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Respiratory pattern of diaphragmatic breathing and pilates breathing in COPD subjects

Karina M. Cancelliero-Gaiad[1], Daniela Ike[1], Camila B. F. Pantoni[1], Audrey Borghi-Silva[1], Dirceu Costa[1,2]

ABSTRACT | **Background:** Diaphragmatic breathing (DB) is widely used in pulmonary rehabilitation (PR) of patients with chronic obstructive pulmonary disease (COPD), however it has been little studied in the scientific literature. The Pilates breathing (PB) method has also been used in the rehabilitation area and has been little studied in the scientific literature and in COPD. **Objectives:** To compare ventilatory parameters during DB and PB in COPD patients and healthy adults. **Method:** Fifteen COPD patients (COPD group) and fifteen healthy patients (healthy group) performed three types of respiration: natural breathing (NB), DB, and PB, with the respiratory pattern being analyzed by respiratory inductive plethysmography. The parameters of time, volume, and thoracoabdominal coordination were evaluated. After the Shapiro-Wilk normality test, ANOVA was applied followed by Tukey's test (intragroup analysis) and Student's t-test (intergroup analysis; $p<0.05$). **Results:** DB promoted increase in respiratory volumes, times, and SpO_2 as well as decrease in respiratory rate in both groups. PB increased respiratory volumes in healthy group, with no additional benefits of respiratory pattern in the COPD group. With respect to thoracoabdominal coordination, both groups presented higher asynchrony during DB, with a greater increase in the healthy group. **Conclusions:** DB showed positive effects such as increase in lung volumes, respiratory motion, and SpO_2 and reduction in respiratory rate. Although there were no changes in volume and time measurements during PB in COPD, this breathing pattern increased volumes in the healthy subjects and increased oxygenation in both groups. In this context, the acute benefits of DB are emphasized as a supporting treatment in respiratory rehabilitation programs.

Keywords: physical therapy; COPD; plethysmography; breathing.

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Introduction

Diaphragmatic breathing (DB) is widely used in pulmonary rehabilitation in patients with chronic obstructive pulmonary disease (COPD). The main objectives are to improve abdominal movement and at the same time reduce the time of thoracic excursion and the activity of the respiratory muscles of the ribcage[1,2]. Some of the beneficial effects of DB are the improvement in maximum exercise tolerance[3], blood gases (increase in partial oxygen pressure and reduction in partial carbon dioxide pressure)[1], and in diaphragm muscle mobility[2].

The Pilates breathing (PB) method is another frequently used type of respiration that differs from DB. PB requires deep breathing while keeping the abdomen pulled in by means of active contraction of the transverse abdominal (TrA) and pelvic floor muscles[4]. Although the Pilates method is growing in both the area of fitness and rehabilitation, there is scarcely any scientific research on the subject, particularly in the area related to respiration. Thus, better knowledge of the specific breathing technique of this method is necessary, particularly when applied to individuals with diseases such as COPD, who present diaphragmatic muscle dysfunction[2].

Therefore, we hypothesized that the respiratory patterns during DB and PB are different because in DB there is a diaphragmatic excursion with abdominal projections and in PB the abdomen is contracted and chest breathing is encouraged, and we conducted the present study in order to investigate the different respiratory patterns induced by the two techniques. In this context, the aim of the present study was to compare these respiratory patterns in COPD patients and healthy adults, evaluated by the respiratory inductance plethysmography (RIP) method.

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Method

Design and study population

This was a prospective, randomized, and crossover trial. To establish the COPD population, a total of 30 subjects of both genders were screened, including patients with stable and moderate to severe COPD[5], among whom fifteen subjects (8 men and 7 women) were selected for inclusion in the study. The selected subjects had a documented medical history of COPD, were receiving medical therapy with pulmonary drugs, were smokers or former smokers, and none had any clinical or physiological features of bronchial asthma. The exclusion criteria were age over 80 years, obesity, history of recent exacerbation, uncontrolled arterial hypertension, and need for home oxygen therapy.

For the healthy group, 15 subjects were also included according to these criteria: healthy men and women aged between 40 and 80 years. The exclusion criteria were obesity, presence of pulmonary, cardiovascular, neurological, and orthopedic diseases, or any other dysfunction that hindered the participation in the study. In this group there was no sample loss.

The study was approved by the Research Ethics Committee of Universidade Federal de São Carlos (UFSCar), São Carlos, SP, Brazil (protocol 073/2009). All the subjects signed an informed consent form to participate in the research.

Measurements

The measurements that were studied were taken on two different days. On the first day, the subjects underwent a clinical assessment, and baseline characteristics, such as age, gender, weight, height, body mass index (BMI), were recorded. Respiratory muscle strength represented by maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP) were assessed with an analog vacuum manometer (Ger-Ar®, São Paulo, SP, Brazil) in accordance with the recommendation in the literature[6]. Spirometry was performed with a portable spirometer (Easy One®, Andover, MA, USA) to obtain forced vital capacity (FVC); forced expiratory volume in 1 second (FEV_1); and the FEV1/FVC ratio. The procedure was performed in accordance with the guidelines of the American Thoracic Society[7].

On the second day, the subject returned for the experimental procedure. Initially, for the baseline measure, the respiratory pattern was recorded for two minutes during NB. After this, the physical therapist taught the participants the DB and PB techniques (learning phase). Next, these patients were asked to perform each technique in turn to retain their effectiveness. After the learning phase and a period of 15 minutes rest, the respiratory pattern was recorded for 2 minutes during DB and PB performed in a randomly assigned order, which was contained in opaque, sealed envelopes that were shuffled, distributed, and opened immediately before the evaluation. The breathing techniques were performed in the supine position[2] with a 15-minute interval. The inspiratory and expiratory times were not standardized, and the subjects were free to perform the exercises at their own pace (Figure 1). All subjects completed both breathing techniques and care was taken to ensure that the proportion of subjects who started assessing DB was equal to that of PB.

Experimental procedures

In the present study, the measurements were investigated at baseline (NB) and during two types of respiration as follows:

Baseline/Natural breathing (NB) - the patients were placed in the supine position and were instructed to remain relaxed during the specified time. In this period, no breathing frequency was induced to allow the detection of each patient's breathing pattern.

Diaphragmatic breathing (DB) - the patient lay in the supine position with one hand placed at the top of the abdominal area and the other, at the top of the upper thorax. The emphasis was on outward abdominal movement during inspiration and inward abdominal movement during expiration[2,8].

Pilates breathing (PB) - PB was performed according to the recommendations of Menezes[9]: "Keep the neck and shoulders relaxed; Allow the respiration to flow: do not hold your breath at any point; Breathe through your nose without allowing your shoulders to lift; Without stopping, breathe out through your mouth with a sigh; Breathing out through your teeth, with your lips pursed". In addition to deep breathing, the abdomen had to be kept pulled in by active contraction of the TrA and pelvic floor muscles[4].

Respiratory Pattern measurements

The respiratory pattern was assessed by respiratory inductive plethysmography (RIP) using the LifeShirt System (Vivometrics Inc., Ventura, CA, USA) and was monitored using the thoracic and abdominal inductance plethysmography bands integrated in the

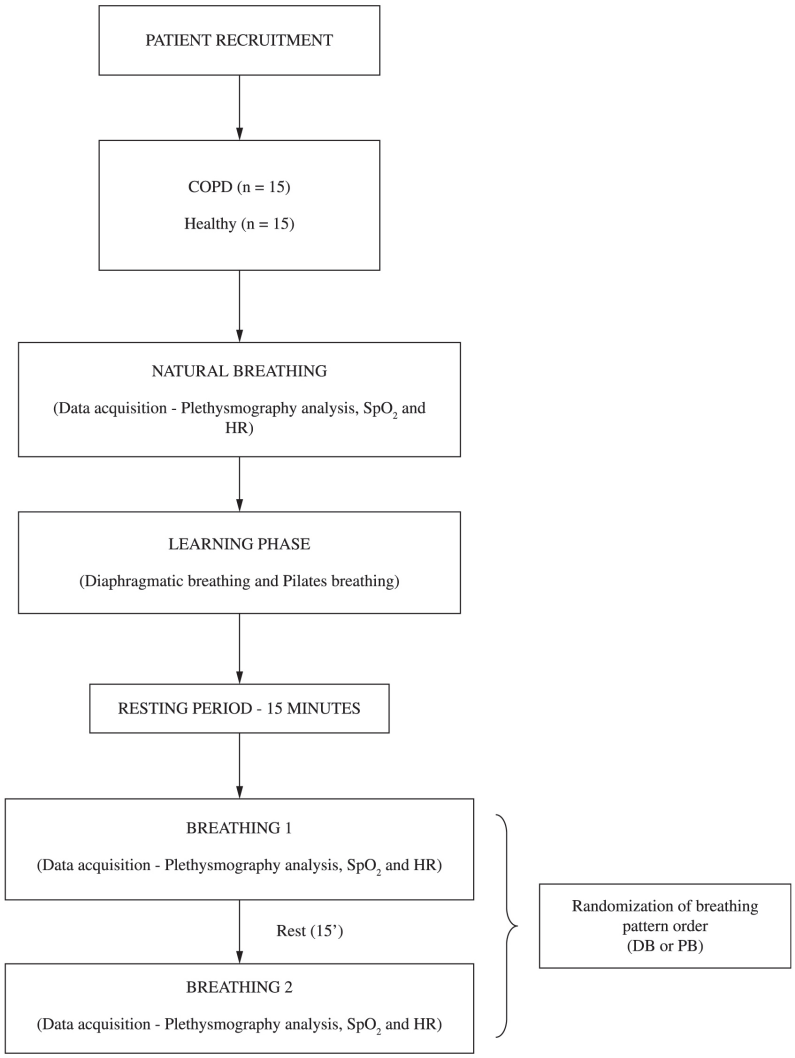

Figure 1. Experimental protocol.

LifeShirt positioned at the level of the nipples and umbilicus, respectively. Data were recorded with a portable device and stored in a flash memory card inserted in the LifeShirt recorder, then downloaded to a computer and analyzed with the VivoLogic analysis software program (Vivometrics Inc., Ventura CA, USA) that accompanies the LifeShirt.

For the volumetric adjustment procedure, the participants were asked to wear a nose clip and breathe in and out 7 times through a mouthpiece attached to an 800-ml plastic bag, filling and emptying the bag completely with each breath. This procedure was conducted in the sitting and standing posture after appropriate pauses, twice for each posture, and repeated if participants did not adhere to instructions, until it was successfully performed.

In the respiratory pattern analyses, the following variables were used:

- Volume measures: Inspiratory tidal volume (ViVol); expiratory tidal volume (VeVol), and minute ventilation (Vent);
- Time measures: Respiratory Rate (Br/M); inspiratory time (Ti); expiratory time (Te), and total breath time (Tt);
- Thoracoabdominal coordination measures: Percent Rib Cage Inspiratory Contribution to Tidal Volume Ratio (%RCi); Labored Breathing Index (LBI); phase relation during inspiration (PhRIB); phase relation during expiration (PhREB); phase relation of the entire breath (PhRTB); and phase angle (PhAng).

To obtain the RIP sum signal for absolute volume in ml, a quantitative calibration was carried out before the analysis of respiratory variables. Breath-by-breath

analysis was performed during a 2-minute period and converted into mean values for later comparisons by statistical analysis.

Peripheral oxygen saturation measurements

During the breathing exercises, peripheral oxygen saturation measurements (SpO_2) and heart rate (HR) were determined by pulse oximetry (Nonim® 8500A, Plymouth, MN, USA).

Statistical analysis

The Shapiro-Wilk test was applied to establish data frequency distribution and as data presented normality, repeated measures ANOVA with Tukey's post-Hoc (intragroup analyses) and unpaired Student's t-test (intergroup analysis) were performed. A *p*-value of 0.05 was considered statistically significant. The Prism 3.0® software program was used. The power analysis was performed using GraphPad StatMate® 2.00 and the statistical power was 99%.

Results

The characteristics of the healthy group and the COPD group are shown in Table 1.

In the COPD group, 9 individuals were former smokers and 6 were smokers. As regards the classification of COPD, 6 presented with a moderate obstruction and 9 with severe obstruction. As expected, the healthy group presented higher values for pulmonary variables compared with the COPD group.

Considering the respiratory pattern in the intragroup analysis, only DB differed from NB in the COPD group, with an increase in volume measures (ViVol: 121%; VeVol: 120%; Vent: 63%), Ti (46%), Te (55%), and Tt (52%) and a decrease in Br/M (34%). In addition, DB induced an increase in the thoracoabdominal coordination measures (PhRIB: 187%; PhREB: 167%; PhRTB: 178%; PhAng: 178%) when compared with NB. SpO_2 increased in both DB (4.2%) and PB (4.1%) compared with NB (Table 2). In contrast, HR did not differ between the three respirations (NB:74±10; DB:75±10; PB:79±10 bpm). When comparing PB with DB, DB showed higher values for ViVol (49%), VeVol (65%), Ti (35%), Te (67%), Tt (56%), PhRIB (81%), PhREB (71%), PhRTB (68%), and PhAng (119%) and lower values for Br/M (35%; Table 2).

Similarly, in the healthy group, DB induced an increase in volume measures (ViVol: 272%, VeVol: 286%, Vent: 143%), an increase in Ti (107%), Te (126%), and Tt (119%) and a decrease in Br/M (28%) when compared with NB. DB also showed higher values for thoracoabdominal coordination variables when compared with NB (PhRIB: 419%; PhREB: 429%; PhRTB: 370%, PhAng: 330%). PB presented an increase in volume (ViVol: 162%; VeVol: 170%; Vent: 157%) and thoracoabdominal coordination values (PhRIB: 353%; PhREB: 383%; PhRTB: 360%; PhAng: 132%; %RCi: 28%) when compared with NB. Similarly to the COPD group, SpO_2 increased in both DB (2.4%) and PB (2.2%) compared with NB (Table 2). When comparing PB with DB, the latter showed higher values for ViVol (42%), VeVol (43%), Ti (61%), Te (108%), Tt (93%), and PhAng (85%) and lower values for Br/M (27%) and Ti/Tt (12%; Table 2). HR did not differ between

Table 1. Anthropometric variables and spirometric variables of the healthy group and COPD group (n=15/group).

Variable	Healthy	COPD	P
Age (years)	62.5±9.4	65.3±7.3	0.37
Gender (M/F)	7/8	8/7	1.00
Height (m)	1.70±0.05	1.65±0.11	0.11
Weight (kg)	70.1±8.1	66.3±10.9	0.29
BMI (kg/m^2)	24.2±2.3	24.6±4.8	0.78
FVC (% predicted)	102.6±10.4	70.2±16.2	<0.0001
FEV_1 (% predicted)	102.8±10.6	46.9±11.1	<0.0001
FEV_1/FVC (% predicted)	98.4±6.1	68.6±11.0	<0.0001
MIP (cmH_2O)	–84.7±29.8	–64.7±27.2	0.07
MEP (cmH_2O)	104.7±35.8	81.4±28.6	0.06

BMI= body mass index; FVC= forced vital capacity; FEV_1= forced expiratory volume in 1 second; FEV_1/FVC: Tiffeneau index; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure. Values are mean±SD.

Table 2. Plethysmography analysis measures and peripheral oxygen saturation (SpO_2) of the COPD group (A) and the healthy group (B) (n=15/group).

A	**NB**	**DB**	**PB**
Volume measures			
ViVol	397.9±125.3	880.5±421.4 *	591.4±377.5 # †
VeVol	400.9±128.7	881.7±426.4 *	533.5±291.3 # †
Vent	6.0±2.4	9.8±2.5 *	8.9±4.3
Time measures			
Br/M	16.7±3.8	11.0±3.5 *	16.9±7.4 #
Ti	1.3±0.3	1.9±0.4 * †	1.4±0.3 # †
Te	2.9±1.3	4.5±2.0 *	2.7±0.9 #
Tt	4.2±1.5	6.4±2.1 *	4.1±1.1 #
Ti/Tt	0.34±0.06	0.33±0.09	0.36±0.07 †
Thoracoabdominal coordination measures			
%RCi	54.5±28.1	50.6±48.4	61.1±28.2
LBI	1.07±0.26	1.18±0.26	1.03±0.03
PhRIB	13.5±12.9 †	38.8±21.6 *	21.4±10.5 #
PhREB	13.9±8.0 †	37.1±19.0 *	21.7±9.8 #
PhRTB	13.4±8.0 †	37.2±19.6 *	22.1±9.5 #
PhAng	24.1±22.1 †	67.0±47.7 * †	30.6±12.3 # †
Oximetry			
SpO_2	95.4±3.4	99.4±1.4 *	99.3±1.6 *
B	**NB**	**DB**	**PB**
Volume measures			
ViVol	361.9±145.4	1347.8±524.3 *	948.6±439.3 * #
VeVol	368.3±145.2	1420.5±584.3 *	993.0±457.9 * #
Vent	5.6±1.8	13.6±5.6 *	14.4±4.7 *
Time measures			
Br/M	16.4±3.7	11.8±4.8 *	16.2±3.4 #
Ti	1.4±0.4	2.9±0.9 *	1.8±0.4 #
Te	2.3±0.5	5.2±1.8 *	2.5±0.6 #
Tt	3.7±0.8	8.1±2.5 *	4.2±0.9 #
Ti/Tt	0.39±0.04	0.38±0.07	0.43±0.04 #
Thoracoabdominal coordination measures			
%RCi	63.3±16.3	66.7±15.5	80.9±18.3 *
LBI	1.00±0.00	1.08±0.06	1.05±0.08
PhRIB	5.7±3.0	29.6±14.6 *	25.8±12.3 *
PhREB	5.8±2.7	30.7±14.2 *	28.0±10.1 *
PhRTB	5.7±2.5	26.8±12.7 *	26.2±10.4 *
PhAng	9.1±4.2	39.1±19.1 *	21.1±9.5 * #
Oximetry			
SpO_2	97.4±1.6	99.7±0.7 *	99.5±0.8 *

NB= natural breathing; DB= diaphragmatic breathing; PB= pilates breathing; ViVol= inspiratory tidal volume; VeVol= expiratory tidal volume; Vent= minute ventilation; Br/M= Respiratory Rate; Ti= Inspiratory Time; Te= Expiratory Time; Tt= Total Breath Time; Ti/Tt= fractional inspiratory time; %RCi= Percent Rib Cage Inspiratory Contribution to Tidal Volume Ratio; LBI= Labored Breathing Index; PhRIB= phase relation during inspiration; PhREB= phase relation during expiration; PhRTB= phase relation of entire breath; PhAng= phase angle (PhAng), SpO_2= peripheral oxygen saturation. Values are mean±SD. Intragroup analysis: *<0.05 compared with NB. #<0.05 compared with DB (ANOVA). Intergroup analysis: † compared with healthy group in the same breathing (unpaired Student's t test).

the three breathing patterns (NB:69±4; DB:70±5; PB:70±5bpm).

In the intergroup analysis, the COPD group showed lower values for ViVol (37%), VeVol (46%), Ti (22%), and Ti/Tt (16%) and higher values for PhAng (45%) during PB, with lower values for Ti (35%) and higher values for PhAng (71%) during DB. In NB, the COPD group showed higher values for PhRIB (137%), PhREB (140%), PhRTB (135%), and PhAng (165%). With regard to SpO_2, there was no difference between the groups during any of the breathing patterns. HR was higher in the PB of the COPD group (79±10bpm) when compared with the healthy group (70±5bpm, p=0.005).

Discussion

The main results of this study showed that DB favored greater respiratory volumes and times in both groups, contributing to the reduction in Br/M and increase in SpO_2, compared with NB. PB was able to increase respiratory volumes in the healthy group, compared with NB, with no additional benefits in the respiratory pattern of the COPD group. With respect to thoracoabdominal coordination, as expected, both groups presented higher asynchrony during DB, compared with NB, with a greater increase in the healthy group. These results are important, since they may co-substantiate the potential beneficial effects of these respiratory breathing modalities in COPD patients in contrast with healthy subjects.

It is known that diaphragmatic dysfunction is an important deleterious consequence of the progression of the severity of COPD. With the increase in air flow resistance, air trapping, and hyperinflation in this disease, the inspiratory muscles are passively shortened and placed at a mechanical disadvantage[10,11]. Therefore, a progressive reduction occurs in the mobility of the diaphragm and in its relative contribution to thoracoabdominal movement[12-14], and as a compensatory mechanism, there is greater recruitment of the respiratory muscles of the rib cage[15,16]. In this context, both the reduction in diaphragm mobility and the greater activity of the rib cage respiratory muscles are associated with the increase in dyspnea and intolerance to physical exercise[17-19].

To reduce or minimize these alterations, studies have been conducted with DB as a form of therapy for improving diaphragmatic mobility and thereby reducing the deleterious effects of diaphragmatic dysfunction. According to the ATS[20], DB is a respiratory strategy frequently taught as a component of self-treatment in COPD patients, with the goal of minimizing the respiratory demand of the disease and reducing its impact on daily life. In the study by Yamaguti et al.[2], a DB training program in COPD patients promoted improvement in diaphragm mobility, with an increase in the participation of the diaphragm during natural respiration, resulting in an improvement in functional capacity, in addition to improvement in health-related quality of life. Other studies[1,21] found an improvement in gas exchange in the respiratory patterns[22,23] and in oxygen consumption[24].

