

Association between motor proficiency and oral health in people with intellectual disabilities

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Abstract

Background People with intellectual disabilities (IDs) may be at increased risk of developing periodontal diseases and dental caries due to poor oral hygiene. Our aim was to investigate motor proficiency factors associated with presence of visible plaque and gingival bleeding in people with IDs. We were particularly interested in the level of dependence, manual coordination and fine manual control of people with ID, as well as the level of exhaustion of the primary caregiver.

Methods In this cross-sectional study, 299 people with ID were evaluated for oral hygiene using the simplified Visible Plaque Index and for gum inflammation using the Gingival Bleeding Index. The Bruininks-Oseretsky Motor Proficiency Test assessed motor proficiency through fine manual control (fine motor integration and fine motor precision) and manual coordination (manual dexterity and upper limb coordination). The level of dependence was assessed by the Katz dependency index, and the caregiver was tested for exhaustion using the fatigue severity scale. Prevalence ratios [and 95% confidence intervals (CI)] were calculated using crude and adjusted Poisson regression with robust variance.

Results The exhaustion of the caregiver was associated positively to visible plaque [prevalence ratio (PR) = 1.36; 95% CI 1.06–1.65]. For gingival bleeding, people with IDs that had better fine motor integration (PR = 0.49; 95% CI 0.33–0.75) and precision (PR = 0.50; 95% CI 0.26–0.94), as well as manual dexterity (PR = 0.62, 95% CI 0.49–0.77), presented better results.

Conclusion Poor oral hygiene and gum inflammation were associated with motor proficiency of people with IDs and caregivers' exhaustion. Interventions to improve the oral health of people with IDs should take into account such conditions.

Keywords caregiver exhaustion, level of dependence, motor proficiency, motor skill, oral health, people with intellectual disabilities

Introduction

Intellectual disability (ID) is characterised by significant limitations that interfere with intellectual functioning and adaptive behaviour, which involves social skills and daily practices (Luckasson and Schalock 2013). Four areas are mainly affected in the psychomotor development of the person with ID: motor, cognitive, communication and socio-educational (Dandashi *et al.* 2015). Commonly, individuals with IDs have lower physical fitness and impaired motor skills when compared with

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individuals with typical development (Eichstaedt and Lavay 1992; Borji *et al.* 2019).

Adequate levels of motor skills are essential not only for the development of activities of daily living and less dependence on care by others but also for living a healthier lifestyle (Wall 2004; Krombholz 2006). Manual dexterity is the most difficult ability to perform in children with IDs (Wuang *et al.* 2008). Fine motor skills exert a greater demand on the maturity and integrity of the cortical nervous system, in particular the fronto-parietal network, which may be affected in individuals with IDs (Davare *et al.* 2006).

The most common oral disorders of people with IDs are the same as the oral disorders of the general population (i.e. gingivitis, periodontal disease, dental caries and malocclusion), but with higher prevalence and greater severity (Anders and Davis 2010). Some of the main factors contributing for this are difficulties to conduct oral hygiene, dependence on others, use of various medications, low education and lack of information, besides difficulty in accessing dental services (Faulks and Hennequin 2000; Shenkin *et al.* 2001; Jepsen *et al.* 2017; Arweiler *et al.* 2018; Zhou *et al.* 2019).

Maintenance of oral health through oral hygiene requires the ability of an individual to remove dental biofilm. Toothbrushing as a mechanical measure is the most easy and effective way to obtain and maintain proper oral hygiene (Faulks and Hennequin 2000; Shenkin *et al.* 2001; Jepsen *et al.* 2017; Arweiler *et al.* 2018). Although toothbrushing is a simple and effective means of biofilm removal, the high prevalence of gingivitis and the presence of visible plaque in the population of people with IDs indicate that the performance of toothbrushing is inadequate (Ward *et al.* 2019; Zhou *et al.* 2019). Recent review points clear benefits only for electric and manual toothbrush that were similarly effective for reducing gingival inflammation. The benefits evidence for oral hygiene interventions for people with ID, such as oral hygiene training, scheduled dental visits with supervised toothbrushing, plaque-disclosing agents and individualised care plans, present unclear clinical importance (Waldron *et al.* 2019). Attention, coordination and manual dexterity are necessary to perform proper oral hygiene with toothbrushes (Jírovec *et al.* 2019). Oral hygiene care and advice should be based on professional

expertise and the needs and preferences of the individual with ID and their caregivers (Waldron *et al.* 2019).

