits from 2-3 supplemental physical fitness training sessions a week (Twitchett, Nevill, Angioi, Koutedakis, & Wyon, 2011; Angioi, Metsios, Twitchett, Koutedakis, & Wyon (2012); Koutedakis et al., 2007). As highlighted, the dance-alone approach seems not to contribute to the betterment of fitness parameters in dance, and great improvements can be achieved with relatively small intervention due to their current high hours of training.

One of the most important factors towards appropriate conditioning is the acceptance of rest to allow for recovery and regeneration of the dancers' bodies. It is also known that rest is one of the most required items to prevent overtraining. Also known as overtraining syndrome, overwork, staleness and chronic fatigue syndrome (Koutedakis & Jamurtas, 2004), this condition can be recognized when a dancer complains of reduced physical performance, constant fatigue and behavioural or emotional changes (Budgett, 1990). Effects of overtraining can include a decrease in performance levels, change in mood states, fatigue, weight loss, depression, increase in resting heart rate and blood pressure, disturbed sleep, painful muscles, and decreased muscular strength (Budgett,1990; Budgett, 1998; Kreider, Fry, & O'toole, 1998; Koutedakis & Sharp, 1999). Proper recovery includes rest, nutrition and hydration. More does not always mean better and there needs to be a balance of intensity of training and rest periods (Wyon, 2018).

Furthermore, the importance of warm-up and cool down cannot be overemphasized, and an exercise regimen that includes both of them should be part of the habitual daily activities of a dancer. The idea is that dancers need to develop more of a whole-body warm-up before getting to their familiar motor vocabulary that mirrors the variety of gestures, such as jumps, lifts, etc., and speed of succession found in a dance class or performance (Wyon, 2018) (Table 1).

Table 1 – *Key Aspects*

Add training 2-3 times/week, or as necessary
Rest is extremely necessary and must be planned
Add warm-up/cool-down before/after any physical activity

2. SUPPLEMENTAL TRAINING CONCEPTS FOR DANCERS

2.1 Principles of Individuality, Specificity, Progressive Overload and Periodization

Individuality in dance refers to the knowledge that all dancers from every genre need to first and foremost recognize that each person has unique abilities and needs, and that each dancer responds differently to the same training program (Sands, Wurth, & Hewit, 2012). Singularities such as gender, age, body composition (percentage of fast or low-twitch muscle fibers) and environmental aspects play a major role in determining varied training responses to the same exercise regimens (Bompa & Buzzichelli, 2018; Koutedakis, Metsios, & Stavropoulos-Kalinoglou, 2006).

Dancers should inform their coaches and health professionals about any injuries, impairments, or movement deficiencies. The dance conditioning team must be able to identify the dancers' movement patterns, and to apply principles of adequate motion to address any weaknesses, lack of motor skills to perform the necessary dance vocabulary or postural compensations (Howse & Hancock, 2014).

The principle of **Specificity** states that the adaptation of the body to training depends on the type of training the dancer undertakes. Essentially, if the dancer stretches, he/she is working on flexibility. If dancers are lifting weights, they are working on muscle function. Training must go from general to the highly specific. Using free weights or circuit weight training would allow dancers to increase strength and power (general training) before transferring the benefits into dance vocabulary on a later stage (specific).

In relation to **Progressive Overload**, dancers should start a supplemental training gradually and build progressively, as the body can cope with 5 - 10% increase in load a week (Wyon, 2018). If dancers do not progressively increase the stress on the musculature throughout the conditioning program, they will plateau (Bompa & Buzzichelli, 2018). Therefore, it is helpful to change intensity (heavier weights or more resistance), volume (increase the repetitions or sets) depending on the goal of the supplemental physical fitness training.

Dancers who do not add to their routine a heavy resistance training may be missing a chance to foster a greater involvement of the nervous system and of increasing muscle protein synthesis, which are both mechanisms in which muscles build strength (Bompa & Buzzichelli, 2018; Koutedakis, 2005). However, training load (defined for strength training as the number of repetitions multiplied by total weight lifted) and muscles targeted should be adapted to the dancer's routine, so it cannot negatively affect class/rehearsals/performing (the primary goal of dance) or increase the risk of overtraining.

According to Wyon (2010), it is recommended that dancers vary their training throughout the year, to prevent monotony, overtraining, injuries and adaptations to training. This is called **Periodization**, and the main goal of it is to improve the dancer as a whole person, developing the dancer's full potential on a psycho-physiological basis, focusing on physiological, psychological, biomechanical and skill elements. Therefore, the performance calendar of the year should be planned with caution, as it is recommended to consider the total hours spent in classes, rehearsals, performances and supplementary training while at the same time leaving dancers free to rest and engage in health treatments and recreational activities.

Periodization is split in different phases, including micro, macro or meso cycles. A micro cycle is a week's or few weeks' training. A group of micro cycles aimed at a specific objective is a macro cycle. When grouped, macro cycles are named meso cycles. Volume is normally high at the beginning of a macro cycle. Gradually, the inverse occurs, with intensity raising and volume decreasing (Bompa & Buzzichelli, 2018). But dancers do have hectic schedules, and periodization needs to acknowledge that, by implementing training that target multiple fitness components simultaneously, with aerobic, anaerobic, strength, power, and flexibility parameters all being trained within the same phase (Wyon, 2010). In this case, individualized training would take into consideration each dancer's role in the company and the piece being performed, not to mention individual's fitness levels. 'Tapering' is also a strategy that should be included in companies and vocational schools. Dancers involved in performing should diminish their training loads two weeks prior to performances and cease heavy supplemental training completely a week prior to it (Wyon, 2010).

The key to supplemental physical fitness training is to know what to do and when to do it. The point is to enhance fitness levels adding needed stress to the body, in order for it to get well conditioned. At the same time, though, avoid exhausting routines, extreme positions and sweltering heat (Hamilton, 2008). Proper frequency of training must be observed, to avoid over or undertraining. When off work in vacation, dancers would benefit the most from starting physical activities they normally do not engage in. In doing so, they give their bodies a break from the same habitual routines, while at the same time keeping active and in good shape (Table 2).

Table 2 – *Physical Conditioning for Dancers*

Each dancer needs a specific individual fitness program
Effective communication between the dancer and the DMS team is critical to detection of problems and troubleshooting
Overtraining must be avoided at any cost
An optimized calendar needs to take into consideration classes, rehearsals, performances, fitness routines, health treatments, rest and recreation
Implement trainings that address multiple components of fitness simultaneously
Tapering should be applied 2 weeks before the performances, with a reduction in heavy trainings, which should stop completely 1 week before the performance
On holidays, every dancer should engage on new physical activities to stay fit

Abbreviations: DMS - Dance Medicine & Science

2.2 Cardiorespiratory Training

Supplemental physical fitness training for the dancer should include cardiorespiratory (aerobic and anaerobic) conditioning, because ballet, contemporary and modern performances are classified as high intensity intermittent exercise that have periods of varying length and differing intensities that utilize the diverse body energy systems (Wyon, 2005). Technique classes do not generally increase cardiorespiratory fitness, and research pointed out there is a higher demand of energy required when dancers perform than when they are in class or rehearsals (Wyon et al., 2004).

Aerobic training forms the foundation of the other cardiorespiratory training interventions, as without a good aerobic base the ability to fully recover during the rest periods is severely reduced, thereby compromising the work periods. Aerobic conditioning can be obtained in continuous or interval training sessions and should initially be 3-4 times a week to build up a foundation. Continuous trainings need to be done for 15-30 minutes, at an intensity of 70-90% of the maximum heart rate; whilst aerobic interval training follows a 1:1 ratio, with high-moderate intensity periods of 1-3 minutes, reaching 85-90% of maximum heart rate, followed by recovery periods of lower intensity, in 10 sets.

Anaerobic training (lactate training) should be introduced only after 3-4 weeks of aerobic training; it uses a 1:3 ratio, with the high intensity period lasting between 60-90 seconds with very gentle recovery periods; aim for 10 intervals, 1-2 times/week. Less importantly is the anaerobic phosphate training. This is supramaximal training and uses a 1:5 ratio, a work time of 10-20 seconds, in 10-20 sets, 1-2 times/week. Long slow distance training can prepare dancers prior to their return from holidays and also help with the recovery mechanism: intensity should be 60-70% of maximum heart rate, in 30-60 minutes, once a week for recovery and 3-5 times a week (Table 3) for conditioning (Wyon, 2018).

Table 3 – *Cardiorespiratory Training for Dancers*

Focus	Type	Intensity	Sessions per week
Aerobic	Continuous	15-30 mins, 70-90% HRmax	4 times/week in initial phase, dropping to 2 times/week in heavy rehearsals and performances
Aerobic	Interval	1-3 mins of moderate to heavy intensity, 80-90% HRmax, followed by 1-3 mins active recovery, 10 series	
Anaerobic - lactate	Interval	60-90 secs high intensity, 3-4½ mins rest, 10 intervals	1-2 times/week after week 4
Anaerobic - phosphate	Interval	10-20 secs supra-high intensity, 50-100 secs rest, 10-20 series	1-2 times/week depending on choreography
Aerobic - long duration	Continuous	30-60 mins, 60-70% HRmax	1 time/week for recovery, 3-4 times/week for conditioning prior to return from holidays

Abbreviations: mins - minutes; HRmax - maximal heart rate; secs - seconds

2.3 Muscular Training

Strengthening muscles can help dancers move more effortlessly while increasing range of motion (ROM) and speed, and weight training is still considered to be the best option. However, a balance between strength training and activities that improve flexibility, coordination and ROM is recommended.

According to Wyon (2018), resistance training can be split into five areas: preparation, strength, hypertrophic, power and muscular endurance training.

Initially, it is necessary to provide a solid basis in the body from where to move from. This means that a dancer should acquire intrinsic strengthening, with stabilizers being trained, in order to maintain good posture and biomechanics. This should be the aim of the preparation training, normally implemented after holidays and injuries, with a focus on stability, protected mobility and muscle balance. Then, it is time to gain the foundational strength required.

Wyon (2018) suggests that for **strength** improvements at least 2 focused training sessions a week are required. If the goal is to strength, the load (% of 1 maximal repetition - 1 MR) should be 80-90%; number of repetitions per set should be 1-5; number of sets per exercise should be 4-7; rest period between sets, in minutes, should be 2-6; the speed of repetitions should be slow to moderate. If the goal is **power**, load should be 70-90%; number of repetitions per set should be 1-5; number of sets per exercise should be 3-5; rest period between sets, in minutes, should be 2-6; the speed of repetitions should be fast. For **hypertrophy**, load should be 60-80%; number of repetitions per set should be 6-12; number of sets per exercise should be 4-8; rest period between sets, in minutes, should be 2-5; the speed of repetitions should be moderate. For **endurance**, load should be 40-60%; number of repetitions per set per exercise should be 15-60; number of sets per exercise should be 2-4; rest period between sets, in minutes, should be 1-2; and speed of repetitions should be slow to moderate (Table 4).

Exercise selection is just as important and needs to either mimic dance specific movements or act as a counterbalance to dance specific loading that has resulted in a muscular imbalance. Generally, closed chain (multi-joint) movements are more complete and functional than open chain (single joint) movements. Functional training uses these closed chain movements that involve whole body gestures, such as squats and deadlifts.

Plyometric training is a useful conditioning tool as well, as dancers aren't told how to jump or improve their jump correctly (Wyon, 2018). It is defined as a modality in which jumps, hops, bounds or skips are used, taking advantage of the stretch-shortening muscle cycle to improve athleticism in young and adult dancers. Intensity depends on the exercise categories prescribed, number of jumps and sets per exercise, i.e. single leg jumps are much harder than squat jumps; beginners often perform approximately 80-100 foot contacts per session, while children and older dancers might need half of this amount (Table 4). Evidence has shown that plyometric training has been primarily used to enhance neuromuscular function and explosive and endurance performances, helping the neural and musculotendinous systems generate the maximal force in the shortest amount of time (Markovic & Mikulic, 2010).

Table 4 – *Muscular Training*

Area	Characterístics
Preparation	Focus on stabilization, protected mobility and muscle balance; 2 times/week
Strength	80-90% 1MR; 1-5 reps/set; 4-7 sets; 2-6 mins rest between sets; slow to moderate speed, 2 times/week
Hypertrophic	60-80% 1MR; 6-12 reps/sets; 4-8 sets; 2-5 mins rest between sets; moderate speed, 2 times/week

Power	70-90% 1MR; 1-5 reps/sets; 3-5 sets; 2-6 mins rest between sets; fast speed, 2 times/week
Endurance	40-60% 1MR; 15-60 reps/sets; 2-4 sets; 1-2 mins rest between sets; slow to moderate speed, 2 times/week
Neuromuscular function (agility and velocity), jump resistance and power	Plyometric training, depends on the exercises intensities prescribed; 80-100 foot contacts per session, divided in sets per session, 2 times/week

Abbreviations: 1 MR - 1 maximal repetition; reps - repetitions; mins - minutes

2.4 Core Training

Core training can also be classified as resistance training, and it involves the use of exercises that strengthen the lower back, hips, abdomen and pelvis, focusing on improving balance and stability. Reed, Ford, Myer, & Hewett (2012) found out on a systematic review that core stability training could provide marginal benefits to athletic performance. Conflicting findings and lack of standardization for measurements of outcomes and training are considered as difficulties in its use and proof of effectiveness.

It seems that from middle 1990s onwards, there has been a global scale confusion regarding the definition of core and its functioning, with major incongruences in core training application. In "Core Training: Stabilizing the confusion", Farries and Greenwood define the core musculature as the 29 pairs of muscles that support the lumbar spine, pelvis and hip complex, stabilizing the body during functional movements:

> The core is also commonly referred to as the "powerhouse" or the foundation of all limb movement. These muscles

> are theorized to create this foundation for movement through muscle contraction that provides direct support and increased intra-abdominal pressure to the inherently unstable spine. To ensure stability of the spine in order to produce force and to prevent injury, trunk muscles must have sufficient strength, endurance, and recruitment patterns. (Faries & Greenwood, 2007, p. 10)

Nonetheless, misinterpretations of Hodges and Richardson's (1997) discoveries about the deep trunk muscle layer, a primary spinal stabilizer, led movement professionals to apply in healthy people, athletes and dancers the same strategies used for low back pain. Then, supine, neutral spine and breathing exercises were inadvertently used. In part, this was due to the knowledge that slow-twitch fibers would be trained at low resistance levels (30-40% of maximal voluntary contraction). Moreover, neutral spine was found to be ideal for the specific conditioning of the Transversus Abdominis (TrA) and Multifidi. Still, little consideration was given that training the TrA and Multifidi in an isolated manner would inhibit other trunk stabilizers: "[…] too much strength or force from core musculature actually can cause greater instability if it is not directed correctly." (Faries & Greenwood, 2007, p. 11).