It has been suggested that the beneficial effects of DB depend on the COPD patients' characteristics, such as severity of the disease, pulmonary hyperinflation, and adequate diaphragmatic movement, an essential condition for the success of the respiratory technique[8]. Moreover, a paradoxal abdominal respiratory pattern and worsening of dyspnea and fatigue during the technique are criteria for modifying or interrupting DB[8]. In this context, it is important to mention that the subjects of the present study adequately performed DB, which was monitored by the physical therapist, without any report of dyspnea. DB was beneficial to the COPD patients because it promoted a reduction in respiratory rate and increased the lung volumes, which is in agreement with the proposal of Cahalin et al.[8].

DB is frequently applied in pulmonary rehabilitation programs, and its efficacy in improving pulmonary volumes and SpO_2 and reducing Br/M has been documented[18,25]. In the present study, the beneficial effects of DB on respiratory volumes and times and oxygenation in both groups were also observed when compared with NB. An important issue to consider as regards DB is the thoracoabdominal coordination during the technique, which was shown to be increased[26]. Therefore, the benefits of the technique could be questioned, particularly in COPD patients, who already present higher asynchrony in comparison with healthy subjects.

To clarify this issue, the thoracoabdominal measures were evaluated during the technique, comparing the COPD patients' results with those of healthy-matched subjects. A similar response was found in both groups, with an increase in asynchrony values in comparison with those of NB. Moreover, the healthy subjects presented a higher increase in all asynchrony measures. As expected of a respiratory technique that emphasizes greater use of the diaphragm and abdominal breathing components thus generating "asynchrony" during the respiratory cycle, both groups presented a similar respiratory

pattern behavior. In this study, asynchrony between the thoracic and abdominal compartments was evaluated by PhAng[23], and when the rib cage and abdomen move in perfect synchrony, the PhAng is 0º. However, with the increase in thoracoabdominal asynchrony, this value is close to 180º. In this context, although DB increased the PhAng, it maintained mean values of 70° and did not attain maximum asynchrony values. For this reason, the changes in the measurements related to synchronism cannot be interpreted as an increase in asynchronism, since the increase in mean values remained below 70°.

The increase in thoracoabdominal asynchrony during DB is possibly related to the greater use of the diaphragm. This has also been reported in healthy subjects[25] and other respiratory exercises[26] as mentioned above. It is important to emphasize that DB was performed with inward abdominal movement during expiration. This action can improve the next inspiration since it provides a better mechanical positioning of the diaphragm.

In the present study, although the subjective perceived exertion scale was not used, the SpO_2 was elevated and none of the patients reported dyspnea when breathing correctly and during the proposed time.

The PB technique differs to a great extent from that of DB. To perform the exercises of the Pilates® method, it is necessary to breathe deeply, maintaining the abdomen contracted by active contraction of the local and overall stabilizing muscles of the lumbar spine, in addition to the diaphragm muscle and the pelvic floor muscles[9]. According to Barr et al.[27], the diaphragm muscle works as the roof of a cylinder of muscles that surround the spine and assist with stability. It is one of the main contributors towards maintaining intra-abdominal pressure and preventing displacement of the viscera by contraction, mainly of the TrA muscle.

The specific respiration of the Pilates method is known as lateral breathing, which avoids expansion of the abdomen with the aim of using the thoracic and ribcage muscles to generate lateral expansion of the ribcage, increasing the space for the lungs to expand and avoiding the movement of the abdomen so as not to leave the lumbar region unprotected[9,28]. Thus, it is clear that the objectives of the breathing techniques differ and that the diaphragm muscle in PB also acts as a stabilizer of the lumbar spine. Therefore, as respiration is a little restricted because no movement occurs in the abdominal compartment, the results of this study showed that in the COPD group there were no changes, for example, in the pulmonary volumes, unlike DB, in which there is a diaphragmatic excursion with abdominal projection. This more restricted respiratory movement in PB did not promote alteration in any respiratory patterns evaluated in the individuals with COPD in the present study. In the healthy group, however, PB promoted alterations such as an increase in lung volumes, %RCi, and SpO_2. %RCi has been described as a measure that represents the percent contribution of the rib cage excursions to the tidal volume. Thus, because the movement of the rib cage is greater in the healthy subjects, this was probably detected only in the healthy group. This fact may also explain the alterations in other measures, for example, lung volume and synchronism, due to the fact that the ribcage of the healthy group showed no rigidity and thus the movements were greater.

It should be pointed out that PB specifically promoted a breathing pattern with greater thoracic expansibility. In individuals with COPD, this respiratory pattern may have been influenced by the disease because there is the presence of thoracic rigidity and diminished expansibility, which may also explain the absence of increases in pulmonary volumes, respiratory times, and even in thoracoabdominal asynchrony. However, the active contraction of the TrA muscle can bring long-term benefits, since it provides stabilization of the abdominal compartment and supports the descent of the diaphragm.

With regard to SpO_2, the results of the present study showed that there was an increase during PB in both groups, which may be due to the use of pursed-lip breathing. According to some authors[29], this type of breathing is associated with a partial increase in oxygen pressure in the arterial blood and SpO_2.

With regard to the limitations of this study, one is that the SpO_2 measurements were made using a system that did not store memory as in the plethysmography measurements. Other limitations were the absence of a COPD control group and the sample size.

In view of the foregoing discussion, DB showed positive effects such as an increase in lung volumes, respiratory motion, SpO_2, and reduction in respiratory rate. Although there were no changes in the volume and time measurements during PB in COPD, this breathing pattern increased volumes in the healthy subjects and increased oxygenation in both groups. In this context, the acute benefits of DB are emphasized as a supporting treatment in respiratory rehabilitation programs. Future studies should focus on the effects of both respiratory patterns in other outcomes in

order to confirm the positive or negative effects of these interventions.

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Relationship between static postural control and the level of functional abilities in children with cerebral palsy

Relação entre o controle postural estático e o nível de habilidades funcionais na paralisia cerebral

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ABSTRACT | Background: Postural control deficits can impair functional performance in children with cerebral palsy (CP) in daily living activities. **Objective:** To verify the relationship between standing static postural control and the functional ability level in children with CP. **Method:** The postural control of 10 children with CP (gross motor function levels I and II) was evaluated during static standing on a force platform for 30 seconds. The analyzed variables were the anteroposterior (AP) and mediolateral (ML) displacement of the center of pressure (CoP) and the area and velocity of the CoP oscillation. The functional abilities were evaluated using the mean Pediatric Evaluation of Disability Inventory (PEDI) scores, which evaluated self-care, mobility and social function in the domains of functional abilities and caregiver assistance. **Results:** Spearman's correlation test found a relationship between postural control and functional abilities. The results showed a strong negative correlation between the variables of ML displacement of CoP, the area and velocity of the CoP oscillation and the PEDI scores in the self-care and caregiver assistance domains. Additionally, a moderate negative correlation was found between the area of the CoP oscillation and the mobility scores in the caregiver assistance domain. We used a significance level of 5% ($p<0.05$). **Conclusions:** We observed that children with cerebral palsy with high CoP oscillation values had lower caregiver assistance scores for activities of daily living (ADL) and consequently higher levels of caregiver dependence. These results demonstrate the repercussions of impairments to the body structure and function in terms of the activity levels of children with CP such that postural control impairments in these children lead to higher requirements for caregiver assistance.

Keywords: cerebral palsy; postural balance; children; functionality; PEDI; rehabilitation.

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RESUMO | Contextualização: Os déficits de controle postural em crianças com PC podem comprometer suas atividades na rotina diária. **Objetivo:** Verificar a relação entre o controle postural em ortostatismo de crianças com PC e suas habilidades funcionais. **Método:** O controle postural de dez crianças PC (GMFCS I e II) foi avaliado em ortostatismo na plataforma de força por 30 segundos. Variáveis analisadas: deslocamento ântero-posterior e médio-lateral do centro de pressão (CoP), área e velocidade de oscilação do CoP. As habilidades funcionais foram avaliadas por meio do *Pediatric Evaluation of Disability Inventory* (PEDI), considerando-se escores de autocuidado, mobilidade e função social nos domínios habilidades funcionais e assistência do cuidador. **Resultados:** O teste de correlação de Spearman verificou a relação entre controle postural e funcionalidade. Constatou-se correlação negativa forte entre as variáveis amplitude ML de deslocamento do CoP, área de oscilação do CoP e entre a variável de velocidade média de oscilação do CoP e os escores do domínio de autocuidado. Observou-se também correlação negativa moderada entre área de oscilação do CoP e mobilidade. O nível de significância adotado foi de 5% ($p<0,05$). **Conclusões:** Crianças com maiores oscilações do CoP em ortostatismo apresentam maiores escores de assistência do cuidador para a realização de AVDs, indicando maiores níveis de dependência. Isso demonstra as repercussões dos componentes de estrutura e função do corpo sobre o nível de atividade em crianças com PC, uma vez que o comprometimento do controle postural pode levar a uma maior dependência das crianças em relação a seus cuidadores.

Palavras-chave: paralisia cerebral; equilíbrio; crianças; funcionalidade; PEDI; reabilitação.

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Introdução

Crianças com paralisia cerebral (PC) apresentam desordens motoras que se caracterizam por incoordenações dos movimentos, modificações não adaptativas do comprimento muscular, além de distúrbios do controle postural[1,2]. É o controle postural que garante o adequado posicionamento do corpo no espaço, mantendo estabilidade e alinhamento corporal a partir da manutenção da projeção do centro de pressão (CoP) dentro dos limites da base de suporte[3,4].

Crianças com PC apresentam dificuldades de controlar a posição do corpo no espaço, de realizar ajustes antecipatórios à execução de atividades funcionais e de reagir a perturbações inesperadas do equilíbrio[3,5,6]. As principais causas dos déficits nos ajustes finos do controle da postura em crianças com PC são: ordem de recrutamento muscular e taxa de coativação agonista/antagonista, incoordenação entre os segmentos articulares e recrutamento de menor número de unidades motoras, responsáveis pela coordenação das respostas posturais[6-8]. Em conjunto, essas alterações dificultam o controle do corpo no espaço e determinam uma baixa coordenação entre os segmentos articulares do corpo[9], fazendo com que a criança apresente uma maior oscilação do seu CoP para conquistar sucesso adaptativo em suas atividades diárias[4]. Nessas crianças, por conta dos déficits neuromotores e alterações biomecânicas, o alinhamento entre os segmentos corporais e a manutenção do CoP nos limites da base de suporte estão comprometidos[9,10].

Dessa forma, o conjunto de disfunções presentes na PC pode afetar o controle postural quando na postura em pé e levar a um comprometimento de suas atividades funcionais. Tal inferência é reforçada pelos achados de alguns estudos, que afirmam que essas crianças podem encontrar dificuldades na manutenção da postura ereta e no desempenho das atividades de vida diária (AVDs)[3,11], o que pode reduzir seu nível de independência[3,6,8,12,13].

Estudos relatam, ainda, a repercussão funcional de déficits nos mecanismos de controle postural sobre a marcha[11,12] e o alcance em crianças com PC[14,15], revelando dificuldades em situações de mudanças rápidas de descarga de peso[16] e perturbações inesperadas na postura ortostática[9,17], como requerido durante a realização de diversas AVDs.

No entanto, embora a literatura sinalize uma aparente relação entre controle postural e funcionalidade[3,15], não foram encontrados, nas bases pesquisadas, estudos que relacionem o controle postural estático com o nível de habilidades funcionais apresentado pela criança. O conhecimento dessa relação demonstra a importância da manutenção da estabilidade e do alinhamento entre os segmentos corporais na postura ortostática para execução de atividades funcionais e permite a extrapolação das análises em plataforma de força para AVDs da criança.

Existem, na literatura, instrumentos de avaliação das habilidades funcionais, como o *Pediatric Evaluation of Disability Inventory* (PEDI), com padronização, confiabilidade e validade para a população brasileira[18,19], o que permite mensurar a funcionalidade a partir das atividades que a criança realiza em sua rotina diária e de sua dependência do cuidador[20].

Levando-se em conta o potencial do PEDI para avaliar habilidades funcionais na PC por meio de atividades próximas às executadas em suas rotinas diárias, bem como a carência de estudos que relacionem o controle postural estático nessa população com o nível de habilidades funcionais, acredita-se que o estudo dessa relação possa demonstrar a repercussão direta dos déficits de controle postural sobre o nível de independência de crianças com PC para atividades de mobilidade, autocuidado e função social.

Dessa forma, o presente estudo teve por objetivo verificar a relação entre o controle postural estático em pé de crianças com PC e o nível de habilidades funcionais por elas apresentado.

Método

Participantes

O presente estudo teve caráter transversal e natureza aplicada. Foram selecionadas crianças de ambos os gêneros, com diagnóstico de PC espástica, níveis I e II de função motora grossa (GMFCS)[21], com idade entre cinco e 12 anos. Nesse intervalo de idade, a integração sensorial no controle postural é aprimorada, com aperfeiçoamento dos mecanismos sensoriais integrativos e maior participação da visão[22], gerando respostas que garantem sucesso na manutenção do equilíbrio.

As crianças deveriam apresentar capacidade de atender a comandos simples necessários à realização das tarefas propostas, permanecer na postura ortostática sem apoio por, ao menos, 30 segundos. Os pais ou responsáveis deveriam assinar o termo de consentimento livre e esclarecido (TCLE) para a participação das crianças no estudo. Não foram incluídas crianças com encurtamentos musculares de

membros inferiores limitadores da função na postura em pé, tais como encurtamentos de isquiotibiais, adutores e flexores de quadril e flexores plantares. Também não foram incluídas crianças submetidas a cirurgias ortopédicas em membros inferiores nos últimos doze meses, ou à aplicação de toxina botulínica nos últimos seis.

Procedimentos

O estudo foi submetido ao Conselho Nacional de Saúde e ao Comitê de Ética em Pesquisa com Seres Humanos da Universidade Federal de São Carlos (UFSCar), São Carlos, SP, Brasil e foi aprovado (Parecer Nº 490/2010). Após formalizar a participação no estudo por meio da assinatura do TCLE, as crianças foram submetidas a uma avaliação inicial para coleta de dados antropométricos e ortopédicos.

Na sequência, foi avaliado o controle postural de cada criança na permanência em ortostatismo. Foi utilizada uma plataforma de força BERTEC 400 (EMG Sistem do Brasil®), com frequência de aquisição de 100 Hz. A criança deveria permanecer em pé e sobre a plataforma de força com os pés paralelos e alinhados com a lateral dos quadris[7]. A posição inicial dos pés foi demarcada para garantir sua consistência ao longo das tentativas. Sobre a plataforma, a criança deveria permanecer o mais imóvel possível pelo período de 30 segundos, olhando para uma figura circular posicionada à sua frente, a uma distância de 1metro, na altura de seus olhos. Cada criança realizou a tarefa de permanência em pé, em um total de cinco vezes, duas tentativas de adaptação e três válidas, separadas por um período de descanso de 120 segundos[23].

Na sequência, foi realizada a avaliação das habilidades funcionais da criança por meio do instrumento PEDI, padronizado e validado para a população brasileira[19]. O instrumento avalia crianças com idade entre seis meses e sete anos e meio. Porém, como as crianças avaliadas no presente estudo apresentavam habilidades funcionais compatíveis à idade limite determinada pela PEDI, avaliamos crianças com idade superior à indicada pelo instrumento. Dessa forma, não foi possível utilizar o cálculo dos escores normativos, sendo utilizados apenas os escores brutos de cada criança[2].

O PEDI é dividido em três partes distintas que informam sobre três diferentes áreas do desempenho funcional. A primeira parte avalia habilidades funcionais das crianças nos domínios de autocuidado, mobilidade e função social. Cada item avaliado recebe pontuação 1, caso a criança desempenhe a função, ou 0, caso não desempenhe. A segunda parte quantifica o auxílio fornecido pelo cuidador à criança no desempenho de tarefas de autocuidado (8), mobilidade (7) e função social (5). Nessa parte, cada item é avaliado numa escala ordinal de 0 a 5, em que 0 indica necessidade de assistência máxima, e 5 indica independência. A somatória dos escores resulta em um escore total bruto para cada uma das três áreas de habilidades funcionais. Assim, quanto maior o escore, melhor o desempenho funcional da criança. A terceira parte do teste informa sobre as modificações necessárias para o desempenho das tarefas funcionais nas mesmas três áreas já descritas.

Para o presente estudo, foram utilizados apenas os dados das duas primeiras partes do instrumento, habilidades funcionais e assistência do cuidador, nos três domínios avaliados (autocuidado, mobilidade e função social)[20]. Para a aplicação da escala, o avaliador foi treinado, sendo obtido um índice de concordância intraobservador de 85%.

Análise dos dados e estatística

A captura dos dados obtidos a partir das análises cinéticas em plataforma de força foi realizada por meio do software BERTEC, e a análise dos dados e cálculo das variáveis dependentes foi efetuada por meio da implementação de rotinas em ambiente MATLAB. Os dados foram normalizados pelo peso das crianças[7]. Os dados da plataforma de força foram filtrados pelo filtro digital Butterwoth de 4º ordem, passa baixa, com frequência de corte de 5 Hz por meio do software Matlab (Mathworks Inc, Natick, MA, USA).

As variáveis cinéticas analisadas no presente estudo para análise do controle postural estático em pé foram: a) amplitude ântero-posterior de deslocamento do CoP (Amp AP) (cm); b) amplitude médio-lateral de deslocamento do CoP (Amp ML) (cm); c) área de oscilação do CoP (Área) (c^2); d) velocidade de oscilação do CoP (Vel) (cm/s)[24].

As variáveis dependentes do instrumento PEDI foram: escore bruto do instrumento na área de habilidades funcionais para os domínios de autocuidado (HFac), mobilidade (HFmob) e função social (HFfs) e, na área de assistência do cuidador, domínio de autocuidado (ACac), mobilidade (ACmob) e função social (ACfs).

Os resultados descritivos foram obtidos por meio do cálculo de média e desvio padrão. Para a análise estatística dos dados, foi utilizada a média das três tentativas realizadas na plataforma de força em cada uma das variáveis. O teste de Shapiro-Wilk verificou

Tabela 1. Valores da correlação de Spearman para as variáveis relacionadas ao CoP na permanência em ortostatismo amplitude ântero-posterior de deslocamento do CoP (Amp AP), amplitude médio-lateral de deslocamento do CoP (Amp ML), área de oscilação (Area) e velocidade média de oscilação do CoP (Vel) e as variáveis dependentes do instrumento PEDI.

	PEDI Habilidades Funcionais			PEDI Assistência do Cuidador		
Variáveis COP	**Autocuidado**	**Mobilidade**	**Função social**	**Autocuidado**	**Mobilidade**	**Função social**
Amp AP (cm)	r=–0,19 p=0,6	r=–0,46 p=0,18	r=0,33 p=0,34	r=–0,60 p=0,06	r=–0,58 p=0,07	r=–0,45 p=0,18
Amp ML (cm)	r=–0,23 p=0,50	r=–0,55 p=0,09	r=0,22 p=0,54	**r=–0,82** **p=0,003**	r=–0,57 p=0,08	r=–0,42 p=0,21
Área (cm²)	r=–0,22 p= 0,54	r=–0,52 p=0,12	r=0,42 p=0,22	**r=–0,78** **p=0,007**	**r=–0,63** **p=0,04**	r=–0,36 p=0,30
Vel (cm/s)	r=–0,28 p=0,43	r=–0,50 p=0,13	r=0,28 p=0,42	**r=–0,70** **p=0,02**	r=–0,62 p=0,06	r=–0,56 p=0,08

Tabela 2. Apresentação das correlações significantes (r), da significância estatística (p), da classificação, segundo a proposta de Munro, e do coeficiente de determinação (%).

VARIÁVEIS	r	P	CLASSIFICAÇÃO	%
Amplitude ML (cm) - ACac	– 0,824	<0,05	Forte	67
Área (cm²) - ACac	– 0,784	<0,05	Forte	61
Velocidade (cm/s) - ACac	– 0,704	<0,05	Forte	49
Área (cm²) - ACmob	– 0,635	<0,05	Moderada	40

a ausência de normalidade na distribuição dos dados ($p \geq 0,05$).

Para o estudo da relação entre a média das três tentativas na permanência em ortostatismo na plataforma de força e os escores do instrumento PEDI, foi utilizada a correlação de Spearman em virtude de os dados não serem paramétricos. Foi utilizada, como base, a classificação de valor (r) proposta por Munro[25]. Realizada a correlação entre as variáveis, foi realizado o cálculo do coeficiente de determinação. O nível de significância de 5% foi considerado para todas as análises. O *software* utilizado nas análises e representação gráfica foi o SPSS, versão 10.0.

Resultados

Participaram do estudo dez crianças com PC espástica (M=9; ±4,9), cinco do sexo masculino e cinco do feminino, sete crianças com PC hemiplégica espástica e três PC do tipo diplégica espástica. Os resultados de todas as correlações encontram-se na Tabela 1.