Caregivers have an important role in assisting persons with IDs; their role goes beyond simple monitoring of daily activities, but also helping and encouraging the person to take care of themselves and even acting in supporting, including to maintain oral hygiene and thus oral health (Wilson *et al.* 2019). However, in a broad context of caring, several caregivers have high levels of exhaustion (Gérain and Zech 2019), and greater caregiver burden was associated with less preventive dental care use (Chi *et al.* 2014). Besides that, a revision highlighted that caregivers play a vital role in the provision of oral health support, and this changes according to the degree of severity of the ID (Wilson *et al.* 2019). Despite this, levels of exhaustion and burnout of caregivers have not been studied in the context of oral hygiene.

Describing the oral hygiene of persons with ID, and their associated factors, can aid in early identification of susceptible individuals. Additionally, it contributes to the improvement of clinical practice by increasing the evidence and need for coordinated and specialised care to persons with ID. Therefore, this study aims to investigate motor proficiency of persons with ID as well exhaustion levels of primary caregivers associated with oral hygiene in persons with IDs. Our hypothesis is that higher levels of dependence, lower levels of manual coordination and fine manual control among persons with ID as well as higher levels of exhaustion of primary caregivers are associated with higher levels of visible plaque and gingival bleeding.

Methods

Study design and setting

This is a cross-sectional study conducted in six special care schools in the metropolitan region of the state of Rio Grande do Sul, Brazil, between August 2018 and July 2019. Special care schools are schools exclusively attended by students with a medical diagnosis of ID and include formal and technical education. To calculate the sample size, the prevalence of gingival disease of 10% was considered in the population with ID (Brasil 2012), with a possible variation of 5%. An $\alpha = 0.01$ was used, with standardised amplitude of the

interval and two-tailed hypothesis test with $\beta = 0.20$. The sample size calculation indicated a minimum number of 299 participants. A total of 299 volunteers [people with IDs ($n = 299$) and their respective caregivers ($n = 299$)] participated in this study with a 98% acceptance rate. Both the person with a medical diagnosis of ID and their caregiver were included in the study. A pilot study was conducted to test the research protocol, questionnaires, instruments and clinical evaluations with 25 dyads of persons with ID and caregivers. The participants of the pilot study were not included in the final sample. The Committee for Research Ethics, under protocol number 2,762,720, approved the project.

Selection of participants

Participants were recruited in the schools using a proportional multistage probabilistic sampling scheme. Initially all special care schools ($n = 12$) in the metropolitan region were contacted. The State Department of Education provided the list of institutions. Through random selection, six schools were sampled. After contact with all selected schools, the total number of enrolled students was established, and a proportion was defined for each school, according to the sample size calculation, stipulating as basis the proportional distribution of the total enrolled students in the six schools. From this, in each school, the proportion by gender was evaluated following the distribution of ID in the Brazilian population (1.2% women and 1.5% for men) (Brasil, IBGE 2012). The school principal informed all students and caregivers about the research through a newsletter. To participate in the research, students and primary caregivers were informed about the research. Informed consent was obtained from the participants after reading a consent form, plus explanations to all caregivers about their participation and also of the persons with IDs under their responsibility. Within a school, enrolment was systematic: potential participants were included in the study in the order of receipt of the consent forms, until the sample size for that school was reached.

Data sources/measurement

Participants were evaluated using a three-stage protocol successively: (1) questionnaire completed by their primary caregiver; (2) clinical examination of

gingival health, visible plaque and gingival bleeding; and (3) motor proficiency assessment.

