UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

FACULDADE DE MEDICINA

PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS MÉDICAS:

ENDOCRINOLOGIA

Atividade física habitual em mulheres na pós-menopausa: associações com fatores dietéticos, composição corporal, variáveis metabólicas e hormonais e fatores de risco cardiovascular

Thaís Rasia da Silva

Porto Alegre, agosto de 2012.

UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL

FACULDADE DE MEDICINA

PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS MÉDICAS:

ENDOCRINOLOGIA

Atividade física habitual em mulheres na pós-menopausa: associações com fatores dietéticos, composição corporal, variáveis metabólicas e hormonais e fatores de risco cardiovascular

Thaís Rasia da Silva

Dissertação apresentada ao Programa de Pós-Graduação em Ciências Médicas: Endocrinologia, como requisito parcial para obtenção do título de Mestre.

Orientadora: Profª. Drª. Poli Mara Spritzer

Porto Alegre, agosto de 2012.

CIP - Catalogação na Publicação

Rasia da Silva, Thaís
Atividade física habitual em mulheres na pós-menopausa: associações com fatores dietéticos, composição corporal, variáveis metabólicas e hormonais e fatores de risco cardiovascular / Thaís Rasia da Silva. -- 2012.
40 f.

Orientadora: Poli Mara Spritzer.

Dissertação (Mestrado) -- Universidade Federal do Rio Grande do Sul, Faculdade de Medicina, Programa de Pós-Graduação em Ciências Médicas: Endocrinologia, Porto Alegre, BR-RS, 2012.

1. Pós-menopausa. 2. Nutrição. 3. Atividade física. I. Spritzer, Poli Mara , orient. II. Título.

Elaborada pelo Sistema de Geração Automática de Ficha Catalográfica da UFRGS com os dados fornecidos pelo(a) autor(a).

AGRADECIMENTOS

Agradeço a minha orientadora, Poli Mara Spritzer, que foi fundamental para o meu crescimento profissional através da sua dedicação e afinco pela pesquisa.

À Bruna Cherubini, Maria Augusta Maturana, Roberta Franz e Tássia Maciel pela contribuição durante a execução da pesquisa.

Aos colegas da Unidade de Endocrinologia Ginecológica do Serviço de Endocrinologia do Hospital de Clínicas de Porto Alegre: Betânia Rodrigues dos Santos, Débora Martinho Morsch, Fabíola Satler, Fabrício Mattei, Fernanda do Amarante, Gislaine Casanova, Livia Paskulin, Marcela Metzdorf, Ramon Bossardi, Raquel Amaral Vieira, Roberta Martins Costa Moreira, Scheila Karen Graff, Sheila Lecke, Vânia Andrade e Verônica Colpani. Obrigada pelo apoio à pesquisa e por proporcionarem um excelente ambiente de trabalho. À Miriam Sant'Helena e Natália Goulart, pelo auxílio em todas as etapas.

Agradeço também aos meus pais, Valdir e Marilaine, e a minha irmã, Giovana, que me incentivaram em todos os momentos na busca pelos meus resultados, souberam entender quando não pude estar presente e me deram todo o apoio, mesmo que à distância. Ao meu namorado, Bruno, obrigada pelo carinho e companheirismo.

Esta Tese de Mestrado segue o formato proposto pelo Programa de Pós-Graduação em Ciências Médicas: Endocrinologia, Faculdade de Medicina, Universidade Federal do Rio Grande do Sul, sendo apresentada na forma de 1 revisão geral e 1 manuscrito sobre o tema da Tese:

- **Revisão:** Atividade física em mulheres na pós-menopausa: associações com fatores dietéticos, composição corporal, variáveis metabólicas e fatores de risco cardiovascular.

- **Artigo original:** Contribution of habitual physical activity to healthier dietary intake and lower risk of metabolic syndrome in postmenopausal women.

SUMÁRIO

Atividade física em mulheres na pós-menopausa: associações com fatores dietéticos, composição corporal, variáveis metabólicas e fatores de risco cardiovascular

A menopausa é definida como a ausência permanente das menstruações, em decorrência da perda da função folicular ovariana ou remoção cirúrgica dos ovários. A pós-menopausa abrange os estágios precoce e tardio. O estágio pós-menopáusico precoce abrange os oito primeiros anos depois do último sangramento menstrual, e a menopausa tardia são os anos posteriores (HARLOW et al., 2012). O período pós-menopáusico traz intensas modificações hormonais, principalmente a diminuição nos níveis de estrogênio (CLARKSON, 2007), porém o impacto clínico dessas alterações hormonais é variável entre diferentes mulheres, etnias e populações, e apresenta influências de fatores socioculturais e psicológicos (OBERMEYER et al., 2007).

Mulheres na pós-menopausa em comparação com mulheres na pré-menopausa apresentam duas vezes mais risco de insuficiência coronariana (GRODSTEIN et al., 2000) sendo a doença cardiovascular (DCV) a principal causa de morte em mulheres na pós-menopausa (MOSCA et al., 2006). Ativação de mecanismos pró-inflamatórios e alterações na atividade fibrinolítica parecem ter um importante papel na patogênese da aterosclerose e DCV (CARR, 2003 e PRIPP et al., 2005).

O sedentarismo e a diminuição do gasto energético, associados ao aumento na ingestão alimentar, contribuem para o aumento do peso com a idade. Já as alterações hormonais da menopausa estariam mais relacionadas às modificações na distribuição da massa de gordura (DONATO G et al., 2006). Estudos mostram que a mudança nos níveis circulantes de FSH está correlacionada com a variação do índice de massa corporal (IMC), assim como a deficiência de estrogênio (LOVEJOY et al., 2008). O status menopausal e a idade parecem promover modificações no metabolismo do tecido adiposo subcutâneo, abdominal e gluteal, resultando em um padrão de acumulação de gordura central ou de distribuição andróide (DOUCHI et al., 2007; MISSO et al., 2005). O aumento do depósito de gordura abdominal parece ser influenciado pelo hipoestrogenismo (POEHLMAN et al., 1995). Sabe-se que as características funcionais do tecido adiposo variam de acordo com a sua localização anatômica. O tecido adiposo visceral apresenta maior atividade lipolítica (ARNER, 2005), maior resistência à ação da insulina (FRIED et al., 1993), maior expressão de marcadores inflamatórios, maior secreção de leptina e outras adipocinas (FAIN et al., 2004) levando ao aumento da fibrinólise e coagulação (PEVERILL et al., 2007). O aumento da gordura intra-abdominal associado com a alteração metabólica levam a um maior risco de desenvolver a síndrome metabólica (SM) e eventos cardiovasculares (CANOY, 2008). Estudos epidemiológicos têm demonstrado que a prevalência de SM atinge seu nível mais alto em mulheres com 60 anos ou mais de idade (FORD et al., 2002). Nahas e colaboradores (2009) observaram alta prevalência de SM entre mulheres na pós-menopausa brasileiras (39,6%), sendo a obesidade abdominal, o diabetes, a hipertensão e a PCR-us fortemente associados ao risco de SM.

Vários estudos têm demonstrado efeito positivo de diversos tipos de programas de treinamento na função vascular, em pacientes com ou sem DCV em ambos os sexos (CAMERON et al., 1994; EDWARDS et al., 2004; MORREAU at al., 2006), e em mulheres na pós-menopausa, com efeitos endoteliais benéficos comparáveis ao uso de intervenções farmacológicas, como a terapia hormonal (HARVEY et al., 2005). O exercício físico melhora o perfil de risco cardiovascular como resultado de seus efeitos benéficos em vários parâmetros, IMC, massa de gordura (subcutânea e visceral), consumo máximo de oxigênio, perfil lipídico, pressão arterial e, como já exposto, função endotelial (ROUSEL et al., 2009; WESSEL et al., 2004). O gasto energético com a atividade física é um preditor independente de proteína C reativa ultra-sensível (PCR-us) em mulheres na pós-menopausa com sobrepeso ou obesidade. Portanto, a atividade física tem o papel de reduzir a inflamação subclínica e o risco de doenças metabólicas e cardiovasculares (LAVOIE et al., 2010). Além disso, alguns estudos demonstram melhora dos sintomas menopáusicos com a prática de atividade física (VALLANCE et al., 2010; SKRZYPULEC et al., 2010 e DALEY et al., 2011). Canário e colaboradores (2012) demonstraram diferenças significativas entre categorias do *International Physical Activity Questionnaire* (IPAQ) e o índice de Blatt-Kupperman, que inclui: fogachos, parestesia, insônia, impaciência, depressão, vertigem, artralgia/mialgia e palpitação, sendo que as pacientes ativas apresentavam menos sintomas.