O presente estudo verificou correlações significantes e negativas entre o comportamento do CoP em ortostatismo e as habilidades funcionais da criança. Encontrou-se correlação negativa forte entre as variáveis amplitude ML de deslocamento do CoP (r=–0,82; p<0,05); área de oscilação do CoP (r=–0,78; p<0,05); velocidade média de oscilação do CoP (r=–0,70; p<0,05) e os escores do domínio de autocuidado na área de assistência do cuidador. Observou-se também correlação negativa moderada entre área de oscilação do CoP e os escores de mobilidade (r=–0,63; p<0,05) na área de assistência do cuidador. Os valores das correlações bem como os coeficientes de determinação encontram-se na Tabela 2.

De acordo com os coeficientes de determinação apresentados na Tabela 2, pode-se inferir, para a permanência em ortostatismo, que 67% da variabilidade da Amp ML do CoP pode relacionar-se à variação do escore de autocuidado na área de assistência do cuidador, indicando que o deslocamento no sentido médio-lateral determina menores escores da criança no domínio de autocuidado em 67%. Também observou-se que 61% da variabilidade na área de oscilação do CoP pode relacionar-se à variação no escore de autocuidado na área de assistência do cuidador, indicando que oscilações maiores e mais rápidas do CoP relacionam-se a menores escores de autocuidado na área de assistência do cuidador em 61%. Observou-se que 49% da variabilidade na velocidade de oscilação do CoP parece relacionar-se à variação no escore de autocuidado na área de assistência do cuidador, indicando que oscilações maiores e mais rápidas do CoP relacionam-se a menores escores de autocuidado

na área de assistência do cuidador em 49%. Por fim, observou-se que 40% da variabilidade na área de oscilação do CoP relaciona-se à variação do escore de mobilidade na área de assistência do cuidador, indicando que maiores áreas de deslocamento determinam menores escores de mobilidade em 40%.

Discussão

O objetivo do presente estudo foi verificar a relação entre controle postural na postura ortostática e nível de habilidades funcionais em crianças com PC por meio da análise de variáveis relativas ao comportamento do CoP em ortostatismo e da avaliação do desempenho funcional da criança, avaliado por meio do instrumento PEDI.

Os resultados encontrados permitiram observar que, em crianças com PC, maiores valores de amplitude médio-lateral de deslocamento do CoP, área e velocidade média de oscilação do CoP estão relacionados a menores valores nos escores da área de assistência do cuidador nos domínios de autocuidado e mobilidade do PEDI.

Tal relação vai ao encontro dos preceitos da Classificação Internacional de Funcionalidade, Incapacidade e Saúde (CIF), segundo a qual a condição de saúde dos indivíduos é determinada por uma relação multidirecional entre seus domínios de saúde. Dessa forma, alterações em estrutura e função do corpo (como os déficits de controle postural observados na PC) relacionam-se com seu nível de atividade e participação[26]. Assim, o comportamento do CoP na permanência em ortostatismo pode estar relacionado a um menor desempenho das crianças em habilidades funcionais e menor nível de independência em relação aos seus cuidadores. Da mesma forma, os déficits na execução de atividades funcionais vivenciados por essas crianças, por restringirem sua participação no meio em que estão inseridas e limitarem sua experiência em diferentes posturas, podem relacionar-se a maiores excursões no CoP na permanência em ortostatismo.

Nas crianças avaliadas no presente estudo, as alterações em estrutura e função do corpo, representadas por maiores valores de deslocamento ML do CoP (indicativos de menor controle sobre os ajustes posturais para manutenção do equilíbrio[27]), estiveram relacionados a uma maior dependência em relação a seus cuidadores para a realização de atividades de autocuidado, relacionadas à alimentação, banho, troca de roupas, higiene pessoal e uso do banheiro.

Estudos anteriores demonstraram maiores valores de deslocamento do CoP em crianças com PC na direção médio-lateral em diferentes posições comparadas a seus pares típicos[1]. De acordo com os presentes resultados, esse maior deslocamento ML pode relacionar-se de forma significativa com o nível de funcionalidade dessas crianças (67%), refletindo déficit na manutenção de uma oscilação adequada para execução de tarefas funcionais, como as avaliadas pelo instrumento PEDI. Os outros 33% podem estar relacionados a alterações de tônus ou de força muscular comumente verificadas nessas crianças.

A relação de maiores deslocamentos ML com menores escores no domínio de autocuidado pode explicar-se pelas estratégias utilizadas por essa população para manutenção do equilíbrio. Crianças típicas utilizam preferencialmente a estratégia de tornozelos para evitar desequilíbrios e potenciais quedas[4,9]. No entanto, em virtude dos distúrbios neuromotores presentes na PC, observam-se déficits de recrutamento da musculatura em volta da articulação do tornozelo[4,9,23]. Dessa forma, crianças com PC utilizam preferencialmente a musculatura em volta do quadril[9], estratégia essa associada a maiores deslocamentos ML[23].

Assim, os déficits neuromotores, tais como a ordem de recrutamento muscular alterada e a perda da coordenação interarticular em crianças com PC[9], parecem estar associados a maior dependência em relação a seu cuidador para a realização de atividades como banho, escovação dos dentes, troca de roupas e cuidado com os cabelos. Essas são atividades comumente realizadas em ortostatismo, posição em que o corpo é mais intensamente sujeito a forças de desestabilização.

Embora fundamental para a manutenção do controle postural em ortostatismo[23], a Amp AP de deslocamento do CoP não mostrou relação com o nível de funcionalidade das crianças em nenhum dos domínios avaliados do PEDI. Possivelmente, as crianças avaliadas não apresentaram uma grande variabilidade de deslocamentos nessa direção, não sendo possível encontrar uma correlação. Elas apresentaram maiores oscilações na direção ML. Tais resultados podem justificar-se pela preferência na utilização da estratégia de quadril para manutenção do equilíbrio em crianças com PC[23], o que se reflete em maiores deslocamentos ML. Por conta dos déficits de ativação da musculatura em torno do tornozelo, as crianças acabam por recrutar os músculos do quadril para manter a estabilidade[9].

Também se pode verificar que as crianças com maiores valores da área de oscilação do CoP apresentaram menores escores para os domínios de autocuidado e mobilidade. Maiores áreas de oscilação do CoP representam menor controle sobre o corpo nas respostas ao desequilíbrio corporal[17,28]. A realização das atividades de autocuidado e mobilidade envolvem alcance e manipulação de objetos, além de colocarem o CoP propositadamente em movimento[4,7,15], gerando forças internas que produzem instabilidade e alteram o alinhamento entre os segmentos corporais. Dessa forma, no presente estudo, o controle postural esteve associado à independência das crianças em autocuidado em 61% e da independência em mobilidade em 40%. Como se pode notar, outros fatores, não avaliados no presente estudo, também guardam relação com a independência das crianças com PC para as atividades de autocuidado e mobilidade.

Crianças com PC apresentam maiores áreas de oscilação do CoP em ortostatismo[28]. Essas maiores áreas de oscilação representam estratégia de melhor exploração da base de suporte para gerar ajustes posturais de sucesso e evitar o desequilíbrio. Por conta de déficits neuromotores, crianças com PC apresentam dificuldades em coordenar suas respostas ao desequilíbrio, necessitando explorar mais amplamente sua base de sustentação. Essa maior exploração busca a captação de um volume maior de aferências proprioceptivas para regular o posicionamento de seu corpo no espaço[15,27,29].

No presente estudo, déficits na regulação do controle postural observado em crianças com PC, representados por maior área de oscilação, relacionaram-se a menores níveis de funcionalidade, representados por maior dependência da criança em relação a seu cuidador para executar tarefas de mobilidade. Estudos indicam que o controle postural em crianças com PC, influenciado pelo grau de deficiência neuromotora[5] e restrições biomecânicas apresentadas pela criança[30] relaciona-se de forma direta à locomoção independente[12]. Dessa forma, o treino do controle do equilíbrio na permanência em ortostatismo na prática clínica pode ser uma forma de ganhar independência com a criança nas tarefas de locomoção.

O estudo também revelou que crianças com maiores valores de velocidade média de oscilação apresentaram maior dependência para a realização de atividades de autocuidado. A velocidade de oscilação do CoP é uma das principais preditoras da estabilidade corporal nas análises do controle postural e está inversamente relacionada ao controle dos segmentos corporais no espaço[3,28]. Assim, maiores velocidades refletem menor controle sobre as respostas posturais, seja por déficits neuromotores ou alterações biomecânicas[30]. Nesse sentido, os déficits de controle postural verificados em crianças com PC determinam um aumento da instabilidade postural em ortostatismo[23], postura em que a maior parte das atividades funcionais de autocuidado são realizadas.

De forma geral, os resultados do presente estudo permitem inferir que as dificuldades de controle do posicionamento do corpo no espaço vivenciadas por crianças com PC, um déficit em estrutura e função do corpo, guardam relação com outros domínios da condição de saúde da criança, interferindo em seu nível de atividade e participação social[26].

Ao tornar-se mais dependente de seu cuidador para executar as tarefas da rotina diária e ao ter sua mobilidade limitada, a criança acaba por ser restringida em sua capacidade de explorar o meio à sua volta e de estabelecer uma série de vínculos sociais com pessoas que não sejam de suas famílias. A necessidade contínua de auxílio para realizar determinadas tarefas impede que as crianças participem de muitas atividades de forma independente, tornando-se, assim, dependentes de seus cuidadores até mesmo para sua inserção social.

Tendo em vista que alterações no controle postural podem determinar alterações funcionais, o aumento da estabilidade postural deve ser um dos objetivos do programa de fisioterapia, a fim de que a reabilitação física possa melhorar o nível de funcionalidade dessas crianças, determinando também maior nível de interação social com o meio à sua volta. Da mesma forma, levando em conta os resultados do presente estudo e o caráter amplo e abrangente de saúde preconizado pela CIF, crianças com PC devem ser estimuladas a participar de suas atividades da rotina diária de forma efetiva e o menos dependente possível, a fim de que possam apresentar maior estabilidade postural na permanência em ortostatismo.

De acordo com os novos preceitos da Organização Mundial da Saúde, por meio da CIF, cada vez mais a prática clínica deve buscar abordar a condição de saúde dos indivíduos de forma ampla e abrangente, não tendo apenas foco nas disfunções em estrutura e função do corpo, mas buscando também enfatizar as repercussões desses déficits nas atividades realizadas pelo indivíduo em sua participação social[13].

Assim, determinada a relação entre controle postural e nível de habilidades funcionais em crianças com PC, são necessários mais estudos para verificar o tipo de abordagem terapêutica a ser

trabalhada nessa população, capaz de promover maior funcionalidade e participação social. Acredita-se que o estabelecimento dessa relação possa gerar novos rumos para a prática clínica, direcionando estratégias de tratamento para distúrbios de equilíbrio, ganho de habilidades funcionais específicas e para a independência da criança em relação ao cuidador.

Conclusão

O controle postural em ortostatismo apresenta importante relação com o nível de funcionalidade em crianças com PC, guardando estreita relação com seu nível de dependência em relação ao cuidador. Dessa forma, a maior dificuldade da criança para manter-se estável na postura em pé guarda relação com seu desempenho em AVDs e seu nível de dependência do cuidador.

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Effect of low-level laser therapy on the modulation of the mitochondrial activity of macrophages

Efeito da laserterapia em baixa intensidade na modulação da atividade mitocondrial de macrófagos

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ABSTRACT | Background: Macrophages play a major role among the inflammatory cells that invade muscle tissue following an injury. Low-level laser therapy (LLLT) has long been used in clinical practice to accelerate the muscle repair process. However, little is known regarding its effect on macrophages. **Objective:** This study evaluated the effect of LLLT on the mitochondrial activity (MA) of macrophages. **Method:** J774 macrophages were treated with lipopolysaccharide (LPS) and interferon – gamma (IFN- γ) (activation) for 24 h to simulate an inflammatory process, then irradiated with LLLT using two sets of parameters (780 nm; 70 mW; 3 J/cm^2 and 660 nm; 15 mW; 7.5 J/cm^2). Non-activated/non-irradiated cells composed the control group. MA was evaluated by the cell mitochondrial activity (MTT) assay (after 1, 3 and 5 days) in three independent experiments. The data were analyzed statistically. **Results:** After 1 day of culture, activated and 780 nm irradiated macrophages showed lower MA than activated macrophages, but activated and 660 nm irradiated macrophages showed MA similar to activated cells. After 3 days, activated and irradiated (660 nm and 780 nm) macrophages showed greater MA than activated macrophages, and after 5 days, the activated and irradiated (660 nm and 780 nm) macrophages showed similar MA to the activated macrophages. **Conclusions:** These results show that 660 nm and 780 nm LLLT can modulate the cellular activation status of macrophages in inflammation, highlighting the importance of this resource and of the correct determination of its parameters in the repair process of skeletal muscle.

Keywords: macrophages; low-level laser therapy; muscle repair; rehabilitation.

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RESUMO | Contextualização: O macrófago tem papel de destaque dentre as células inflamatórias que invadem o músculo após as lesões. Por outro lado, o laser em baixa intensidade (LBI) tem sido muito utilizado na clínica para acelerar o reparo muscular, e pouco se conhece sobre seu efeito nos macrófagos. **Objetivo:** Avaliar o efeito do LBI sobre a atividade mitocondrial (AM) de macrófagos ativados para simular um processo inflamatório. **Método:** Macrófagos J774 foram tratados com lipopolissacarídeo (LPS) e IFN-gamma (ativação) por 24 horas para simular um processo inflamatório e então foram irradiados com LBI (780 nm; 70 mW; 3 J/cm^2 e 660 nm; 15mW; 7,5 J/cm^2). A AM foi avaliada pela técnica MTT após um, três e cinco dias das irradiações. Foram realizados três experimentos independentes, e os dados, submetidos à análise estatística. **Resultados:** Após um dia de cultivo, os macrófagos ativados e irradiados com o laser de 780 nm mostraram AM menor que os somente ativados, já os macrófagos ativados e irradiados com o laser de 660 mostraram AM semelhante aos somente ativados. Após três dias, os macrófagos ativados e irradiados (660 e 780 nm) mostraram AM maior que os macrófagos ativados; já após cinco dias, os grupos ativados e irradiados (660 e 780 nm) mostraram AM semelhante aos macrófagos somente ativados. **Conclusões:** Esses resultados mostram que tanto o LBI de 660 nm como o de 780 nm são capazes de modular a ativação celular de macrófagos em situação de inflamação, ressaltando a importância desse recurso e da determinação de seus parâmetros dosimétricos no processo de reparo do músculo esquelético.

Palavras-chave: macrófagos; laser em baixa intensidade; reparo muscular; reabilitação.

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Introdução

A regeneração muscular após uma lesão geralmente segue o mesmo padrão do desenvolvimento embrionário do músculo em termos de expressão gênica, porém o microambiente em que esses dois processos similares ocorrem é totalmente diferente[1].

Essa diferença está fundamentada na presença de mais de 100.000 células inflamatórias/mm^3 no tecido muscular em regeneração[1,2]. Essas células estão ativadas e podem secretar inúmeros fatores solúveis, especialmente citocinas que irão afetar a viabilidade, a diferenciação e as atividades de transcrição das células musculares regenerativas[1].

A resposta inflamatória inicial após a lesão muscular é do tipo Th1, ou seja, dominada por neutrófilos e macrófagos do fenótipo M1. Esses macrófagos produzem citocinas (TNF-α e IL-6) e enzimas pró-inflamatórias (ciclooxigenase 2) e liberam óxido nítrico (NO) que, em conjunto com as citocinas, pode ampliar o dano tecidual[1,3-5].

Depois de 48 horas da ocorrência da lesão, o tecido muscular passa a apresentar macrófagos do fenótipo M2 que atenuam a população de macrófagos M1 por meio da liberação de citocinas anti-inflamatórias que incluem a IL-10[1]. O número dessas células alcança seu pico após quatro dias e permanece elevado por muitos dias[1].

A mudança no fenótipo dos macrófagos de M1 para M2 é um evento chave na regeneração muscular e coincide com a mudança do estágio proliferativo para a fase de diferenciação inicial da miogênese[1].

Os macrófagos M2 são ativados em particular pelas citocinas IL-4, IL-10 e IL-13[6] e expressam citocinas como a IL-10[1].

A complexidade e o antagonismo dos fenótipos dos macrófagos envolvidos nos quadros inflamatórios gerados por lesões musculares evidenciam a necessidade de considerar os macrófagos como células-alvo para as intervenções terapêuticas[1].

Dentre as intervenções terapêuticas utilizadas com o intuito de acelerar o processo de reparo do tecido muscular esquelético após diferentes tipos de lesões, a utilização do laser em baixa intensidade (LBI) tem ganhado destaque[7-12].

Porém, poucos estudos avaliaram o efeito da LBI isoladamente sobre os macrófagos e, em especial, sobre a atividade mitocondrial (ativação-AM) dessas células após a laserterapia[13].

De posse desses dados, parece lícito inferir que ainda há muito a ser pesquisado para compreender os efeitos da laserterapia sobre os macrófagos envolvidos no processo de reparo muscular, bem como para encontrar os parâmetros dosimétricos ideais que possam modular e acelerar esse processo.

Este trabalho buscou colaborar no preenchimento dessa lacuna no conhecimento avaliando o efeito do LBI sobre a atividade mitocondrial de macrófagos ativados para simular um processo inflamatório (fenótipo M1).

Método

Cultivo celular

A linhagem de macrófagos J774 foi cultivada em meio de cultura de Eagle modificado por Dulbecco (DMEM, Vitrocell, Campinas, SP, Brasil), suplementado com 10% de soro fetal bovino (SFB) e L-glutamina 2 mM (Vitrocell, Campinas, SP, Brasil). As culturas foram mantidas em estufa (HEPA *class 3110, Thermo Electron Corporation*, Marietta, OH, EUA) a 37°C, numa atmosfera úmida contendo 5% de CO_2. O crescimento celular foi avaliado a cada 24 horas, utilizando-se microscópio invertido de fase (Eclipse TE 2000U, Nikon, Melville, NY, EUA).

Simulação da inflamação

Para simular a ocorrência de um processo inflamatório e o sofrimento celular, os macrófagos foram tratados, por 24 horas, com 1 μg/mL de lipopolissacarídeo (LPS) de *Escherichia coli* (E Coli) O26: B6 (Sigma, St. Louis, MO) e 0,2 μg/mL de Interferon-γ (IFN- γ) (Sigma, St. Louis, MO, EUA), simulando o fenótipo M1, e foram cultivados em meio de cultura DMEM contendo somente 5% de SFB[14-17]. As células dos grupos controle foram cultivadas da mesma maneira, porém sem a adição de LPS e de IFN-γ. Após 24 horas, as placas foram lavadas com solução salina tamponada por três vezes. As células foram descoladas (com uso de um raspador celular) e transferidas para tubos Falcon (*Techno Plastic Products* [TPP], Trasadingen, Suíça) de 50 mL.

Laser em baixa intensidade (LBI)

Os tubos de 50 mL contendo as suspensões celulares foram centrifugados (1200 rpm a 10°C por cinco minutos em Centrífuga Excelsa 4-280R, Fanem, São Paulo, SP, Brasil) e irradiados de baixo para cima em sua extremidade inferior, de modo que o feixe laser atingisse diretamente o *pellet* celular sem passar pelo meio de cultura[17]. As irradiações foram realizadas utilizando o aparelho *Twin-laser (MM Optics*, São Carlos, SP, Brasil) no modo contínuo, em um ambiente com obscuridade parcial para não

sofrer interferência da luz externa. As células do grupo controle sofreram a mesma manipulação, porém não foram irradiadas. Os parâmetros (descritos na Tabela 1) foram determinados de acordo com os estudos prévios[18-20]. A potência de saída do aparelho foi verificada utilizando um medidor de potência (*Laser Check, MM Optics*, São Carlos, SP, Brasil). Na Tabela 1, estão descritos os valores de saída e os valores efetivos considerando a passagem da luz pelo tubo de polipropileno que continha os precipitados celulares, conforme descrito anteriormente[21].

Grupos experimentais

Grupo1

Controle (macrófagos não ativados e não irradiados); Grupo 2: macrófagos ativados com LPS e IFN-γ; Grupo 3: macrófagos irradiados com LBI de 660 nm; Grupo 4: macrófagos ativados com LPS e IFN-γ e irradiados com laser de 660 nm; Grupo 5- macrófagos irradiados com laser de 780 nm; Grupo 6- macrófagos ativados com LPS e IFN-γ e irradiados com laser de 780 nm

Ensaio de atividade mitocondrial celular – MTT

A técnica MTT (Brometo de 3-(4,5-dimetiltiazol-2-yl)-2,5-difeniltetrazólio) está fundamentada na análise colorimétrica da habilidade da enzima mitocondrial succinato desidrogenase, localizada em células viáveis de clivar os anéis de tetrazólio do MTT, formando cristais azuis escuros de formazana, os quais são impermeáveis às membranas celulares e que ficam retidos no interior das células viáveis. A posterior lise dessas células faz com que esses sais de formazana sejam liberados. Os macrófagos ($1X10^3$/poço) foram incubados em placas de cultura de fundo chato de 96 poços (TPP) em meio DMEM (5% de SFB) por um, três e cinco dias. Depois desses períodos, foi realizada lavagem com 100 µl de PBS, foi adicionado o MTT (0,5 µg/mL) (Thiazolyl Blue – Sigma), e as placas foram incubadas por três horas a 37°C em estufa de CO_2. Foram então adicionados 100 µl de isopropanol, e foi realizada a leitura da absorbância a 620nm com auxílio de um leitor de placas (2020, *Anthos*, Eugendorf, Áustria).