In the first stage, a structured socio-demographic and health behaviour questionnaire was applied to the main caregivers to determine family socio-economic conditions as well as characteristics of the person with ID. The following variables were evaluated: gender; age in years (categorised as 7–14, 15–30, 31–62); household income (categorised as ≥ 2 or < 2 minimum wages, with two minimum wages $\approx \$530$); toothbrushing frequency measured in quantity per day/week (categorised as two times or more per day; one time or less per day); use of the following oral hygiene tools: toothpaste, toothbrush, dental floss, mouthwash, mouth gel, tongue cleaner, gauze, cloth or other [categorised as (1) toothpaste and toothbrush or (2) auxiliary instrument (toothpaste and toothbrush in addition to some other of the following instruments: floss, mouthwash, mouth gel, tongue cleaner, gauze, cloth)]; continued use of prescription medications (categorised as 0–2, 3 or more). The level of dependence was assessed by the Katz dependency index (categorised as high and low dependence), which assesses the functional capacity of individuals with IDs. The index has high specificity and sensitivity for diagnosis of normal dementia, cognition and function (Ferretti-Rebustini *et al.* 2015). Finally, the caregiver, as a facilitator in adherence and healthy oral health habits, was assessed for exhaustion through the Fatigue Severity Scale (categorised as with or without exhaustion). The scale assesses fatigue through questions related to subjective loss of physical and/or mental energy, which is perceived by the caregiver as interference in the execution of their daily activities (Gomes *et al.* 2013).

The second stage consisted of oral examinations of the person with ID by a single dentist specialised in patients with special needs. The exam was performed using a periodontal probe (CPI-WHO), odontoscope, cotton tweezers, cotton rollers, suction, air compressor and portable lighting, as well as personal protective equipment. The outcomes studied were oral hygiene indicators assessed by Visible Plaque Index and Gingival Bleeding Index. A sextant simplified periodontal recording method was used, where one tooth per sextant was evaluated. Both indices were categorised by the number of sextants with alteration (0–2 or 3–6 sextants).

The third stage consisted of motor proficiency test of the person with ID. The Bruininks-Oseretsky Motor Proficiency Test second edition assesses the motor skills of persons with developmental disabilities and is useful for research and evaluation of mobility training programmes (Deitz *et al.* 2007). The sub-tests evaluating fine manual control (fine motor integration and precision) and manual coordination (manual dexterity and upper limb coordination) were applied because these are the motor proficiencies used during oral hygiene activities.

Statistical analysis

Statistical analysis was conducted using SPSS, version 21.0 (Chicago: SPSS Inc). Descriptive and association analyses were performed, and chi-squared tests were used to assess the association between predictors and outcome ($P < 0.05$). Prevalence ratios (PR) and confidence intervals (95% CIs) were estimated using Poisson regression with robust variance (Zou and Donner 2013). A hierarchical model was constructed for the analysis (Victoria *et al.* 1997). The distal level consisted of socio-demographic and oral hygiene variables; the intermediate level consisted of variables related to drug use and motor proficiency, and the proximal level consisted of variables related to the dependence level of the person with ID and caregiver fatigue. Exposure variables with $P < 0.10$ in the crude analysis were included in the adjusted analysis. 'Backward stepwise' procedure was used for final variable selection where variables with $P < 0.05$ were retained in the final model. Model fit was assessed with the deviance and omnibus test.

Results

We evaluated 299 dyads of students with IDs and caregivers. More than half of the students with disabilities were male ($n = 166$, 55.5%), with a mean age of 17.8 (SD \pm 9.8) years. The majority was using three or more medications ($n = 170$, 56.9%). Most caregivers were female ($n = 275$, 92.0%), with a mean age of 45.6 (SD \pm 11.3). Family income was predominantly low, with most of the families ($n = 162$, 54.2%) earning less than two minimum wages.