Existem vários instrumentos que avaliam o exercício físico de uma população, porém, poucos analisam a atividade física habitual. Evidências indicam que, dependendo da freqüência e intensidade, não só o exercício físico, mas também a atividade física habitual, definida como todas as formas de movimento que elevem a taxa metabólica acima do basal, podem exercer benefícios em diversos parâmetros de saúde (BEMBOM et al., 2009). Dados de uma coorte de mulheres na pós-menopausa indicaram que não só o exercício físico vigoroso, mas também a caminhada estava associada com redução do risco de eventos cardiovasculares (MANSON et al., 2002). Por essa razão, torna-se necessário recorrer a métodos objetivos que não dependam dos indivíduos para sua avaliação, como por exemplo, os detectores mecânicos e eletrônicos do movimento, como o pedômetro (LOPES, 2003). Estes detectores fornecem uma medida acurada, simples e confiável do número de passos por dia permitindo a medição acumulada das atividades ocupacionais, de lazer e domésticas (HORNBUCKLE et al., 2005; GRAFF et al, 2012). No primeiro e recente estudo, publicado com mulheres de meia-idade, utilizando o pedômetro como método para aferição da atividade física habitual, observou-se um menor % de gordura corporal entre as participantes que caminharam mais (THOMPSON et al., 2004).

Dietas inadequadas, obesidade e deficiências nutricionais levam ao aparecimento de diversas doenças (A PINES, 2009). Ainda não existem recomendações nutricionais específicas para mulheres na pós-menopausa sendo que as diretrizes para prevenção de doenças cardiovasculares em mulheres (MOSCA et al., 2007) recomendam: uma dieta rica em frutas e legumes; escolha de grãos integrais e ricos em fibras; consumo de peixes, especialmente peixes gordos (duas vezes por semana); limitar a ingestão de gordura saturada entre 5 - 10% do valor calórico total (VCT) e, se possível até no máximo 7%; colesterol 300 mg / dia; álcool para não mais de um *drink* por dia; e a ingestão de sal de 2,3 a 5 g / dia. O consumo de ácidos graxos trans deve ser o mínimo possível (< 1% do VCT).

Estudos epidemiológicos vêm sendo desenvolvidos a fim de avaliar o padrão alimentar de mulheres na pós-menopausa e sua associação com desenvolvimento de DCV. Em 24.444 mulheres pós-menopausicas participantes do *Swedish Mammography Cohort* que não apresentavam diagnóstico de câncer, DCV e diabetes mellitus no início do estudo, durante 6,2 anos de seguimento os padrões dietéticos identificados como “saudável” e “álcool” foram significativamente associados com a diminuição do risco de infarto do miocárdio. A dieta de menor risco era caracterizada pelo alto consumo de vegetais, frutas, grãos integrais, peixe e legumes em combinação com moderada ingestão de álcool (≥ 5 g de álcool por dia) (AKESSON et al., 2007). Outro estudo realizado com 1313 mulheres com 50 anos ou mais, participantes do *National Health and Nutrition Examination Health Survey* (NHANES) destacou nos Estados Unidos a carência de fibras e ômega 3 na dieta dessas mulheres, fatores que podem aumentar os riscos para DCV. (LÓPEZ et al., 2008). E mais recentemente foi observado em 3564 mulheres de 45 a 68 anos que os piores escores de qualidade da dieta estavam associados com inatividade física e com menor nível educacional e socioeconômico (GARCÍA-ARENZANA et al., 2012).

A avaliação da ingestão alimentar requer metodologia padronizada, com o uso de instrumentos válidos, reprodutíveis e confiáveis (WILLETT, 1998). Entre os métodos de avaliação do consumo alimentar mais utilizados destacam-se o diário alimentar (DA), o inquérito recordatório de 24 horas (IR24h) e o questionário de freqüência alimentar (QFA). Enquanto os dois primeiros podem ser aplicados em qualquer população, sem necessidade de validação, o QFA precisa ser validado na população objeto de estudo, uma vez que mudanças sutis nos alimentos que o compõem podem afetar o seu desempenho (WILLET, 1998). Para identificar e descrever padrões alimentares, o QFA tem sido relatado por diversos autores como o método mais adequado (LOPES et al., 2003, ROSNER e WILLET, 1988). Permitem avaliar a ingestão dietética sobre um extenso período de tempo, como meses e anos, baseado em uma lista de alimentos e na freqüência de consumo destes (WILLET, 1998; MARGETS, 1997).

Já é bem descrito na literatura que a doença cardiovascular é a principal causa de morte em mulheres na pós-menopausa. Apesar da reconhecida importância da atividade física e da dieta, individualmente, poucos estudos tem enfocado na interação destes dois aspectos (GILLMAN et al., 2001). Portanto, o principal objetivo deste estudo foi investigar a associação entre a atividade física habitual e ingestão dietética, composição corporal, variáveis hormonais e metabólicas e fatores de risco cardiovascular em mulheres na pós-menopausa sem diagnóstico prévio de doença cardiovascular.

REFERÊNCIAS

Akesson A, Weismayer C, Newby PK, Wolk A. Combined effect of low-risk dietary and lifestyle behaviors in primary prevention of myocardial infarction in women. Arch Intern Med. 2007;22;167(19):2122-7.

A. Pines. Lifestyle and diet in Postmenopausal women. Climateric. 2009;12(Suppl 1):62–65.

Arner P. Human fat cell lipolysis: biochemistry, regulation and clinical role. Best Pract Res Clin Endocrinol Metab 2005; 19:471–482.

Bembom O, van der Laan M, Haight T, Tager I. Leisure-time physical activity and all-cause mortality in an elderly cohort. Epidemiology. 2009; 20: 424–430

Cameron JD, Dart AM. Exercise training increases total systemic arterial compliance in humans. Am J Physiol. 1994; 266: H693–H701.

Canário ACG, Cabral PU, Spyrides MH et al. The impact of physical activity on menopausal symptoms in middle-aged women. Int J Gynecol Obstet. 2012;118: 34–36.

Canoy D. Distribution of body fat and risk of coronary heart disease in men and women. Current Opinion in Cardiology. 2008; 23:591–600.

Carr MC. The emergence of the metabolic syndrome with menopause. J Clin Endocrinol Metab. 2003; 88 (6): 2404-2411.

Clarkson TB. Estrogen effects on arteries vary with stage of reproductive life and extent of subclinical atherosclerosis progression. Menopause. 2007; 14 (3): 373-384.

Daley A, Stokes-Lampard H, Macarthur C. Exercise for vasomotor menopausal symptoms. Cochrane Database Syst Rev 2011(5):CD006108.

Donato GB, Fuchs SC, et al. Association between menopause status and central adiposity measured at different cutoffs of waist circumference and waist-to-hip ratio. Menopause. 2006; 13(2): 280– 5.

Douchi T, Yonehara Y, Kawamura Y et al. Difference in segmental lean and fat mass components between pre and postmenopausal women. Menopause; 2007.

Edwards DG, SchoWeld RS, Magyari PM, Nichols WW, Braith RW.Effect of exercise training on central aortic pressure wave reflection in coronary artery disease. Am J Hypertens. 2004; 17:540–543.

Fain JN, Madan AK, HilerML, et al. Comparison of the release of adipokines by adipose tissue, adipose tissue matrix, and adipocytes from visceral and subcutaneous abdominal adipose tissues of obese humans. Endocrinology. 2004; 145:2273–2282.

Ford ES, Giles WH, Dietz WH. Prevalence of the metabolic syndrome among US adults. Findings from the Third National Health Nutrition Examination Survey. JAMA. 2002; 287:356–9

Fried SK, Russell CD, Grauso NL, Brolin RE. Lipoprotein lipase regulation by insulin and glucocorticoid in subcutaneous and omental adipose tissues of obese women and men. J Clin Invest 1993; 92:2191–2198.

García-Arenzana N, Navarrete-Muñoz EM, Peris M et al. Diet quality and related factors among Spanish female participants in breast cancer screening programs. Menopause. 2012 [Epub ahead of print].

Gillman, M.W., Pinto, B.M., Tennstedt, S., Glanz, K., Marcus, B. and Friedman, R.H. 2001. Relationships of physical activity with dietary behaviors among adults. Prev Med. 32(3): 295-301.

Graff SK, Alves BC, Toscani MK, Spritzer PM. Benefits of pedometer-measured habitual physical activity in healthy women. Appl Physiol Nutr Metab. 2012 Feb;37(1):149-156.