Furthermore, formulas for the activation of the core got more and more complicated. Richardson and Jull (1995) and Richardson, Jull, Hides, & Hodges (1999) described the "draw-in" maneuver, ideal to activate the core, as a gentle excavation of the lower abdomen. Deep exhalation and automatic activation of the TrA was proved to cause stabilization of the spine, through a gentle raise in intra-abdominal pressure and a bracing effect. Though, the draw-in maneuver, also called hollowing, or "navel to spine", started to be used too intensively by many, forced exhalation was added to it, intra-abdominal pressure peaked up, and the synergetic muscle actions around the spine were disrupted.

Vera-Garcia, Brown, Gray, & McGill (2006) showed that co-activation of all abdominal trunk muscles through a voluntary tightening of the abdomen (bracing), and not a draw-in, would cause more stability and less lumbar displacement after loading. Therefore, a new paradigm started to emerge, with bracing being the right strategy for core training. This was mainly used for functional training and strength/power training.

Independently of this dilemma, in core training, intensity of training will be progressed by changing the base of support (more or less unstable), lever, resistance or center of gravity (Anderson & Spector, 2000). Holding the same posture or exercise for 30-45 seconds is recommended, and adjustments should be made in postures and exercises should this time not be challenging anymore (Kisner, Colby, & Borstad, 2017). Postures and exercises should be specific to dance and consideration should be given to current fitness level, exercise history and performance goal (Table 5).

Table 5 – *Core Training*

Type of Manouver	**Intensity**
Draw-in: gentle excavation of the lower abdomen or *Bracing*: voluntary tightening of the abdomen	Keep postures and exercises that mimic dance gestures for 30-45 secs; make it easier or harder by altering the base of support, lever, resistance or center of gravity

Abbreviations: secs - seconds

2.5 Range of Motion and Flexibility Trainings

Dancers have been known to sit in a straddle split for an hour while watching the television only to discover a muscle fiber tear in the adductors (inner thigh muscles) (Hamilton, 2008). In addition, if there is a joint laxity or the dancer is hypermobile, more stretching is not necessary. Hypermobile dancers need to balance flexibility with strength training to find joint stability and prevent recurring injury.

Sometimes dancers get stiff by overworking a part of their bodies. It is advised in this situation, and when they are warming-up, that they move through their normal ROMs (intensity of stretch 7-8/10) before classes, rehearsals and performances, applying 15 seconds static stretches to those specific areas (Wyon, 2010). On the other hand, Wyon (2010) suggests that immediately post-exercise muscles should be taken to their full ROM and held for just 5-6 seconds to reset the muscle's length, in what he calls fast stretching, for 1-2 repetitions only.

When dancers need to increase their passive ROM and recover from a stressful daily routine, they can use Microstretching, that promotes very low intensity stretching (4-6/10) (Apostolopoulos, 2004; Wyon, 2010). Microstretching should be carried out two hours post-exercise, when muscles are back to their normal resting temperature, allowing for lengthening of myofilaments and muscle fibers. Wyon, Felton and Galloway (2009) showed that Microstretching had a greater positive effect on recreational dancers' lower-limbs ROMs than moderate-intensity static stretching. This research suggests that low-intensity stretching potentially has a restorative component as well. Low-intensity stretching (40-60% maximum perceived stretch) was also found to bring beneficial effects to recreationally active males when compared to high-intensity or no stretching (Apostolopoulos et al., 2018). In such a study, low-intensity stretching resulted in less significant perceived muscle soreness and in a better muscle function recovery.

Dynamic stretches, such as controlled dance-like movements (i.e.: dynamic *cloches* taking the leg through its full ROM, from flexion to extension, or adduction to abduction), and a combination of dynamic and static stretches (holding the stretch at 8/10 intensity, or just below the point it starts shaking, for 15-60 seconds, in a single or multiple repetition) are also used to get dancers flexible and to improve balance and jump height (Peterson, 2011). Morrin and Redding (2013) showed that in female adult trained dancers dynamic stretches and a combination of dynamic and static stretches used after a light cardio-vascular warm-up enhanced vertical height scores and balance performance when compared to static stretches. ROM was better obtained by the application of static and combined dynamic and static stretches.

If a dancer is interested in gaining functional ROM, and not just passive range, strengthening the agonist muscles in a functional manner is important. According to Wyon (2010), this could happen when a dancer is being stretched by a partner while standing up, on a *développé a la second*, for example. In this case, the partner holds the exerciser foot in a leg abduction, and the exerciser attempts to lift her/his foot out of the partner's hands, without changes in posture. Each repetition should be held for 2-3 seconds before returning the foot to the partner's hands, and 6-8 repetitions should be carried out. If the height of the *développé* increases, so must the partner's hand positions.

If a dancer is seeking to increase the flexibility of a body segment, it should occur during at least six weeks of continuous stretches applied. Bompa & Buzzichelli (2018) suggests that athletes with the aim to increase flexibility need to stretch at least twice per day, with each muscle group being stretched at least three times per session. Activation of the neural structures recover 15 minutes after a static 30-seconds stretch. However, the muscle activation will only get back to normal after an hour of this stretch. Prolonged static stretches of 20 minutes or more should be avoided (Table 6).

However, stretching should be better understood by science, as different aspects of it, such as the importance of body position and its influence on stretch intensity, is relatively under-researched (Apostolopoulos, Metsios, Flouris, Koutedakis, & Wyon, 2015; Pessali-Marques, 2016). Please be aware that young dancers going through their skeletal growth spurt and adults with increasing age become less flexible. In those cases, caution must be taken and forced stretches should not be applied (Storm, Wolman, Bakker, & Wyon, 2018).

Table 6 – *Types of Stretches in Dance*

Scenarios	Movement	Intensity
Warming-up to decrease muscle stiffness and overwork (before classes, rehearsals and performances)	Statically stretch specific areas in normal (not maximum) ROMs	6-8/10 (60-80% of MPE), for 15 secs, one or more reps
Immediately after exercise (after the ballet bar, rehearsals or performances; at the end of the day, etc.)	Statically stretch in full ROM	8-9/10 (80-90% of MPE), for 5-6 secs, 1-2 reps

To increase passive ROM and recover (2h after exercise, at the end of the day, or at home)	Microstretching	4-6/10 (40-60% of MPE), for 60 secs, 3 reps, for 6 weeks
Increase ROM	Dynamic stretches using adapted dance gestures or Static stretches or Mix static and dynamic stretches	Dynamic: 2 sets of 8 reps; for 6 weeks or Static: 2 times a day, 60 secs, 3 reps, for 6 weeks
Increase functional ROM	Passively lengthen the desired region; activate the antagonist muscles; passively hold in new ROM, if any	Stretch until you reach full ROM, maintaining good posture; activate antagonists for 2-3 secs; 6-8 reps

Abbreviations: MPE - maximum perceived exertion; secs - seconds; reps - repetitions.

CONCLUSIONS

As the physical demands of dance increase, and as dancers are asked to perform movements with more power, bigger ROMs and faster speed, it is clear that they cannot rely on dance technique classes alone. Supplementary training regimes are becoming more and more necessary, as dancers in both small and large companies are challenged to keep up with the technical demands of artistic directors and choreographers alike. As dancers acknowledge the artistic as well as athletic demands on their bodies, dancer-athletes can begin to meet these demands through cross-conditioning activities.

Today, many dance companies and schools are aware that dancers need facilities and a specific trained group of professionals available to implement supplemental practices. Mainly in large-scale companies, where finances are available, dancers will be provided with individual assessments and conditioning programmes designed by exercise physiologists, biomechanics specialists and Pilates teachers (Laws, 2005). Though, in smaller, less-funded dance groups, this implementation is still a dream come true.

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CHAPTER 7

RELATED TOPICS:
SOMATICS AND PILATES IN DANCE

Adriano Bittar / Aline Haas / Janine Bryant
Diego Pizarro / Cláudia Daronch
Guest Editor: *Karen Wood*

INTRODUCTION

The quotation "Dancers are the athletes of God", is often used in the dance community to describe the mix of athleticism and spirituality with which professional dancers dance. This saying is attributed to Albert Einstein and, although no one seems to be able to pinpoint when, where and in what context Einstein said it, this citation withstands and aptly applies to dancers everywhere.

Silvia Davini (2007, 2002), in her research about the training of performing artists, shed some light on the understanding of this seemingly beautiful, yet "unknown state", in which dancers' bodies create an art form totally based on physical qualities, skills and a highly developed kinesthetic awareness, dependent on: "[…] a body production capable of creating complex senses, controllable on stage. From this perspective, voice and movement are body productions of the same category, able to organize complex speeches and to establish performance control parameters." (Davini, 2002, p. 60).

Thus, for the body to become a danced poetry and dancers, "athletes of God", it is necessary that they develop an awareness that each body is capable and producer of its own syntax, so that transformations based "[…] on how each dancer deals with his/her own body can determine the boundaries and extensions of the artwork itself." (Tourinho & Silva, 2006, p. 127). Ferreira & Silva (2012) and Ferreira (2013) have also delved into defining what it means to be poetic in dance: to put oneself in *poiein* (a Greek word, meaning "to create or make"); to hatch or break through a place in which body structures and paths are transformed into materiality, which can be triggered by the artist's needs. Bittar (2015) tries to synthetize it, stating: "[…] to dance is to learn principles of movement and to expand them in one's own ways; […] movements should be both inward and outwardly focused; […] the organisation of the perceptive sphere determines the dance that is made." (p. 169-171).

In recent years this body construction has been overstretched, because increases in the physical and poetic demands of dance have required that dancers perform powerful and faster moves, in extreme ranges of motion (ROMs) and with varied movement qualities, often resulting in debilitating injuries, that suggest dance technique classes alone are insufficient for this contemporary phenomenon (Bittar, 2004, 2015; Pizarro, Cunha & Vellozo, 2019). Moreover, as explained by Batson (2007, p. 70): "To convey meaningful and nuanced beauty through an expanded movement range, dancers must spend supranormal numbers of hours practicing in class and rehearsal, with additional hours devoted to personal physical cultivation".

Therefore, the training of dancers has come to be a complex combination of dance technique classes, somatic practices and conditioning (Chmelar & Fitt, 1990), with the two latter often not available and not included in the dancers' working hours, even in major dance companies. The introduction of regimes based on such an assumption is becoming more and more necessary, as vocational and professional dancers are challenged to keep up with the technical and poetic demands of artistic directors and choreographers alike (Bittar, 2004; Batson, 2007; Bittar, Melo, Noleto, & Lemos, 2017).

In this chapter, Somatics[79] and Pilates are presented as tools often used by dancers for injury prevention and performance enhancement. The following are some reasons why it is time to rethink dance training, including biomechanical, physiological and motor control principles within the context of overall dance training.

1. SOMATICS AND DANCE

The combination of complex qualities found in the dance technique class may be one of the main reasons for Somatics[80] to be

79 Throughout the whole chapter you will find Somatics spelled with a capital "S", as advised by Diego Pizarro, one of the authors. According to Pizarro: "*Somatics with a capital "S" refers to a neologism created by Hanna to describe a specific field of knowledge. We use it in lowercase whenever it is functioning as an adjective.*". When quoting other authors' original works, such as books and articles, and parts of what they wrote, we kept the word Somatics/somatics as used by these authors.

80 Somatics is the term used nowadays to substitute a variety of other words used to describe this field of study. For example, in Brazil the terms "body awareness" and "body expression" were present for decades before they were replaced by "somatic education", especially inspired by the Vianna family's proposals (Angel, Klauss and Rainer Vianna). In the United States of America (USA), prior to the popularization of Somatics, the most common terms were body therapy, bodywork, body awareness, or mind-body practices. Fortin (2002) remarks that in France, Somatics was something unheard of not so long ago, and there is hardly any use of the term, since institutionalization as an official formation of dance-education teaching policy established it as the L'*Analyze Fonctionelle du Corps no Mouvement Dansé – AFCMD* (Functional Analysis of the Body in the Dance Movement).

used in the training of dancers (Batson, 2007; Bittar, 2015). Body therapies, guided imagery, neural patterning, proprioception and constructive rest are but a few of the possibilities available. The general idea is to give the dancer's body some quality time to let things "sink in" and find its inner potency, achieved by a deeper listening to the body. Somatic interventions are normally performed in a slow manner[81], so that integration and sensibility can be fostered for artistry and emotion to be expressed. Even though medical research has not provided clear scientific evidence that these practices are effective, social science research, anecdotal information and more than one century of lived experiences within somatic research suggest they play a striking role in dance.

The term somatic education became popularized by Thomas Hanna (1928-1990) around 1980. He defined it as an experience of bringing awareness to the inner body in synergy with the World. This awareness is related to the processes in the body, breath, voice, circulation, emotions, habitual movement patterns, postures and tensions, as opposed to the idea of the body as an object (Hanna, 1993. The result from engaging in somatic activities is that a deeper attention is given to the body in space and to the interpretation of body sensations. Such a heightened state of being enables dancers to consciously search for better mechanics and for a mindful state, in which, by staying more connected to the present time while moving or not, they can turn pain free and perform with greater vitality and expressiveness (Eddy, 2009).

In Somatics, self-empowerment and critical thinking through experience are key, and the body is considered as a

81 Minimization of effort and speed of movement is only one strategy utilized specially during initial stages of somatic learning (Batson & Schwartz, 2007).

self-regulatory mechanism. As such, it is capable of refining its perceptual, kinesthetic, proprioceptive and interoceptive sensitivity in order to recognize habitual patterns of postural and movement interactions with the environment. The ultimate goal is to improve movement coordination and overall body integration, which can lead to a transformation of one's self.

The inaugural techniques in Somatics include Alexander Technique, Laban-Bartenieff Fundamentals of Movement, Eutony, Feldenkrais, Ideokinesis, and Rolfing. As time passed, other second and third generation methods, like Body-Mind Centering®, Continuum and Experiential Anatomy, to name a few, appeared. Even now it is possible to have a Somatics-based ballet class, meaning that some of the somatic principles are in use in that class. Although, there are rules that keep Somatics unique and different from the majority of dance technique classes, such as a shift from outside authority to a self-responsibility and autonomy, decentralization of decision-making and cultural pluralism (Batson & Schwartz, 2007).

Since Thomas Hanna announced Somatics as a field of study and practice in the 1970s, bringing together various Euro-American techniques, methods, and systems, developed since the late 19th century, it has developed itself consistently in various corners of the Western world. Moreover, rather than focusing on specific methods, the field of Somatics is widening as a breeding ground for first-person experience research and its inclusion within the collective in relation to the environment (Pizarro, 2016).