Most caregivers reported that the persons with ID brushed their teeth at least twice a day ($n = 191$,

63.9%), using toothpaste and toothbrush to perform their oral hygiene. Besides that, 52.8% ($n = 158$) used at least one other instrument: dental floss ($n = 131$, 43.8%), mouthwash ($n = 107$, 35.8%) and tongue cleaner ($n = 27$, 9.0%). Manual coordination was better than fine manual control: 59.2% ($n = 177$) had normal upper limb coordination and 48.8% ($n = 146$) had manual dexterity. However, only 25.8% ($n = 77$) had fine motor integration and 18.4% ($n = 55$) fine motor precision. The prevalence of visible plaque was 58.2% ($n = 174$) and gingival bleeding was 67.6% ($n = 202$). The prevalence of the caregivers presenting exhaustion was 41.1% ($n = 123$), and 64.5% ($n = 193$) cared for persons with ID with low level of daily dependence.

Table 1 presents prevalence of the socio-demographic, oral health condition, medication and motor proficiency of IDs associated with visible plaque and gingival bleeding. There were no statistically significant associations between the outcomes and gender or age of the person with ID, frequency of brushing, number of oral hygiene instruments used and family income. A positive and direct association was found for both plaque index and gingival bleeding with the amount of medication, motor proficiency of the persons with ID (fine motor integration, fine motor precision, manual dexterity and upper limb coordination), and the level of dependence and caregiver fatigue ($P < 0.001$).

Results of the crude and adjusted prevalence ratios for visible plaque are shown in Table 2. In the crude analysis, all variables were statistically significant. In the adjusted analysis, the use of two or more medications (PR = 1.48; 95% CI 1.24–1.77) and caregiver fatigue (PR = 1.36; 95% CI 1.06–1.65) were positively associated with visible plaque, while manual dexterity was a protective factor (PR = 0.39; 95% CI 0.27–0.56). The quality of the adjusted model was acceptable when considering the deviance ($P = 0.360$) and omnibus ($P < 0.001$) tests.

Similarly, Table 3 presents the crude and adjusted prevalence ratios for gingival bleeding. In the adjusted analysis, the use of two or more medications (PR = 1.34; 95% CI 1.16–1.54) was associated with a higher prevalence of bleeding. Fine motor integration (PR = 0.49; 95% CI 0.33–0.75), fine motor precision (PR = 0.50; 95% CI 0.26–0.94) and manual dexterity (PR = 0.62, 95% CI 0.49–0.77) were protective factors. The quality of the adjusted

A. Baumgarten *et al.* • Motor proficiency and oral health**Table 1** Prevalence of visible plaque and gingival bleeding of persons with ID by explanatory variables, Brazil, 2019 (*n* = 299)

	Visible plaque		<i>P</i> value [‡]	Gingival bleeding	
	Yes (3–6 sextants) [†]			Yes (3–6 sextants) [†]	
	<i>N</i>	<i>n</i> (%)		<i>n</i> (%)	<i>P</i> value [‡]
Sex					
Male	166	102 (61.4)	0.203	114 (68.7)	0.645
Female	133	72 (54.1)		88 (66.2)	
Age					
7–14 years	140	81 (57.9)	0.870	95 (67.9)	0.994
15–30 years	122	70 (57.4)		82 (67.2)	
31–62 years	37	23 (62.2)		25 (67.6)	
Income					
<2 minimum wages	137	72 (52.6)	0.109	87 (63.5)	0.168
≥2 minimum wages	162	102 (63.0)		115 (71.0)	
Toothbrushing frequency					
1 time or less/day	107	68 (63.6)	0.150	68 (63.6)	0.282
2 times or more/day	192	105 (55.0)		133 (69.6)	
Oral hygiene instrument					
Only paste and toothbrush	141	89 (63.1)	0.103	99 (70.2)	0.354
Auxiliary Instrument [§]	158	85 (53.8)		103 (65.2)	
Medication use					
0–2	129	48 (37.2)	<0.001	64 (49.6)	<0.001
3 or more	170	126 (74.1)		138 (81.2)	
Fine motor integration					
Inadequate	222	158 (71.2)	<0.001	184 (82.9)	<0.001
Normal	77	16 (20.8)		18 (23.4)	
Fine motor precision					
Inadequate	244	166 (68.0)	<0.001	192 (78.7)	<0.001
Normal	55	8 (14.5)		10 (18.2)	
Manual dexterity					
Inadequate	153	142 (92.8)	<0.001	145 (94.8)	<0.001
Normal	146	32 (21.9)		57 (39.0)	
Upper limb coordination					
Inadequate	122	102 (83.6)	<0.001	106 (86.9)	<0.001
Normal	177	72 (40.7)		96 (54.2)	
Dependency level					
Low	106	30 (28.3)	<0.001	50 (47.2)	<0.001
High	193	144 (74.6)		152 (78.8)	
Caregiver fatigue					
Without exhaustion	176	61 (34.7)	<0.001	89 (50.6)	<0.001
With exhaustion	123	113 (91.9)		113 (91.9)	