Grodstein F, Manson JE, Colditz GA et al. A prospective, observacional study of postmenopausal homone therapy and primary prevention of cardiovascular disease. Ann Intern Med. 2000; 133 (12): 933-941.

Harlow SD. Gass M, Hall JE, Lobo R et al. Executive summary of the Stages of Reproductive Aging Workshop + 10: addressing the unfinished agenda of staging reproductive aging. J Clin Endocrinol Metab. 2012; 97(4):1159-68.

Harvey PJ, Pictin PE, SU W S, Morris BL et al. Exercise as an alternative to oral estrogen for amelioration of endothelial dysfunction in postmenopausal women. American Heart Journal. 2005; 7: 149:291.

Hornbuckle LM, Bassett DR Jr, Thompson DL. Pedometer-determined walking and body composition variables in African-American women. Med Sci Sports Exerc. 2005; 37(6): 1069–74.

Lavoie ME, Rabasa-Lhoret R, Doucet É, Mignault D, Messier L, Bastard JP, Faraj B. Association between physical activity energy expenditure and inflammatory markers in sedentary overweight and obese women. Int J Obes. 2010; 34: 1387-1395.

Lopes A, Caiaffa W, Mingoti S, Lima M. Ingestão alimentar em estudos epidemiológicos. Rev Bras Epidemiol. 2003; 6:209-19.

López EP, Rice C, Weddle DO, et al. The Relationship among Cardiovascular Risk Factors, Diet Patterns, Alcohol Consumption, and Ethnicity among Women Aged 50 Years and Older. J Am Diet Assoc. 2008; 108 (2): 248-256.

Lovejoy JC, Champagne CM, Jonge L, Xie H, Smith SR. Increased visceral fat and decreased energy expenditure during the menopausal transition. Int J Obes. 2008; 32(6): 949–958.

Margetts BM, Nelson M. Design concepts in nutritional epidemiology. 2nd ed. Oxford; University Press; 1997.

Manson JE, Greenland P, LaCroix A. Walking compared with vigorous exercise for the prevention of cardiovascular events in women. N Engl J Med. 2002. 347(10): 716 – 725.

Misso ML, Jang C, Adams J et al. Differential expression on factors involved in fat metabolism with age and the menopause transition. Maturitas. 2005; 51 (3): 299-306.

Mosca L, Edelman D, Mochari H et al. Waist circunference predicts cardiometabolic and global Framingham risk among women screened during National Woman's Heart Day. J Women's Health. 2006; 15 (1): 24-34.

Mosca L, Banka CL, Benjamin EJ, et al. Evidence-based guidelines for cardiovascular disease prevention in women: 2007 update. Circulation. 2007; 115:1481–501.

Nahas EAP, Padoani NP, Nahas-Neto J et al. Metabolic syndrome and its associated risk factors in Brazilian postmenopausal women. Climacteric. 2009;12:431–438.

Obermeyer CM, Reher D, Saliba M. Symptoms, menopause status, and country differences: a comparative analysis from DAMES. Menopause. 2007; 14 (4): 788-797.

Poehlman RT, Toth MJ, Gardner AW. Changes in energy balance 3. and body composition at menopause: a controlled longitudinal study. Ann Intern Med. 1995;123(19):673-5.

Peverill RE, Teede HJ, Malan E, et al. Relationship of waist and hip circumference with coagulation and fibrinolysis in postmenopausal women. Clin Sci (Lond) 2007; 113:383–391.

Pripp U, Eriksson-Berg M, Orth-Gomer K et al. Does body mass index, smoking, lipoprotein levels, surgically induced menopause, hormone replacement therapy, years since menopause, or age affect hemostasis in postmenopausal women? Gender Medicine. 2005; 2 (2): 88-95.

Rosner B, Willett W. Interval estimates for correlation coefficients corrected for within-person variation: implications for study design and hypothesis testing. Am J Epidemiol. 1988; 127:377-86.

Rousel M, Garnier S, Lemoine S, et al. Influence of a walking program on the metabolic risk profile of obese postmenopausal women. Menopause. 2009;16(3):566-75.

Skrzypulec V, Dabrowska J, Drosdzol A. The influence of physical activity level on climacteric symptoms in menopausal women. Climacteric 2010;13(4):355–61.

Thompson DL, Rakow J, Perdue SM. Relationship between Accumulated Walking and Body Composition in Middle-Aged Women. Medicine and Science in Sports and Exercise. 2004; 36 (5):911–4.

Vallance JK, Murray TC, Johnson ST, Elavsky S. Quality of life and psychosocial health in postmenopausal women achieving public health guidelines for physical activity. Menopause 2010;17(1):64–71.

Wessel TR, Arant CB, Olson MB, et al. Relationship of physical fitness vs body mass index with coronary artery disease and cardiovascular events in women. JAMA. 2004; 292:1179–87.

Willett W. Nutritional epidemiology. Oxford: Oxford University Press; 1998.

Contribution of habitual physical activity to healthier dietary intake and lower risk of metabolic syndrome in postmenopausal women

(Submitted to Applied Physiology, Nutrition and Metabolism)

Thaís Rasia da Silva[a], MD; Bruna Cherubini Alves, BSci[a]; Maria Augusta Maturana, PhD[a]; Poli Mara Spritzer, PhD [a,b,c]

[a]Gynecological Endocrinology Unit, Division of Endocrinology, Hospital de Clínicas de Porto Alegre, RS, Brazil. [b]Laboratory of Molecular Endocrinology, Department of Physiology, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS, Brazil. [c]National Institute of Hormones and Women’s Health, Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Porto Alegre, RS, Brazil.

Corresponding author:

Poli Mara Spritzer, M.D., Ph.D.

Division of Endocrinology, Hospital de Clínicas de Porto Alegre

Rua Ramiro Barcelos, 2350, 90035-003, Porto Alegre, RS, Brazil

Phone: +55 51 3359.8027 - Fax: +55 51 3359.8777

E-mail: spritzer@ufrgs.br

ABSTRACT

Regular physical activity and a healthful diet are important influences on health. Nevertheless, few studies have focused on the influence of habitual physical activity on diet preferences. The aim of this cross-sectional study was to investigate the relationship between habitual physical activity and dietary intake, body composition, metabolic and hormonal variables and cardiovascular risk factors in postmenopausal women with no evidence of cardiovascular disease. One hundred and five women (mean age: 55.2±4.9 years) consulting for climacteric symptoms underwent anthropometric and hormonal assessment. Usual dietary intake was assessed with a food frequency questionnaire, and habitual physical activity with a digital pedometer. Participants were classified as physically inactive (5 999 steps daily) or physically active (≥ 6 000 steps daily). A negative correlation was observed between steps/day and percent body fat (r = - 0.470; P<0.001), waist circumference (r = - 0.356; P<0.001) and body mass index (r = - 0.286; P=0.003). Compared to the inactive group, active participants had lower diastolic blood pressure (P=0.012), ultrasensitive C-reactive protein (us-CRP) (P=0.011), fasting glucose (P=0.003), fasting insulin (P=0.019) and homeostasis model assessment index (P=0.017), and higher intake of protein, total fat, cholesterol, calcium, iron, zinc, selenium, meats, eggs, and whole-fat dairy foods. After adjustment for age and time since menopause, the risk for metabolic syndrome increased with physical inactivity, high blood pressure, us-CRP, and percent body fat. In conclusion, both habitual physical activity and dietary choices may have contributed towards a more favorable cardiovascular profile and lower risk of metabolic syndrome in postmenopausal women.

Key words: Habitual physical activity, metabolic syndrome, cardiovascular risk, menopause, dietary pattern, food consumption.

INTRODUCTION

Participation in regular physical activity and eating a healthful diet are among the most important influences on health (U.S. Department of Health and Human Services 1995). Epidemiological studies indicate that moderate to vigorous physical activity is associated with decreased risk of developing the metabolic syndrome (MS), independent of aerobic fitness and obesity (Franks et al. 2004; Lakka and Laaksonen 2007). There is also evidence that daily physical activity prevents the onset of chronic diseases such as type 2 diabetes and MS (Laaksonen et al. 2005; Mendez-Hernandez et al. 2009). A positive effect of various types of training programs on vascular function has been described in studies with postmenopausal women, with improvement of endothelial function comparable to that obtained with drug treatments such as hormone therapy (Harvey et al. 2005).