In this sense, it is even observed that the ritualistic, cultural and social practices of native people in various countries share an extended somatic coexistence. Thus, holism, communion, subjectivity, integration with nature, and belief, based on practice and doing, forge intrinsic aspects of a field that has been named by the global north in its tendency to capture and delimit movements and practices. Such movements have existed for millennia as characteristics of worldwide traditional cultures. Hence, the field of Somatics today is as broad as the existence of living expression approaches, according either to the actuality of structured methods or the simple gathering of people together in order to promote integration through the experience of their physical, mental, energetic, emotional, and spiritual bodies (Pizarro, 2016). The way each culture relates to this "international movement" is peculiar and differentiated in relation to social, political and economical contexts. Therefore, according to Fortin (2002), Somatics is neither homogeneous nor a unified international field, especially when we delve into the somatic manifestations carried out in each country.

When expanding the notion of Somatics as a way of being in the world – a process that encompasses the lived experience from the perspective of the first person with the collective in the environment without necessarily setting immutable rules for its existence – new processes arise to think about Somatics in dance and its integration with Dance Science, remarking its differences and expanding possible points of contact and integration (Pizarro, 2016). Indeed, it would be reductive to talk about Somatics without commenting on the breadth of development that the somatic field has taken over the last decades.

Academia's embrace of Somatics, driven by the efforts of Hanna (1970, 1976, 1980) and Don Hanlon Johnson (1992, 1995) and their somatic theories, for instance, has grown dramatically since the 1970s. Thus, Somatics has also become a methodological approach to research, following the international movement of artistic Practice as Research (Barret & Bolt, 2007).

Understanding the place of Somatics, as a new paradigm in academic research, then gained additional outlines. Somatics as Research (Fernandes, 2014) brings forth Somatics as a way of exploring, structuring and organizing research processes:

> The point is that somatics reverses a fundamental principle of scientific research, namely, that one must distance oneself from the research object in order to analyze it. The somatic researcher is an immersive performer, i.e., he/she integrates experience and real-time analysis, deconstructing the study subject as a passive and tractable object, and instead dancing with(in) it. [...] The somatic researcher/performer is not only immersed in research as an imminent field of discovery, but is him/herself part of this field, starting from the experience lived in space time. (Fernandes, 2014, p. 122)

For instance, the Somatic-Performative Research proposed by Fernandes (2014) is a methodological approach that proposes new pathways for the wide scope of Performing Arts research. It involves several principles embedded with its foundational, thematic and contextual characteristics. As an approach, it includes several possibilities, being based in the concept of "Art to the Art" as a fundamental element of its procedures. Subject and object are utterly integrated into their roles within this research. By affirming the unique ability of the artist researcher on "transforming secular dichotomies into somatic and ecological modes of contemporary life" (Fernandes, 2014, p. 77), the author quoted affirms another type of privileged intelligence in this approach, a somatic intelligence.

However, this type of intelligence, which is usually part of the cellular consciousness, long before it is processed by the nervous system, has another time, quite different from the actual time – the one that attends the productive and "reproductive" demands of the academic universe –. Somatic-Performative Research products also include multisensory data records such as drawings, texts, testimonials, moving images, still images and sounds, among others. This should not be confused with lack of rigor, as the research rigor in Somatics aligns itself with other paradigms, which may be fallible, because they are at the same time exploring possibilities within the internal logic of each and every research. Ultimately, any research is then considered a pulsating soma, as living organisms that claim for their space and for their issues to be experientially considered.

Notwithstanding, the subjective aspect of such research paradigm, somatic narratives and data are a complex product borne out of a high level of critical reflection. For instance, in thinking about somatic epistemologies, Isabelle Ginot (2010) analyzed the written discourse of some pioneers of somatic practices, such as Matthias Alexander, Moshé Feldenkrais, Elsa Gindler and Bonnie Bainbridge Cohen. She argues that these authors draw on science and experience reports as a way of feeding belief in their methods, producing endogenous discourses that are unrelated to each other. Despite the relevance of this study, one must first consider that in somatic practices written discourse does not stand apart from its practice and its oral tradition. However, Ginot (2010) affirms positively that, when leaving the comfort zone of the founding discourse contexts, several practitioners have experimented Somatics in diverse contexts of precariousness, interculturality and underprivileged groups. As a result, these practices have developed innovative discourses by themselves, moving away from the domain of the belief in science evidenced by the founding discourses. For instance, both

Hanna and the pioneers of Somatics would, thus, have created a functional fiction among various discursive strategies (De Giorgi, 2015).

Considering that this criticism makes sense, especially in the breadth of Somatics academic development as a field of study and practice, it seems also important to accept that paradoxes are inevitable:

> As a feminist post-structuralist researcher, I see somatic practices as a site of "normal conflict" produced through a whole range of discourses, always under co-construction, and full of grey zones. As practitioners or researchers, we constitute ourselves as hybrid subjects with contradictions in our lives. (Fortin, 2017, p. 150)

Although Hanna (1973) advocated Somatics as a science, Batson, Quin, & Wilson (2012) claim that it took decades for Dance Science and Somatics to find a common basis for conversation towards their integration. As in a vicious cycle of exclusions, each has developed apart from the other with its specific paradigms. While Somatics remained tied to the individual narratives and subjectivity characteristic of their processes, the objectivist pragmatism of Dance Science remained true to analytic empiricism. But Batson (2007; Batson & Wilson, 2014), for instance, has been looking for ways to integrate Somatics and Dance Science in academic research for at least three decades. By doing so, the author utilizes narratives and first-person somatic research as well as scientific integration of both fields.

On the other hand, Jill Green (2015) deeply questions the issues concerned with the location of Somatics under the "umbrella" of Dance Sciences, as she notes it is happening in several higher education dance programs in the United States of America (USA). However, she states that, when invited to take part in a research initiated in the sciences, she began to think more complexly about the issue. Looking at research carried out by Batson and Green, such integration seems to be possible. Just as Batson uses participant narratives as well as evidence-based data, Green uses both the phenomenological experience and the critical rigor of postmodernism in her research. As professors, practitioners and researchers of Somatics, both of them are well aware of the importance of integrating the subjectivity of Somatics with the objectivity of science, each of the fields teaching the other how to emancipate and coexist in a fruitful dialogue.

While recognizing the limits of first-person experience, Green refuses to relinquish experience to the detriment of a theoretical framework, and vice versa. Batson dives deeper into the quest for the integration of Somatics with Dance Science, highlighting the specifics of each of these fields in research, and recognizing their different paradigms, without submitting one to another:

> Both somatics and dance practices create an embodied consciousness and turn us towards cognition and self-knowledge. Somatics opens us up to the world of actuality (an opening to the possible) and dance training opens us to the possibility of expanding our notion of being in the world. Dance science tends towards a different lens – looking at the mechanics of movement, physiology and psychology as a means of optimizing our dance training and performative goals. Combining somatics and dance science provides a more comprehensive understanding for dance training that could feed and progress our dance practices. (Batson et al., 2012, p. 187)

For the authors, "[…] scientific constructs of embodied cognition and phenomenological constructs of embodiment […]" (Batson et al., 2012, 184) present themselves as emerging paradigms that readily may link Somatics and science. Indeed, said authors reaffirm the richness and emergence of such integration, with theories and practices coming together as a reality today. Forty years ago, when differences between both science and Somatics were thought to be unbridgeable, the connection between these fields was not possible, existing only as a desire and a need within dance training (Eddy, 1991; Myers, 1991). Despite the fact that there is still a lack of scientific research showing outcomes of Somatics in dance training, denying the affinities between both fields means to erase innovative theories coming from sciences itself, as Neurophenomenology, for example. In addition, beyond claiming for scientific research on Somatics, researchers might perceive and recognize the paradigmatic instances concerning both fields, highlighting their affinities[82], as well as their differences.

The creation of the Brazil-United Kingdom Dance Medicine & Science Network (BRUK DMS NET) is a great opportunity to carry out research for the integration of Somatics and Dance Science. In this realm, many kinds of projects may be developed, including, but not limited to, at least three different themes: 1 – scientific research about Somatics in dance; 2 – somatics research concerning dance training and dance creative processes; 3 – Somatics and Dance Science in conversation for the enhancement of both fields.

82 "Etymologically, an affine is one who is situated *ad finis*, one whose domain borders mine. The affines are those who communicate by the edges, who have "in common" only what separates them.". (De Castro, 2018, p. 67).

2 PILATES FOR DANCERS

Dancers need sufficient strength, flexibility and neural integration to meet the ever-increasing demands of differing roles. The artists-athletes who can expertly perform demanding roles understand that the artistry of the role cannot be compromised because their activities have been solely focused on one aspect of training over another. The best dancers seek balance. The issue raises legitimate questions regarding what activities are most effective for building strength as well as flexibility (Koutedakis & Jamurtas, 2004).

It is thought that a great activity that offers a balance between strengthening, stretching, core functional activation, alignment and coordination is Pilates (Bittar, 2004, 2015; Ahearn, Greene, & Lasner, 2018), but medical scientific research is still to prove it. Pilates seems to work with sophisticated and integrated movement patterns that train both types of muscle fibers at the same time. It could be thought of as whole-body re-education system, implementing corrective exercises that might prove to be necessary for dancers.

Pilates is a system of movement that uses a varied set of body conditioning, corrective and therapeutic exercises developed over a span of 60 years by German-born athlete and pioneer, Joseph Hubertus Pilates (1883-1967) and his “wife” Clara Zeuner (1883-1976). Initially known as “the art and science of Contrology”, Pilates was defined by Joseph Pilates as the complete coordination of body, mind and spirit (Pilates & Miller, 1998).

It is believed that Pilates originally created his method by linking oriental techniques and philosophies, such as Yoga and Martial Arts, to western body education methods, such as Ling Medical Gymnastics and dance techniques developed by Rudolph von Laban. Pilates follows six basic principles: concentration, centering, flow, breath, precision and control (Friedman & Eisen, 2005). This set of principles functions in an integrated manner in all of the more that 500 exercises created by the German masters (Panelli & De Marco, 2017).

Used by many dancers and non-dancers, Pilates incorporates matwork exercises and also machines, such as the Reformer, Cadillac/Trapeze Table, Chairs, Barrels, etc. Anecdotal data shows Pilates can increase core conditioning, overall body awareness and stability (Kloubec, 2011; Barbosa, Guedes, Bonifácio, Silva, Martins, & Barbosa, 2015; Bernardo, 2007), improving posture and alignment, leading to an economy of energy during movements and an increased ROM (Emery, De Serres, McMillan, & Côté, 2010; Phrompaet, Paungmali, Pirunsan, & Sitilertpisan, 2011). It is also speculated that Pilates stimulates circulation and promotes new neuromuscular patterns and more precise coordination (Parrott, 1993; Segal, Hein, & Basford, 2004). All these things combine to possibly prevent injury, and may aid in alleviating chronic pain (Amorim et al., 2011; Amorim et al., 2011a; Bittar, 2004). Unfortunately, these are not well-designed evidence-based studies (Bergeron et al., 2017).

In the United Kingdom (UK), Pilates instructors can work in several different environments including private Pilates or fitness studios, in conjunction with rehabilitative specialists such as physical therapists, athletic trainers, and occupational therapists, as independent contractors, in dance companies and schools. In Brazil (BR), Pilates is normally another tool used by Physiotherapy, Physical Education and Dance graduates, in studios, gyms, hospitals, universities, dance companies and schools.

Why is it that, as far as supplemental training is concerned, so many dancers seem to gravitate toward Pilates in the first instance? It might be because since 1926, after arriving in New York city from Germany, Pilates established his studio in 8th Avenue, beside the School of American Ballet and New York City Ballet. By word of mouth, many injured dancers got to know that a certain "German master" applied a conditioning technique that resembled lots of gestures practiced in dance. Joseph also mingled with dancers and created a collection of exercises using them as guinea pigs. From early 1940s onwards, Joseph was also a frequent teacher at the Jacob's Pillow Festival, contributing with his teachings for the body conditioning of many dancers (Pérez & Aparicio, 2013). Some of those dance students became the first followers of the Pilates method, turning to be masters and true disseminators of this work. They became responsible for keeping this method alive (Siler, 2008).

Ever since, Pilates has been linked to dance training, gradually evolving to integrate current biomechanics, physiology, motor control, and DMS concepts. The roots of Pilates are derived from Joseph's philosophy and movement patterns, with dance and gymnastics being at the core of its development. It is important for all dancers to know the lineage that each Pilates teacher belongs to. It may seem complicated at first, but it is required of teachers that they keep learning with the elders, as Pilates has always been taught in a master-apprentice manner, the same as in classical ballet.

2.1 Powerhouse or whole-body training?

According to Siler (2008), in Pilates the trunk is the main place for understanding movements. This is where the "powerhouse" is located, and from this "center"[83], movement initiates and radiates throughout the entire body. Therefore,

83 To know more about the "powerhouse", please refer to "Core Training" on Chapter 6.

muscles of the abdomen, lower back and gluteus are the ones that act constantly in all Pilates exercises. They are trained so that right body positioning is attained and endurance is increased, collaborating for the maintenance of posture and of the physiological curvatures (Loss et al., 2006). Trunk stability and organized overall body mobility in all planes of movement are key, and quality of movement brings about a sense of self and moving from within that are important characteristics in the method.

Pilates exercises are divided into four levels: basic, intermediate, advanced and super advanced. All of them, regardless of their levels, have as main goal; full body development through proper activation of the "powerhouse" (Panelli et al., 2017). Even with the "powerhouse" being considered the most important region of the body, Pilates is also intended to work the upper and lower limbs, requiring simultaneous participation of the whole body (Albuquerque, 2006; Panelli et al., 2017).

In Pilates, different types of breathing patterns are used for core training and whole-body organisation. Deep exhalation is key to a full inhale (Pilates et al., 1998). Some say inhalation should not expand the abdomen, but this might be more restrictive than beneficial. Thus, an overall distribution of the inhale through the abdomen and thorax seems a better strategy (Anderson et al., 2000; Bittar, 2015). When exhaling, a gentle tridimensional drawing-in of the abdomen is required. Too much contraction of the Transverse Abdominis (TrA) is seen as not such a good strategy. Ron Fletcher, a Pilates elder, created the Percussive Breath®, done with air being blown out through the back of the teeth. The difference from other breathing techniques used by related lineages is that they exhale through an open mouth, or through the nose. Research about Ron's breath has suggested it is useful for a better activation of the respiratory systems of adolescent ballet dancers (Bittar et al., 2017; Melo, Noleto, Bittar, & Lemos, 2018).

Different pre-Pilates exercises were created by most Pilates schools. They normally start in neutral spine, but not all are performed in supine. Pilates mat favors spine flexion and a balance between spine available motions is advisable. Mat exercises work in chains and the right execution of movements is key to take the dancer beyond. Exercises on the machines constantly mimic mat exercises, and the springs used facilitate or make the exercises even harder. Repetitions of each posture/exercise do not go above 8 times in general. Then, for endurance, different postures are used to activate the same muscle group in more sets and repetitions. Super advanced Pilates is geared towards more gymnastics movements, requiring full body activation and a lot of control.