[†]Three to six sextants with visible plaque or gingival bleeding.[‡]Chi-squared test.[§]Auxiliary oral hygiene instruments – toothpaste and toothbrush in addition to some other of the following instruments: floss, mouthwash, mouth gel, tongue cleaner, gauze and cloth.

Table 2 Crude and adjusted prevalence ratios for the outcome visible plaque of persons with intellectual disabilities, Brazil, 2019 ($n = 299$)

	Crude PR			Adjusted PR		
	PR [†]	95% CI	P value [‡]	PR [†]	95% CI	P value [‡]
Medication use						
0–2	1	–	–	1	–	–
3 or more	1.99	1.56–2.53	<0.001	1.48	1.24–1.77	<0.001
Fine motor integration						
Inadequate	1	–	–	1	–	–
Normal	0.29	0.19–0.46	<0.001	0.71	0.46–1.09	0.121
Fine motor precision						
Inadequate	1	–	–	1	–	–
Normal	0.21	0.11–0.41	<0.001	0.68	0.33–1.37	0.282
Manual dexterity						
Inadequate	1	–	–	1	–	–
Normal	0.24	0.17–0.32	<0.001	0.39	0.27–0.56	<0.001
Upper limb coordination						
Inadequate	1	–	–	1	–	–
Normal	0.49	0.40–0.59	<0.001	1.14	0.96–1.34	0.882
Dependency level						
Low	1	–	–	1	–	–
High	2.64	1.93–3.61	<0.001	1.23	0.94–1.60	0.136
Caregiver fatigue						
Without Exhaustion	1	–	–	1	–	–
With Exhaustion	2.65	2.15–3.26	<0.001	1.36	1.06–1.65	0.012

[†]Prevalence ratio by robust Poisson Regression. All variables in the table were included in the final model.

[‡]Wald Chi-square.

PR, prevalence ratio.

model was acceptable when considering the deviance ($P = 0,344$) and omnibus ($P < 0.001$) tests.

Discussion

This study demonstrated that motor proficiency is important to maintain oral hygiene in persons with IDs. Manual dexterity was associated with better control of gingival plaque and bleeding, while fine manual control, measured by motor integration and precision, with better control of gingival bleeding. These associations are present regardless of the levels of dependence of the person with ID. In addition, caregivers' exhaustion was associated with presence of gingival plaque in the persons with ID. The initial hypothesis, which assumes that motor proficiency is positively associated with better oral hygiene indicators, was confirmed. Our secondary hypothesis was also confirmed as fatigue of the caregivers were associated with visible plaque, one of the indicators of

poor oral hygiene. To our knowledge, this was the first study to empirically demonstrate these associations.

To ensure the correct practice of oral hygiene, the first step is to identify the functional capacity of the individuals using the oral hygiene tools (Faulks and Hennequin 2000). Functional capacity has been studied in older adults, and there is a tendency to lose manual dexterity needed to perform daily activities as we age (Williams *et al.* 1990), including performing oral hygiene (Bauer 2001). As a consequence of decreasing dexterity, high accumulation of dental biofilm occurs (Erbe *et al.* 2018; Barouch *et al.* 2019). Our study expands on these findings from the literature by using a refined categorisation of motor skills. We demonstrated that not only limited manual dexterity but also limited fine motor skills, measured by fine motor integration and precision were associated with gingival bleeding.