Dietary strategies are also useful to maintain health and prevent a variety of disorders, including cardiovascular disease (CVD), which is still the leading cause of death among men and postmenopausal women worldwide (Lloyd-Jones et al. 2010). Recommendations to prevent CVD in women include intake of fruits and vegetables, whole grains, fiber, and fish, with avoidance of saturated fat, salt, and alcohol excess (Mosca et al. 2007). However, as reported by the Health and Nutrition Examination Health Survey (NHANES), the dietary pattern of American women over 50 years of age lacks nutrients such as fiber and omega 3 (Wright et al. 2007).

Despite the recognized importance of physical activity and diet individually, only a few studies have focused on the interaction between these two aspects (Gillman et al. 2001). Therefore, the aim of the present study was to investigate the relationship between habitual physical activity and dietary intake, body composition, metabolic and hormonal variables and cardiovascular risk factors in postmenopausal women with no evidence of cardiovascular disease.

METHODS

Subjects

This cross-sectional study was carried out with postmenopausal women consulting for climacteric symptoms at the Gynecological Endocrinology Unit at Hospital de Clínicas de Porto Alegre, Brazil and recruited by advertisement in a local newspaper and radio station. Inclusion criteria were as follows: 1) menopause, defined as last menstrual period at least 1 year before the beginning of the study plus follicle stimulating hormone (FSH) levels higher than 35 IU/L; 2) age between 45 and 65 years; and 3) no use of hormonal therapy in the past 3 months. Diabetic patients, patients with prior diagnosis of heart disease, and current smokers were excluded. One hundred and five postmenopausal women fulfilling all the inclusion criteria were consecutively enrolled in the study. The study protocol was approved by the local Ethics Committee, and written informed consent was obtained from every subject.

Study Protocol

All participants completed a questionnaire about their sociodemographic characteristics (e.g., age, education, household income, and marital status). The Kupperman score was assessed for each participant (Kupperman et al. 1953).

Anthropometric measurements were performed in duplicate and included body weight, height, BMI (kg/m^2) and waist circumference (WC - measured at the midpoint between the lower rib margin and the iliac crest, perpendicularly to the long axis of the body, with the subject standing balanced on both feet, spread approximately 20 cm apart, with both arms hanging freely) (Donato et al. 2006; Toscani et al. 2007). Obesity was defined as BMI ≥ 30 kg/m^2 (WHO 1995). Measurement of body composition was performed using bioelectrical impedance analysis (BIA) (Inbody 230, Biospace Inc., Los Angeles, USA). Total body fat percentage, lean mass and fat mass were obtained using the manufacturer’s formula. Resting metabolic rate (RMR) was obtained by indirect calorimetry (Fitmate®, Cosmed, Rome, Italy).

Blood pressure was measured after a 10-minute rest, in the sitting position, with feet on the floor and the arm supported at heart level. Two measurements were performed at a 10-min interval, using an automatic blood pressure monitor (Omron HEM 742, Rio de Janeiro, Brazil) with appropriate cuff for the arm diameter. FSH, estradiol, total testosterone, SHBG, ultrasensitive C-reactive protein (us-CRP), total and high-density lipoprotein (HDL) cholesterol, triglycerides, fasting glucose and insulin were determined using the 12h fasting blood sample. All samples were obtained between 8AM and 10AM. The presence of the metabolic syndrome (MS) and the frequency of its isolated components were defined in accordance with the Joint Scientific Statement (Alberti et al. 2009).

Assays

Total cholesterol, HDL cholesterol and triglycerides were determined by colorimetric-enzymatic methods (Bayer 1800 Advia System), with intra and interassay coefficients of variation (CV) <3%. Glucose was determined by the hexokinase method (Advia 1800) with intra-assay CV <3.4% and interassay CV <2.1%. us-CRP was assayed using stored specimens. A validated high-sensitivity nephelometric method (Dade Behring Marburg, Marburg, Germany) was used for us-CRP analysis, with sensitivity of 0.17 mg/L and intra and interassay CV of 4.4% and 5.7% respectively. Individual results below the limit of sensitivity were considered as equal to 0.17 mg/L (Maturana et al. 2011). FSH was measured by chemiluminescence immunoassay (Centaur XP), with sensitivity of 0.3 IU/L and intra and interassay CV of 2.9% and 2.7% respectively. TT levels were also measured by chemiluminescence immunoassay (Centaur XP) with sensitivity of 10 ng/mL and intra and interassay CV of 3.3% and 7.5% respectively. Sex hormone-binding globulin was measured by chemiluminescence enzyme immunoassay (Immulite 2000), with sensitivity of 0.02 nmol/L and intra- and interassay CV of 5.3% and 6.6% respectively. Serum insulin levels were measured using chemiluminescent immunoassays (Centaur XP), with a sensitivity of 0.200 μIU/mL and intra- and interassay CV of 2.0% and 4.3% respectively. FAI was estimated by dividing TT (in nanomoles per liter) by SHBG (in nanomoles per liter) × 100. Low-density lipoprotein (LDL) cholesterol was determined indirectly using the Friedewald formula LDL = total cholesterol – HDL – (triglycerides / 5). Homeostasis model assessment (HOMA) was calculated by multiplying insulin (μIU/ml) by glucose (mmol/l) and dividing this product by 22.5, as previously described (Matthews et al. 1985; Wiltgen et al. 2009).

Dietary Assessment

Usual dietary intake was assessed with a validated food frequency questionnaire (FFQ) consisting of 120 items that evaluated the intake for the previous month (Zanolla et al. 2009). The following were evaluated: calorie intake, carbohydrate intake, and glycemic load (GL) (Howlett and Ashwell 2008); and intake of protein, saturated, monounsaturated, and polyunsaturated fatty acids, fiber, cholesterol, alcohol, calcium, magnesium, iron, zinc, sodium, selenium, folate, and vitamins B12, D, E, C, and A. Nutritional composition was calculated using the Brazilian Table of Food Composition (NEPA 2006) except for vitamin B12, D, E, and A, which were assessed using the United States Department of Agriculture (USDA) National Standard Reference Database.

Physical Activity Assessment

Assessment of habitual physical activity was performed with a digital pedometer (BP 148, Tech Line, São Paulo, Brazil). The device was configured individually according to weight (kg) and individual step length. The equipment was used for six consecutive days, providing a weekly average number of steps. Subjects were encouraged not to change their physical activity habits during the study. Participants were classified as inactive if they walked up to 5 999 steps daily, and as active if they walked 6 000 or more steps daily (Thompson et al. 2004; Graff et al. 2012).

Sample size estimation and statistical analyses

The sample size was estimated based on a previous study (Gillman et al. 2001)**,** considering a power of 80% and alpha of 5%. Forty-two women were required in each group to detect a difference of 120mg in calcium intake between physically active and inactive women.

Results are presented as mean ± standard deviation (SD), or median and inter-quartile range, depending on the Gaussian or non Gaussian distribution of variables. The two-tailed Student t test or Mann-Whitney's test were used to compare the differences between means of parametric and non-parametric data respectively. χ^2 was calculated for comparisons of dichotomous variables. Pearson's rank correlation coefficient was calculated using a two-tailed significance test for variables with Gaussian distribution. Univariate analysis, using a logistic regression model (odds ratio), was used to evaluate the influence of different variables on the risk for MS, which was considered as the dependent variable. All analyses were performed using the Statistical Package for the Social Sciences 19.0 (SPSS, Chicago, IL, USA). Data were considered to be significant at $P < 0.05$.

RESULTS

Of 119 volunteers, 14 were excluded (five with diabetes, one with hyperthyroidism, two with untreated hypothyroidism, two with breast cancer and one who was premenopausal). An additional three participants dropped out. Thus, 105 women were enrolled in the study.

Mean age was 55.2 ± 4.9 years and mean time since menopause was 6.8 ± 1.0 years. Participants attended school for a mean of 8.5 ± 4.2 years, and 92 (87.6%) were white. Mean BMI was 27.1 ± 4.7 kg/m², mean systolic pressure was 127.7 ± 17.3 mmHg, and mean diastolic pressure was 78.7 ± 9.9 mmHg. MS was diagnosed in 22 (21%) subjects.

Table 1 presents the distribution of demographic and anthropometric variables according to physical activity status. The groups (< 6 000 or ≥ 6 000 steps/day) were similar regarding age, time since menopause, years at school and skin color. However, as shown in Figure 1, a negative correlation was observed between steps/day and percent body fat (r = - 0,470; P < 0.001), WC (r = - 0.356; P < 0.001) and BMI (r = - 0.286; P = 0.003). Active participants also had lower diastolic blood pressure (P = 0.012) and RMR (P = 0.021) in comparison to the inactive group.