Análise estatística

Os experimentos foram realizados de forma independente em triplicata, e cada amostra foi feita em octuplicata. Para a análise dos dados, foram utilizados média, desvio padrão e análise de variância (ANOVA) com auxílio do software "*GraphPad InStat-3*". A significância estatística foi verificada pelo teste Tukey e considerada aceitável quando $p \leq 0,05$.

Resultados

Células ativadas (simulação de inflamação)

Após um dia de cultivo, os macrófagos ativados mostraram AM semelhante à dos macrófagos ativados e irradiados com laser de 660 nm, mas os macrófagos ativados e irradiados com laser de 780 nm mostraram AM inferior à dos macrófagos ativados ($p<0,05$). As células do grupo ativado e irradiado com laser de 660 mostraram AM maior ($p<0,05$) que as do grupo ativado e irradiado com laser de 780 nm. Também observamos que os macrófagos ativados mostraram AM maior ($p<0,001$) que os do grupo controle. Esse comportamento se repetiu nas culturas ativadas e irradiadas (laser 660 e laser 780 nm) que mostraram AM superior ($p<0,001$) à das culturas somente irradiadas nos respectivos parâmetros de energia (Figura 1). Após três dias de cultivo, macrófagos ativados e irradiados com laser de 660 ou de 780 nm mostraram AM superior ($p<0,01$ e $p<0,001$, respectivamente) à dos macrófagos ativados. As células do grupo ativado e irradiado com laser de 660 mostraram AM semelhante às do grupo ativado e irradiado com laser de 780 nm. Além disso, os macrófagos ativados continuaram mostrando AM maior ($p<0,001$) que os do grupo controle (não ativado, não irradiado), e tal diferença ficou mais evidente (Figura 1).

Tabela 1. Parâmetros do laser em baixa intensidade (LBI).

Comprimento de onda (nm)	Potência de saída (mW)	Densidade de energia de saída (J/cm^2)	Potência efetiva (mW)	Área cabeçote (cm^2)	Tempo (s)	Área irradiada (cm^2)	Densidade de potência efetiva (mW/cm^2)	Densidade de energia efetiva (J/cm^2)
780	70	3	53,9	0,04	1,5 (2x)	0,196	275	0,41
660	15	7,5	11,25	0,04	20	0,196	57,4	1,15

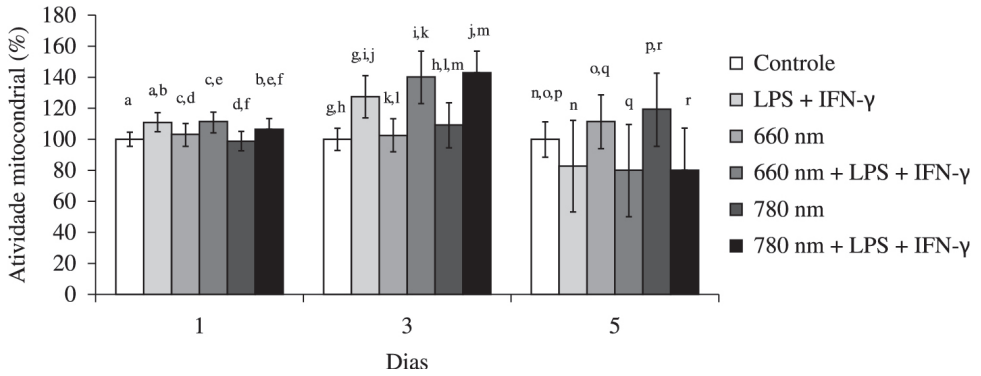

Figura 1. Percentual de atividade mitocondrial (método MTT) das células dos diferentes grupos experimentais em relação às células do grupo controle. As letras iguais representam diferenças estatisticamente significantes (a,c,f,g,h,j,k,m,p,q,r=p<0,001; d,i,n=p<0,01; b,e,l,o=p<0,05).

Após cinco dias de cultivo, os macrófagos ativados mostraram AM semelhante à dos macrófagos ativados e irradiados com laser de 660 ou de 780 nm, e as células do grupo ativado e irradiado com laser de 660 também mostraram AM semelhante às do grupo ativado e irradiado com laser de 780 nm. Os macrófagos ativados passaram a mostrar AM menor (p<0,01) que os do grupo controle (Figura 1). Na comparação entre as culturas ativadas e irradiadas (laser 660 e laser 780 nm) e culturas somente irradiadas, o comportamento observado no primeiro e no terceiro dia agora foi invertido, ou seja, a AM das células ativadas e irradiadas foi menor que a das culturas somente irradiadas nos respectivos parâmetros de energia (p<0,001).

Células não ativadas

Após um dia, não houve diferença entre a AM do grupo controle e a AM dos grupos irradiados. As células irradiadas com laser de 660 nm mostraram AM superior (p<0,01) às irradiadas com laser de 780 nm (Figura 1). Após três dias, a irradiação com laser de 660 nm não alterou a AM das células quando comparadas às células não irradiadas, já a irradiação com laser de 780 nm causou um aumento na AM quando em comparação com o grupo controle (p<0,001). As células irradiadas com laser de 660 nm mostraram AM inferior (p<0,05) às irradiadas com laser de 780 nm (Figura 1). Após cinco dias, as irradiações com laser de 660 nm (p<0,05) e principalmente com laser de 780 nm (p<0,001) aumentaram a AM das células quando comparadas às células não irradiadas. As células irradiadas com laser de 660 nm mostraram AM semelhante às irradiadas com laser de 780 nm (Figura 1).

Discussão

A modulação das diferentes fases do processo de reparo do músculo esquelético se dá principalmente pela mudança no perfil de ativação dos macrófagos, que tem como consequência a alteração de seu fenótipo e de suas funções[1]. Por essa razão, os macrófagos são considerados células-alvo para as intervenções terapêuticas[1].

Por outro lado, na área da reabilitação das lesões musculares, muitos estudos têm evidenciado que o LBI é capaz de modular o processo de reparo muscular tanto em estudos experimentais como em estudos clínicos[22-28], mas ainda não foi descrito se a laserterapia é capaz de alterar o estado de ativação dos macrófagos.

Neste estudo, avaliamos o efeito do LBI, em dois diferentes parâmetros, sobre a atividade mitocondrial de macrófagos J774 após um, três e cinco dias da irradiação, sendo que as células foram cultivadas em situação de deficiência nutricional e tratadas com LPS e IFN-γ para simular um processo inflamatório e induzir o fenótipo M1.

Nos artigos científicos que avaliaram os efeitos do LBI e até do LED (*light emitting diode*) sobre macrófagos ou seus precursores (monócitos), não foi avaliada a atividade mitocondrial, mas sim diferentes funções dos macrófagos irradiados[13,14,18-20,29-31].

A mitocôndria exerce um efeito modulatório crucial na via de ativação dos macrófagos inflamatórios, o que gera a produção de citocinas, ou seja, a via das MAK quinases (MAPK, *Mitogen Activated Protein Kinases*) e do NF-κβ (fator nuclear κβ)[32]. Quando o macrófago é ativado por meio de um estímulo inflamatório (ex: LPS+IFNγ), essa organela amplifica a via MAPK aumentando a produção de citocinas e de outros mediadores inflamatórios[33]. A técnica MTT,

utilizada neste estudo, avalia a atividade mitocondrial e reflete diretamente o estado de ativação celular[32,33].

Nos dois primeiros períodos de cultivo, houve aumento da AM dos macrófagos tratados com IFNγ e LPS quando comparados aos macrófagos não ativados, o que demonstra que o modelo de ativação utilizado foi efetivo. Já no quinto dia de cultivo, a situação inverteu-se, ou seja, as células ativadas passaram a ter AM menor que as do grupo controle, provavelmente porque, neste período, elas tenham diminuído sua ativação e/ou sua viabilidade pela intensa estimulação nos dias anteriores e/ou pela ação dos produtos secretórios por elas produzidos.

Nas células ativadas, pudemos observar uma diminuição na AM quando da irradiação com laser de 780 nm no primeiro dia de cultivo. Já no terceiro dia, os lasers de 660 e de 780 nm modularam positivamente a AM dos macrófagos, o que pode sugerir que houve um aumento no estado de ativação celular nesse período. No quinto dia, os lasers não modularam a atividade mitocondrial das células ativadas.

Nas células irradiadas não ativadas, foi observada uma modulação positiva do LBI de 780 nm sobre a AM no terceiro dia e dos dois lasers (660 e 780 nm) no quinto dia de cultivo.

Somente o trabalho de Young et al.[13] avaliou a viabilidade e proliferação de uma linhagem de monócitos irradiados com laser, porém os autores usaram um laser pulsado de 820 nm (15 mW; 2,4 J/cm^2; 0,3 J). Após 36 horas de cultivo, os autores também observaram, por meio do teste azul de *trypan*, um aumento no número de células viáveis quando comparado ao número de células do grupo não irradiado. A comparação direta com nossos resultados é difícil, pois os parâmetros dosimétricos, metodológicos e o desfecho são diferentes, além disso, os autores usaram monócitos, enquanto nosso trabalho avaliou uma linhagem de macrófagos.

De fato, muitos artigos têm demonstrado que o LBI atua em vários tipos celulares, principalmente por meio da ativação da cadeia respiratória mitocondrial, aumentando a produção de ATP e induzindo fatores de transcrição[34,35]; desse modo, nossos resultados podem evidenciar que a energia entregue às células por meio da irradiação laser foi capaz de estimular esses mecanismos, aumentando a ativação nos macrófagos não ativados (780 nm no terceiro dia e 660 e 780 nm no quinto dia de cultivo) e ampliando (660 nm após um e três dias e 780 nm após três dias) esses efeitos nos macrófagos ativados.

Porém, também pudemos observar a redução da AM nas células ativadas e irradiadas com laser de 780 nm após um dia de cultivo. Esse resultado corrobora os achados de Sousa et al.[18], que descreveram a diminuição da produção de TNF-α 24 horas após irradiação de macrófagos ativados para o perfil M1 com os mesmos parâmetros dosimétricos e metodologia por nós utilizados.

Embora os estudos *in vitro* nos proporcionem modelos padronizados de alta reprodutibilidade e possibilitem avaliações celulares e moleculares, logicamente, não podemos estabelecer uma correlação direta dos resultados obtidos *in vitro* com os desfechos clínicos futuros. Porém, é muito importante conhecer previamente o efeito do LBI e dos demais recursos terapêuticos sobre cada tipo celular que compõe o tecido muscular para podermos propor protocolos *in vivo* que modulem mais efetivamente o processo de reparo desse tecido.

Além disso, é fundamental conhecer as características ópticas dos tecidos/células a serem irradiados e das barreiras que a luz irá atravessar para atingi-los. No modelo experimental utilizado neste estudo, os lasers precisaram atravessar o fundo do tubo de ensaio para atingir os macrófagos, assim, parte da energia de saída foi perdida devido aos fenômenos de reflexão, espalhamento e absorção pelo polipropileno que constitui o tubo de ensaio[21]. Por essa razão, os valores de potência efetiva (remanescente) foram incorporados aos cálculos de densidade de potência e de densidade de energia apresentados. Esses valores foram calculados conforme proposto com Silva et al.[21].

Para transpor os parâmetros dosimétricos para outro modelo experimental, deve-se conhecer o comportamento da luz nas diferentes barreiras que ela atravessará até atingir o seu alvo e ainda conhecer o coeficiente de absorção do tecido alvo, já que somente a energia absorvida é responsável pelo efeito terapêutico da luz.

De posse de dados experimentais tanto em nível celular como em ensaios com animais e humanos, o uso clínico de cada recurso será baseado em evidências científicas que o justifiquem e determinem e não no empirismo.

Conclusão

Os LBI de 660 nm (15 mW, 7,5 J/cm^2) e de 780 nm (70 mW, 3 J/cm^2) podem modular a atividade mitocondrial e, portanto, o estado de ativação de macrófagos da linhagem J774 cultivados de maneira a simular a presença de um quadro inflamatório. Desse modo, mais estudos se fazem necessários para entender os mecanismos envolvidos na modulação desse processo bem como para avaliar os efeitos

da irradiação sobre outras funções importantes dos macrófagos.

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Gait profile score and movement analysis profile in patients with Parkinson's disease during concurrent cognitive load

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ABSTRACT | Background: Gait disorders are common in individuals with Parkinson's Disease (PD) and the concurrent performance of motor and cognitive tasks can have marked effects on gait. The Gait Profile Score (GPS) and the Movement Analysis Profile (MAP) were developed in order to summarize the data of kinematics and facilitate understanding of the results of gait analysis. **Objective:** To investigate the effectiveness of the GPS and MAP in the quantification of changes in gait during a concurrent cognitive load while walking in adults with and without PD. **Method:** Fourteen patients with idiopathic PD and nine healthy subjects participated in the study. All subjects performed single and dual walking tasks. The GPS/MAP was computed from three-dimensional gait analysis data. **Results:** Differences were found between tasks for GPS ($P<0.05$) and Gait Variable Score (GVS) (pelvic rotation, knee flexion-extension and ankle dorsiflexion-plantarflexion) ($P<0.05$) in the PD group. An interaction between task and group was observed for GPS ($P<0.01$) for the right side (Cohen's $\bar{}d=0.99$), left side (Cohen's $\bar{}d=0.91$), and overall (Cohen's $\bar{}d=0.88$). No interaction was observed only for hip internal-external rotation and foot internal-external progression GVS variables in the PD group. **Conclusions:** The results showed gait impairment during the dual task and suggest that GPS/MAP may be used to evaluate the effects of concurrent cognitive load while walking in patients with PD.

Keywords: Parkinson's disease; gait; kinematics; attention; rehabilitation.

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Introduction

Walking is one of the tasks most affected by idiopathic Parkinson's disease (PD). A particular problem is the way that the condition interferes with the management of attention to stimuli when two tasks are performed simultaneously[1]. In daily living, the environment invariably forces an individual to divide his or her attention among various stimuli that occur simultaneously and often require motor responses. The ability to perform such concurrent tasks is particularly limited in patients with PD, especially when one of the tasks is walking. This leads to the impairment of one or both tasks, with a negative impact on the activities of daily life[2]. The potential consequences of gait impairment in PD are significant and include increased disability, a greater risk of falls, and a reduced quality of life[3].

Defective functioning of the basal ganglia results in increased cortical involvement in motor control among individuals with PD, leading to an increase in difficulty managing dual tasks[4]. Moreover, the ability to prioritize gait and balance appropriately during dual-task activities is impaired in patients with this disease, likely due to the deterioration of executive processes, which is correlated with increased gait variability[1]. Individuals with PD exhibit an increase in gait variability in response to dual tasks, which places increased demands on attention resources[4-7].

The relationship between cognitive function and gait impairment has received considerable attention

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in recent years. Biomechanical studies have addressed spatiotemporal gait parameters in PD[8-10], but few have focused on angular parameters. A reduction in the angular excursion of lower limb joints has been noted in parkinsonian syndromes with the primary gait deficit in PD having been described as an inability to generate sufficient range of motion[11-13].

Three-dimensional gait analysis (3DGA) measures angular changes in lower limb joints during locomotion. Typically, kinematic graphs are generated to assess gait quality, to guide decisions regarding the management of gait disorders, and to help evaluate treatment outcomes. Although routinely viewed, kinematic graphs are complex and require significant expertise to interpret and describe[14]. Due to the large amount of information generated by gait analysis, a number of indices and scores have been designed to condense complex kinematic data and provide simple, easy-to-interpret data for use in clinical practice[15].

The Gait Profile Score (GPS) was developed to summarize data on kinematics and to facilitate the understanding of the results of gait analysis. The GPS can be broken down to provide the Gait Variable Score (GVS), based on nine kinematic variables[16] and establish a Movement Analysis Profile (MAP), which describes the magnitude of the deviation of those nine variables across the gait cycle[17-19].

To our knowledge, no studies have previously employed the GPS to evaluate the effects of a dual task (concurrent cognitive load while walking) on adults with PD.

Thus, the aim of the present study was to investigate the effectiveness of the GPS and the MAP regarding the quantification of changes in gait during a dual task performed by healthy adults and individuals with Parkinson's disease.

Method

Participants

From a total of 14 individuals diagnosed with idiopathic PD, 7 female and 7 male participated in the present study [mean age and standard deviation (SD): 67.5 years (5.6)]. The following were the inclusion criteria for the PD group (PDG): ability to walk barefoot independently without a gait-assistance device; absence of any other neurologic disorder or dementia, having achieved a score of ≥24 on the Mini-Mental State Examination[20]; classification Stages 2 and 3 on the Modified Hoehn and Yahr Scale[21]; and in the "ON" phase of the active medication cycle. The Freezing of Gait questionnaire (FOG-Q)[22] also was used. Thirty individuals were excluded due to the following exclusion criteria: subjects with other types of PD, individuals with rheumatic disease, and orthopaedic problems or previous orthopaedic surgery of the lower limbs.

The control group (CG) consisted of nine healthy elderly individuals (5 female and 4 male) with a mean age of 65.1 years (SD: 5.3) with no history of pre-existing diseases or complaints affecting activities of daily living, specifically gait; having achieved a score of ≥24 on the Mini-Mental State Examination.

All patients participated in the same physical therapy program once a week. The healthy elderly did not perform physical activity. All subjects gave informed consent to perform the experimental procedure and the study received approval from the local ethics committee Centro Universitário São Camilo, São Paulo, SP, Brazil (protocol 93/08).

Procedures

The participants were informed regarding the data acquisition procedures, familiarized with the place at which data would be collected and trained so that gait would be as normal as possible. The participants did not use any gait-assistance devices and absolute silence in the laboratory was requested during data acquisition so that no noises interfered with the participant's attention during the tasks. The assessments were done at the same time period and on the same day.

Initially, the subjects walked barefoot at a comfortable speed with no other competing tasks (simple task) and then rested for 20 minutes. A dual task was then implemented, requiring the participants' attention to an activity during gait. The dual task involved walking while doing a cognitive task which consisted of a mathematical test of decreasing consecutive subtraction. The participants walked while performing a set of seven subtractions out loud, starting from 500[11]. No instructions were given regarding the priority of one task over the other (walking vs. cognitive task). All were instructed to walk on a track which was 1.5 meters wide × 6.0 meters long.

Equipment

An eight-camera motion analysis system (Motion Analysis Corporation, Santa Rosa, CA, USA) (sample rate, 60 Hz and fourth-order Butterworth filter with cut-off frequency of 8 Hz) was used to capture the three-dimensional marker trajectories. A total of 23 reflective markers were attached to the

skin of each participant at specific anatomic points based on the Helen Hayes model[23]. The markers were placed on the iliac spine, thighs, lateral femoral epicondyle, legs, lateral malleolus, metatarsals, calcaneus and hallux.

Data processing and analysis

Kinematic variables for analysis were based on the Helen Hayes biomechanical model used in the Orthotrack® 6.2 software (Motion Analysis Corporation, Santa Rosa, CA, USA). All data obtained from the 3DGA were normalized to a percentage of the gait cycle and the angular gait values were exported as ASCII archives from the Orthotrack® program to Microsoft Excel® for each group (Parkinson's disease and control) under the simple task and dual task conditions. A total of six gait cycles were used to obtain these values.

Subsequently, the GPS scores for the PD and control groups were calculated for each leg in relation to data for normal healthy adults captured at the movement analysis laboratory. The GPS was based upon 15 clinically important kinematic variables (pelvic tilt, obliquity, rotation from one side and hip flexion, abduction, internal rotation, knee flexion, dorsiflexion and foot progression for left and right sides)[24]. The GPS represented the root mean square difference between a particular gait trial and averaged data from individuals without a gait impairment[19,25]. Neither the GPS nor the MAP components were normally distributed; thus, logarithmic transformations were performed before applying parametric statistics to the data.

Analysis of variance (ANOVA) was used for comparisons between groups. For the overall GPS and pelvic tilt, obliquity and rotation, a two-way ANOVA was used considering group and task as the factors. For the other variables, a three-way ANOVA was used considering side, group and task as the factors, after checking the assumptions of the equality in error variances (Levene). Interactions between variables were also analyzed. The existence of an interaction may indicate, for example, whether differences between groups only occurred on a particular side. If the F test was significant, multiple comparisons were performed using the Bonferroni test. Cohen's $\bar{d}$ was used to measure the effect size for both the CG (normal vs dual task) and PDG (normal vs dual task) for power analysis purposes[26]. The effect size was classified as high, medium or low. Statistical significance in all tests was 5% ($P<0.05$). The Statistical Package for Social Sciences, version 15, was used for the analysis (SPSS Inc., Chicago, USA).