2.2 Scientific data

Unfortunately, until this day, there is a scarce number of well-designed studies about Pilates and dance, showing there is a lack of medical scientific information in the area, and a weak support to account for the effectiveness of Pilates in dance (Bergeron et al., 2017). Bernardo et al. (2006), for instance, published a literature review about Pilates training in dancers and found that just five clinical trials were scientifically sound. The weakness on the scientific data was related to research methodology: small sample size, no determined statistical power and lack of true experimental designs. The authors suggested more studies should be developed with control groups and randomized subjects, calculation of statistical power and use of valid and reliable methods to measure outcomes.

Bergeron et al. (2017) published another systematic review about Pilates and dance, and 11 years after Bernardo and Nagle's first review, only nine well-designed clinical trials were found. Again, the majority of the studies in the area were considered poor in quality, according to PEDro scale's rules, presenting lacked blinding protocol, insufficient statistical data, and using assessment methods that are not specific for dancers. These authors concluded that Pilates in dance is effective in improving muscular conditioning and flexibility, but appears to be ineffective to increase vertical jump and balance.

Studies that could contribute for the understanding of what Pilates effects in dance are, from 1996 to 2018, added in a chronological order, include Self, Bagley, Triplett, & Paulos (1996), that analysed knees ranges of motion (ROMs) (flexion and extension) and forces in play during *demi-pliés* in *fifth* and *first positions* in standing, and on the Pilates Reformer with two and with four springs engaged. The subjects were 5 males and 5 females, 16-31 years of age, of a professional ballet company in the USA. The results showed that the subjects had greater ROMs in the *first position*; and female dancers had more extension than males. The highest force in the knee was obtained on *demi-plié* in standing and the largest knee flexion angles were on the Pilates Reformer with four springs added.

McLain, Carter, & Abel (1997) developed another study using Pilates exercises on the Reformer as a training protocol. They analysed 24 dance students from California State University/USA; 14 in the experimental group, exercised for 8 weeks on the Reformer, and 10 in the control group, received no Reformer classes. The jump height from a supine position on the Reformer and the pelvic alignment in jumps in standing (parallel and *first position*) were evaluated. No significant difference was found between the groups in jump high in the supine position after 8 weeks of intervention; nonetheless, each group showed significant improvements. The alignment of the pelvis did not improve after the Reformer training protocol, showing Pilates has no significant impact on this variable while executing jumps from standing.

McMillan and colleagues (1998) also designed a study to examine the effects of a Pilates-based training on ballet dancers' dynamic postures during *grand plié*. Participants were 10 young dancers from the École Supérieure de Danse du Québec, divided into control and experimental groups. The experimental group trained individually twice a week, for three months (23 classes), with a Pilates teacher in matwork and Reformer routines; and did some mat exercises as homework. The control group continued its normal routine. The vertical alignments of the head, shoulder, and pelvis on the anterior-posterior axis during *grand plié* were measured before and after the Pilates-based training. The experimental group was more stable in the upper body than the control group. These results indicate Pilates on the Reformer could improve dynamic alignment of the torso in ballet dancers.

In a study conducted by Albuquerque (2006), it was verified that contemporary dancers who practiced Pilates had improved technique, proprioception and concentration, which led to more fluid movements. Amorim et al. (2011), Amorim, Sousa, & Santos (2011a) and Leitão, Silva, & Rasia (2013) also found that Pilates can significantly improve muscular strength and flexibility of classical dancers; being a promising tool to be used as supplementary training to ballet dancers.

Wang, Lin, Huang, Liang, & Lee (2012) examined the effects of an 8-week Pilates training program on the ability to maintain dynamic bilateral and unilateral postural stability on static or unstable surfaces, and abdominal muscle strength in young dancers. The participants were 25 female dancers, randomly assigned as experimental or control groups. All subjects received the same dance lessons but the experimental group underwent extra Pilates mat classes for 40 minutes, three times a week, for 8 weeks. The results showed that an 8-week Pilates training program could improve the limits of stability and abdominal strength in young dancers.

Amorim et al. (2011a) developed another comprehensive research in which they verified whether Pilates could be used as a tool to improve ballet dancers' performances. In their study, 15 ballet dance students were tested on how long they could sustain their legs raised while performing a *developpé* at the barre. They also verified the dancers' active flexibility (*developpé* height front, side and back) for both legs. Results showed that all dancers who participated in the Pilates sessions increased strength and flexibility, adding between 4-10° to their *developpé* height. These authors state Pilates was effective because the dancers learned to continuously engage the abdominals, hip flexors and gluteus muscles, which caused muscular adaptation, thus contributing to a stronger core, leading to an increased ability to hold their *developpés* for a longer period of time (nine seconds longer, on average).

Additionally, Amorim et al. (2011a) suggest that teachers should be aware of the importance of conditioning outside the dance classes, not only to improve performance but also to protect dancers from injuries. Pilates is recommended because it develops capacities crucial for dance performance, without neglecting the artistic component. They state that Pilates has principles very close to dance technique and uses movements very similar to certain dance technical skills. By emphasizing breathing, alignment, positioning and abdominal work, Pilates can support dancers in the development of optimum dance technique. Pilates approaches the needs of dance technique, making it possible to develop dancers' physical capacities in a specific way.

Recently, Ahearn, Greene, & Lasner (2018) designed a study to examine the effects of Pilates training on pelvic alignment, strength and flexibility in dancers. The participants were 20 female dancers, from 17-22 years old, from two post-secondary dance programs and one performing arts high school in the USA. They participated in a three-stage screening: Screening I – in the beginning of the study; Screening II – after 14 weeks of normal dance and exercise classes; Screening III - after a 2-hour pelvic alignment workshop followed by two weekly Pilates training (Mat and Apparatus) for 14 weeks. The Screening tests consisted of an AlignaBod posture assessment, double leg lower test (DLL), upper abdominal manual muscle test, modified Thomas test, and hamstring flexibility test. After Pilates intervention, the number of postural misalignments (prevalence of forward head posture, knee hyperextension, and foot-ankle pronation or supination) decreased significantly; the prevalence of iliotibial band and hamstring lack of flexibility had a significant decrease; and lower abdominal muscle strength improved significantly. All participants reported they felt that Pilates improved their core stability, pelvic alignment, strength, and body awareness.

CONCLUSIONS: IS IT TIME TO RETHINK DANCE TRAINING?

In BR and UK pre-professional and professional dance, the common dance training scenario fosters the emergence of athleticism and aesthetics from the dance technique classes, which focus basically on skill acquisition, working with general strength/endurance, flexibility, balance, timing, rhythm and orientation in space (Bittar, 2015). Conditioning seems to be included when overload and pain starts kicking in, and may develop muscle strength and power, flexibility, anaerobic and aerobic capacities, core stability and agility (Koutedakis & Sharp, 1999; Rafferty, 2010; Wyon, 2018). Somatics and Pilates are additions that normally follow through when dancers become injured, as well as adding constructive rest, neural integration, stability and alignment to dancers' daily routines (Bittar, 2004, 2015, 2017).

While regular dance class is essential to excel in a specific dance technique, it bypasses certain muscle groups and it does not raise the heart rate sufficiently (Hamilton, 2015). According to Krasnow and Chatfield (1996), dance classes exist primarily to: "[…] broaden one's movement vocabulary and skills, to develop one's musicality and phrasing, and to enhance one's unique creativity and expressiveness through a particular voice or style." (p. 162). In this case, an individualized cross-training program can help improve areas of weakness and increase fitness levels such as strength, flexibility or cardiorespiratory endurance, therefore decreasing risk for injury (Wyon, 2018). Koutedakis et al. (2007) and Angioi (2012) reported that contemporary/modern dancers who participated in just two-three hours of supplemental fitness training per week, adding a circuit-like training with weights and functional exercises, and exercises on a vibration machine, not only improved their physical fitness, but also their aesthetic competence.

Pilates claims to work with principles very close to dance, while also introducing a mind-body conditioning training that uses corrective exercises, verbal cues, imagery and touch inputs, not usually found in dance technique classes. This method targets a more precise use of the whole body, its inner and outer musculature, through the application of integrated eastern/western exercise and therapeutic philosophies and principles (Bittar, 2004, 2015, 2017; Komeroski, Dallagnol, & Haas, 2018). According to Wyon, et al. (2007) some professional ballet dancers that do supplementary training, including cardiovascular, weights and Pilates, have self-reported higher aerobic power and power capacity (jump height).

At the same time, Somatics relies largely on augmented sensory processes (in stillness and movement) (Batson, 2007), that triggers a better understanding, dialogue and use of the body through listening deeply to it (Eddy, 2009). The use of Somatics may help dancers manage pain, move more easily, and perform with greater vitality and expressiveness (International Somatic Movement Education and Therapy Association [ISMETA], 2019). Somatics techniques support homeostasis, co-regulation and neuroplasticity, adding postural and movement evaluation; experiential anatomy; and movement patterning that increases efficiency, while refining perceptual, kinesthetic and proprioceptive sensitivity (ISMETA, 2019).

In programming the utmost complete dance training, awareness of supplemental training techniques is only the beginning. It is also key to understand that professional dancers develop, via technique-specific modalities, strategies that are often based on multimodal and sensory-motor integrations. These strategies elicit somatic motor (equilibrium, postural control and energy expenditure), and cognitive (memory, learning and attentional) processes, making them accessible for higher cognitive functioning (Bläsing et al., 2012). Moreover, dancers can adapt those strategies to external acoustic or visual cues and touch:

> Therefore, even though dancers' movement expertise can be examined and described via biomechanical measures (see Krasnow, Wilmerding, Stecyk, Wyon, & Koutedakis, 2011), physical skills in dance can hardly be regarded separately from the cognitive functions and strategies that enable dancers to make use of them in a way that makes dance an art form (Bläsing et al., 2012, p. 302).

One specific strategy developed by dancers is the use of proprioception, and not vision, in order to enhance postural control and dynamic equilibrium maintenance (Golomer, Dupui, Sereni, & Monod, 1999; Jola, Davis, & Haggard, 2011; Ramsay & Riddoch, 2001). However, this is not true for static equilibrium tasks, in which dancers still depend heavily on vision (Golomer et al., 1999; Hugel, Cadopi, Kohler, & Perrin, 1999; Perrin, Deviterne, Hugel, & Perrot, 2002). Furthermore, dancers apparently achieve control of complex movements by optimizing motor synergies and consequently reducing energy costs in terms of force and muscle tension (Wilson, Lim, & Kwon, 2004; Lepelley, Thullier, Koral, & Lestienne, 2006).

In the motor learning realm, different theories in the last few years have been questioning the paradigm that skilled performance is only acquired through strenuous repetition (Karni et al., 1998; Korman, Raz, Flash, & Karni, 2003). A tapered practice, involving reduction of the training load, and a balance between volume and intensity of work (Batson, 2007; Wyon et al., 2007), promotes efficiency in motor performance and fitness parameters. Equilibrium of the rest-to-activity ratio in dance practice needs to be fostered urgently. Repetitive dance practice may induce alterations in the muscle chemistry and sensitivity of the muscle spindle, leading to rapid modulation in the primary motor cortex. Byl and colleagues (Byl & Melnick, 1997; Byl, Nagarajan, Merzenich, Roberts, & McKenzie, 2002) presented an "aberrant learning hypothesis for repetitive strain injury," in which repetitive motion could result not only in a peripheral injury, but in the creation of a brain "strain" or "engram" that might activate degraded patterns of movement.

Gentry and Feron (2004) also discovered that dancers use attention to maintain synchronicity in performance in different ways. In this case, physical contact between dancers facilitates synchronicity between them in an even more distinct manner than musical cues. Learning and memory have also been found to be different in dancers (Bläsing et al., 2012). Jean, Cadopi and Ille (2001) discovered that sequences of dance movement are better recalled if they are structured (e.g.: ballet sequences with determined steps and rhythm) and not unstructured, such as in some modern dance.

How could one re-think dance training based upon all of the above? Would it be possible to consider that dancers need special attention and guidance when lifting weights, so that proprioception, alignment and breath are further addressed? Pilates and Somatics' instructors, on the other hand, could be aware of the different strategies used to build strength or flexibility, applying those to their classes? Therefore, the question posed is: would it be possible to use all necessary conditioning, Somatics and Pilates and mix paradigms from science and dance to create a state-of-the-art manner of training dancers, or, better yet, a so called poetic preparation (Bittar, 2004; 2015; Bittar et al., 2017), from which dancers would benefit the most (Table 1)?

Within dance training, it is extremely difficult to adjust all the activities required for the programming of an adequate training regimen that could address the entirety of the needs of the well-rounded dancer. The reasons for this range from a lack of full somatic awareness by professionals, a lack of provisions and time in order to organize those needs, and cultural beliefs that prohibit changes or modifications from occurring (e.g.: supplemental training hours are not added to dancer's contracts in professional companies; dance companies often struggle to put these changes in place, etc.).

Table 1 – *Training and Educating Dancers to Better Develop Multimodal Integration and Motor Control Strategies*

<table>
<tr><th>Strategies</th><th>Training</th></tr>
<tr><td>Improved postural control and balance maintenance (proprioceptive system)</td><td rowspan="4">Emphasize breathing, alignment, positioning, exercise sequencing and use of verbal, images and tactile cues in classes, rehearsals and conditioning; balance rest-activity ratio; add constructive rest; Pilates matwork or in equipments; or Somatics; 30-45 mins; 1-2 times/week</td></tr>
<tr><td>Enhanced static balance (visual system)</td></tr>
<tr><td>Motor synergy optimization and lower energy expenditure (adapted muscle tension and strength)</td></tr>
<tr><td>Use attention following a leader, music tracks, physical contact and movement dynamics to maintain synchronicity</td></tr>
</table>

Nevertheless, the incorporation of supplemental training, such as conditioning, Pilates and Somatics into dancers' schedules, must take into account their present workloads, which can already involve six to eight hours a day of exercise at varying intensities. Timing here is key. Conditioning training sessions need to be scheduled preferably at the end of the day to prevent fatigue from interfering with the high-skill elements of dance. If this is not possible, at least a 2-hour recovery period is needed after strength training, and an hour after cardiorespiratory training, before dancers can return to their routines (Wyon, 2018). The selection of exercises can be tailored to the choreographic demands, if these are known in advance (Amorim, Sousa, Machado, & Santos, 2011; Angioi, Metsios, Twitchett, Koutedakis, & Wyon, 2009). A fitter dancer is more able to concentrate, suffers less often from fatigue and is therefore potentially less at risk of injury, presenting better movement efficiency and performance excellence (Laws, 2005; Rafferty, 2010; Angioi et al., 2009).