Table 2 shows metabolic and hormonal variables in active and inactive women. SHBG (P = 0.011) was higher, and us-CRP (P=0.011), fasting glucose (P = 0.003), fasting insulin (P = 0.019), and HOMA-IR (P = 0.017) were lower in active women in comparison to inactive ones. There was a trend towards a lower prevalence of MS (11 vs. 28%; P = 0.052) in active compared with the inactive participants. The Kuppermann score was similar in both groups.

Dietary intake of macro- and micronutrients is presented in table 3. Active women had higher protein intake considering both the total and percent of total energy intake as well as total fat intake, but no difference was found in fatty acids. While fiber, ethanol, magnesium, and sodium intake did not differ between the groups, cholesterol, calcium, iron, zinc, and selenium intake was found to be higher in the active group. This group also had greater intake of meats and eggs and whole-fat dairy foods, and lower intake of chips than the inactive group. Intake of fruits, vegetables, beans, whole and refined grain, processed meats, and fried foods was similar between active and inactive participants. Vitamins B12, D, E, C, A, and folate intake was also similar between the groups.

The odds ratios of risk factors associated with MS are shown in Table 4. After adjustment for age and time since menopause, the risk for MS increased with physical inactivity, high blood pressure, us-CRP, and percent body fat. Years at school, low protein intake (defined as the mean consumption of participants in this sample, which was <16% of total energy), and high glycemic load (>120g) intake had no influence in the risk for MS.

DISCUSSION

In the present study, we found a healthier dietary pattern in active postmenopausal women, who also had a better anthropometric, metabolic and hormonal profile than their physically inactive counterparts. Physical inactivity was an independent risk factor for MS, impaired blood pressure, high us-CRP levels, and percent body fat, even after adjustment for potential confounders, including age and time since menopause.

Other recent studies have shown a positive influence of physical activity on prevalence of MS. Kim et al. showed that moderate to vigorous physical activity > 26.5 metabolic equivalent h/week (measured using a triaxial accelerometer) was sufficient to decrease the prevalence of MS and pre-MS in 483 Japanese women aged 30 to 64 years (Kim et al. 2011). One cross-sectional study with 3 090 French subjects aged 35 to 64 years showed a dose–response association between sitting time, an energy-dense dietary pattern, and MS (Wagner et al. 2012). Also, a few studies have reported negative associations between level of physical activity and MS in women. Irwin and coworkers (Irwin et al. 2002) showed that moderate and vigorous physical activity and greater maximal treadmill duration were inversely associated with MS among an ethnically diverse sample of women. Another study showed that a high level of physical activity may reduce the prevalence of MS among never and past smokers after the menopausal transition (Kwasniewska et al. 2012).

Physical activity is associated with improved body composition (BMI, WC, percent body fat, and total fat mass) in postmenopausal women (Wessel et al. 2004; Roussel et al. 2009). In a study investigating 898 women aged 45 to 54 years, weight gain was associated with changes in physical activity level estimated by questionnaire rather than with increase in energy intake (Macdonald et al. 2003). Interestingly, in the present study, active participants were found to have a lower RMR, possibly due to their lower BMI in comparison to the inactive group (Wyatt et al. 1999; Major et al. 2007). Evidence suggests that increased adipose tissue and the consequent increase in leptin secretion may translate into higher energy expenditure and curtail hunger mechanisms, leading to weight control (Lazzer et al. 2004).

Our physically active participants had lower diastolic blood pressure, fasting glucose and insulin, HOMA-IR and us-CRP, denoting a healthier metabolic profile than that of inactive women. Moderate-intensity physical activity (16-week endurance training program consisting of 3 sessions/week of 45-min walking at approximately 60% of heart rate reserve) has been deemed as sufficient to reduce both systolic and diastolic blood pressure in postmenopausal women (Roussel et al. 2009). Lavoie et al. (Lavoie et al. 2010) have also reported physical activity as an independent predictor of us-CRP levels in postmenopausal women. Those authors suggest that physical activity could potentially reduce subclinical inflammation and the risk of metabolic and cardiovascular diseases. Among middle-aged adults from a community dwelling, a higher daily step count at five-year follow-up had an independent beneficial impact on insulin sensitivity, further supporting an increase in physical activity levels in this age group. The apparent beneficial effect of physical activity on insulin sensitivity seemed to be largely mediated by reduced adiposity (Dwyer et al. 2011).

Concerning dietary intake, both our active and inactive groups ingested an adequate proportion of macronutrients (carbohydrate, proteins, and fat). However, active participants had a higher intake of protein and food groups containing sources of protein, such as meat and eggs and whole dairy foods, than the inactive group. Josse et al. (Josse et al. 2011) showed that diet- and exercise-induced weight loss with higher intake of protein and dairy products promoted favorable changes in body composition characterized by greater total and visceral fat loss and lean mass gain in 90 premenopausal women. Another recent study has demonstrated that dietary patterns that incorporate high intakes of dairy food may reduce the risk of diabetes in men, but not in women (Grantham et al. 2012). Some investigators have suggested that lactose and protein in dairy products enhance satiety, having a favorable impact on weight loss (Choi et al. 2005; Snijder et al. 2007). Others have suggested that calcium intake plays a central role in the effects of dairy food (Kirii et al. 2009). In a study comparing a low glycemic index and soluble fiber diet to a low-calorie conventional diet, the low glycemic index diet was associated with improvement in some cardiometabolic risk factors and greater reduction in adipocyte size (Rizkalla et al. 2012). Also, a prospective randomized parallel trial involving 61 adults with type 2 diabetes reported a reduction in insulin dose after 6 months with a low carbohydrate diet as compared to a low-fat diet, whereas weight changes did not differ between the diet groups (Guldbrand et al. 2012). In the present study, protein consumption was higher in active women, but was not identified as a protection factor against MS. This might be explained by the small magnitude of the difference in protein consumption between the active and inactive groups. Moreover, active participants reported a lower intake of chips, a source of trans fats and refined grains. In a prospective investigation involving three separate cohorts that included 120 877 U.S. women and men, starches or refined carbohydrates were positively associated with weight gain, while low-fat and skim milk did not differ from whole-fat milk and the consumption of nuts was inversely associated with weight gain (Mozaffarian et al. 2011). A Korean study with 406 adults demonstrated that fruit and dairy intake was strongly associated with a decreased likelihood of having MS, impaired fasting glucose, and hypertriglyceridemia.

Regarding the consumption of micronutrients, our active group reported a significantly higher intake of calcium, iron, selenium, and zinc. Matthews et al. (1997) evaluated the relationship between physical activity and dietary variables and found that active adults consume greater amounts of micronutrients in relation to sedentary individuals. Selenium and zinc are micronutrients with antioxidant potential. Increased energy storage as fat as well as increased mitochondrial macronutrient oxidation favor an increased production of free radicals and oxidative stress, which has long been proposed as a unifying mechanism linking excess nutrient intake, insulin resistance, MS, and diabetes (Avignon et al. 2012). Thus, successful strategies to remove free radicals are important in preventing chronic diseases of aging, especially in postmenopausal women, in whom low estrogen levels are associated with worse antioxidant protection in the myocardium (Barp et al. 2002; Massafra et al. 2002). In the Women's Health and Aging Study, disabled, community dwelling women aged ≥65 years with the lowest serum selenium levels had a significantly higher risk of 5-year mortality (hazard ratio = 1.54, 95% confidence interval: 1.03, 2.32) (Walston et al. 2006). A cross-sectional study including 8 335 U.S. adults aged ≥ 19 years from the 1999-2002 NHANES suggests that high selenium intake is associated with lower blood concentrations of CRP and homocysteine (Floegel et al. 2011). Adequate zinc consumption may also reduce cardiometabolic risk and especially the number of cardiovascular events in individuals with type 2 diabetes (Catania et al. 2009).

Adequate intake of calcium, especially in postmenopausal women, is essential for bone health (Price et al. 2012) and seems to be important for cardiovascular health (Chung et al. 2009). However, despite the higher intake of calcium by active participants in our study, consumption was still below the recommended levels (Trumbo et al. 2002). In the Iowa Women's Health Study, low dietary calcium intake (<700 mg/day) was associated with an increased risk of ischemic heart disease death in postmenopausal women (Chung et al. 2009).

One limitation of the present study is that it does not allow the establishment of a causal relationship between dietary pattern, specifically a higher intake of protein and antioxidants, and lower risk of CVD in postmenopausal women. Thus, further longitudinal or RCT studies are needed to test this hypothesis.