Results

Table 1 displays the descriptive and demographic characteristics at baseline for the control and PD groups. Table 2 summarizes the results in mean and standard deviation values for all variables during normal gait and gait with dual task for both groups.

Statistically significant differences were found between groups for GPS and GVS variables (pelvic tilt, pelvic obliquity, pelvic rotation, hip flexion-extension, hip internal-external rotation, knee flexion-extension and ankle dorsiflexion-plantar flexion). Differences were found between tasks regarding the GPS and GVS (tilt pelvic, pelvic

Table 1. Clinical and demographic characteristics of patients in the Parkinson's disease group (PDG; n=14) and control group (CG; n=9) of healthy individuals.

	CG	PDG
Age (years)	65.11 (5.3)	67.50 (5.6)
Male/Female	4M/5F	7M/7F
Height (m)	1.64 (0.05)	1.66 (0.10)
Body Mass (kg)	68.11 (10.52)	68.50 (15.16)
*Gait velocity (m/s)	1.01 (1.48)	0.95 (0.26)
Mini-Mental State Examination	28.11 (2.08)	27.64 (1.9)
Modified Hoehn & Yahr stage – (in each stage)	-	2 (4); 2.5 (8); 3(2)
Freezing of gait questionnaire	-	10.7 (6.23)
Medication (number of patients)	-	Levodopa (14) / Carbidopa (14) / Entacapone (2) / Bromocriptine (1)

Values expressed in mean (standard deviation); *During normal gait; (-) data not collected.

Table 2. GPS/MAP during normal gait and gait with task on both sides in control group (CG) and Parkinson's disease group (PDG).

		Normal Gait	Dual Task	Effect size Group vs Task
GPS_Overall [a†,b†,d§]	CG	6.65 (1.28)	7.09 (1.15)	-
	PDG	9.17 (1.18)	10.30 (1.37)	0.88
Pelvic_ant_pst [a†,b§,d§]	CG	5.13 (2.27)	5.25 (2.60)	-
	PDG	5.63 (1.93)	6.87 (1.64)	0.69
Pelvic_obliquity [a†,b§,d§]	CG	2.73 (1.09)	2.79 (1.11)	-
	PDG	2.87 (0.98)	3.12 (0.82)	0.30
Pelvic_rotation [a†,b†,d§]	CG	3.44 (1.53)	3.83 (0.92)	-
	PDG	4.57 (1.44)	5.98 (2.88)	0.61

		Right			Left		
		Normal Gait	Dual Task	Effect size Group vs Task	Normal Gait	Dual Task	Effect size Group vs Task
GPS [a†,b†,d§]	CG	6.25 (1.54)	6.56 (1.31)	-	6.18 (1.16)	6.62 (1.23)	-
	PDG	8.08 (1.61)	9.69 (1.64)	0.99	8.04 (1.21)	9.22 (1.36)	0.91
Hip_flex_ext [a†,b§,d§]	CG	7.22 (1.84)	7.43 (1.62)	-	6.60 (1.75)	6.90 (1.56)	-
	PDG	10.62 (5.36)	12.13 (4.73)	0.30	10.18 (4.01)	11.87 (4.09)	0.41
Hip_ad_abd [b§,d§]	CG	5.27 (2.16)	5.66 (2.39)	-	4.96 (1.86)	4.74 (1.72)	-
	PDG	4.64 (2.00)	5.98 (2.64)	0.57	5.03 (2.13)	5.80 (2.83)	0.30
Hip_int_ext [a†]	CG	5.21 (2.25)	5.08 (0.98)	-	4.87 (1.14)	5.62 (0.91)	-
	PDG	10.46 (3.45)	10.70 (3.10)		10.71 (2.92)	10.71 (3.36)	
Knee_flex_ext [a†,b†,d§]	CG	6.55 (2.02)	7.28 (2.04)	-	6.46 (1.87)	7.54 (1.81)	-
	PDG	12.73 (4.25)	15.09 (4.10)	0.56	12.76 (3.46)	14.73 (3.59)	0.55
Ankle_Dor_plan [a†,b†,d†]	CG	4.87 (1.14)	5.35 (1.20)	-	4.53 (1.87)	5.22 (1.64)	-
	PDG	8.08 (2.19)	10.04 (2.17)	0.89	8.32 (2.61)	10.37 (2.55)	0.80
Foot_int_ext	CG	7.86 (5.05)	8.22 (3.69)	-	6.36 (3.02)	7.96 (3.59)	-
	PDG	8.22 (3.69)	8.68 (6.21)		6.90 (3.50)	9.38 (4.92)	

[a]Mean difference between groups, [b]Mean difference between task, [c]Mean difference between side, [d]interference effect between group and task, [e]interference effect between group and side, [f]interference effect between task and side, [g]interference effect between group, task and side. †Mean difference is significant at the .050 level. §Mean difference is significant at the .001 level. Ant_post = anteversion_retroversion; flex_ext = flexion_extension; ad_abd = adduction_abduction; dor_plan = dorsiflexion_plantarflexion; int_ext = internal_external rotation.

obliquity, pelvic rotation, hip flexion-extension, hip adduction-abduction, knee flexion-extension and ankle dorsiflexion-plantar flexion) in PDG. When sides were compared, differences were not found (Table 2).

An interaction between task and group was observed in GPS and almost all GVS variables, except for hip internal-external rotation and foot internal-external rotation in PDG. No interactions between side and task or side, task and group were observed. The effect size observed between the PD group and task interaction was high for GPS: right side (Cohen's ¯d=0.99), left side (Cohen's ¯d=0.91) and overall (Cohen's ¯d=0.88). The effect size for GVS was medium in all variables (Table 2).

Discussion

The aim of the present study was to investigate the effectiveness of the GPS/MAP component regarding the quantification of changes in gait during dual tasking in individuals with PD. Previous studies report strong, significant correlations between the GPS/MAP component scores and kinematic gait deviation[19,27]. However, no studies have employed the GPS/MAP to assess the gait of individuals with

PD during a dual-task activity. The representation of angular kinematics through this score may be useful in interpreting the results of analyses of the main changes in gait in this population.

There is a growing line of evidence showing that concurrent cognitive load while walking has significant ramifications on the gait of patients with PD. Consistent with previous studies, the results of the present investigation demonstrated that dual tasking and attention influence gait[5,10,12].

The PDG exhibited different movement patterns when compared to healthy individuals, as demonstrated by a visual comparison of the MAP in Figure 1 (A/B and C/D). When the cognitive task was added, the PDG changed the gait pattern. These findings are seen in the results of the GVS (pelvic tilt, pelvic obliquity, pelvic rotation, hip flexion-extension, hip adduction-abduction, knee flexion-extension and ankle dorsiflexion-plantar flexion) and, consequently, in the GPS. The analysis of interactions between factors revealed that the GPS and GVS variables were only different for the PD group during the dual task. These results are supported by those obtained from previous studies on the effect of the dual task on gait in patients with PD, which report changes in the kinematics of the gait pattern[1,4,28-30].

The PDG showed significant differences during gait with dual task. Gait alterations in patients with PD and elderly individuals submitted to dual-task activities have been described in the literature, but no previous study has employed the GPS/MAP. The MAP provided an overview of the gait deviation from the normal pattern, illustrating changes due to interference from the dual task. Gait in patients with PD is characterized by a decrease in the angular range[12]. Previous studies have shown that the range of motion of the knee and ankle joint in the sagittal plane undergoes significant variation during the gait cycle, with a reduction in knee and ankle range of motion during a dual task[12,13]. Some authors report that, among patients with PD on levodopa, dual tasks lead to a significant increase in multi-joint and multi-plane lower limb joint range of motion[11,12].

Gait deficits are exacerbated during the performance of a dual task by patients with PD, as the need to concentrate on both walking and a concurrent task exceeds the available attention resources[10]. In PD, the extra attention needed to perform the task or

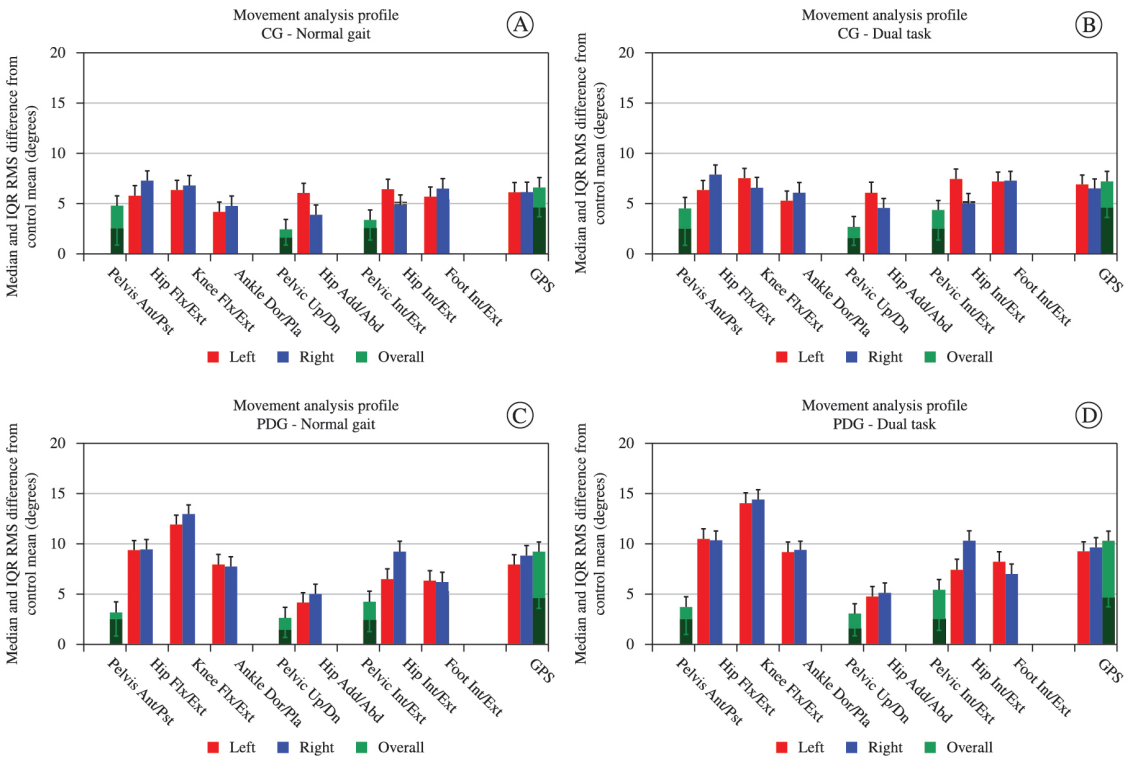

Figure 1. Gait profile score and movement analysis profile in control and Parkinson's disease groups during normal and concurrent cognitive load. A = CG during Normal Gait; B = CG during Dual Task; C= PDG during Normal Gait; D = PDG during Dual Task. Ant_post = anteversion_retroversion; flex_ext = flexion_extension; ad_abd = adduction_abduction; dor_plan = dorsiflexion_plantarflexion; int_ext = internal_external rotation.

hyperstimulation provoked by unexpected stimuli induces a hypo-excitability that can be manifested as a motor block. However, during simultaneous tasks, the response time to the cognitive task was reduced due to the increase in attention needed to perform the motor task, which resulted in the exacerbation of gait defects during the performance of a dual task exercise among patients with PD[4,29].

Our findings show an increase in the GPS scores (sides and overall) with a high effect size, which means that, in general, the gait pattern changed during a concurrent cognitive load. Based on the effect size, the increase in the GVS scores showed that ankle dorsiflexion-plantar flexion, and pelvic anteversion and rotation were more affected with a high effect size and knee flexion-extension; hip flexion-extension, adduction-abduction and pelvic obliquity with a medium effect size in the PDG, suggesting that the dual task exerted substantial influence on balance strategies, and might be related to the risk of falls in these individuals.

Differences were found between tasks for GPS and GVS in the PD group. Studies reported that when two tasks requiring a high degree of information processing were performed simultaneously, the performance of one or both was diminished. This impairment in the primary task and/or secondary task resulted from the fact that the two tasks competed for similar processing demands[4,10]. Dual tasking has also been used to identify the risk of falls in patients with PD due to the secondary relationship to postural strategies stemming from the loss of attention and a reduction in gait performance during a dual task[10,12]. The mathematical problems introduced during gait lead to a high degree of competition for executive motor function, suggesting that the automaticity of the performance under the complex conditions of walking is multidimensional[29-31].

There are few reports of the use of GPS/MAP in clinical research. Some authors observed a strong linear correlation between the GPS and scales of physical function in patients with cerebral palsy. Changes in GPS of 1.6° represents a uniform change of just 1.6° across all gait parameters and represents a mix of much larger changes in some of the constituents of the MAP with much smaller changes in others. Similar factors apply across the gait cycle with substantial changes at critical phases within the gait cycle often being balanced by more modest changes at others. A minimally clinically important difference of 1.6° seems appropriate for the individual GVS in patients with cerebral palsy[24]. However, no studies about the minimal clinically important difference of GPS/MAP for patients with PD were found. There are descriptions only for individuals with cerebral palsy, which differs greatly from the study population, make it impossible to establish any correlation.

The results of the present study have important implications for the rehabilitation of individuals with motor impairment associated with PD and demonstrate that the use of dual tasks should be included in rehabilitation processes. Thus, MAP can be used to complement the traditional presentation of gait kinematics. Although individual terms are selected (unlike other indexes in the literature), the GPS/MAP score points to the gait in general terms and should not be used separately to interpret the origin of changes in gait pattern.

The GPS/MAP may provide a summary of gait data that indicates asymmetry and the relative magnitude of deviations from each of the typical kinematic variables. As clinical decision making requires inspection of individual joint kinematics, we suggest that the GPS scores may reflect the clinical judgment more closely than an overall gait index. Despite the lack of studies, the use of GPS/MAP in patients with PD during a cognitive task showed a sensitive tool to point out the main gait differences in this population, providing simple and easy interpretation for clinical practice measures.

Limitations of this study include its relatively small sample size and the intrinsic procedural limits of 3DG. To minimize this, the effect size (Cohen's $\bar{d}$) was presented, which varied from 0.30 to 0.99, representing values for the PDG normal gait from the 62th to the 84th percentile of the PDG dual task (from medium to large effect size). Further studies are needed to understanding this complex relationship, which has implications for the rehabilitation of gait among patients with PD.

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original article

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Prevalence of musculoskeletal symptoms in hospital nurse technicians and licensed practical nurses: associations with demographic factors

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ABSTRACT | Objective: This cross-sectional study aimed at analyzing: 1. the main musculoskeletal symptoms (MSS) presented by hospital nursing workers and; 2. personal, occupational, and health factors related to MSS among them. **Method**: Two questionnaires were filled in by 245 nurse technicians (NTs) and licensed practical nurses (LPNs) (response rate 95%) associated with direct patient care sectors from a hospital. These questionnaires were: the standardized version of the Nordic Musculoskeletal Questionnaire (NMQ) and one including questions on 15 demographic independent variables potentially related to outcomes from the NMQ. Univariate analyses and binary logistic regression analyses were performed to identify which variables would explain the occurrence of MSS in different body regions. **Results:** The low back (57%), shoulder (52%), and neck (48%) were identified as the most affected regions. The logistic regression analysis showed that low back symptoms in the last 12 months were significantly associated with LPN activities (OR=2.36; CI=1.24-4.5) and previous sick leave due to MSS (OR=5.97; CI=1.2-29.1). Smoking was significantly associated with symptoms in the low back (OR=2.77; CI=1.13-6.8) and thoracic spine (OR=2.37; CI=1.04-5.40). Physical exercise showed a protective effect on the cervical spine (OR=0.42; CI=0.23-0.77). Previous sick leave was significantly associated with pain in the knees (OR=4.24; CI=1.33-13.5) and in the upper limbs (OR=5.36; CI=1.07-26.7). **Conclusions:** The nursing workers who were evaluated presented a high prevalence of MSS. Previous history of sick leave was strongly associated with the presence of symptoms in various body regions. These results indicate the need for preventive programs in the hospital environment in order to control more severe MSS in nursing professionals.

Keywords: occupational health; epidemiology; exercise; physical therapy.

HOW TO CITE THIS ARTICLE

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Introduction

Work-related musculoskeletal disorders (WRMDs) are responsible for early exit from the labor market[1,2] and represent the most common cause of absenteeism among workers[3,4]. In this context, physical therapy plays an important role as an intervention which can reduce the need for more costly or invasive procedures, thus preventing diseases and promoting health[5].

WRMDs are highly prevalent among nursing professionals[6-8] and the most frequent complaints are low back pain, with a prevalence rate of 30 to 60%[6,7,9-13], followed by the neck and shoulder symptoms, with prevalence rates of 30 to 48% and 43 to 53%, respectively[9,11-14].

Various epidemiological studies have reported an association between work overload and musculoskeletal disorders[6,10,15-17]. In addition to ergonomic factors, psychosocial risk factors such as high demand, low job control, and lack of social support have also been recognized as contributing factors to the development of musculoskeletal disorders among nursing professionals[9,10,16,18]. This multifactorial nature of the disorders shows the need for risk factor evaluations that consider a high number of potential contributing factors simultaneously[9,19]. However, due to the multifactorial origin of these disorders[20,21], the relationship between demographic characteristics (gender, age, height, weight, job, work sector, time in current sector, smoking, physical exercise, etc.) and the presence of musculoskeletal disorders has not yet been clarified[7,9,16].

Considering the importance of broadening epidemiological knowledge related to MSS among nursing professionals[22] and the need to evaluate these

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symptoms in a broader context for future preventive and therapeutic programs, the objectives of this study were to investigate: 1) the main symptoms presented by nurse technicians (NTs) and licensed practical nurses (LPNs) and 2) the simultaneous relationship between personal, occupational, and health factors possibly related to the presence of symptoms in different body regions.

Method

The present epidemiological study followed the STROBE methodology[23] of conducting observational epidemiology studies.

Study design

A cross-sectional epidemiological study was carried out to evaluate the prevalence of MSS among NTs and LPNs from a Brazilian hospital and to identify the potentially related factors.

Location of the study

The study was carried out in a hospital in the state of São Paulo, Brazil. The questionnaires were distributed during the work shifts in sectors involving direct patient care. The participants incurred no expense and received no compensation.

Participants and inclusion criteria

Brazilian nursing teams are basically comprised of three occupational groups: nurse technicians, licensed practical nurses, and registered nurses. In Brazil, NTs and LPNs represent most of the nursing workforce. These workers are mainly responsible for activities that involve direct contact with patients and, for this reason, are quite exposed to physical risk factors. Thus, the present study evaluated NTs and LPNs only.

Federal Law 7498/86[24] regulates the activities performed by these professionals and states that NTs and LPNs are responsible for most of the direct care of patients. However, activities carried out by NTs require a lower level of decision-making than the ones performed by LPNs and involve mid-level tasks of a repetitive nature.

All of the NTs and LPNs associated with direct patient care at the hospital were invited to participate in the study (n=292); they worked regularly in either day shifts (7:00 am to 7:00 pm) or night shifts (7:00 pm to 7:00 am). The adopted inclusion criteria were: to be registered as an NT or LPN; work in the department responsible for direct patient care, and to be employed for at least 12 months. All participants signed the informed consent form and the research procedures were approved by the Human Research Ethics Committee of Universidade Federal de São Carlos (UFSCar), São Carlos, SP, Brazil (CAAE: 1080.0.00.135-10).

Hospital department characteristics

A hospital's emergency department is accessible to the general population and is designed to assist patients with or without risk of death who require immediate health care[25]. Patient referral is carried out according to the complexity of the cases treated. Simple cases are dealt with at the emergency care units and more complex cases are sent to other units of the hospital. Hospital wards are departments for patients who do not need constant observation. One companion is allowed to stay with each patient all the time. Intensive Care Units (ICUs) are departments in which high level technology equipment is used for the care of critically ill patients. ICU patients need constant observation, as well as continuous medical and nursing care[25]. In these departments the circulation of both staff and visitors is restricted and controlled. It is important to emphasize that the physical and mental demands of each department vary due to the different levels of assistance, complexity, technology, and nurse-patient relationship of each department.

Evaluated variables and data sources

Two questionnaires were applied: the standardized Nordic Musculoskeletal Questionnaire (NMQ) and a questionnaire specifically designed for the present study that included 15 independent variables potentially related to the response variables of the NMQ[26]. In the customized questionnaire, personal, occupational, and health factors were included based on relevant, previously published epidemiological studies about risk factors[10,27,28] and on the authors' own experience[29-31]. The questions were structured as direct queries. Pilot tests were run before the questionnaires were applied to evaluate the clarity of the content and time taken to respond to the questions.