Considering Somatics and Pilates, these could also be added to the dancer's schedule and should be largely dependent upon each dancer's individual training necessities, in order to improve fine control of movements through the development of a finely tuned kinesthetic awareness (Batson, 2007; Eddy, 2009; McMillan, Proteau, & Lebe, 1998; Amorim, Sousa, & Santos, 2011a; Albuquerque, 2006). Separate and distinctly different from traditional conditioning, these activities could be scheduled either before or after the dancer's daily work activities, with at least an hour recovery period should they be done before those (Bittar, 2015).

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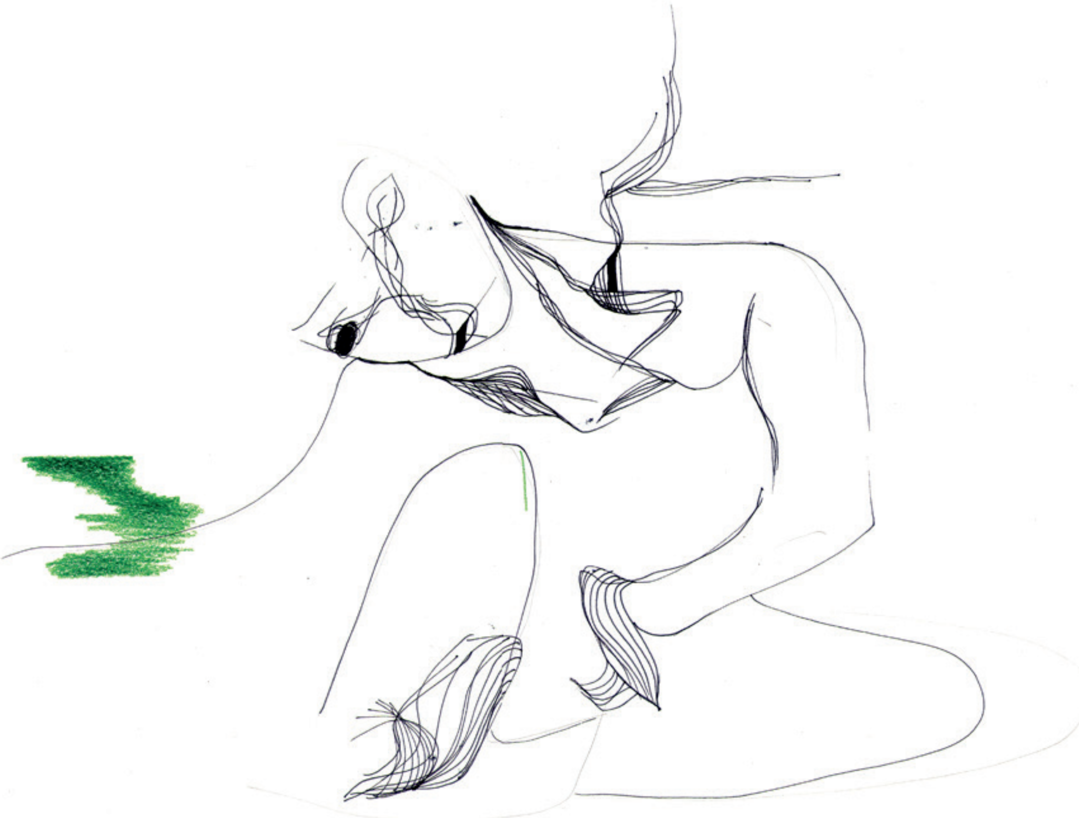

Célula Corporal MADAM. Autora: Anna Behatriz, 2012. Ilustração em papel Canson. 21x29,7cm.
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SECTION III

TREATING DANCERS

CHAPTER 8

INJURIES IN DANCE: DEFINITIONS, SEVERITY, RATES, PREVALENCE, TYPES AND RISK FACTORS

Ross Armstrong / Adriano Bittar

INTRODUCTION

Previous systematic reviews (Hincapie, Morton, & Cassidy, 2008; Jacobs, Hincapie, & Cassidy, 2012; Allen, Ribbans, Nevill, & Wyon, 2014; Kenny, Whittaker, & Emery, 2016; Armstrong & Relph, 2018) have associated high risk of injury with dance, regardless of genre and level. Injury can have a significant impact on a dancer's health and well-being. Therefore, it is vital that the dance world continues to strive to enhance understanding of injury development. This is necessary for the appropriate implementation of injury prevention practices via collaboration within Sports and Dance Medicine (DM) teams, that may include physiotherapists, doctors, rheumatologists, nurse practitioners, strength and conditioning coaches, dance teachers and sports and dance scientists.

This chapter contains an overview of the current understanding of Dance Medicine and Science (DMS) regarding dance injury, including definitions, rates and risk factors. More than a focal phenomenon, injury in dance represents a complex biopsychosocial entity. Thus, it should be managed through the promotion of awareness and consideration of dancers, their injury and social environment. A range of rehabilitation interventions will only be adequately applied to minimise the impact of an injury if there is a clear definition and perception of it, either biologically, psychologically or socially speaking.

1 INJURY DEFINITIONS AND SEVERITY

Difficulties in interpreting dance injury studies have been highlighted by a systematic review and meta-analysis (Armstrong & Relph, 2018) which investigated dance screening tools as a predictor of injury in all dance levels, ages and genres. Of the 42 studies that fulfilled inclusion criteria, only 25 studies provided definitions of musculoskeletal injury, and these lacked consistency. Furthermore, in only 8 studies the diagnosis was made by either a physiotherapist (PT) or a medical doctor (MD), and only 5 studies defined the injury and had the diagnosis made by a PT or MD. Injury studies often use self-reporting of injury. However, this practice can be limited by a lack of injury knowledge, and may result in both over-reporting and under-reporting of injury. With regard to providing a specific injury diagnosis, it is possible that with self-reporting of injury the source of referred pain may be misinterpreted, e.g. pain that has developed in the hamstring muscle group may in fact be referred pain from the lumbar spine. This highlights the importance of a qualified healthcare professional providing a differential diagnosis if possible.

Therefore, despite the reported high incidence of injury in dance (please refer to item 2 of this Chapter), there is no consensus about the definition of injury. Three definitions for dance-related injuries commonly used are: (1) “time-loss” (an inability to complete one or more classes, rehearsals or performances for one or more days beyond onset) (Allen, Nevill, Brooks, Koutedakis, & Wyon, 2012); (2) "medical attention" (an injury that requires the medical attention of a healthcare professional, but does not result in an absence from dancing) (Kenny, Palacios-Derflingher, Whittaker, & Emery, 2017); (3) any complaint sustained by a dancer resulting from performance, class or rehearsal, and resulting in a dancer injury report or triage (Bronner, Ojofeitimi, & Mayers, 2006).

The definitions of dance injuries relating to "medical attention" and "time-loss" may underestimate the burden of injuries in pre-professional contemporary and ballet dancers (Kenny et al., 2017). "Medical attention" injuries can result in over-reporting of injury. To increase robustness of reporting, both methods could potentially be used to allow comparison (Armstrong, 2019). However, "time-loss" is the most effective method, and is utilised in the recording of injury in sports as well.

Lee, Reid, Cadwell, & Palmer (2017) classified injury using Bronner and colleagues' (2006) definition, and then sub-classified, based on current recommendations (Liederbach, Hagins, Gamboa, & Welsh, 2012; Fuller et al., 2007; Finch & Cook, 2013; Dick, Agel, & Marshall, 2007; Bowerman, Whatman, Harris, Bradshaw, & Karin, 2014). Lee et al. (2017) included "time-loss" or non "time-loss", nature of injury (e.g. acute or overuse), and if an injury was new or recurrent. Recurrent injuries were further classified as exacerbations or re-injuries. Injury severity was coded as S0 (no days off or modified), S1 (activity modification), S2 ($\leq$ 7 days off), S3 ($>$ 7 days off) or S4 (year ending).

Armstrong (2019) classified injury via differential diagnosis as either a sprain, strain, contusion, fracture, dislocation, disc pathology, or tendinopathy. This classification system enables different injury types to be recorded. The following information was also recorded: (1) injury location; (2) classification of injury type (overuse or trauma); (3) mechanism of injury: jumping, travelling, turning, stretching, landing, collision, and other; (4) type of dance been performed at the time of injury; (5) when the injury occurred: warm-up, class, rehearsal, performance, and other; (6) injury severity: slight (0-1 days), minimal (2-3 days), mild (4-7 days), moderate (8-28 days), and severe (>28 days) (Allen, Nevill, Brooks, Koutedakis, & Wyon, 2012); (7) whether the injury involves the dominant lower limb which can allow for further analysis.

Injury severity can also be measured by "activity modification", that represents the modifications a dancer has made to training load and performance due to injury. Lee et al. (2017) divided activity modification into: (1) "not at all" - no limitations in all classes, rehearsals and/or performances; (2) "minor" - small limitations in all classes, rehearsals and/or performances; (3) "moderate": moderate limitations in all classes, rehearsals and/or performances (e.g. participating in *petite allegro*, but not *grand allegro*, keeping legs below 45 degrees); (4) and "major": dancer is unable to participate in significant components of classes, rehearsals and/or performances (e.g. participating resumes to *barrework*).

Within injury terminology other definitions are utilised, including: (1) "traumatic injury" which results from an identifiable event or macrotrauma, causing inflammation (pain, oedema, redness and heat) for 7-10 days; (2) "overuse injury" which is normally caused by repetitive microtrauma; and (3) "recurrent injury" which is an injury that returns within two months following recovery and the dancer's return to full participation

(Allen et al., 2012). Recurrent injuries could be further classified as either: (1) exacerbations - when a non-recovered injury worsens, and a dancer cannot fully participate in his/her activities; and (2) re-injury - a previously recovered injury happens again within two months after a dancers' return to full participation (Allen et al., 2012). Re-injury can also be defined as an injury of the same type occurring at the same location (Hagglund, Walden, Bahr, & Ekstrand, 2005). "Reported injury" is any defined injury which was triaged, assessed or managed by an appropriately qualified healthcare professional. "Self-reported injury" is any defined injury reported via questionnaire directly from the dancer.

2. INJURY RATES, PREVALENCE AND TYPES

With reference to calculating injury rate, it is advocated that calculations are based upon 1000 hours of dance exposure. Dance exposure can be calculated from the weekly timetables relating the hours of classes, rehearsals and events/performances (Lee et al., 2017).

Dance injury rates of 0.62 injuries per 1000 hours dance (Nilsson, Leanderson, Wykman, & Strender, 2001), 0.77 injuries per 1000 hours dance (Gamboa, Roberts, Maring, & Fergus, 2008), 1.38 injuries per 1000 hours (Ekegren, Quested, & Brodrick, 2014), 2.6 injuries per 1000 hours dance (Luke et al., 2002), 4.8 injuries (males) and 4.1 injuries (females) per 1000 hours dance (Allen et al., 2012), and 5.5 injuries (males) have been reported in ballet dancers. The majority of the literature focuses upon injury rates in ballet dancers. However, in university dance students performing contemporary dance, ballet and jazz, injury rates of 1.03 injuries per 1000 hours dance (Armstrong, 2019) and injury rates of 4 injuries (modern), 1.8 injuries (Mexican folkloric), and

1.5 injuries (Spanish dance) per 1000 hours training have been reported (Echegoyen, Acuna, & Rodriguez, 2010). A study of pre-professional and professional Chinese dancers of different genres reported injuries per dancer of contemporary dance (4.9 injuries), ballet (4.5 injuries), DanceSport (4 injuries), Chinese Classical Dance (3.9 injuries) and Chinese Folk Dance (3.4 injuries) (Dang, Koutedakis, & Wyon, 2020). This study did not record injury per 1000 hours dance.

In classical ballet, the majority of injuries occur in the lower limbs and trunk, with overuse and knee and ankle injuries most prevalent (Nilsson et al., 2001; Luke et al., 2002; Gamboa et al., 2008; Allen et al., 2012; Ekegren et al., 2014). Lower limb injuries were most prevalent in university dancers performing contemporary, ballet and jazz genres (Armstrong, 2019). Within DanceSport, a competitive form of ballroom dancing, a Fit to Dance survey using a self-reported method of injury reporting found the knee, lower back and ankle to be the most common sites of injuries (McCabe, Ambegaonkar, Redding, & Wyon, 2014). As for hip hop and all its sub-genres, it was found that the knees, lower back, neck, shoulders and wrists were common sites of injuries, and that they experienced a greater injury incidence than their modern, ballet, tap and aerobic colleagues (Ojofeitimi, Bronner, & Woo, 2012).

Classical ballet in particular requires a great amount of torso stability and spine mobility, and every effort is made for the spine to stay in axial elongation. Due to the extreme turnout required of these dancers, the lumbar spine is often found in hyperextension, while lower limbs are misaligned (Livanelioglu, Otman, Yakut, & Uygur, 1998; Gontijo, Candotti, Feijó, Ribeiro, & Loss, 2015). It has also been suggested that lumbar flexion and extension and lateral flexion spinal movements are significantly higher in classical ballet dancers (Livanelioglu et al., 1998). Compensating in this manner results in excessive torsion stress of the lumbar spine and lower limbs, predisposing female classical ballet dancers to lumbar and lower extremity injuries (Allen et al., 2012), including: snapping hip syndrome, hip impingement, labral tears, hip bursitis, hip flexor and thigh adductor tendonitis, sacroiliac joint dysfunctions, patellofemoral pain syndrome, shin splints, Achilles tendinopathy, *os trigonum* syndrome, ankle impingement, trigger toe, stress fractures of the metatarsals, tibia, sesamoids and lumbar spine, bunions, lumbar and cervical spine disorders. Due to their lifting requirements and explosive jumping, male ballet dancers may also present with traumatic injuries, accounting for half of their injuries (Smith et al., 2016). In this case, sites most often injured are lower back, ankle, knee and foot (Novosel, Sekulic, Peric, Kondric, & Zaletel, 2019).

Contemporary, jazz, DanceSport and hip hop dancers' injury rates are also frequent, with lower limb injury particularly prevalent (Baker, Scott, Watkins, Keegan-Turcotte, & Wyon, 2010; Ojofeitimi & Bronner, 2011; Ojofeitimi et al., 2012; McCabe et al., 2014; Pitta, Sacco, & Picon, 2016). Contemporary dance pushes anatomical boundaries in unexpected ways, demanding versatility of dancers (e.g., improvisation, inversions) (Van Winden et al., 2019) that might be detrimental to health. It has been suggested that in contemporary dance, mechanical overload injuries are directly related to diminished lower-extremity strength (Koutedakis, Khaloula, Pacy, Murphy, & Dunbar, 1997; Angioi, Metsios, Koutedakis, Twitchett, & Wyon, 2009). In jazz dance, combinations of hyperflexion/hyperextension of the spine, falls and kneeled movements are considered as very straining motions (Baumann, Thomas, & Von Salis-Soglio, 2001). In a study conducted by Pitta et al. (2016) jazz dancers reported their lower-extremities cartilages to be the main sites for injury. Dancesport is a genre that might be classified as a very heavy to extremely heavy category in energy expenditure, utilizing both aerobic and anaerobic energy systems (McCabe et al., 2014). It involves fast and acrobatic moves and sites often injured are the neck, shoulder, spine, knee, lower leg, and foot.