CONCLUSION

In this study, physically active postmenopausal women had a healthier dietary intake than inactive women, especially regarding consumption of protein and of beneficial micronutrients, as well as a more favorable anthropometric and metabolic profile. Physical inactivity was an independent risk factor for MS, along with impaired blood pressure, high levels of us-CRP, and percent body fat. These results suggest that both habitual physical activity and dietary choices may have contributed towards the healthier profile and lower risk of metabolic syndrome observed in this sample of postmenopausal women.

Acknowledgments

This work was supported by grants from Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq INCT 573747/2008-3) and Fundo de Apoio à Pesquisa do Hospital de Clínicas de Porto Alegre (FIPE-HCPA 10-0544). The funding sources were not involved in study design; in the collection, analysis and interpretation of data; in the writing of the report; or in the decision to submit the paper for publication.

REFERENCES

Alberti, K.G., Eckel, R.H., Grundy, S.M., et al. 2009. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation. **120**(16): 1640-1645.

Avignon, A., Hokayem, M., Bisbal, C. and Lambert, K. 2012. Dietary antioxidants: Do they have a role to play in the ongoing fight against abnormal glucose metabolism? Nutrition. **28**(7-8): 715-721.

Barp, J., Araujo, A.S., Fernandes, T.R., et al. 2002. Myocardial antioxidant and oxidative stress changes due to sex hormones. Braz J Med Biol Res. **35**(9): 1075-1081.

Catania, A.S., Barros, C.R. and Ferreira, S.R. 2009. [Vitamins and minerals with antioxidant properties and cardiometabolic risk: controversies and perspectives]. Arq Bras Endocrinol Metabol. **53**(5): 550-559.

Choi, H.K., Willett, W.C., Stampfer, M.J., Rimm, E. and Hu, F.B. 2005. Dairy consumption and risk of type 2 diabetes mellitus in men: a prospective study. Arch Intern Med. **165**(9): 997-1003.

Chung, M., Balk, E.M., Brendel, M., et al. 2009. Vitamin D and Calcium: Systematic Review of Health Outcomes. Evidence Report/Technology Assessment No. 183. (Prepared by Tufts Evidence-based Practice Center under Contract No. 290-2007-10055-I). Agency for Healthcare Research and Quality., Rockville, MD.

Donato, G.B., Fuchs, S.C., Oppermann, K., Bastos, C. and Spritzer, P.M. 2006. Association between menopause status and central adiposity measured at different cutoffs of waist circumference and waist-to-hip ratio. Menopause. **13**(2): 280-285.

Dwyer, T., Ponsonby, A.L., Ukoumunne, O.C., et al. 2011. Association of change in daily step count over five years with insulin sensitivity and adiposity: population based cohort study. BMJ. **342**: c7249.

Floegel, A., Chung, S.J., von Ruesten, A., et al. 2011. Antioxidant intake from diet and supplements and elevated serum C-reactive protein and plasma homocysteine concentrations in US adults: a cross-sectional study. Public Health Nutr. **14**(11): 2055-2064.

Franks, P.W., Ekelund, U., Brage, S., Wong, M.Y. and Wareham, N.J. 2004. Does the association of habitual physical activity with the metabolic syndrome differ by level of cardiorespiratory fitness? Diabetes Care. **27**(5): 1187-1193.

Gillman, M.W., Pinto, B.M., Tennstedt, S., Glanz, K., Marcus, B. and Friedman, R.H. 2001. Relationships of physical activity with dietary behaviors among adults. Prev Med. **32**(3): 295-301.

Graff, S.K., Alves, B.C., Toscani, M.K. and Spritzer, P.M. 2012. Benefits of pedometer-measured habitual physical activity in healthy women. Appl Physiol Nutr Metab. **37**(1): 149-156.

Grantham, N.M., Magliano, D.J., Hodge, A., Jowett, J., Meikle, P. and Shaw, J.E. 2012. The association between dairy food intake and the incidence of diabetes in Australia: the Australian Diabetes Obesity and Lifestyle Study (AusDiab). Public health nutrition. 1-7.

Guldbrand, H., Dizdar, B., Bunjaku, B., et al. 2012. In type 2 diabetes, randomisation to advice to follow a low-carbohydrate diet transiently improves glycaemic control compared with advice to follow a low-fat diet producing a similar weight loss. Diabetologia. **55**(8): 2118-2127.

Harvey, P.J., Picton, P.E., Su, W.S., Morris, B.L., Notarius, C.F. and Floras, J.S. 2005. Exercise as an alternative to oral estrogen for amelioration of endothelial dysfunction in postmenopausal women. American heart journal. **149**(2): 291-297.

Howlett, J. and Ashwell, M. 2008. Glycemic response and health: summary of a workshop. The American journal of clinical nutrition. **87**(1): 212S-216S.

Irwin, M.L., Ainsworth, B.E., Mayer-Davis, E.J., Addy, C.L., Pate, R.R. and Durstine, J.L. 2002. Physical activity and the metabolic syndrome in a tri-ethnic sample of women. Obes Res. **10**(10): 1030-1037.

Josse, A.R., Atkinson, S.A., Tarnopolsky, M.A. and Phillips, S.M. 2011. Increased consumption of dairy foods and protein during diet- and exercise-induced weight loss promotes fat mass loss and lean mass gain in overweight and obese premenopausal women. J Nutr. **141**(9): 1626-1634.

Kim, J., Tanabe, K., Yokoyama, N., Zempo, H. and Kuno, S. 2011. Association between physical activity and metabolic syndrome in middle-aged Japanese: a cross-sectional study. BMC Public Health. **11**: 624.

Kirii, K., Mizoue, T., Iso, H., et al. 2009. Calcium, vitamin D and dairy intake in relation to type 2 diabetes risk in a Japanese cohort. Diabetologia. **52**(12): 2542-2550.

Kupperman, H.S., Blatt, M.H., Wiesbader, H. and Filler, W. 1953. Comparative clinical evaluation of estrogenic preparations by the menopausal and amenorrheal indices. J Clin Endocrinol Metab. **13**(6): 688-703.

Kwasniewska, M., Pikala, M., Kaczmarczyk-Chalas, K., et al. 2012. Smoking status, the menopausal transition, and metabolic syndrome in women. Menopause. **19**(2): 194-201.

Laaksonen, D.E., Lindstrom, J., Lakka, T.A., et al. 2005. Physical activity in the prevention of type 2 diabetes: the Finnish diabetes prevention study. Diabetes. **54**(1): 158-165.

Lakka, T.A. and Laaksonen, D.E. 2007. Physical activity in prevention and treatment of the metabolic syndrome. Appl Physiol Nutr Metab. **32**(1): 76-88.

Lavoie, M.E., Rabasa-Lhoret, R., Doucet, E., et al. 2010. Association between physical activity energy expenditure and inflammatory markers in sedentary overweight and obese women. Int J Obes (Lond). **34**(9): 1387-1395.

Lazzer, S., Boirie, Y., Montaurier, C., Vernet, J., Meyer, M. and Vermorel, M. 2004. A weight reduction program preserves fat-free mass but not metabolic rate in obese adolescents. Obes Res. **12**(2): 233-240.

Lloyd-Jones, D., Adams, R.J., Brown, T.M., et al. 2010. Heart disease and stroke statistics--2010 update: a report from the American Heart Association. Circulation. **121**(7): e46-e215.

Macdonald, H.M., New, S.A., Campbell, M.K. and Reid, D.M. 2003. Longitudinal changes in weight in perimenopausal and early postmenopausal women: effects of dietary energy intake, energy expenditure, dietary calcium intake and hormone replacement therapy. Int J Obes Relat Metab Disord. **27**(6): 669-676.

Major, G.C., Doucet, E., Trayhurn, P., Astrup, A. and Tremblay, A. 2007. Clinical significance of adaptive thermogenesis. Int J Obes (Lond). **31**(2): 204-212.

Massafra, C., Gioia, D., De Felice, C., Muscettola, M., Longini, M. and Buonocore, G. 2002. Gender-related differences in erythrocyte glutathione peroxidase activity in healthy subjects. Clin Endocrinol (Oxf). **57**(5): 663-667.

Matthews, D.R., Hosker, J.P., Rudenski, A.S., Naylor, B.A., Treacher, D.F. and Turner, R.C. 1985. Homeostasis model assessment: insulin resistance and beta-cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia. **28**(7): 412-419.

Maturana, M.A., Moreira, R.M. and Spritzer, P.M. 2011. Lipid accumulation product (LAP) is related to androgenicity and cardiovascular risk factors in postmenopausal women. Maturitas. **70**(4): 395-399.