Manual dexterity, which is the ability of the hands and fingers to make coordinated movements, and fine

Table 3 Crude and adjusted prevalence ratios for the outcome gingival bleeding of persons with intellectual disabilities, Brazil, 2019. (*n* = 299)

	Crude PR			Adjusted PR		
	PR [†]	95% CI	P value [‡]	PR [†]	95% CI	P value [‡]
Medication use						
0–2		–	–		–	–
3 or more	1.64	1.35–1.97	<0.001	1.34	1.16–1.54	<0.001
Fine motor integration						
Inadequate		–	–		–	–
Normal	0.28	0.19–0.42	<0.001	0.49	0.33–0.75	<0.001
Fine motor precision						
Inadequate		–	–		–	–
Normal	0.23	0.13–0.41	<0.001	0.50	0.26–0.94	0.031
Manual dexterity						
Inadequate		–	–		–	–
Normal	0.41	0.33–0.51	<0.001	0.62	0.49–0.77	<0.001
Upper limb coordination						
Inadequate		–	–		–	–
Normal	0.62	0.54–0.73	<0.001	1.18	0.99–1.37	0.132
Dependency level						
Low		–	–		–	–
High	1.67	1.35–2.07	<0.001	0.92	0.77–1.11	0.394
Caregiver fatigue						
Without exhaustion		–	–		–	–
With exhaustion	1.82	1.56–2.12	<0.001	1.13	0.94–1.35	0.185

[†]Prevalence ratio by robust Poisson Regression. All variables in the table were included in the final model.

[‡]Wald Chi-square.

PR, prevalence ratio.

motor coordination, which makes use of the small muscles of the hands and forearm to perform activities that require greater precision and refinement (Schott *et al.* 2016; Kaur *et al.* 2018; Li *et al.* 2019; Yu and Chang 2019) were important indicators of better oral hygiene performance of persons with ID. These skills develop progressively over the years and need to be exercised. In our sample, prevalence of motor proficiency was 26.1%, lower than other studies who found 45.9% (Suhaili *et al.* 2019) and 38.9% (Jeoung 2018). Some of these differences can be explained the use of distinct instruments to evaluate motor proficiency as well as differences in study sampling methods, and participants characteristic such as severity of ID.

The high prevalence and severity of gingivitis and visible plaque not only in persons with IDs (Anders and Davis 2010; Fisher 2012; Finkelman *et al.* 2014) but also in the general population (Kinane *et al.* 2017)

indicates that toothbrushing performance in general is inadequate. Particularly for persons with IDs, gum inflammations are common (Avraamova and Pakhomova 2016; Gray *et al.* 2017) as well as microorganisms associated with oral infections in the dental plaque (Binkley *et al.* 2009). A meta-analysis of prevalence studies revealed a wide range of prevalences of plaque accumulation and gingival bleeding across studies, but with most studies reporting high levels of prevalences for persons with IDs (Zhou *et al.* 2017).

As demonstrated by this and other studies (Attin and Hornecker 2005; Tosaka *et al.* 2014; Kumar *et al.* 2016), regardless of the amount of times a day, or the use of other oral hygiene tools, toothbrushing as a mechanical measure of biofilm control is the most practical and effective means to obtain and maintain oral cleanliness (Axelsson and Lindhe 1978; Beal *et al.* 1979; Tosaka *et al.* 2014; Kumar *et al.* 2016).

Understanding the patient's level of functioning can predict and estimate the degree to which caregivers and health professionals will need to be involved in health promotion efforts (Petrova *et al.* 2014).