Generally speaking, a higher incidence of knee and lower back injuries is reported in hip hop dancers, either it being breaking, locking, popping or new school, such as krumping, Harlem shake, house or street jazz (Ursej, Sekulic, Prus, Gabrilo, & Zaletel, 2019; Ojofeitimi et al., 2012). This is because of the flexion and screw-type extension performed at differing changes in speed and direction. Moreover, wrists, shoulders and neck are also prone to injury, due to the weight bearing gestures that are common specially in breakers, that have a higher total injury and upper extremity injury incidence compared with Popper/Lockers, and New Schoolers (Ojofeitimi et al., 2012). This same study demonstrated that concerning the types of injuries sustained, breakers refer more bone/stress fracture lesions. Injuries to joints and ligaments were similar in all hip hop dancers participating in the survey, and muscle/tendon injuries were higher in popper/lockers. It is important to notice that from all the hip hop dancers participating, 50% reported overuse as the most common injury mechanism.

3 INJURY RISK FACTORS

Injury risk is multifactorial, and dancers are exposed to a variety of intrinsic and extrinsic injury risk factors throughout their careers. Extrinsic risk factors include flooring types, which combined with the touring schedules that dance companies are required to do, and the various surfaces dancers are exposed to (hard floors, raked/inclined stages, etc.), may increase injury risk (Hopper et al., 2014). Dance surfaces should generate and absorb energy evenly, but not to the point of deforming permanently, and therefore be neither too elastic or rigid. So, the excess force produced by contact with the ground can be attributed to a variety of factors, including inappropriate surfaces, technical failure, inadequate training and footwear (Wanke, Mill, Wanke, A., & Davenport, 2012).

An additional extrinsic factor is footwear, which is important in the absorption of ground reaction forces (Shippen & May, 2010; Wyon, Cloak, Lucas, & Clarke, 2013). It is vital that dancers utilise footwear that is appropriately fitted. Investment should be made in good quality soft and pointe shoes (ballet), sneakers (urban dance genres), boots (Flamenco) and high heels (DanceSport and belly dancing). The sole of dance footwear must be composed of materials that allow sliding on different surfaces and do not interfere with movement, because the increased friction with the ground can accelerate the fatigue process (Walter, Docherty, & Schrader, 2011). Research also reports that increased midsole thickness of dance shoes has a poor influence on landing stability (Wyon et al., 2013). Other equipment considerations include head pieces, which may associate with the development of headaches, neck pain and stiffness.

Intrinsic injury risk factors may include anatomical variation, muscle strength and joint range of motion (ROM). Dance training and performance requires repetitive movement and the absorption and dissipation of large forces (Leanderson et al., 2011) which intensifies demands on the dancer's body and increases injury risk. These high forces combined with movements that often exceed normal anatomical range can potentially result in injury (Luke et al., 2002). Chronic overuse injuries typically occur due to repetitive submaximal loading of the musculoskeletal system with insufficient periods of recovery (Leanderson et al., 2011; Luke et al., 2011) and repetitive movement patterns may result in micro-trauma and injury development (Fietzer, Chang, & Kulig, 2012).

In dance, movements may exceed normal anatomical ROM to obtain aesthetically appealing positions which may increase injury risk (Luke et al., 2002). Joint hypermobility (JH) is the capability of a joint to move passively, and/or actively, beyond normal limits along physiological axes (Castori et al., 2017) and can be evaluated via the Beighton Score[84] (Beighton, Solomon, & Soskolne, 1973), which assesses five joints that provide a maximum score of 9. The high prevalence of lumbar flexion in dancers has been recognised as a performance adaptation and therefore this should be considered when determining JH via the Beighton Score (Klemp & Learmonth, 1984; Klemp, Stevens, & Isaacs, 1984; Armstrong, 2018). JH allows for a broader variety of gestures and more desirable aesthetics, especially for classical ballet dancers. JH has been associated with and increased risk of injury in dance (Klemp, Stevens, & Isaac, 1984; Zikan, 2018, 2019; Armstrong, 2019) and dancers with low (0-2) and high Beighton Scores (5-9) were found to be more likely to sustain injuries than mid-range scores (Bronner & Bauer, 2018).

Due to the performance demands of dance, many dancers perform through pain and it has been suggested that dancers have difficulties differentiating between performance pain, considered

84 For further information about joint hypermobility, see Chapters 5 and 6.

as a normal product of a dancer's routine, and injury pain, that could prove to be detrimental and of concern to general health (Anderson & Hanrahan, 2008). Dancers are therefore required to apply appropriate coping strategies to reduce injury risk[85]. Nevertheless, it has been suggested that dancers sometimes utilise and inappropriate warm-up or cool down, and have insufficient sleep, in addition to excessive alcohol intake, cigarette smoking and use of illicit drugs (Laws, Apps, Bramley, Parker, & Dance UK, 2005).

CONCLUSIONS

As a minimum, it is recommended that studies should provide a definition of musculoskeletal injury and have the diagnosis made by a healthcare professional, ideally a PT or a MD. Furthermore, the inter and intra-rater reliability and validity of injury surveillance that is utilised should be reported. To enhance the understanding of dance injury there is requirement for the duration of dance rehearsal to be recorded to allow the calculation of injury rate and exposure data. Position in the company, floor surface and time point in the season all require consideration, and studies should report the injury severity and duration and provide an injury definition (Armstrong & Relph, 2018). Injury reporting can be prospective and retrospective. However, injury surveillance should favour prospective design to reduce the potential for recall bias which can lead to injury over-reporting. Consideration of these factors should enhance the quality of injury reporting in the future and enable more effective management of dance injury.

85 Refer to Chapter 10 for more information on the psychological well-being of dancers.

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CHAPTER 9

MEDICAL CARE, SCREENING AND MEDICATION IN DANCE

Izabela Gavioli / Adriano Bittar

INTRODUCTION

In pre-professional and professional dance genres, technique mastery is critical, with an overarching belief that dancers must practice or perform every day. This belief is one of the reasons why many professional female classical dancers start dancing at an early age, around five or six years old, and the constant effort to attain perfection, control of gestures and movement dynamics lead to overuse injuries that can be very debilitating. Therefore, dancers often have different types of injuries when compared to athletes, as a result of a combination of long training hours, little supplementary physical fitness training (Laws, Parker, Apps, & Bramley, 2005; Wyon et al., 2007; Wyon, 2018), lack of rest (Batson & Schwartz, 2007) or poor diet (Ravaldi et al., 2003).

Risk factors for injury in professional or vocational dancers could be classified as intrinsic and extrinsic (Solomon, 1990; Solomon, Solomon, Micheli, & McGray, 1995; Russel, 2013; American Orthopedic Society for Sports Medicine, 2010). Extrinsic factors include genre; frequency of classes, rehearsals, and performances; duration of training; environmental conditions and equipment used. Intrinsic factors are related to: individual dancer's body alignment, motor skills, prior history of injury, psychological state and nutritional deficiencies.

There is a growing community of Dance Medicine (DM) expert professionals that delivers quality services to help dancers. This community may be constituted by medical doctors (MDs), physiotherapists (PTs), psychologists (Psys), massage therapists (MTs) and nutritionists (RNDs), to name a few. Their goals are to, as a team, comprehensively assess, prevent and treat dance-related injuries and disorders.

This chapter provides an overall perspective of what MDs do whenever treating dancers: what kind of diagnoses they are trained to do, diagnostic tools, pharmacotherapy, surgeries most often performed and emergency services. Moreover, it presents an overview of which medical services specialised in dance are available in Brazil (BR) and the United Kingdom (UK).

1 MEDICAL CARE, SCREENING AND MEDICATION IN DANCE

Medical care is focused on providing the best support for dancers with injuries, to ensure their safe practice and return to performance as quickly as possible. It is critical to keep dancers dancing and integrated into the class or company as allowed by the limitations of the injury (Hrubes, 2018), because the time taken off work can affect negatively their performances, also creating unnecessary anxiety. Efficient treatment of dance injuries happens when skilled clinicians can understand the complexities of the causes of each injury by creating a specific plan of treatment for a dancer committed to independent management of it. This is only possible when clinicians and dancers properly communicate with each other and there is an understanding of the processes related to healing (Liederbach, 2010; Lai, Krasnow, & Thomas, 2008).

Although it is believed that MDs and the Dance Medicine & Science (DMS) team have a great impact on implementing prevention strategies, this is not always the reality of dance schools or companies. Even though, early and ongoing assessments of the dance environment, dancer's physical conditions and weaknesses should be thought as a team effort; time management in a dance company or school is key and it is difficult for teachers, directors, choreographers, dancers and the health team collectively agree upon what is best and adhere to plans and modifications suggested. The effective dance health team aims to put in place a pre-season screening and verify previous injury history of dancers to identify risk factors for an early detection of injuries. This would allow prehabilitation interventions that correct biomechanics and continually assess the dancers' progress throughout treatment itself (Howse & Hancock, 1988; Bronner & Bauer, 2018).

There are several educational outlets for non-surgical medical professionals that decide to work within the DMS field. In general, MDs that normally evaluate and treat dancers are often trained as Sports Medicine, Performing Arts Medicine, or Rehabilitation Medicine. They can be primary care sports MDs that are usually trained in rheumatology, rehabilitation medicine or other clinical medical specialties, as most cases in dance rehabilitation should be managed by non-surgical MDs, since the injuries that dancers present generally do not require surgery. Surgical treatment should be reserved for situations of absolute failure to conservative (non-surgical) treatment, including the clinical care of a multidisciplinary team. One should keep in mind the permanent limitations that may be associated with surgery and the longer recovery time. A clinical treatment may also provide valuable information about technical errors that may have led to injury, and the change in biomechanical habits that may prevent relapse or new injuries resulting from the same error.

Most clinical medical specialties can contribute to the dancer's health, since they go through their regular training, before specializing in a specific area (Kater, 2001). Even though this is true, dancers normally seek help initially from a physiotherapist (PTs), who would refer on to a medical specialist for non-musculoskeletal dysfunctions. However, if needed, musculoskeletal doctors can provide the triage diagnosis as the majority of complaints are musculoskeletal. Cardiologists and lung specialists can adequately assess cardiorespiratory issues, like asthma or congenital heart problems, for example. Endocrinologists might be able to help in growth, sexual maturation and thyroid problems. Rheumatologists, being the clinical specialists of the locomotor system, may be the professionals to address any illness that affects this system, including autoimmune diseases like Systemic Lupus Erythematosus or Rheumatoid Arthritis. Osteopenia, osteoporosis and vitamin D deficiency can usually be assessed by rheumatologists, as well as endocrinologists. Psychiatrists contribute to the health of dancers too, as mental health issues like performance anxiety, bulimia, anorexia, depression, abnormal body perception and adjustment disorder are relatively common among dancers. Collaboratively speaking, any physician who is familiar with dance practice, is attentive, has a clinical holistic reasoning and is sensitive to the dancers' needs (De Romo, Aliseda, & Arauz, 2008) could potentially treat dancers. It is considered to be an advantage if the physician has been a dancer.

It is important to differentiate disease diagnosis from musculoskeletal, biomechanical or syndromic diagnoses. Nosological diagnosis results from clinical investigation, defines a disease, classifies and differentiates it from other diseases with a similar clinical picture (Lifshitz, 2009). Generally speaking, disease diagnosis is a primary assignment of the physician (Guimarães & Rego, 2005). Musculoskeletal, biomechanical or syndromic diagnoses identify and address functional aspects of a particular complaint; proposed therapeutic measures are non-pharmacological and often inserted into a global treatment strategy.

Thus, for example, a young female dancer with low back pain will be firstly evaluated by a PT at a school or company, to rule out any musculoskeletal problem that could be dealt with locally, before referring on to MDs. At the medical office, this dancer would be evaluated nosologically to determine whether she has nephrolithiasis, disc tuberculosis, autoimmune myelitis or a simple mechanical low back pain. It is very important that the multidisciplinary team has a cordial and collaborative attitude among its members, since all the spheres of attention, diagnosis and correct treatment strategy will only benefit the patient.

Regarding the musculoskeletal system, most common diagnostic tools in medical care include blood tests, X-rays, ultrasound-guided examination, computed tomography (CT), or magnetic resonance imaging (MRI). Eventually, Nuclear Medicine methods (such as scintigraphy) and also thermography may also be needed (Guermazi et al., 2017). When considering the overall health of the dancer, routine follow-ups may include cardiorespiratory tests (ergospirometry, cardiac ultrasonography, chest X-ray, etc.), abdominal ultrasonography, biochemical and metabolic examinations, and adequate protocols for each age group. In the case of teenagers, it is important not to forget the gynecological and urological follow-ups as needed (Schneider, Seither, Tönges, & Schmitt, 2006).

In the treatment of dancers, there is a restricted role for pharmacotherapy. The use of medications in dance medicine should be approached with great discretion and caution. Pain-relieving drugs, such as analgesics, opioids (narcotics), anti-inflammatories (hormonal or non-hormonal), or miorelaxants can mask the intensity of the symptom and act contrary to the improvement and rehabilitation (Harrison & Ruddock-Hudson, 2017). The perception of pain is important to regulate the possible level of effort at a certain point in the therapeutic process. Many dancers have a high degree of resistance to pain, either by a stoic personality profile or by the professional demands of this art form (Tajet-Foxell & Rose, 1995). It is advisable to use analgesics very carefully, in the case of significant discomfort or in really acute situations (symptomatic use). In these cases, the use may be oral or injectable. Although these medications are available for sale with no medical prescription ("over-the-counter" - OTC medications), their use should be monitored by the MD, and they should be discontinued as soon as possible.

The use of anti-inflammatory drugs deserves special consideration. Hormonal anti-inflammatory drugs (cortisone derivatives) have extremely rapid and potent analgesic and anti-inflammatory action. As OTC medications, they represent a significant consumption appeal among dancers who want quick responses to their issues. These drugs, however, have significant and undesirable acute side effects, such as fluid retention, increased appetite (with consequent increase in weight), mood fluctuations, changes in blood pressure and sleep. If used chronically, the risk of diabetes, arterial hypertension, osteoporosis and Cushing Syndrome increases considerably (Konstantinidis, Papageorgiou, Kyrgidis, Tzellos, & Kouvelas, 2013). Even when used intermittently, it takes the user to rely on the fast and seductive effect for an immediate, but highly self-defeating, medium and long-term result. Corticosteroids also affect the integrity of connective tissue, increasing the chances of weakening and rupturing tendons. The use of corticosteroids, therefore, whether oral or injected, must be strictly prescribed and accompanied by the MD. Articular or periarticular infiltrations of corticoid should not have periodicity greater than every six months; in case of continued need, other factors should be considered in the treatment, such as technical errors and biomechanical conditions that are enabling the continuation or recurrence of the injuries. It is worth remembering that infiltrations are never a first choice of treatment, because they corroborate the non-holistic approach of many dancers in relation to their injuries (Berthelot, Goff, & Maugars, 2013). They should be preceded by physiotherapy, re-patterning of movements and careful oral analgesia. Therapeutic thinking should always be questioning and preventive, much more than curative.