Mendez-Hernandez, P., Flores, Y., Siani, C., et al. 2009. Physical activity and risk of metabolic syndrome in an urban Mexican cohort. BMC Public Health. **9**: 276.

Mosca, L., Banka, C.L., Benjamin, E.J., et al. 2007. Evidence-based guidelines for cardiovascular disease prevention in women: 2007 update. J Am Coll Cardiol. **49**(11): 1230-1250.

Mozaffarian, D., Hao, T., Rimm, E.B., Willett, W.C. and Hu, F.B. 2011. Changes in diet and lifestyle and long-term weight gain in women and men. N Engl J Med. **364**(25): 2392-2404.

NEPA – Núcleo de Estudos e Pesquisas em Alimentação. 2006. Tabela brasileira de composição de alimentos. NEPA-UNICAMP, Campinas.

Price, C.T., Langford, J.R. and Liporace, F.A. 2012. Essential Nutrients for Bone Health and a Review of their Availability in the Average North American Diet. The open orthopaedics journal. **6**: 143-149.

Rizkalla, S.W., Prifti, E., Cotillard, A., et al. 2012. Differential effects of macronutrient content in 2 energy-restricted diets on cardiovascular risk factors and adipose tissue cell size in moderately obese individuals: a randomized controlled trial. Am J Clin Nutr. **95**(1): 49-63.

Roussel, M., Garnier, S., Lemoine, S., et al. 2009. Influence of a walking program on the metabolic risk profile of obese postmenopausal women. Menopause. **16**(3): 566-575.

Snijder, M.B., van der Heijden, A.A., van Dam, R.M., et al. 2007. Is higher dairy consumption associated with lower body weight and fewer metabolic disturbances? The Hoorn Study. Am J Clin Nutr. **85**(4): 989-995.

Thompson, D.L., Rakow, J. and Perdue, S.M. 2004. Relationship between accumulated walking and body composition in middle-aged women. Med Sci Sports Exerc. **36**(5): 911-914.

Toscani, M., Migliavacca, R., Sisson de Castro, J.A. and Spritzer, P.M. 2007. Estimation of truncal adiposity using waist circumference or the sum of trunk skinfolds: a pilot study for insulin resistance screening in hirsute patients with or without polycystic ovary syndrome. Metabolism. **56**(7): 992-997.

Trumbo, P., Schlicker, S., Yates, A.A. and Poos, M. 2002. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. J Am Diet Assoc. **102**(11): 1621-1630.

U.S. Department of Health and Human Services. 1995. Healthy People 2000: national health promotion and disease prevention objectives. Midcourse review and 1995 revisions. U.S. Govt. Printing Office, Washington, DC.

Wagner, A., Dallongeville, J., Haas, B., et al. 2012. Sedentary behaviour, physical activity and dietary patterns are independently associated with the metabolic syndrome. Diabetes Metab.

Walston, J., Xue, Q., Semba, R.D., et al. 2006. Serum antioxidants, inflammation, and total mortality in older women. Am J Epidemiol. **163**(1): 18-26.

Wessel, T.R., Arant, C.B., Olson, M.B., et al. 2004. Relationship of physical fitness vs body mass index with coronary artery disease and cardiovascular events in women. JAMA. **292**(10): 1179-1187.

Wiltgen, D., Benedetto, I.G., Mastella, L.S. and Spritzer, P.M. 2009. Lipid accumulation product index: a reliable marker of cardiovascular risk in polycystic ovary syndrome. Hum Reprod. **24**(7): 1726-1731.

World Health Organization. 1995. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. World Health Organ Tech Rep Ser. **854**: 1-452.

Wright, J.D., Borrud, L.G., McDowell, M.A., Wang, C.Y., Radimer, K. and Johnson, C.L. 2007. Nutrition assessment in the National Health And Nutrition Examination Survey 1999-2002. J Am Diet Assoc. **107**(5): 822-829.

Wyatt, H.R., Grunwald, G.K., Seagle, H.M., et al. 1999. Resting energy expenditure in reduced-obese subjects in the National Weight Control Registry. Am J Clin Nutr. **69**(6): 1189-1193.

Zanolla, A.F., Olinto, M.T., Henn, R.L., Wahrlich, V. and Anjos, L.A. 2009. [Assessment of reproducibility and validity of a food frequency questionnaire in a sample of adults living in Porto Alegre, Rio Grande do Sul State, Brazil]. Cadernos de saude publica / Ministerio da Saude, Fundacao Oswaldo Cruz, Escola Nacional de Saude Publica. **25**(4): 840-848.

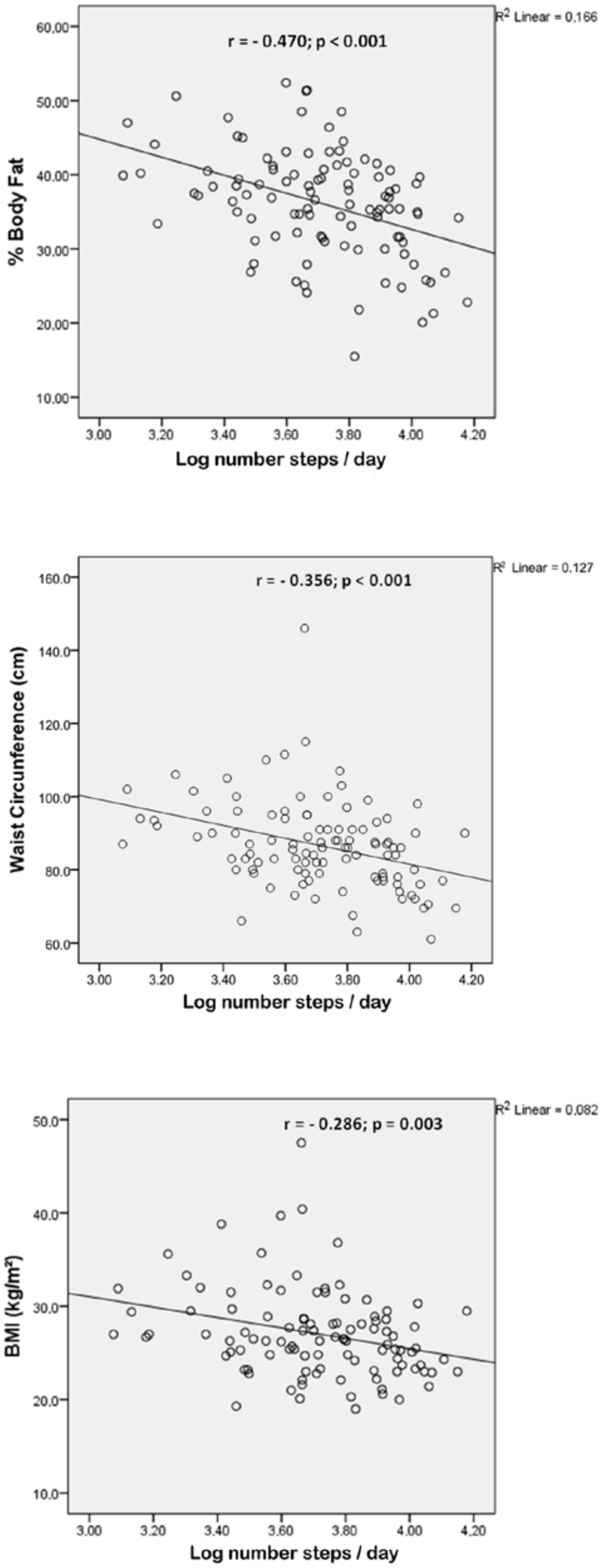

Figure 1. Pearson's correlation between physical activity and body composition in postmenopausal women

Table 1. Characteristics of 105 postmenopausal women according to physical activity status