The following information was covered by the questionnaire: 1) occupational aspects - work department (emergency room, hospital wards or intensive care), shift (day or night), job position (NT or LPN), time in this position (years), time at the institution (years), other paid activity (yes or no); 2) personal characteristics - gender (male or female), age (in years), body mass index classification (normal, overweight, obese), marital status (married or single), children (yes or no), routine housework (yes or no);

3) health condition: regular physical activity (yes or no), smoking (yes or no), and history of sick leave of more than 15 days due to musculoskeletal disorders (yes or no).

The Brazilian version of the NMQ[32] was used to identify the presence of symptoms in the previous 7 days and previous 12 months in different regions of the body, the impairment these symptoms caused in daily life activities (DLAs) and whether or not medical assistance was sought for the symptom. The questionnaires were answered by the workers during their work shift. It should be mentioned that there was no interference from superiors or compensation for the workers.

Independent and dependent variables

The discrete independent variables: age, time in the current job position, and time at the institution were categorized according to quartiles (Table 1). The BMI values were categorized as: 1) normal (≤ 25), 2) overweight (>25 and <30), and 3) obese (>30)[33].

All dependent variables were dichotomous (presence or absence). Variables related to neck, thoracic spine, and lumbar spine symptoms were grouped under the term "spine segment". Variables related to shoulder, elbow, wrist, and hand symptoms were grouped as "upper limb (UL) segment". Variables related to hip, thigh, knee, ankle, and foot symptoms were grouped as "lower limb segment". The dependent variable "symptoms in any body region" corresponded to the nine body regions evaluated by the NMQ.

Controlling sources of bias

Initial clarification was given to all participants to prevent misunderstandings in their responses. If asked, additional information was provided individually, avoiding interpretations or any other form of inducement toward particular responses.

Sample size

All NTs and LPNs who were present (i.e. not on leave, vacation or day off) when the evaluation took place (n=292) were evaluated. The final sample consisted of 245 workers who matched the study's inclusion criteria.

Statistical methods

The data were descriptively analyzed by calculating the frequencies, quartiles, means, and standard deviation. A univariate analysis was carried out with the chi-square association test (χ^2). The independent variables significantly associated ($P \leq 0.25$) with the dependent variables were included in a logistic regression model[34]. The objective of the logistic regression analysis was to identify which variables explain the occurrence of musculoskeletal symptoms in different body regions. The data were analyzed in SPSS 11.5.

Results

Subjects

Out of the 292 LPN and NT active workers in the direct patient care sectors, 258 matched the study inclusion criteria. Thirteen workers did not participate because on the day of data collection they either had the day off (n=8), were absent from work (n=4) or they were unavailable to answer the questionnaire (n=1). Therefore, the sample included 245 individuals, representing 95% of the eligible subjects. There were 226 women and 19 men; the mean age was 35.5 years old (±10.7; min. 19 and max. 68). The mean time that the participants had been employed in their current position was 8.6 years (±8.5; min. 1 and max. 47) and the mean time at the institution was 6.8 years (±7.3; min. 1 and max. 47). The demographic characteristics of the sample (n=245) regarding occupational, personal, and health aspects are presented in Table 2.

The evaluated population consisted predominantly of women (92.2%) who did not exercise regularly in their free time (70.6%) and were exposed to double work shifts due to housework (91.8%). Most subjects (55.2%) were in the overweight or obese categories

Table 1. Categorization of quantitative variables according to quartiles.

Categories	Age (years)	Time employed in the current position (years)	Time employed at the institution (years)
Category 1($\leq 25^{th}$)	≤ 26	≤ 2	≤ 1.5
Category 2 ($>25^{th}$ and $\leq 50^{th}$)	$>26 \leq 34$	$>2 \leq 5$	$>1.5 \leq 4$
Category 3 ($>50^{th}$ and $\leq 75^{th}$)	$>34 \leq 42.5$	$>5 \leq 14$	$>4 \leq 10$
Category 4 ($>75^{th}$)	>42.5	>14	>10

Table 2. Demographic characteristics of the sample regarding occupational, personal, and health aspects.

Occupational aspects		***N* (%)**
Job	Nurse technician	168 (68.6%)
	Licensed practical nurse	77 (31.4%)
Work shift	Day	134 (54.9%)
	Night	111 (45.1%)
Job sector	Emergency room	21 (8.6%)
	Hospital wards	161 (65.7%)
	ICUs	63 (25.7%)
Time in this position	up to 2	79 (32.2%)
(years)	+2 to 5	50 (20.4%)
	+5 to 14	60 (24.5%)
	+14	56 (22.9%)
Time at the institution (years)	Up to 1.5	65 (26.5%)
	+1.5 to 4	65 (26.5%)
	+4 to 10	60 (24.5%)
	+10	55 (22.5%)
Other paid activity	Yes	61 (25.2%)
	No	184 (74.8%)
Personal aspects		***N* (%)**
Gender	Female	226 (92.2%)
	Male	19 (7.8%)
Age (years)	Up to 26	62 (25.3%)
	+26 to 34	58 (23.7%)
	+34 to 42.5	56 (22.8%)
	+42.5	59 (24.2%)
Body mass index	Normal	91 (44.8%)
	Overweight	63 (31%)
	Obese	49 (24.2%)
Marital status	Single	122 (50%)
	Married	122 (50%)
Children	Without	93 (38.4%)
	With	149 (61.6%)
Housework	Performs	224 (91.8%)
	Does not perform	20 (8.2%)
Health aspects		***N* (%)**
Regular physical exercise	Yes	72 (29.4%)
	No	173 (70.6%)
Smoker	Yes	34 (13.9%)
	No	210 (86.1%)
Previous sick leave due to musculoskeletal symptoms	Yes	14 (5.8%)
	No	226 (94.2%)

and approximately 53% had been nurses for less than 5 years.

The number and percentage of symptomatic workers evaluated by the NMQ, as well as for the categories: 'spine', 'UL', 'lower limb', and 'at least one body region' are presented in Table 3.

Table 3 shows the high prevalence of MSS in at least one body region among the evaluated nursing professionals, both in the last 12-month and seven-day periods. The symptoms led the worker to seek medical assistance and impaired the performance of DLAs in approximately 1/3 of the individuals affected.

Analysis of the symptoms according to the body region showed that during the previous 12 months the spine was the most affected part in 3 out of 4 individuals evaluated, followed by the lower limbs and the ULs. Considering the regions individually, the lumbar spine, shoulder and cervical spine were the regions with the highest prevalence of symptoms in the previous 12 months, followed by the thoracic spine and the ankle and foot regions.

Regarding the effects of symptoms on the performance of DLAs, more than ¼ of the individuals experienced some impairment. The lumbar region was the most critical, followed by the cervical spine, thoracic spine, ankle, and foot. Among the professionals evaluated, the spine was identified as the part that most affected the DLAs. Symptoms in at least one body region led more than 1/3 of the participants to seek medical assistance, and symptoms in the lumbar region were the most prevalent.

The logistic regression showed the variables associated with the presence of MSS in the evaluated population. The results of this analysis are presented in Table 4.

The logistic regression analysis (Table 4) showed that spinal pain in the last 12 months, particularly in the lumbar region, was significantly associated with job position, i.e. LPNs presented with more symptoms. Despite the differences in work demand between departments, there was no relationship between job sector and musculoskeletal symptoms. Smoking was significantly associated with thoracic spine symptoms; physical exercise had a protective effect on the cervical spine. Pain in the lower limbs, particularly in the knees, was significantly associated with the presence of previous sick leave; and UL symptoms were significantly more frequent in women.

DLA impairment due to symptoms in different body regions, particularly the lumbar spine followed by the spine in general, shoulders, and thoracic spine, were significantly associated with a history of previous sick leave due to musculoskeletal problems (Table 4). DLA impairment due to UL symptoms was also significantly associated with housework.

Seeking medical assistance was associated with previous sick leave due to MSS in general, particularly in the cervical spine and ULs (Table 4). Having another paid occupation also led workers who experienced pain in the thoracic spine and shoulders to seek medical assistance. Job position as an LPN was associated with seeking medical assistance for lumbar pain.

Table 3. Proportion of symptomatic subjects for the body regions evaluated by NMQ (n=245).

Body region	Symptoms in the last 12 months (%)	Impairment in DLAs (%)	Seeing a physician due to symptoms (%)	Symptoms in the last 7 days (%)
At least one region	229 (93.5)	68 (27.8)	95 (38.8)	157 (64.1)
Cervical spine	117 (47.8)	22 (9)	17 (7)	55 (22.4)
Thoracic spine	120 (50.8)	19 (7.8)	26 (10.7)	62 (25.3)
Lumbar spine	140 (57.1)	29 (11.8)	35 (14.3)	83 (33.9)
Spine	187 (76.3)	44 (18)	56 (22.9)	121 (49.4)
Shoulder	127 (52)	16 (6.5)	26 (10.7)	58 (23.8)
Elbow	19 (7.8)	3 (1.2)	6 (2.4)	6 (2.4)
Wrist and hand	78 (31.8)	10 (4.1)	16 (6.5)	32 (13.1)
Upper limb	152 (62)	23 (9.4)	40 (16.3)	76 (31)
Hip and thigh	80 (32.7)	9 (3.7)	16 (6.5)	35 (14.3)
Knee	78 (31.8)	16 (6.5)	15 (6.1)	30 (12.2)
Ankle and foot	99 (40.4)	19 (7.8)	23 (9.4)	52 (21.2)
Lower limb	160 (65.3)	31 (12.7)	43 (17.6)	85 (34.7)

Table 4. Factors associated with the presence of musculoskeletal symptoms based on analysis of the binary logistic regression.

Body Region	Factor	β	SE	Wald	p	OR	CI (OR)	R^2	χ^2 (df)
Symptoms in the last 12 months									
Cervical spine	Physical exercise	–0.862	0.930	7.848	0.005	0.422	0.231-0.772	0.010	17.63 (7)*
Thoracic spine	Smoking	0.863	0.420	4.213	0.04	2.369	1.04-5.398	0.084	15.13 (6)*
Lumbar spine	Job position	0.861	0.329	6.855	0.009	2.364	1.242-4.503	0.120	20.19 (6)*
	Smoking	1.021	0.458	4.973	0.026	2.775	1.132-6.807		
	Sick leave	1.787	0.809	4.885	0.027	5.973	1.224-29.142		
Vertebral column	Job position	0.924	0.394	5.487	0.019	2.519	1.163-5.457	0.150	25.09 (4)*
	Physical exercise	–0.981	0.334	8.609	0.003	0.375	0.195-0.722		
	Smoking	0.176	0.759	5.398	0.02	5.826	1.317-25.765		
Wrist and hand	Sick leave	1.641	0.594	7.638	0.006	5.159	1.612-16.514	0.090	15.84 (5)*
Upper limbs	Gender	–1.328	0.053	6.254	0.012	0.265	0.094-0.75	0.073	12.64 (3)*
	Sick leave	1.679	0.82	4.195	0.041	5.358	1.07-26.71		
Knee	Sick leave	1.445	0.592	5.957	0.015	4.243	1.329-13.542	0.074	11.9 (4)*
Lower limbs	Sick leave	1.723	0.804	4.598	0.032	5.603	1.16-27.1	0.090	14.25 (6)*
Impairment in DLAs due to symptoms									
Any region	Sick leave	2.054	0.631	10.585	0.001	7.797	2.263-28.87	0.100	17.65 (3)*
Thoracic spine	Sick leave	1.951	0.691	7.971	0.005	7.037	1.816-27.27	0.05	12.33 (3)*
Lumbar spine	Sick leave	3.858	1.239	9.701	0.002	47.38	4.18-53.69	0.300	29.30 (9)*
Vertebral column	Sick leave	2.43	0.633	14.72	0.000	11.360	3.283-39.307	0.160	23.13 (6)*
Shoulder	Sick leave	1.772	0.785	5.098	0.024	5.88	1.263-27.367	0.160	15.23 (5)*
Upper limbs	Housework	–1.637	0.606	7.298	0.007	0.194	0.059-0.638	0.110	12.43 (5)*
Symptoms for which medical assistance was sought									
Any region	Gender	–1.830	0.745	6.036	0.014	0.16	0.04-0.69	0.170	28.15 (6)*
	Sick leave	2.008	0.782	6.59	0.01	7.45	1.61-34.5		
Cervical spine	Sick leave	2.216	0.786	7.953	0.005	9.173	1.96-42.80	0.100	17.63 (7)*
Thoracic spine	Other paid activity	1.015	0.49	4.148	0.042	2.76	1.04-7.33	0.140	15.30 (4)*
	Sick leave	1.678	0.649	6.685	0.01	5.35	1.5-19.1		
Lumbar spine	Job position	1.217	0.469	6.745	0.009	3.378	1.35-8.46	0.230	28.24 (8)*
	Sick leave	1.94	0.65	8.97	0.003	6.954	1.95-24.74		
Vertebral column	Sick leave	2.58	0.724	12.683	0.000	13.18	3.18-54.5	0.200	27.62 (8)*
Shoulder	Other paid activity	1.081	0.519	4.332	0.037	2.947	1.065-8.155	0.250	28.17 (6)*
	Sick leave	2.263	0.715	10.02	0.002	9.614	2.36-39.04		
Upper limbs	Sick leave	1.576	0.59	7.04	0.008	4.836	1.51-15.5	0.100	12.33 (5)*

β - logistic regression coefficient; *SE* - standard error; *Wald* - logistic regression coefficient divided by the square SE; *P* - significance level of the Wald statistics; *OR* - odds ratio*; CI(OR)*- confidence interval of the 95% odds ratio; *dg* - degrees of freedom; **P*<0.05.

Discussion

The most prevalent body regions for symptoms in the previous 12 months were the lumbar spine, shoulders, and neck, followed by the thoracic spine and the ankle and foot region. Similar results were found in studies that used the NMQ to evaluate LPNs and NTs in Brazil[11-13], as well as in studies from other countries with nursing assistants[7,9,18,19,35,36].

A mean of 92.1% of the participants of these studies reported symptoms in at least one body region

compared to 93.5% in the present study, indicating a very high and similar prevalence (Table 5). The percentages per region were also high and similar between the other studies and the present one: 65.8 and 57% for the lumbar spine, 50.3 and 52% for the shoulder, and 49.3 and 48% for the neck, respectively. Most of the studies in Table 5 also identified the lumbar spine, neck, and shoulder as the most prevalent regions for MSS among nursing professionals.

A high prevalence of MSS in the lumbar spine, shoulder, and neck regions was reported by nursing professionals[28,37]. The activities performed in direct patient care usually involve upper limb force, trunk flexion, and extension movements causing an impact on the musculoskeletal system, particularly for the spine and shoulder regions[17,35,38]. Along these lines, Tullar et al.[39] recognized the role of patient transfer and lifting activities on the presence of musculoskeletal disorders among healthcare workers. The main risk factors for the development of musculoskeletal disorders among these workers are: pushing occupied beds, lateral patient transfers, repositioning patients in bed, making occupied beds, as well as lifting and carrying heavy equipment over long distances[40].

Even though the results presented in Table 5 were from different countries and involve different cultures and availability of equipment, the MSS prevalence was high in all of them. Several aspects seem to contribute to this in different ways, such as mean worker age, time in job position, patient impairments, and technology available for facilitating patient transportation[39,41].

The results of the logistic regression showed that previous sick leave due to musculoskeletal pain was strongly associated with seeking medical assistance due to MSS. Similar results were found among general workers evaluated by Haahr et al.[42]. Even though sick leave policies vary according to each country's legislation, in general, these benefits are given only after medical confirmation of the seriousness of the injury and degree of functional impairment[43]. Therefore, an association between sick leave, severe symptoms, the search for medical assistance, and DLA impairment is not surprising. Another aggravating factor is poor recovery after musculoskeletal injury. According to Rosenman et al.[44], this is often due to the workers' lack of access to qualified rehabilitation services.

Job position was a major factor for spine-related outcomes; LPNs had a greater chance of presenting symptoms and seeking medical assistance than NTs. This subject still seems to be controversial in the literature. In a number of countries, the education level of nursing assistants is lower than registered nurses and they are acknowledged to have a greater predisposition to low back pain than registered nurses[18,35,38]. Considering that the names used to classify nursing professionals vary from country to country according to the work organization and the workers' educational level, direct comparisons between groups should be avoided. Despite this, as previously described, both NTs and LPNs perform highly demanding physical tasks. Nevertheless, LPNs are exposed to a higher cognitive overload due to accumulated activities and the greater complexity of their tasks, which could explain the present results for these two job positions.

Housework was associated with symptoms. However, this result must be interpreted with caution, since the negative value found for the β coefficient

Table 5. Comparison of the prevalence of musculoskeletal symptoms among studies carried out with nursing assistants.

Country	NA Population	Lumbar (%)	Shoulder (%)	Neck (%)	At least one region	Study
Brazil	100%	57	52	48	93.5	Present study
Brazil	70%	73	62	67	96.3	Magnago et al.[13]
Brazil	100%	68	54	56	96	Barbosa et al.[12]
Brazil	100%	59	40	28	93	Gurgueira et al.[11]
Taiwan	100%	66	----	----	----	Feng et al.[36]
Turkey	75%	69	46	54	90	Tezel [35]
Greece	40%	75	37	47	85	Alexopoulos et al.[20]
Japan	5%	54	43	31	----	Ando et al.[7]
Sweden	100%	64	60	53	----	Josephson et al.[18]
Sweden	40%	65	60	59	----	Lagerström et al.[9]

NA: Nursing Assistant.

could suggest that performing housework would reduce the probability of DLA impairment by 0.194 due to UL symptoms. In fact, this association might be interpreted as an antalgic, rather than a protective factor.

Women had a 30% greater chance of developing UL symptoms than men. A review study[45] reinforces this finding, demonstrating that women have a greater tendency to present upper MSS than men. Among several other factors, an association between housework, gender, and UL symptoms is recurrent in several studies. Nordander et al.[46] hypothesize that the dedication of free time to housework reduces the recovery period required by the muscle groups involved at work and increases the risk of injury, particularly for physically demanding jobs, as is the case of the evaluated workers.

Regarding personal risks, smoking was identified as an important factor for symptoms in the thoracic region, lumbar region, and spine in general. Power et al.[47] and Bejia et al.[48] also found a positive association between lumbar pain and smoking for individuals who performed physically demanding activities. Nevertheless, Lagerström et al.[9] found no such association in a study conducted with NTs.

It has been acknowledged that nicotine causes vasoconstriction which reduces the amount of oxygen and nutrients available to muscles, ligaments, and intervertebral discs, increasing chances for degenerative processes in the intervertebral discs[49] and injuries[50]. Furthermore, continued smoking affects lung clearance, causing an accumulation of secretion and increasing coughing reflexes[51], which overloads intercostal muscles and increases intra-abdominal pressure. The main biological mechanisms triggered by smoking that could explain spinal symptoms are linked to: 1) coughing reflexes; 2) increased fibrin deposition which leads to chronic inflammation; and 3) reduced blood flow and oxygenation of the tissues, which affect the metabolic balance of the discs and accelerate degenerative processes leaving the spine more susceptible to mechanical deformations and injuries[52].

It is important to consider that, even though several epidemiological studies have reported an association between smoking and lumbar pain, factors such as the variety of definitions of lumbar pain, the multiple causes of the symptoms, and the variations in evaluation approaches and results make it difficult to come to a conclusive understanding of the literature[8,53] and limit comparison of the results.

Among the personal aspects investigated here, some attenuating factors were identified, such as the protective effect of physical exercise against neck symptoms. This subject still seems to be controversial in the literature. Lagerström et al.[9] identified that a poor physical condition increases the chance of cervical symptoms by 1.43, which supports the possibility that exercise has a protective effect against neck symptoms. However, other studies have reported that the incidence of neck pain in workers who exercise regularly in their free time is similar to that of those who do not[54,55]. This controversy may be related to the definition of physical exercise because when the control of this variable (exercise) is increased, its protective effect becomes more consistent.

Systematic reviews about the effects of exercise on musculoskeletal pain in active workers[29,31] found a protective effect in the occupational environment against lumbar and cervical pain in workers with heavy and sedentary activities, respectively. Martins and Marzialle[56] also identified benefits of therapeutic exercises for nursing workers with shoulder pain.

Additionally, a cohort study[57] with 1,742 symptomatic and asymptomatic workers demonstrated that regular involvement in sports for at least 10 months per year reduced the risk of symptoms in the neck and shoulder regions (OR:0.82). Thus, in the case of exercise carried out regularly in an occupational environment, as well as the regular practice of sports, there was a protective effect of physical activity on musculoskeletal pain in active workers.

Limitations and final considerations

The cross-sectional design of the present study does not allow for causal relations to be established between the symptoms and exposure to the tasks performed by NTs and LPNs. According to Punnett and Wegman[58], another limitation associated with cross-sectional studies carried out in work environments is the selection bias due to the exclusive evaluation of active workers, which can underestimate the symptoms of the full staff as it does not include data from individuals on leave.

A positive aspect of this study was the evaluation of personal factors and their participation in work-related disorders, which has not been clearly established so far. Considering the high prevalence of MSS among the evaluated professionals and the impairments that these symptoms might cause, public policy should encourage their prevention to reduce sick leave. Stimulating physical exercise, organizing anti-smoking campaigns, controlling risk factors through ergonomic intervention, ensuring proper

training and breaks are some of the measures that should also be undertaken.