Concerning acute or subacute musculoskeletal pain, the focus of non-steroidal (or non-hormonal) anti-inflammatory drugs (NSAIDs), has changed dramatically over the past few years. Some of the most marketed medications are diclofenac, ibuprofen, naproxen, piroxicam and nimesulide, among others. They bring on significant gastrointestinal, cardiovascular and renal side effects (Richy, Carmelo, Angel, & Reginster, 2009; Yuan et al., 2016). If it's a fact that decades ago MDs have been prescribing their use for several weeks, at this point in pharmacological research there is no more room for this, especially when it comes to healthy movement restoration. The inflammatory reaction is repairing, promoting local vasodilation, liberation of inflammatory mediators and migration of cells and other figurative elements to the lesion site. Of course, this is desirable for tissue reconstruction, and blocking this mechanism makes no sense at all (Carvalho & Lemônica, 1998). Nowadays, the use of oral anti-inflammatories is acceptable, when it is absolutely necessary, for example, in cases of acute events such as fractures or postoperative. It is easy to have access to non-prescription NSAIDs, and it is common in the circle of peers and dance professionals to have someone always suggesting the use of these medications (Tajet-Foxell & Rose, 1995; Harrison & Ruddock-Hudson, 2017). As practitioners of DM, the rule is to educate and discourage the overuse of these medications, which may have the opposite effect to what is desired.

Topical medications, such as menthol and camphor sprays, and even NSAIDs, can be used with fewer restrictions, as they are expected to have little or no systemic effect. Culturally, they are very well accepted and widely used by dancers and athletes. Even so, they can also play a role in masking pain, and eventually represent an object of psychological support in chronic use (Tajet-Foxell & Rose, 1995; Harrison & Ruddock-Hudson, 2017).

The constant use of medications for some of the dancer's underlying conditions, such as asthma, diabetes, psychiatric conditions, etc., must, of course, be prescribed and controlled by the responsible physician. It is important to address possible interactions between medications discussed in this chapter and the ones constantly prescribed. In this case, physicians should evaluate the present risk-benefit relationship (De Romo et al., 2008).

Other pharmacological options include ultrasound-guided joint infiltrations, platelet-enriched plasma injections, trigger-point infiltration, and periradicular blocks. Traumatic-orthopedic surgeries (foot, ankle, knees, hips, spine, shoulders and elbows) may also play a reconstructive role, maintaining the artistic longevity (Guermazi et al., 2017). However, these resources should be viewed as exceptions and as final means of treatment, after trying all other conservative measures. The adoption of these measurements should always be followed by the multidisciplinary team.

The need for emergency services for injuries resulting from the dance practice may occur, but this situation is rare. The most common injuries that need emergency care are usually ankle sprains, patellar dislocation, rib or extremities fractures, falls from own height or in *portés* (Ramkumar, Farber, Arnouk, Varner, & McCulloch, 2016). The intervention of emergency care doctors and PTs is fundamental in those injuries. In the case of professional dancers, employers should pay special attention to effective recovery period, avoiding performance pressure before the appropriate time. The denial of pain, or its high threshold in dancers, tends to entail a late search for help for these conditions (Tajet-Foxell & Rose, 1995; Harrison & Ruddock-Hudson, 2017). The first symptoms are often consequence of long-standing errors. Before dealing with the injury itself, it is necessary to take care of the anxiety with which many dancers perceive their musculoskeletal problems, and to work essentially with the correction and re-patterning of movements.

Rest has an important role in the rehabilitation of the dancer. In the acute or extremely symptomatic phases, an absolute pause of activities may be required. However, in many situations, relative rest may be the most appropriate. Absolute rest (stopping every activity, "staying in bed") has been only used in few occasions in sports and DM, early initiation of rehabilitation being preferable (Southwick & Crupi, 2017).

1.1 Medical Care for Dancers in Brazil and United Kingdom

Information about the dancer's health status gathered by the DM team either in BR or the UK is private and should not be disclosed unless specific consent is given. In their daily routines, DM experts are advised to get consent from all dancers, or parents, especially if they are minors of age, for all types of treatment.

Although Brazilian and British DM staff keep up-to-dated in the run of services for dancers, the reality is that dancers often have very little financial support to maintain health or to heal themselves. Usually, Brazilian dancers in small project companies work as contract employees, and do not receive employment benefits due to that. Just the few ones working in bigger and more stable companies, such as the more established ballet and contemporary ensembles, would be hired as salaried employees. The independent self-employed dancer, that typically has to hop from one performance at a smaller venue, to teaching dance classes at a school, or dancing at another singer's gig, has to work harder and face, at the same time, reduced access to free healthcare within the National Health System (NHS).

In the 1960s in BR, *Theatro Municipal do Rio de Janeiro* (*TMRJ*) Foundation employed orthopaedic doctors on a regular basis to assist the entire body of dancers[86]. Nowadays, this service is not available anymore and very few companies

86 Learn more about the history of DMS in BR on Chapter 3.

offer treatments for injured dancers at their headquarters. In BR, it is very complicated to offer specialised medical care for dancers when even the state-funded companies have very little financial support. Not to mention that dance is not well represented politically, making it hard for dancers to fight for their rights, including health and well-being. Otherwise, almost all injured dancers need to either visit sports medicine specialists, rheumatologists and orthopaedic surgeons at the Brazilian NHS, that can be extremely slow in providing help, or in private practice. Should there be the need, they will refer injured dancers to other NHS or private PTs, PEs, Psys or RNDs.

In the UK there is a free health service for dancers through the National Institute of Dance Medicine and Science (NIDMS). NIDMS works with Sport and Exercise Medicine clinics based in NHS hospitals[87] to provide a dance-specific service; currently clinics exist in London, Birmingham and Bath, with more planned over the coming years. At all sites, dancers have free access to specialised consultants, PTs, radiologist and surgeons with the necessary expertise in the treatment of dance injuries and conditions. Dancers need to be referred by their General Practitioners (GPs) in order to have access to these services, and may wait around 4 to 8 weeks to get an appointment.

One Dance UK[88] also offers a private healthcare plan called Performance Optimization Package (POP) for dancers, which includes a cash plan, allowing individuals to be reimbursed up to 700 sterling pounds for private healthcare treatment, including physiotherapy without a GP referral. More expensive POP options include specific assessments, planning of a treatment or injury prevention routine.

87 Learn more about the history of DMS in the UK on Chapter 2.
88 Refer to Chapter 2 to learn more about the One Dance UK.

CONCLUSIONS

It is not about diagnosing and treating just the dancer's pain, range of motion, disorder or strength. MDs and all of the DMS professionals need to have specific knowledge and experience of dance technique and performance, including its vocabulary, related injuries, disorders and their causes, shoes they wear, the different mechanical overloads dancers face in the various dance genres, the psychological stress they endure, a clear definition of dance-centered movement modification and the dancers' routines in companies or as independent workers. Understanding all of that is essential for treating dancers safely and as fast as possible.

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CHAPTER 10

PHYSIOTHERAPY AND PSYCHOLOGICAL WELL-BEING IN DANCE

Adriano Bittar / Ana Rosa
Lucie Clements / Moira McCormack / Ross Armstrong
Flora Pitta / Fernando Zikan

INTRODUCTION

Dance is an art form totally dependent on the artist's body to convey emotion and expression through movement. Perfectionism is a dancer characteristic and maintenance of the ideal, lightweight, athletic physique and a high workload of classes, rehearsals and performances are demanding and stressful. In the profession, the incidence of injury is high with eating disorders (ED) common. With body mass index (BMI) and fat body percentage ideals often far lower than for the general population (Danis, Jamaludin, Majid, & Isa, 2016; Grochowska-Niedworok et al., 2018; Robbeson, Kruger, & Wright, 2015) health and recovery from injury are at risk.

A high incidence of injury in different dance genres has been widely reported by dance science researchers. In elite professional ballet male and female dancers, 1.4 and 1.1 injuries per 1000 hours of dance, respectively, have been observed (Novosel, Sekulic, Peric, Kondric, & Zaletel, 2019). In contemporary dance students, 1.9 injuries per 1000 dance-hours was reported (Van Winden et al., 2019).

In their 2011 enquiry into the efficacy of an in-house dance medicine (DM) programme for a professional modern dance company, Ojofeitimi and Bronner found that the incidence of injury, time loss and injury-related costs were all positively affected. Moreover, an in-house programme offered dancers trusted, experienced specialists with no lost rehearsal time travelling out for treatment, facilitated communication between therapists and artistic management, where stressors in choreography could be discussed and early attention to injuries prevented them from increasing in severity, with an earlier return to dance.

A systematic review by Arcelus, Witcomb and Mitchel (2014) estimated that the overall prevalence of ED in dance was 12.0%, 2.0% for anorexia nervosa, 4.4% for bulimia nervosa and 9.5%for EDs not otherwise specified. EDs might come to the attention of the company, school or colleagues, as the dancer begins to lose weight, energy and health through calorie restriction, vomiting, the use of laxatives or excessive exercise. If such a disorder is diagnosed, a dancer will need to see a doctor, a psychologist and a nutritionist experienced in EDs to verify what the problem is and plan the appropriate treatment.

Other psychological disorders, such as performance anxiety, depression, and abnormal body perception are relatively common amongst dancers, making psychological interventions necessary in this environment (Grove, Main, & Sharp, 2013; Walker & Nordin-Bates, 2010).

In this chapter, experienced health care professionals, such as Physiotherapists (PTs), a Nutritionist (RND) and a Psychologist

(Psys), explain their daily routines with pre-professional and professional dancers. They emphasize the important role played by these professionals in the care of dancers with injuries, nutritional problems and depression.

1 PHYSIOTHERAPY IN DANCE

Physiotherapists are healthcare professionals that use differential diagnosis formulated from subjective and objective assessments which evaluate range of motion (ROM), muscle strength and movement patterns in order to confirm, or add to the diagnosis provided by Medical Doctors (MDs) and implement an individually tailored treatment plan. Their therapeutic intervention is aimed at relieving pain or inflammation, increasing ROM, balance or muscle strength, improving ligament and tendon function, restoring normal movement and dance function and preventing or limiting lasting problems.

Physiotherapists in dance medicine are skilled in manual therapy, and biomechanical analysis, using hands-on treatment modalities, such as joint mobilization, manipulation, soft tissue therapy, taping, orthotics and exercise. Cryotherapy and electrothermotherapy are adjuncts to these. Furthermore, PTs evaluate and diagnose stability dysfunctions, altered movement patterns and proprioception, educating dancers to self-manage by teaching them exercises to activate weaker muscles, correct muscle imbalances and restore fine control (Howse & Hancock, 1988).

Manual therapy techniques utilized in dancers, including soft tissue therapy, influence neural activity and muscle tension, reducing muscle spasm and pain (Lee, Wu, & You, 2009). Massage therapy in university female dancers was found to reduce stress levels, diminishing the incidence of neck and back pain, and improving the mood and ROM (Leivadi et al., 1999). However, a systematic review on sports massage (Moraska, 2005), also used in dancers, argued that despite the fact that some studies showed that muscle soreness associated with delayed onset of muscle soreness is reduced with massage, tissue healing and the psychological effects of massage are still unclear, and further research is warranted.

Joint mobilizations, which involve peripheral joints and spinal mobilization, may also have a hypoalgesic effect (Vicenzino, Paungmali, Buratowski, & Wright, 2001). Furthermore, in a subjective study, semi-structured interviews were applied to dancers that had received osteopathic care for their injuries. It was concluded that these dancers preferred to be treated by professionals that adopted a global physical approach to assessment and treatment of their musculoskeletal pain (Pollard-Smith & Thomson, 2017).

Physiotherapists also apply compression bandaging and taping to dancers, with a variety of techniques. Alternatively, the dancer can be educated to self-administer these techniques, but application by a professional is always recommended. Kinesio taping has been advocated to facilitate skeletal muscle activity through tactile and proprioceptive input, therefore improving function and/or reducing pain (Griebert, Needle, McConnell, & Kaminski, 2016; Lim & Tay, 2015). The use of kinesio taping in professional dancers has also undergone scrutiny. A literature review performed by Berezutsky (2019) revealed that kinesio taping can be effective in reducing muscle spasms, rebuilding muscle strength of the injured area, improving static and dynamic balance and easing pain. Furthermore, it also reduces the risk of overuse syndromes and dance-related injuries during dance training and strenuous exercise.

As for exercise therapy, also called kinesiotherapy, it has been shown that one session of whole body vibration training (WBV) is effective in improving static balance and *sauté* height in female professional contemporary dancers (Karim, Roddey, Mitchell, Ortiz, & Olson, 2019). Dancers in the experimental group underwent a warm-up, and a training session, where they received a 75-second randomly assigned WBV intervention under four conditions: static demi-plié (0 Hz), static demi-plié (30 Hz), dynamic demi-plié (0 Hz), and dynamic demi-plié (30 Hz).

Another study aimed at systematically reviewing the effects of strength and/or plyometric training on functional dance performance in elite ballet and modern dancers (Girard, Koenic, & Village, 2015) reported that strength training resulted in significant improvements in jump height and enhanced aesthetic. Plyometric training was found to enhance both vertical and subjective jump height. Concomitantly, strength or plyometric interventions did not impact lower extremity anthropometric measures such as thigh and calf girth. Furthermore, exercise therapy and an appropriate exercise programme can be used to improve muscle function and physical performance, by encouraging dancers to take greater responsibility for their rehabilitation.

Hydrotherapy, which involves exercises in water, can be used to reduce the weight bearing stress on joints and injury exacerbation (Vaile, Halson, Gill, & Dawson, 2008) and maintain physical fitness with reduced joint loading. Despite the fact that scientific evidence is still scarce on methods such as Pilates (Bergeron, Greenwood, Smith, & Wyon, 2017), Franklin Method (Heiland, Rovetti, 2013) or Gyrotonic, they can also be used by physiotherapists with these same goals.

Physiotherapists may also be involved in dance shoe advice and pointe shoe fitting. Calleja (2020) affirms that in classical ballet, the extreme breaking in of pointe shoes and dancing with too worn-down or “dead” pointe shoes can compromise stability of the lower limbs, leading to overstretching of metatarsal ligaments and to possible injuries. Thus, evaluating and giving advice about how to choose, adapt and take care of point shoes is imperative for the safety of dancers. In addition, PTs can prescribe the use of toe spacers or other orthotics, aimed at increasing comfort and reducing injury risk.