	All (n = 105)	**Active** (n = 44)	**Inactive** (n = 61)	***P***
Age*, years	55.2 ± 4.9	54.8 ± 5.2	55.4 ± 4.6	0.546
Time since menopause†, years	6.8 ± 1.0	6 (2.5-10)	5 (3-10)	0.773
Years at school†	8.5 ± 4.2	8 (5-11)	8 (5-11)	0.683
White†, n (%)	92 (87.6)	41 (93.0)	51 (83.0)	0.142
BMI†, kg/m^2	27.1 ± 4.7	**25.3 (23.0-27.7)**	**27.1 (24.9-31.5)**	**0.004**
WC†, cm	86.6 ± 12.0	**83.5 (74.6-87.9)**	**88.0 (82.0-95.5)**	**0.001**
Body fat* %	36.2 ± 7.3	**32.9 ± 6.7**	**38.5 ± 6.7**	**<0.001**
Lean mass†, kg	23.8 ± 4.4	22.7 (21.1-25.1)	23.2 (21.1-26.1)	0.157
Fat mass†, kg	25.1 ± 9.2	**20.4 (16.5-26.4)**	**26.3 (21.4-31.4)**	**<0.001**
SBP†, mmHg	127.7 ± 17.3	120 (111.5-136.5)	125 (120-140)	0.202
DBP†, mmHg	78.7 ± 99	**80 (70-80)**	**80 (80-82.5)**	**0.012**
RMR† (Kcal/day)	1291.4 ± 122.2	**1182 (1 113-1 322)**	**1 291 (1 169-1 413)**	**0.021**
Mean steps/day†	5178 (3 597-8 043)	**8457 (6 855-10 313)**	**3 970 (2 777-4 724)**	**<0.001**

*Student t test; †Mann-Whitney test; BMI: body mass index; WC: waist circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; RMR: resting metabolic rate

Table 2. Metabolic and hormonal variables in 105 postmenopausal women according to physical activity status

	All (n = 105)	**Active (n = 44)**	**Inactive (n = 61)**	***P***
Total cholesterol*, mg/dL	216.1 ± 34.9	210.4 ± 32.6	220.2 ± 36.3	0.157
LDL cholesterol*, mg/dL	140 ± 30	134.7 ± 27.1	143.5 ± 31.2	0.149
HDL cholesterol†, mg/dL	53.7 ± 12.8	53 (46-64)	51 (43-59)	0.400
Triglycerides†, mg/dL	116 ± 63	87 (70-138)	110 (73-142)	0.150
Fasting glycemia*, mg/dL	93.4 ± 8.7	**90.5 ± 7.8**	**95.5 ± 8.8**	**0.003**
Fasting insulin† µUI/mL	8.8 (6.0-14.1)	**7.8 (5.4-11.4)**	**9.9 (6.3-15.5)**	**0.019**
HOMA IR†	1.91 (1.3-3.2)	**1.77 (1.20-2.69)**	**2.52 (1.42-3.77)**	**0.017**
us-CRP†, mg/L	1.52 (0.41-4.83)	**0.67(0.22-2.47)**	**2.28 (0.59-6.67)**	**0.011**
Estradiol†, pg/mL	20.5 (12.0-31.1)	18.0 (10.7-30.8)	23.0 (12.8-31.8)	0.136
SHBG†, nm/L	44.0 (33.9-59.9)	**54.6 (38.8-71.7)**	**40.4 (31.4-54.5)**	**0.011**
FAI†	2.26 (1.49-4.04)	2.16 (1.37-3.87)	2.56 (1.68-4.43)	0.385
TT†, ng/mL	0.37 (0.24-0.50)	0.40 (0.26-0.53)	0.36 (0.22-0.47)	0.468
Kuppermann scores†	15.0 (9.0-23.5)	16.0 (9.0-24.0)	14.0 (9.0-23.0)	0.784
Metabolic syndrome#, n (%)	22 (21)	5 (11)	17 (28)	0.052

*Student t test; †Man-Whitney test; #χ^2 test; us-CRP: high-sensitivity c-reactive protein; FAI: free androgen index; TT: total testosterone

Table 3. Daily dietary intake according to physical activity status

Intake/day	Active (n = 44)	Inactive (n = 61)	*P*	Reference values[a]
Macro/micronutrients				
Kcal*	2008 (1579-2398)	1687 (1388-2212)	0.063	-
Carbohydrate,* %	56 (51-58)	57 (51-63)	0.253	45 – 65
Total carbohydrate,* g	292 (192-343)	244 (190-319)	0.130	ND
Glycemic load,* g	137 (106-172)	135 (96-161)	0.296	< 120
Protein,† %	**17.2 ± 3.2**	**15.8 ± 3.0**	**0.028**	10 – 35
Total protein,* g	**81 (66-106)**	**69 (52-82)**	**0.004**	-
Fat,† %	24.3 ± 4.5	23.0 ± 6.0	0.238	20 – 35
Total Fat,* g	**51 (41-68)**	**46 (32-56)**	**0.017**	ND
SFA,† %	7.0 ± 1.8	6.7 ± 2.2	0.355	< 10%[b]
MUFA,* %	7.2 (6.0-8.3)	6.7 (5.1-7.9)	0.256	-
PUFA,* %	3.2 (2.6-4.0)	3.1 (2.4-4.0)	0.697	-
Cholesterol,* mg	**218 (161-278)**	**160 (120-264)**	**0.031**	<300
Fiber,* g	29 (21-40)	25 (20-33)	0.185	25
Ethanol,* g	0.0 (0.0-1.4)	0.0 (0.0-4.7)	0.476	≤12 [b]
Calcium,* mg	**808 (583 - 1034)**	**679 (439-883)**	**0.043**	1200
Magnesium,* mg	283 (205-350)	236 (189-294)	0.099	320
Iron,* mg	**9.0 (7.0-13.0)**	**8.0 (6.0-10.0)**	**0.016**	8
Zinc,* mg	**9.0 (7.0-10.0)**	**7.0 (5.0-9.0)**	**0.009**	8
Sodium,* mg	1849 (1540-2542)	1784 (1423-2171)	0.192	<1500
Selenium,* µg	**95 (81-116)**	**79 (61-106)**	**0.017**	55
Vitamin B12,* µg	4.6 (3.2-6.0)	3.7 (2.2-5.4)	0.089	2.4
Folate,* µg	509 (382-703)	479 (367-620)	0.333	400

Vitamin D,* µg	4.9 (2.6-12.5)	4.0 (2.0-7.9)	0.107	10-15
Vitamin E,* mg	3.9 (2.6-5.1)	3.5 (2.5-4.7)	0.640	15
Vitamin C,* mg	156 (119-330)	173 (109-287)	0.953	75
Vitamin A,* µg	826 (556-1308)	721 (397-1444)	0.608	700
Food groups (g/day)				
Fruits*	332.8 (232.9-748.5)	329.5 (217.7-563.3)	0.563	-
Vegetables[8]	211.2 (95.9-322.1)	159.0 (102.7-260.1)	0.512	-
Beans*	119.4 (60.0-140.0)	100.0 (49.0-140.0)	0.407	-
Whole grain*	135.8 (102.5-245.1)	123.0 (92.1-182.4)	0.284	-
Refined grain*	112.5 (73.5-189.4)	108.1 (54.3-183.0)	0.495	-
Processed meats*	2.1 (0.2-13.0)	5.8 (0.0-13.6)	0.487	-
Meats and eggs*	**106.6 (77.9-147.8)**	**86.2 (52.9-135.1)**	**0.038**	-
Sweets and desserts*	49.9 (26.9-79.9)	41.1 (22.3-97.2)	0.723	-
Whole-fat dairy foods*	**164.5 (40.0 -362.7)**	**65.7 (16.7-203.3)**	**0.011**	-
Low-fat dairy foods*	42.9 (0.0-198.7)	15.0 (0.0-150.0)	0.573	-
Fried food*	15.3 (4.2-35.6)	9.8 (0.8-26.7)	0.224	-
Chips†	**0.02 ± 0.15**	**0.67 ± 2.31**	**0.012**	-

*Mann-Whitney test; †Student t test.

[a]I Brazilian Society for Cardiology and Brazilian Menopause Association Guideline on the Prevention of Cardiovascular Disease in Menopausal Women and the Influence of Hormone Therapy, 2008.

[b]Dietary Reference Intakes, 2002.

SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: poliunsaturated fatty acids.

Table 4. Odds ratio of risk associated with the metabolic syndrome

Risk factors	**OR**	**95% CI**	***P*[a]**
Years at school (< 8 years)	0.85	0.31-2.34	0.750
Physical inactivity (< 6 000 steps/day)	**3.55**	**1.08-11.66**	**0.037**
us-CRP (≥ 3 mg/dL)	**6.57**	**2.20-19.56**	**0.001**
% Body fat[c]	**5.65**	**1.19-26.89**	**0.030**
Protein intake (< 16% of total energy)	2.68	0.97-7.44	0.058
Glycemic load (> 120g)	1.33	0.47-3.77	0.585

[a]Logistic regression adjusted for age and time since menopause.

[b]Sistolic blood pressure ≥ 130mmHg or diastolic blood pressure ≥ 85mmHg or use of antihypertensive drugs (Alberti et al. 2009).

[c]Body Fat % > 33.9 for 40 to 59 years and > 35