Conclusion

The LPNs and NTs evaluated in this study showed a high prevalence of musculoskeletal disorders, and the most affected regions were the lumbar spine, shoulder, and neck. The spinal symptoms caused the greatest DLA impairment and were the most frequent reason for seeking medical assistance, which suggests that disorders in this region were severe.

Previous history of sick leave due to MSS was the strongest variable associated with the presence of symptoms in several body regions. This result shows the importance of preventive programs designed for hospital work environments in order to control more severe musculoskeletal consequences among nursing professionals such as those identified in the present study.

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Balance and muscle power of children with Charcot-Marie-Tooth

Equilíbrio e potência muscular em crianças com doença de Charcot-Marie-Tooth

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ABSTRACT | Background: In certain diseases, functional constraints establish a greater relationship with muscle power than muscle strength. However, in hereditary peripheral polyneuropathies, no such relationship was found in the literature. **Objective:** In children with Charcot-Marie-Tooth (CMT), to identify the impact of muscle strength and range of movement on the static/dynamic balance and standing long jump based on quantitative and functional variables. **Method**: The study analyzed 19 participants aged between 6 and 16 years, of both genders and with clinical diagnoses of CMT of different subtypes. Anthropometric data, muscle strength of the lower limbs (hand-held dynamometer), ankle and knee range of movement, balance (Pediatric Balance Scale) and standing long jump distance were obtained by standardized procedures. For the statistical analysis, Pearson and Spearman correlation coefficients were used. **Results:** There was a strong positive correlation between balance and the muscle strength of the right plantar flexors (r=0.61) and dorsiflexors (r=0.59) and a moderate correlation between balance and the muscle strength of inversion (r=0.41) and eversion of the right foot (r=0.44). For the long jump and range of movement, there was a weak positive correlation with right and left plantar flexion (r=0.20 and r=0.12, respectively) and left popliteal angle (r=0.25), and a poor negative correlation with left dorsiflexion (r=–0.15). **Conclusions:** The data on the patients analyzed suggests that the maintenance of distal muscle strength favors performance during balance tasks, while limitations in the range of movement of the legs seem not to be enough to influence the performance of the horizontal long jump.

Keywords: Charcot-Marie-Tooth disease; strength; balance; range of movement; assessment; physical therapy.

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RESUMO | Contextualização: Em algumas doenças, limitações funcionais têm maior relação com a potência do que com a força muscular, porém, nas polineuropatias periféricas hereditárias, tal relação não foi relatada na literatura. **Objetivo:** Identificar, a partir da análise de variáveis quantitativas e funcionais, o impacto da força dos músculos dos membros inferiores e das amplitudes de movimento (ADM) sobre o equilíbrio estático/dinâmico e o salto horizontal de crianças com doença de Charcot-Marie-Tooth (CMT). **Método:** Foram incluídos 19 participantes de seis a 16 anos, de ambos os sexos, com diagnóstico clínico de CMT de subtipos variados. Foram obtidos, de forma padronizada, dados antropométricos, força muscular dos membros inferiores (*Hand-Held Dynamometer*), ADM de tornozelos e joelhos, equilíbrio (Escala de Equilíbrio Pediátrica) e distância de salto horizontal (*Long Jump*). Para a análise estatística, utilizaram-se os Coeficientes de Correlação de Pearson e Spearman. **Resultados:** Houve forte correlação positiva entre equilíbrio e força muscular de flexores plantares direito (r=0,61) e dorsiflexores (r=0,59) e correlação moderada com inversores dos pés (r=0,41) e eversores do pé direito (r=0,44). Considerando o *Long Jump* e as ADM, houve fraca correlação positiva para ADM de flexão plantar direita (r=0,20), esquerda (r=0,12) e ângulo poplíteo esquerdo (r=0,25) e fraca correlação negativa para dorsiflexão esquerda (r=–0,15). **Conclusões:** Os dados dos pacientes analisados sugerem que a manutenção de força muscular distal favorece o desempenho em tarefas de equilíbrio. E as restrições nas ADM passivas de membros inferiores parecem não ter sido suficientes para influenciar a potência muscular no salto horizontal.

Palavras-chave: doença de Charcot-Marie-Tooth; força muscular; equilíbrio; amplitude de movimento; avaliação; fisioterapia.

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Introdução

A doença de Charcot-Marie-Tooth (CMT) consiste em uma polineuropatia de origem genética com vários subtipos. Como fenótipo comum, há o acometimento dos nervos periféricos motores e sensoriais por um processo degenerativo desmielinizante e axonal[1]. A predominante fraqueza muscular distal pode determinar, em crianças e adultos, significativas disfunções motoras na deambulação, na participação em atividades de vida diária e socioculturais. Em destaque, a fraqueza da musculatura dorsiflexora do tornozelo cursa com associado encurtamento dos músculos flexores plantares e desenvolvimento de deformidades nos pés[2].

A principal hipótese clínica para o desenvolvimento das deformidades dos pés destaca a íntima relação entre o desequilíbrio de força da musculatura inversora e eversora dos pés e sobrecarga dos músculos flexores plantares em contraposição à fraqueza do grupo de dorsiflexores[3]. Essa última é considerada a principal manifestação da doença e contribui para deformidade dos pés (pé cavo), contratura de tornozelo, função motora pobre e dificuldades na marcha em crianças e adultos afetados[2].

Acredita-se que as perdas nas amplitudes de movimento (ADM) distais de pacientes com CMT comprometam a potência muscular à medida que prejudicam o ciclo alongamento-encurtamento. No caso do salto horizontal, *Long Jump*, 50% do desempenho muscular é atribuído ao tornozelo[4]. Dessa forma, as ADM de membros inferiores podem correlacionar-se ao desempenho no teste *Long Jump*, utilizado para inferir a potência muscular.

Força muscular, ADM e diferentes exigências neuromusculares sobre a extremidade inferior são fatores que modificam os limites de estabilidade postural e podem influenciar o desempenho de uma tarefa funcional específica[5]. Portanto, a seleção de condutas fisioterapêuticas na doença de CMT pode ser direcionada e assertiva se baseada na compreensão da real contribuição das variáveis envolvidas no equilíbrio estático e dinâmico.

É relevante direcionar pesquisas acerca da polineuropatia hereditária de CMT, uma vez que sua incidência é relativamente alta, atingindo um em cada 2.500 indivíduos[2]. Embora os sintomas iniciais da doença geralmente apareçam na primeira ou segunda década de vida, com progressão lenta ao longo das décadas consecutivas, a maioria dos estudos tem como população-alvo os adultos[6-8].

Estudos intervencionistas envolvendo medicamentos ainda estão em curso, já que não existe uma terapia efetiva para a doença de CMT[1]; e o uso de órteses apresenta resultados controversos[8]. Além disso, investigações focadas em esclarecer a contribuição dos principais déficits (musculoesqueléticos, neuromusculares, e biomecânicos) sobre o equilíbrio de crianças com CMT são escassas. Dessa forma, torna-se preemente investigar o comportamento de variáveis biomecânicas na fase inicial da doença, como um passo preliminar à proposição de intervenções fisioterapêuticas potencialmente auxiliares da reabilitação dessas crianças e adolescentes.

Em crianças e adultos, a tríade fraqueza muscular, hiper/hipomobilidade articular e desarranjos biomecânicos compensatórios podem determinar significativas disfunções motoras de predomínio distal-proximal, com prejuízo do equilíbrio, da deambulação e da participação em atividades de vida diária[2]. De modo similar, as relações entre ADM passiva com salto horizontal, medida no teste *Long Jump*, e o equilíbrio, avaliado com a Escala de Equilíbrio Pediátrica (EEP), foram testadas. Em suma, o objetivo do presente estudo foi avaliar a influência das ADM passivas e da força dos principais grupos musculares dos membros inferiores sobre o equilíbrio estático/dinâmico e a capacidade de salto horizontal de crianças com a doença de CMT.

Método

Participaram do estudo 19 crianças e adolescentes voluntários admitidos no Ambulatório de Doenças Neurogenéticas do Hospital das Clínicas da Faculdade de Medicina de Ribeirão Preto da Universidade de São Paulo (HCFMRP/USP), Ribeirão Preto, SP, Brasil, no período de 2011-2012, com diagnóstico da doença confirmado, de ambos os sexos, com idade entre cinco e 16 anos, marcha independente, sem doenças associadas à doença de CMT que acometam o sistema cardiorrespiratório.

Uma autorização foi obtida dos pais ou responsáveis mediante o preenchimento do termo de consentimento livre e esclarecido, previamente aprovado pelo Comitê de Ética em Pesquisa do HCFMRP/USP (Processo n. 4334/2011).

De forma padronizada, foram obtidos de todos os participantes os dados antropométricos, a goniometria, a força muscular (dinamômetro *Hand-Held- Lafayette Instrument*, Lafayette, UK), a potência de membros inferiores (teste *Long Jump)* e o equilíbrio estático/dinâmico (Escala de Equilíbrio Pediátrica).

A ADM passiva foi mensurada em joelhos (ângulo poplíteo) e tornozelos (flexão plantar e dorsiflexão), conforme método descrito por Marques[9]. As medidas foram realizadas com um goniômetro universal (CARCI – Indústria e Comércio de Aparelhos Cirúrgico e Ortopédicos Ltda.).

Um dinamômetro *Hand-Held* (*Lafayette Instrument*, Lafayette, UK) mensurou por três vezes as forças musculares (em quilograma-força) de extensores de quadril, extensores de joelho, dorsiflexores, flexores plantares, supinadores e pronadores do pé, alternando entre os membros inferiores direito e esquerdo, a fim de prevenir fadiga. O valor mais elevado foi considerado para análise. Durante as mensurações, para garantir que o dinamômetro se mantivesse perpendicular ao segmento testado e o mais distal possível, havia um assistente estabilizando o participante, e foram adotados os seguintes posicionamentos corporais: decúbito dorsal, membros inferiores em posição anatômica e pés para fora da maca para mensurar as forças musculares dos dorsiflexores, flexores plantares, supinadores e pronadores; decúbito ventral e joelho fletido a 90° para mensurar a força muscular de extensores de quadril; sedestação e joelho fletido a 90° para mensurar a força muscular dos extensores do joelho. O comando de voz "força" durante os testes foi usado enquanto o avaliador impedia qualquer arco de movimento para garantir uma contração isométrica de cinco segundos.

O teste *Long Jump*, também denominado de salto horizontal ou salto em distância, é de fácil aplicação, necessitando apenas de giz ou lápis para marcação em solo, fita métrica ou trena para mensurar a distância do salto. Os participantes foram posicionados atrás de uma linha marcada no solo, com os pés ligeiramente afastados e solicitou-se que saltassem horizontalmente a maior distância possível com a ajuda da flexão das pernas e o impulso transmitido pelo balanço dos braços[10]. Assim, foi permitida tal estratégia para recuperar ou manter o equilíbrio por meio da transferência do movimento angular dos braços para o resto do corpo. Foram realizadas três tentativas, e o maior valor foi considerado para a análise. O resultado foi dado em centímetros, considerando a distância entre a linha de partida e a marca alcançada pelo calcâneo no solo.

A EEP foi utilizada como medida de equilíbrio funcional, pois segundo Franjoine et al.[11], é adequada para crianças com idade escolar com deficiência motora de leve a moderada. Sua administração tem duração aproximada de 15 minutos, não requer uso de equipamento especializado e fornece dados clínicos para a medição de tarefas de equilíbrio funcional. Utilizou-se para aplicação do teste a versão brasileira da EEP descrita por Ries et al.[12]. Para sua aplicação, foram utilizados os seguintes materiais: cadeira com encosto, altura ajustável e descanso de braços, marcações para os pés, cronômetro, trena e degrau. Os participantes foram orientados, por meio de demonstrações, a fazer os testes. Uma tentativa preliminar de cada tarefa proposta foi permitida para cada item testado.

A EEP é composta por 14 itens que requerem da criança tarefas que exigem equilíbrio estático e dinâmico. Cada item pode ser pontuado de 0 a 4, sendo 4 a pontuação que corresponde à melhor habilidade para a realização da tarefa exigida. Soma-se a pontuação de cada uma das 14 tarefas e, a partir desse número, determina-se a pontuação final, cujo valor máximo é de 56. Quanto maior a pontuação, maior a habilidade para a realização da tarefa exigida e, portanto, melhor o equilíbrio da criança. A partir de sete anos de idade, a pontuação máxima de 56 deve ser alcançada, não havendo na literatura menção às classificações de escores menores[11].

Para atender ao objetivo do estudo, que foi correlacionar os dados de dinamometria de membros inferiores com equilíbrio e da amplitude de movimento de membros inferiores com impulsão horizontal mensurada pelo teste *Long Jump*, foi proposto o Coeficiente de Correlação de Pearson (r) e o Coeficiente de Correlação de Spearman, que quantificam a associação entre duas variáveis quantitativas. Tais coeficientes variam entre os valores –1 e 1. O valor 0 (zero) significa que não há relação linear, o valor 1 indica uma relação linear perfeita, e o valor –1 também indica uma relação linear perfeita, mas inversa, ou seja, quando uma das variáveis aumenta, a outra diminui. Quanto mais próximo estiver de 1 ou –1, mais forte é a associação linear entre as duas variáveis. A classificação dos Coeficientes de Correlação de Spearman foi feita a partir do estudo descrito por Hulley et al.[13], e a classificação dos Coeficientes de Correlação de Pearson foi feita a partir do estudo descrito por Pagano e Gauvreau[14]. Foram realizados os testes das seguintes correlações: força muscular × equilíbrio e *Long Jump* × ADM.

Resultados

Os dados antropométricos e a classificação dos participantes são mostrados na Tabela 1. Dos 19 pacientes que compuseram o estudo, nove eram do sexo masculino e dez do sexo feminino, a idade média foi de 10,11 anos (desvio padrão de 2,64), o peso médio foi de 40,59 kg (desvio padrão de 15,37) e a altura de 1,43 m (desvio padrão de 0,18). Considerando valores normativos disponibilizados pela OMS[15], nove participantes apresentaram IMC (índice de massa corporal) adequados para suas idades, enquanto quatro apresentaram subnutrição, duas sobrepeso e quatro obesidade.

Tabela 1. Dados antropométricos e classificação dos participantes conforme o tipo de CMT.

Idade (anos)	Participante	Sexo	Peso (Kg)	Altura (m)	IMC	Tipo de CMT
6	**A**	F	36,1	1,3	20***	CMT 1A
6	**B**	F	20,2	1,2	14,5	CMT 1A
6	**C**	F	25,1	1,2	17,7***	CMT****
8	**D**	M	21,2	1,2	15,0*	CMT 1A
9	**E**	M	32,8	1,3	18,5	CMT 1A
9	**F**	F	30,9	1,3	17,2	CMT****
9	**G**	M	27,7	1,4	14,8*	CMT****
10	**H**	F	51,0	1,4	24,9***	CMT****
10	**I**	F	28,0	1,4	14,0*	CMT****
10	**J**	F	48,0	1,5	21,3**	CMT****
10	**K**	F	68,0	1,5	28,7***	CMT****
10	**L**	M	32,5	1,4	15,6*	CMT****
11	**M**	F	53,0	1,7	19,5	CMT****
11	**N**	M	30,1	1,3	17,5	CMT****
12	**O**	M	64,0	1,7	21,4**	CMT****
12	**P**	M	50,3	1,6	20,9	CMT****
13	**Q**	M	37,3	1,4	19,0	CMT****
14	**R**	F	46,4	1,6	19,1	CMT****
16	**S**	M	68,7	1,8	20,5	CMT****

* IMC - abaixo do peso normal; ** IMC – sobrepeso; *** IMC – obesidade; **** Subtipo de CMT não especificado.

As forças musculares dos membros inferiores, as ADM passivas, o teste *Long Jump* e as pontuações da EEP obtidas estão contidos na Tabela 2.

Os valores de força muscular isométrica não acompanharam a ordem crescente de idade dos participantes. Os grupos musculares dorsiflexores, inversores e eversores apresentaram os menores valores de força muscular isométrica, sendo que a força de dorsiflexão foi nula nos participantes C e K.

Em relação ao equilíbrio, verificado a partir da EEP, os dados obtidos mostraram pontuação alta para os participantes com CMT (entre 51 e 56), indicando bom desempenho geral. Porém, considerando os itens isolados da EEP, foram identificadas as tarefas mais desafiadoras: em pé com os olhos fechados, em pé com um dos pés à frente, apoio unipodal, apanhar objeto do chão e alcance anterior.

Os dados de ADM evidenciaram preservação da mobilidade articular de tornozelo bilateralmente, salvo três casos em que houve restrição (participantes H, N e R), com dorsiflexão menor que 10 graus, e três casos de ausência da mobilidade (participantes K, M e O), com dorsiflexão igual ou menor que zero. O ângulo poplíteo bilateral da maioria dos participantes estava preservado (exceção para valores menores que 140°) (Tabela 2).

Quanto ao teste *Long Jump*, não houve aumento do desempenho conforme a idade, e os valores de sete dos 19 participantes (A, H, I, K, L, O, Q) apresentaram-se inferiores aos descritos como normativos[16] (Tabela 2).

Correlações entre EEP e força muscular de membros inferiores

Os resultados do teste de Spearman indicaram forte correlação positiva entre o equilíbrio e a força dos seguintes grupos musculares: flexores plantares direito (r=0,61; p=0,01), dorsiflexores direito (r=0,59; p=0,01) e dorsiflexores esquerdo (r=0,59; p=0,01), e correlação moderada entre o equilíbrio e a força muscular dos seguintes grupos musculares: inversores direito (r=0,44; p=0,06), inversores esquerdo (r=0,41; p=0,08) e eversores direito (r=0,44; p=0,06) – Tabela 3.

Correlações entre o teste *Long Jump* e as ADM passivas de membros inferiores

Os valores obtidos pela correlação do teste *Long Jump* com as ADM dos membros inferiores indicaram uma fraca correlação positiva entre as ADM de flexão plantar direita (r=0,20; p=0,41), flexão

Tabela 2. Força muscular de membros inferiores, amplitude de movimento – Goniometria de membros inferiores, *Long Jump* e pontuação da Escala de Equilíbrio Pediátrica dos participantes.

Participante	Idade (anos)	Força Muscular (Kgf)												Goniometria (graus)						*Long Jump* (cm)	EEP
		ID	IE	ED	EE	FPD	FPE	DFD	DFE	EJD	EJE	EQD	EQE	FPD	FPE	DD	DE	ÂPD	ÂPE		
A	6	6	5	7	6	17	20	6	5	12	8	13	13	50	42	10	12	190	145	38	55
B	6	4	4	7	6	14	14	7	6	9	10	13	10	65	60	20	20	145	155	60	54
C	6	2	3	2	2	6	8	0	0	14	10	10	12	45	45	10	10	150	140	49	51
D	8	4	6	5	4	18	20	8	5	12	10	14	11	40	45	22	20	140	150	102	55
E	9	6	7	6	7	9	10	9	7	16	17	13	11	50	40	10	0	154	150	115	55
F	9	7	3	4	5	7	10	2	1	17	18	19	17	50	50	10	10	150	150	99	54
G	9	4	5	7	5	21	18	11	9	14	14	16	17	50	45	20	20	155	140	113	56
H	10	8	9	7	10	18	18	7	6	10	10	9	11	32	36	8	10	134	132	59	56
I	10	11	9	7	8	13	15	10	8	24	22	14	13	35	40	22	22	130	140	18	53
J	10	12	12	13	11	19	22	12	12	20	20	16	18	34	34	20	18	145	140	94	56
K	10	4	5	2	2	12	14	0	0	18	19	16	15	50	52	-10	0	140	130	62	51
L	10	6	4	8	10	9	15	6	5	9	9	17	14	40	35	10	17	130	130	63	53
M	11	9	9	10	12	11	9	10	10	20	23	20	24	42	52	0	0	138	138	94	56
N	11	7	5	5	5	15	15	6	4	18	16	13	13	50	40	5	10	140	145	108	56
O	12	7	8	6	6	13	16	7	7	18	17	11	11	36	30	0	0	136	140	83	56
P	12	8	6	7	7	20	20	13	11	15	16	11	11	40	50	20	10	120	120	107	56
Q	13	5	4	5	6	18	10	3	2	11	10	10	10	40	50	10	10	150	136	60	56
R	14	9	12	3	5	24	20	2	2	25	19	14	12	50	40	5	10	128	142	88	55
S	16	12	12	8	9	22	22	26	20	29	28	29	29	50	50	15	12	155	150	180	56

ID = Inversores do Pé Direito; IE = Inversores do Pé Esquerdo; ED = Eversores do Pé Direito; EE= Eversores do Pé Esquerdo; FPD = Flexores Plantares Direito; FPE = Flexores Plantares Esquerdo; DFD = Dorsiflexores Direito; DFE = Dorsiflexores Esquerdo; EJD =Extensores de Joelho Direito; EJE = Extensores de Joelho Esquerdo; EQD = Extensores de Quadril Direito; EQE = Extensores de Quadril Esquerdo; FPD = Flexão Plantar Direita; FPE = Flexão Plantar Esquerda; DD = Dorsiflexão Direita; DE = Dorsiflexão Esquerda; ÂPD = Ângulo Poplíteo Direito; ÂPE = Ângulo Poplíteo Esquerdo; 1ª T = Primeira Tentativa; 2ª T = Segunda Tentativa; 3ª T = Terceira Tentativa; EEP = Escala de Equilíbrio Pediátrica.

plantar esquerda (r=0,12; p=0,61) e ângulo poplíteo esquerdo (r=0,25; p=0,31). Houve fraca correlação negativa para dorsiflexão esquerda (r=–0,15; p=0,54) e nenhuma correlação foi encontrada para dorsiflexão direita (r=0,09; p=0,69) e ângulo poplíteo direito (r=0,00; p=1,00), conforme Tabela 4. Portanto, os dados obtidos indicaram não haver correlação entre a ADM articular de tornozelo e joelho com a potência muscular desenvolvida por meio do teste *Long Jump.*

Discussão

O presente estudo identificou que os participantes com CMT apresentaram fraqueza muscular dos seguintes grupos: eversores, inversores, dorsiflexores e flexores plantares. As ADM estavam preservadas, com exceções para dorsiflexão. De modo geral, o equilíbrio estava preservado, porém houve déficit em itens específicos da EEP. O teste *Long Jump* indicou que a potência muscular se manteve preservada na maioria dos participantes, com algumas exceções.