In working closely with MDs, dance teachers and choreographers, PTs ensure dancers receive the best care to return to the stage as fast and safely as possible (Ojofeitimi & Bronner, 2011). Conservative treatment is always the preferred option for dancers but should there be an indication for surgery, PTs treat dancers preoperatively, to guarantee enhanced recovery. Preparation and dancer education is important to create efficient post-surgery rehab with a clear management plan, goals and time-line. After surgery, dancers often take longer to heal and achieve their former levels of fitness. Accelerated rehab should be treated with caution when caring for dancers and, instead, a thorough approach with rigorous return-to-dance testing should be put in place. Physiotherapy monitoring of the patient statistics from day 1 post-surgery, early mobilization and cryotherapy are used.

Cryotherapy involves cooling the injured body part (Bleakley, Bieuzen, Davison, & Costello, 2014; Hubbard, Aronson, & Denegar, 2004), via usage of ice packs or cryotherapy machines, which regulate the temperature of the target area and often incorporates compression to manage swelling and pain. Another option for pain control is heat therapy, which results in increased blood flow, metabolism and elasticity of connective tissue (Malanga, Yan, & Stark, 2014). Electrotherapy can be used as well, but only if evidence shows the modality to be effective (Watson, 2000).

Transcutaneous Electrical Nerve Stimulation (TENS) usage is based on the pain gate theory, which states this electrical current prevents signals from nociceptive nerve fibers arriving at higher centres of the brain, and therefore reduces pain (Melzack & Wall, 1965). Interferential therapy is used for muscle stimulation to reduce muscle atrophy and decrease pain, increase ROM, and decrease oedema (Jarit, Mohr, Waller, & Glousman, 2003; Jorge, Parada, Ferreira, & Tambeli, 2006; Werners, Pynsent, & Bulstrode, 1999). Laser therapy is a non-invasive treatment that has been reported to induce anti-inflammatory effects (Hamblin, 2013), which may aid recovery via pain reduction and increased blood flow. Therapeutic ultrasound consists of high or low frequency pulsed or continuous vibrations (Nelson, Hayes, & Currier, 1999) directed at the target tissue, that has been advocated to diminish pain, oedema and stimulate circulation.

Physiotherapists working in dance schools or companies, provide technique, posture and fitness assessments pre-season and then throughout the season as required. They can also work closely with dance teachers, evaluating pointe readiness, by using tests that are applied to the adolescent ballet dancer prior to start pointe work. These tests assess posture, core, ankle and knee stability and the ability of the dancer to maintain lower extremity alignment. In this situation, dancers are given instructions on how to activate intrinsic muscles to strengthen and work with their feet, as well as to how to use and choose the best pair of ballet shoes. Young dancers need to learn about foot care early in their training.

Lectures about injury prevention or basic health are also part of the responsibility, and subjects covered address various aspects, including cross-training, warm-up, how to stretch and environmental safety. It is important that these lectures include important issues, such as bone health and stress fracture prevention in pre-professional adolescent dancers and the effective management of dancer's turnout which is recognized as a risk factor for injury (Baker, Wyon, & Nevill, 2013; Armstrong & Relph, 2018). These lectures may involve dancers, teachers, parents, directors, choreographers and other healthcare professionals, being aimed at improving the health and well-being of dancers.

Dancer deconditioning must be avoided and motivation encouraged with a proactive approach at all times to exercise for maintenance and recovery. One of the goals is to avoid lost performance time and invest in improved technique and movement strategies that will enhance career longevity (Bronner, Ojofeitimi, & Mayers, 2006). It is necessary to make sure dancers have the best treatment and injury prevention strategies available, and that dancers, parents, schools and/or companies understand fully the dancer's physical and psychological condition, strengths and weaknesses, injury status and any required treatment plan. Therefore, a full PT report within the bounds of confidentiality, regarding dancer development, is a useful asset, from which an effective plan can be formulated to maintain dancer's health and reduce the overall cost of absenteeism.

Physiotherapists in dance are also involved with research and are the healthcare professionals closest to the dancers and best equipped to report on issues and injuries of concern. One of the latest scientific articles presented by Randell, Smith, Peter, Tuttle, & Rauh (2020) indicated that collegiate dancers self-reported that their main health problems were related to DE, and related pathogenic behaviors. They also presented with high levels of lower-extremity injuries and urogenital distress (as in other female athletes). Vosseller, Dennis, & Bronner (2019) reported that *os trigonum* syndrome and flexor hallucis longus tenosynovitis are common ankle injuries in dancers, prevalent especially in classical ballet dancers, because of the greater demand placed on their toe flexors, due to pointe work. Emery, Cook, Ferris, Smith, & Mayes (2019) also discovered that Iliopsoas, tensor fascia latae and sartorius muscle size was larger in ballet dancers compared to other athletes. Furthermore, iliopsoas muscle size was smaller in participants with hip pain. Another example is the study described by Steinberg et al. (2019), that showed both isometric exercises and somatosensory training were effective in diminishing patellofemoral pain and improving functional abilities in young dancers.

1.1 An Overview of the Brazilian and British Physiotherapy in Dance

When comparing Brazilian and British PTs' approach to educating dance students in injury prevention, it becomes clear that minimal differences exist between both systems. In Great Britain, most vocational and established company schools commence student education regarding injury prevention, the value of warm-up and cooling down, at 11 years old. In contrast, Brazilian aspiring dancers start pre-ballet classes when they are 5-8 years old, and ballet is taught from 9 years of age onwards. Injury prevention education commences around 11 years old, when dancers are taught more intensively. This is due to the requirement for Brazilian dancers to be ready to participate in international competitions in their early teens, as the best schools and companies do not offer scholarships or job opportunities for older dancers, and national companies are scarce. Furthermore, it is true in both countries, regardless of when dancers formally start dancing, that it is only through injury that dancers learn how to take care of themselves, and that the education they receive from the PT during rehabilitation and the rehabilitation process is enhanced by the development of trust between the dancer and the PT.

Another difference between British and Brazilian dance physiotherapy is how osteopathy is practiced. In the UK, osteopathy is a regulated health profession that is distinct from medicine and physiotherapy. In BR, however, osteopathy is not a profession *per se*, while manual techniques, such as hands-on bone, cranial or visceral treatment, normally performed by osteopaths, are used by PTs instead. British osteopaths and Brazilian PTs specialised in osteopathy are increasingly helping dancers in injury recovery and prevention. They consider that the body works as a connected muscle chain, with fascia being an important component of an injury. This is supported by the concept of kinetic chain and is highlighted by an injury that might have started, for example, with tightness in a dancer's hip that resulted in a biomechanical disadvantage, and lead to a sprained ankle. Osteopathy techniques aim to evaluate pain and dysfunction and use manual therapy to make fine adjustments to the body (Pollard-Smith & Thomson, 2017).

Most large British dance companies have a facility for treating dancers these days, where dancers who report a health problem are fully assessed. The PT then makes a differential diagnosis formulated from their subjective and objective assessments, and a treatment plan with clear goals is formulated and discussed with the dancer. Treatment normally involves a mixture of manual therapy, exercises that will improve fine control (Pilates) and/or that will improve strength (gym-based work), with each component introduced at the appropriate time. The skill is to balance each of these components, and the PT plans the course of rehabilitation in a daily management plan, so that the dancer can see in the time-line to recovery how long it will take to achieve. The aim is always to allow the dancer to continue dancing. However, stopping dancing for a certain period may be necessary as the dancer's health is of paramount importance. Rehabilitation is intensive and the plan is clearly recorded for each PT and dancer to fully understand the diagnosis, aims and goals and what their responsibilities are. A planning session is scheduled to allow the dancer and all those involved in the dancer's management to attend, to clarify the rehabilitation process.

In contrast, just a few well-established dance companies in BR employ 1-2 PTs to take care of the whole company. It is not unusual to have to wait for more than a week to see a PT. Nevertheless, individual initiatives, such as the physiotherapy services created at Quasar Cia de Dança and Basileu França (Bittar, 2004; 2015), Theatro Municipal do Rio de Janeiro (Zican, 2018; 2019) and the Bolshoi Ballet School in BR, are acknowledged as they have comprehensively developed injury prevention strategies, and treatment for dancers with specific needs. These services have developed consistent strategies, such as: approximation between PTs and dance teachers, so that they speak the same language and understand which activities should be continued or avoided; continued education of dance professionals in pain management and understanding how they can take responsibility in the recovery or prevention process, rather than passive dependence on PT support; and active therapies and self-management with attendance of regular screening to identify dysfunctions. Dancers, however do need support and guidance and regular technical assessment, as any athlete or sportsman.

2 PSYCHOLOGICAL WELL-BEING IN DANCE

Psychological support is sometimes necessary for dancers. The competitive atmosphere is often present in classes, competitions and companies and can negatively affect a dancer's perception of self. This can lead to changes in dancers' motivation, as well as fluctuations in their self-confidence, body image and experience of performance anxiety. For some, persistent exposure to the stress of dance training may result in, or bring to the surface, otherwise latent mental health concerns such as depression, anxiety or DE. Perfectionism is often a problem, with an ever-present culture of "practice makes perfect" and demand to appear (technically, creatively and aesthetically) at one's best at all times. Many dancers report the struggle of balancing these expectations while maintaining a healthy mindset of discipline, focus and tolerance to the challenges of dance. It is crucial to implement a supportive environment that emphasizes autonomy, self-expression and self-acceptance, while fostering simultaneously, a dedication to doing one's best both technically and creativity.

Lately, different psychological approaches have been used with the aim of helping dancers evolve both professionally and personally. The physical, mental and emotional demands of dance are high, and dancers must accept that competition in auditions, or within the company itself, for a contract or for a better role in a performance is an inherent part of the chosen career. They are also asked to dedicate themselves 100% to their profession in order to constantly maintain high levels of performance, and to be prepared to face different audiences in theatres. All these factors can cause stress and anxiety among dancers (Grove et al., 2013; Walker & Nordin-Bates, 2010), making psychological interventions necessary. In the UK, several professional services are available for dancers, most commonly provided by Chartered Psychologists or Counsellors.

Chartered psychologists tend to be academic researchers who work from a scientific evidence base, drawing on their experiences working with published data as well as face to face experiences with dancers. These individuals typically work for schools and companies on small part-time or freelance contracts, delivering educational based workshops around pertinent areas of performance psychology, predominantly underpinned by principles from Sports and Exercise Psychology. In the UK at least, the profession of Dance Psychology is far less developed than that of Sports Psychology, thus the term is not protected or regulated by any professional body. Those Chartered Psychologists acting as dance psychology specialists must have obtained a professional recognition from the British Psychological Society. Many UK schools, such as the Royal Ballet School and Elmhurst School for Dance, invite psychologists to work with students, as do companies such as English National Ballet, Birmingham Royal Ballet and The Royal Ballet.

One of the most commonly used approaches by a Chartered Psychologist is Psychological Skills Training (PST), a systematic approach to training mental skills used to enhance sports performance and well-being. It includes different techniques for instant goal setting, relaxation, and attention control, such as self-talk and imagery. Dance research has mainly focused on imagery, which is reported to help dancers achieve better control over technique, also helping them in memorizing new dance routines (Hanrahan & Vergeer, 2000; Nordin & Cumming, 2005).

In addition to the theoretical education around performance enhancement and preventative based approach taken by psychologists, some dancers may also have access to counsellors, who typically work one-on-one with dancers, addressing complex concerns and drawing on life experiences unique to the presenting dancer. These situations tend to require the building of rapport between counsellor and client, and repeated sessions until symptoms improve. Sometimes, measures such as depression inventories are used to assess the impact of counselling. In the UK, in line with the increasing need for mental health provision in main stream schooling, many dance vocational schools now offer free counselling services. These counsellors are employed part time, and not all are dance specific, or have experience of knowledge of the dance industry, meaning that the degree of support relative to a dancers' specific experience may vary.

Many dancers may feel isolated when experiencing psychological changes and are afraid to discuss their difficulties for fear of, ridicule or isolation. Creating an environment of interest to discussing the role of psychology in dance and performance enhancement can contribute to a greater openness to seeking help. Including access to a psychologist and a counsellor will provide dancers with holistic mental health support.

CONCLUSIONS

Physiotherapy and psychological well-being are vital in the effective management of dancers. The delivery of these requires the intervention of a number of highly qualified professionals. PTs utilise a number of therapeutic interventions including manual therapy techniques such as joint mobilization, manipulation and soft tissue therapy. These techniques can be further supported with taping via a variety of methods, implementation of appropriate orthotics and exercise therapy. Electrotherapy via interferential, TENS, laser and ultrasound therapy is also used to assist with injury recovery. Techniques are generally used in combination with the aim of returning the dancer to activity as soon as is safely possible. These techniques are selected based upon evidence based practice and experience of the PT and via an open dialogue with the dancer to allow the development of appropriate goals.

RNDs have a vital role in ensuring that dancers and dance companies adopt a healthy view of nutrition. They are able to educate dancers, parents and institutions to be aware of nutritional problems that may impact dance performance, and also treat nutritional disorders should they be present. Each dancer will require a bespoke plan dependent on a number of factors including their age, physique, training workload, injury history, general medical history and level of dancing. Dancers who do not have an adequate diet are at risk of a number of health issues including amenorrhea, osteoporosis, fatigue and increased injury risk. A healthy, well-balanced diet must consist of an appropriate combination of both macronutrients (carbohydrate, fat and protein) and micronutrients (vitamins and minerals), as well as adequate hydration.

The physical, mental and emotional demands of dance are high and the competitive nature can lead to changes in dancers' motivation, as well as fluctuations in their self-confidence, body image and experience of performance anxiety. In the UK, Chartered Psychologists use PST which may incorporate goal setting, relaxation, self-talk and imagery to enhance performance and well-being. Counsellors are also involved in providing mental health provision, however not all have previous experience of working with dancers. The provision of psychological support must create a supportive environment that fosters openness and understanding to provide holistic mental health support.

These professionals are vital in ensuring that dancers have a healthy and enjoyable career. Education lectures regarding injury prevention, nutrition and physical and mental well-being are essential to allow dancers to take ownership of their health and it is important that dancers have the opportunity to ask the various professionals involved in their management questions. It is only by teamwork that dancers will have the opportunity to achieve their maximum potential.

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Em apoio à sustentabilidade e à preservação ambiental, a Editora Kelps declara que este livro foi impresso com papel produzido de florestas cultivadas em áreas degradadas e que é inteiramente reciclável.

Este livro foi impresso na oficina da Editora Kelps,
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A revisão final desta obra é de responsabilidade dos autores