Our study also highlights that assessment of the caregiver's fatigue level are important to maintain oral hygiene of persons with IDs as we observed that fatigue was associated with worse plaque index. Primary caregivers of people with ID experience a higher burden than caregivers of typically developing children (Suresh *et al.* 2014) and they have high levels of burnout (Gérain and Zech 2019). Many factors such as daily hassles of medical regimes, social isolation, role restriction, financial strain and search for adequate health services increase the levels of burnout and may interfere in health outcomes. The caregiver, within the family context, maintain a closer and more constant relationship and can directly interfere with oral health control and habits, modifying actions that will promote hygiene habits of the people with IDs. Exhaustion of the caregiver decreases their performance and momentary pleasure, and thus, the observation that only visible plaque was associated with fatigue while gingival bleeding was not may be because visible plaque measures oral hygiene condition at the time of the examination while gingival bleeding is an indication of inflammation of the gingiva and reflects oral hygiene conditions at a longer term (Faulks and Hennequin 2000). In addition, caregiver burden may be directly linked to social support, family function and caring experience mediating the relationship between patient factors and caregiver burden (Yu *et al.* 2015). In addition, an association between caregiver burden and preventive use of dental care has already been demonstrated (Chi *et al.* 2014).

People with ID often have gingival hyperplasia whose known risk factors are medications, genetics and oral hygiene (Alani and Seymour 2014). Some classes of drugs, such as cardiacs, antiepileptics, sedatives and tranquillisers, whose effects are associated with inhibition of stimulated and resting salivary flow, may increase the susceptibility to caries and to gingival hyperplasia (Hatahira *et al.* 2017). However, the presence of dental plaque and gingival inflammation exacerbates gingival hyperplasia, regardless of the use of medications (Dongari-Bagtzoglou 2004). Both a revision of the medications

and good oral hygiene are important strategies to prevent gingival hyperplasia.

Recommendations to clinicians and caregivers based on the findings of this study include the importance of assessing motor proficiency related to toothbrushing and the use of additional strategies to prevent and manage oral conditions. Effective tools available for persons with limited motor proficiency include toothbrushes with adaptive handles, electric toothbrush and floss holder. In addition, alternatives to the brushing effect of gum stimulation could include the use of dentifrice containing an association of chlorhexidine and erythrosine (Teitelbaum *et al.* 2009). These tools and products are effective for gingival health; however, the effectiveness in reducing tooth decay and periodontal disease needs to be further investigated.

This was the first study that associated motor performance of persons with IDs with quality of oral hygiene. The sample was representative, not restricted to dental care services, a place commonly used in research with patients with disabilities (Pradhan *et al.* 2009). However, this study has some limitations. It only assessed the presence of the ID, not the co-occurring of physical disability. Also, the number of medications was assessed, but details on the type, frequency of use or route of administration were not collected. The brushing technique and movement duration are observed aspects that predict brushing abilities in terms of oral cleaning and were not tested (Harnacke *et al.* 2015), as well as individual anatomical dental characteristics of each participant. In addition, the motor proficiency test used asks all participants to perform actions in a fixed order, using a battery of standardised and validated tests, recommended for use in people with moderate deficits; we recognise the lack of objective kinematic measures of motor oral hygiene performance. We recommend that future studies could use these objective assessments, such as kinematic analysis and dynamic methods, to identify subtle variations in oral hygiene movement control. Finally, it was not our objective to assess the impact of motor performance of persons with IDs on oral disorders such as tooth decay and severe periodontal diseases. Future studies could prospectively assess the roles of poor oral hygiene and motor performance on incidence of oral disorders of persons with IDs.

In conclusion, the present study with a representative sample of persons with ID identified a positive relationship between motor skills and quality of oral hygiene – both manual dexterity and fine manual control were positively associated with better control of gingival bleeding. Manual dexterity of the person with ID and lower fatigue of their caregivers was associated with better control of visible plaque. In persons with IDs, motor proficiency should be assessed, and alternative treatments may be needed for them to reach their best oral cleanliness.

Acknowledgements

The authors would like to thank the special care schools and all participants in this study.

Source of Funding

This article was funded by Conselho Nacional de Desenvolvimento Científico e tecnológico (CNPq).

Conflict of Interest

No conflicts of interest have been declared.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author.

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A. Baumgarten *et al.* • **Motor proficiency and oral health**

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Accepted 15 February 2021