Apesar de, por definição, o comprometimento sensório-motor ter caráter simétrico na doença de Charcot-Marie-Tooth, variações na força muscular e flexibilidade e até mesmo coordenação motora podem ser encontradas. Desse modo, alguns resultados das correlações foram encontrados apenas para a força e ADM do lado direito ou esquerdo. As correlações obtidas sugerem que a força preservada de dorsiflexores e flexores plantares influenciou de forma positiva o desempenho em tarefas que demandavam equilíbrio. As ADM obtidas parecem não ter afetado a potência muscular.

Força muscular e equilíbrio

O equilíbrio é um fator essencial para a coordenação de respostas motoras, movimentos e ajustes posturais. Para que ele seja efetivo é necessário que diversos fatores, como sistema vestibular, informações proprioceptivas, percepção visual, força muscular e flexibilidade articular, atuem de forma eficiente e harmônica sobre o corpo[17]. Os músculos

Tabela 3. Valores do Coeficiente de Correlação de Spearman e valor *p* da força muscular de membros inferiores e a Escala de Equilíbrio Pediátrica (EEP).

Grupos musculares	Correlação com o equilíbrio (rho)	Valor p
Inversores do pé direito	0,44	0,06
Inversores do pé esquerdo	0,41	0,08
Eversores do pé direito	0,44	0,06
Eversores do pé esquerdo	0,38	0,10
Flexores plantares direito	0,61	0,01
Flexores plantares esquerdo	0,38	0,11
Dorsiflexores direito	0,59	0,01
Dorsiflexores esquerdo	0,59	0,01
Extensores de joelho direito	0,15	0,54
Extensores de joelho esquerdo	0,20	0,41
Extensores de quadril direito	–0,07	0,77
Extensores de quadril esquerdo	0,04	0,88

Tabela 4. Valores do Coeficiente de Correlação de Pearson *(r)* para as amplitudes de movimento passivas de membros inferiores e o teste *Long Jump.*

Medidas de amplitude de movimento de membros inferiores	Coeficiente Correlação de Pearson (r) com o Teste *Long Jump*	Valor p
Flexão plantar direita	0,20	0,41
Flexão plantar esquerda	0,12	0,61
Dorsiflexão direita	0,09	0,69
Dorsiflexão esquerda	–0,15	0,54
Ângulo poplíteo direito	0,00	1,00
Ângulo poplíteo esquerdo	0,25	0,31

que envolvem o tornozelo são essenciais para a manutenção do equilíbrio, pois fornecem informações proprioceptivas e corrigem pequenas oscilações posturais, além de, através do torque muscular, corrigir possíveis desestabilizações, regulando assim o centro de gravidade e mantendo o centro de massa localizado entre os pés[18]. Tipicamente, a história natural de vários subtipos de CMT envolve, entre outras manifestações, a progressiva redução da força muscular distal, podendo prejudicar a manutenção do centro de massa na base de apoio tanto dinâmica quanto estaticamente[2].

Para a manutenção do equilíbrio, a mais utilizada é a estratégia do tornozelo, na qual é necessária a preservação de força da musculatura flexora plantar, dorsiflexora, eversora e inversora[19]. Essa estratégia é mais eficaz quando as perturbações do equilíbrio são lentas e pequenas, e a superfície de apoio é firme, ou seja, durante o equilíbrio estático[19]. A dorsiflexão do tornozelo produzida durante a estratégia do tornozelo é determinante para que a manutenção do equilíbrio seja obtida após uma desestabilização, isso porque, ao levantar o antepé, cria-se uma força contramovimento que ajuda a reequilibrar o corpo[20]. Desse modo, a diminuição da força da musculatura dorsiflexora observada nos participantes avaliados pode justificar o déficit encontrado na manutenção do equilíbrio estático.

No presente estudo, os participantes avaliados apresentaram dados condizentes com os descritos na literatura[2,3,5], tais como força muscular reduzida, principalmente dos músculos eversores e dorsiflexores, e encurtamento dos músculos flexores plantares. Em um estudo realizado por Nyström et al.[21], foram estabelecidos valores de referência para força muscular isométrica do membro inferior em relação à idade e peso corporal de participantes saudáveis. Comparamos então os dados do presente estudo com os valores de referência obtidos por Nyström et al.[21], utilizando o peso e a altura dos participantes, já que os valores de referência através da idade podem conduzir a erros de interpretação. Observou-se que a maioria dos participantes com CMT apresenta força muscular isométrica compatível com seu peso corporal e altura. Exceções foram encontradas para os músculos dorsiflexores dos participantes C, E e N. Para os músculos inversores e eversores dos pés, não foram encontrados dados normativos para comparação, bem como para os músculos flexores plantares. Porém, vale ressaltar que, em nove dos 19 participantes, a força muscular dos inversores e eversores foi inferior a 5 KgF, sugerindo um déficit de força nesses grupos musculares.

Para os participantes do presente estudo, cuja força muscular distal está diminuída, tarefas envolvendo equilíbrio estático estão afetadas em maior proporção que aquelas de caráter dinâmico, pois posturas estáticas exigem maior ADM e maior torque da musculatura do tornozelo[22].

Os déficits de equilíbrio encontrados nos participantes do presente estudo não eram incapacitantes, já que a pontuação na EEP foi próxima ao máximo (de 51 a 56). Como vários fatores afetam o equilíbrio positiva ou negativamente[17], é possível que compensações aos déficits de força muscular distal tenham sido empregadas, por exemplo, com o uso da estratégia do quadril e auxílio de membros superiores. Além disso, a propriocepção e os mecanismos de estabilização, tais como a rigidez muscular, são fatores determinantes no estabelecimento do equilíbrio[23]. Outro fator que pode ter sido acionado pelos pacientes é o controle antecipatório e, a partir dele, pode ser obtido o controle estático e dinâmico do equilíbrio[22,23].

A correlação positiva observada entre a força muscular isométrica de dorsiflexores, flexores plantares, eversores e inversores com o equilíbrio sugere que a manutenção da força muscular desses grupos pode afetar positivamente o equilíbrio. Ribeiro et al.[24] relacionaram a força da musculatura do tornozelo com o equilíbrio em idosos e, assim como Sundermier et al.[25], que avaliaram crianças, corroboram o presente estudo, concluindo que a força de flexores plantares e dorsiflexores está associada positivamente ao equilíbrio.

ADM e *Long Jump*

A ADM disponível para uma articulação pode ser também definida como flexibilidade, sendo um elemento importante da aptidão física[26]. Ela pode ser atingida pela contração muscular ativa, referenciada como flexibilidade dinâmica, ou pelo movimento passivo causado por uma força externa à articulação. Gênero, medidas antropométricas, composição corporal, características genéticas e patológicas, além do processo de crescimento e desenvolvimento[26], influenciam a capacidade de flexibilidade. Nos participantes com CMT do presente estudo, houve uma ADM articular com relativa flexibilidade e arco de movimento preservado, o que estabeleceu fraca correlação com o desempenho no teste *Long Jump*.

Os resultados do *Long Jump* dos participantes foram comparados aos dados normativos descritos por Condon e Cremin[16], os quais estudaram essa variável em 534 crianças na faixa de quatro a 15 anos. A comparação realizada, considerando as idades compatíveis com os participantes de nosso estudo, mostrou que sete (A, H, I, K, L, O, Q) dos 19 participantes apresentaram valores inferiores aos descritos como normativos.

Na realização do teste *Long Jump*, deve-se considerar que o impulso adicional transmitido para o salto pela oscilação dos braços pode aumentar a distância saltada e a velocidade de decolagem[27]. No caso do presente estudo, todos os participantes eram instruídos a realizar o movimento do teste com a técnica de impulsionar-se com os braços. Ashbya e Heegaard[27] indicaram que o balanço do braço aumenta a capacidade de produzir força dos músculos extensores das extremidades inferiores, diminuindo a velocidade de contração em momentos-chave no salto. Para manter o equilíbrio durante todo o salto, pode haver a adoção de medidas de controle antecipatório ou até mesmo o emprego de mecanismos contraproducentes que reduzem a distância do salto com movimento de braço livre[27]. Considerando que crianças com CMT são conscientes de seus déficits de equilíbrio, é possível que tenham adotado medidas de controle antecipatório com o braço livre. Assim, o restrito uso dos braços pelos participantes talvez explique, em parte, o menor desempenho no salto dos participantes A, H, I, K, L, O e Q, que se apresentaram expressivamente menores que a média dos saltos considerados.

O teste *Long Jump*, enquanto tarefa ou habilidade motora, é um padrão motor complexo que requer o desempenho coordenado de todas segmentos corporais, sendo que o impulso e a aterrissagem devem ser feitos com os dois pés. O salto horizontal mede a força explosiva, tem alta correlação com medidas isocinéticas de força de membros inferiores e é indicado como um bom preditor de desempenho do salto em distância[10].

A inexistência ou até mesmo a fraca correlação encontrada entre a ADM e o teste *Long Jump* pode ser atribuída ao fato de que a maioria dos participantes do presente estudo apresentava as ADM distais relativamente preservadas. Para verificar a influência das ADM passivas sobre o *Long Jump*, seria necessário avaliar um grupo de participantes acometidos cujas ADM não estivessem preservadas, e isso constitui uma limitação do estudo.

O tamanho da amostra, a heterogeneidade dos subtipos de CMT, diferentes níveis de maturação motora e características antropométricas variadas constituem limitações comuns a estudos desta natureza. Com base nos dados antropométricos, foi possível identificar participantes de todas as categorias de classificação de IMC, com 21% de obesos, o que poderia influenciar os resultados obtidos. O IMC parece não ter efeito negativo sobre a flexibilidade, diferente dos testes de propulsão[28]. Obesos ficam em desvantagem em atividades de maior desafio ao equilíbrio, como o apoio unipodal[29]. Quanto à força muscular, uma recente revisão[30] aponta que, embora obesos apresentem maiores valores absolutos comparados a seus pares eutróficos, a obesidade não tem impacto sobre as propriedades intrínsecas do músculo para a geração de força. Assim, consideramos mínima a interferência do IMC sobre nossos dados.

Contudo, os resultados deste estudo podem auxiliar o fisioterapeuta na tomada de decisões durante a prática clínica, pois sugerem que a força muscular preservada de dorsiflexores e de flexores plantares cursa com melhor desempenho de equilíbrio estático e dinâmico. De maneira similar, a manutenção e/ou ganho da mobilidade articular, principalmente de dorsiflexão, por meio de alongamentos, cursa com bom desempenho funcional e potência muscular demonstrada no teste *Long Jump*. Dessa maneira, no tratamento de crianças e adolescentes com doença de CMT, deve-se priorizar a manutenção e/ou ganho de força e flexibilidade dos músculos dorsiflexores e flexores plantares.

Conclusão

A manutenção de força muscular distal em crianças com CMT contribui para o desempenho em tarefas de equilíbrio. As perdas encontradas nas ADM passivas de membros inferiores parecem não ter sido suficientes para influenciar a potência muscular do salto horizontal.

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Sensory processing abilities of children with ADHD

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ABSTRACT | **Objective:** To assess and compare the sensory processing abilities of children with Attention Deficit/Hyperactivity Disorder (ADHD) and children without disabilities, and to analyze the relationship between sensory processing difficulties and behavioural symptoms presented by children with ADHD. **Method**: Thirty-seven children with ADHD were compared with thirty-seven controls using a translated and adapted version of the "Sensory Profile" answered by the parents/caregivers. For the ADHD group, Sensory Profile scores were correlated to behavioural symptoms assessed using the Child Behaviour Check List (CBCL) and the Behavioural Teacher Rating Scale (EACI-P). The statistical analyses were conducted using the Mann Whitney test and Pearson correlation coefficients. **Results**: Children with ADHD showed significant impairments compared to the control group in sensory processing and modulation, as well as in behavioural and emotional responses as observed in 11 out of 14 sections and 6 out of 9 factors. Differences in all Sensory Profile response patterns were also observed between the two groups of children. Sensory Profile scores showed a moderately negative correlation with CBCL and EACI-P scores in the ADHD group. **Conclusion**: These results indicate that children with ADHD may present sensory processing impairments, which may contribute to the inappropriate behavioural and learning responses displayed by children with ADHD. It also suggests the importance of understanding the sensory processing difficulties and its possible contribution to the ADHD symptomatology.

Keywords: ADHD; sensory processing; sensory profile; learning; behaviour, rehabilitation.

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Introduction

Attention Deficit/Hyperactivity Disorder (ADHD) is a common developmental disorder in childhood with an estimated prevalence of up to 6.4% in school age children[1]. The population affected is rather heterogeneous and shows considerable variation in the degree of symptoms, as well as the frequent presence of associated comorbidities[2]. The DSM-IV-TR[3] (APA, 2002) has divided ADHD into three subtypes: Predominantly Inattentive subtype (ADHD-I), Predominantly Hyperactive-Impulsive (ADHD-H/I) and Combined Subtype (ADHD-C). In addition to the impairment caused by the core symptoms, researchers and clinicians have suggested that ADHD may also affect children's sensory processing, particularly sensory modulation[4].

Sensory Processing (SP) is a widely used terminology in the literature to designate a neurological process, and is defined as the ability of the central nervous system to assimilate, process and organize appropriate responses to information. Sensory modulation is the ability to regulate the degree, intensity and nature of a response to a sensory input[5].

Individuals with sensory modulation difficulties may show behaviour patterns related to decreased or *under responsivity* - poor reactions to relevant stimuli in the environment in the form of passivity, apathy, or lethargy (e.g. they have difficulty knowing where their body is in space, and initiating movements); *sensory seeking* - a constant search for intense stimuli (e.g. they engage in activities that provide more intense sensations for their bodies, they are constantly on the move); and increased or *over responsivity* or exaggerated, aversive or intolerant responses to stimuli (e.g. they are distracted by any stimuli, experience non-harmful stimuli as unpleasant and irritating and thus may exhibit negative, impulsive or aggressive responses)[5,6].

These conditions may adversely affect the efficiency of the person's ability to adapt to daily situations, to interact with the environment, to participate in social skills and school activities[6-8], and to demonstrate difficulties with attention, emotions[4,9,10] and learning[11].

According to Dunn and Bennett[10], children with ADHD may not receive and process sensory

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information properly and consequently, have difficulty producing appropriate adaptive responses at school, at home, and in social settings. This condition may affect motor and functional performance, as well as behavioural aspects of children's lives, including their ability to learn, to organize and to maintain appropriate activity levels[12]. Sensory modulation difficulties among ADHD children have been analyzed in some studies using both behavioural and neurophysiology measures.

Mangeot et al.[9] reported significantly higher sensory responsivity among ADHD school children than controls, as measured by electrodermal reactivity. Parush et al.[13] found differences in central processing of somatosensory input among ADHD children with tactile over responsivity, measured by EEG recordings, compared with ADHD children without tactile over responsivity.

From the behavioural point of view, Dunn and Bennett[10] analyzed the ability of the parent-report questionnaire (Sensory Profile-SP)[14] to identify and assess children with ADHD. It was reported that they showed significant differences compared to control children on all 14 sections of the Sensory Profile, including their processing of auditory, touch, multisensory, emotional/social responses and behaviour outcomes.

These results were also reported by Yochman et al.[4] in an Israeli preschooler study. Using the same questionnaire, the authors reported that children with ADHD showed higher sensory responsivity than controls. Cheung and Siu[15] also reported that Chinese ADHD children showed significantly more sensory processing impairments than children without ADHD disorders. Dove and Dunn[8] also used the Sensory Profile and reported impaired sensory responsivity and lower scores on Low Registration, Sensation Seeking and Sensation Avoiding patterns in children with learning disorders (both with and without ADHD). Studies using the Short Sensory Profile (SSP)[16] found that ADHD children's sensory processing was more impaired than that of the controls[6,9,16].

Given the multidimensional nature of ADHD, current research has largely focused on cognitive and behavioural abilities related to attentive and executive functions**,** not paying much attention to the role of the sensorimotor dimension. Although few studies in the literature have indicated the presence of SP difficulties in ADHD children, most researchers have worked with a general profile, and few have explored further characterizations of all components of Sensory Processing. More research is needed to explore and characterize SP impairment patterns in ADHD children, and to verify the impact and possible relation between SP difficulties and symptoms presented in their daily-living activities.

From a behavioural point of view, ADHD-C has been reported to compromise adaptive function with higher incidence of interpersonal relationship issues and externalizing behaviour, such as aggressiveness, impulsiveness or oppositional and conduct disorders. In relation to internalizing behaviour, such as anxiety, somatic and other problems, the differences between subtypes tend to decrease[17]. Furthermore, recent research recognizes the importance of self-regulatory mechanisms in determining ADHD symptoms. In addition, the inability to manage and control behaviour, due to inhibitory control difficulties and impaired self-regulation, stimulates the emergence of important emotional symptoms such as low tolerance of disappointment, impatience, anger, anxiety and intense emotional reactions[18].

Chu and Reynolds[19] discussed the importance of a multidimensional approach when evaluating and treating ADHD. In this context, since SP impairments are related at the neurological level, affecting sensory-motor, psychological, and behavioural aspects, it could be better studied and identified in children with ADHD. Thus, the present study assessed and compared the sensory responses of children with ADHD and children without this disability. This study also analyzed the possible relationship between SP impairments and behavioural symptoms of children with ADHD.

Method

Participants

The sample consisted of 74 children, aged 6-11 (M=8.9, SD=1.49) years, whose parents were the informants. Thirty-seven children with ADHD (30 boys, 7 girls; 24 attending public schools, 13 attending private schools) were recruited from an outpatient clinic, associated with the Universidade Federal de São Paulo (UNIFESP), São Paulo, SP, Brazil, that specialized in the diagnostic of children and adolescents. The children were referred to a multidisciplinary clinical assessment schedule that consisted of psychiatric, neurological and neuropsychological evaluation.

The neuropsychological assessment included the following: the children's intellectual level was tested using the abbreviated (estimated IQ) Wechsler Intelligence Scale for Children (WISC-III)[20], the attention test using the Conners' Continuous

Performance Test (CCPT)[21], the Automated Working Memory Assessment (AWMA)[22] test, and the BRIEF (Behaviour Rating Inventory of Executive Functions)[23] test. The psychiatric interview included criteria based on the DSM-IV-TR[3], the Child Behaviour Checklist (CBCL)[24] and the Brazilian version of the Conners Rating Scale - EACIP-P[25].

The sample was recruited immediately after the diagnosic assessment, prior to the beginning of the medications. Children with pervasive developmental disorders, psychiatric disorders (e.g. bipolar disorders, depressive disorder), neurological disorders (e.g. traumatic and non-traumatic brain injury, such as epilepsy), intellectual disability (IQ<70) and those who were prescribed drugs for ADHD, were excluded.

A DSM-IV-TR-based questionnaire answered by the parents/caregivers found that 21.6% (n=8) of the sample met the criteria for the inattentive subtype (ADHD-I); 19.9% (n=7) for the hyperactive/impulsive subtype (ADHD-H/I); and 59.5% (n=22) for the combined subtype (ADHD-C). The results of the CBCL showed that 13.5% (n=5) presented no comorbidity indicators and 86.4% (n=32) had one or more ADHD-associated comorbidity indicators. Of the 32 children, 40.6% (n=13) met criteria for Affective Disorder indicators; 40.6% (n=13) for Anxiety Disorder indicators; 15.6% (n=5) for Somatic Disorder indicators; 65.6% (n=21) for Opposition Defiant Disorder indicators, and 68.7% (n=22) for Conduct Disorder indicators.

The control group consisted of 37 children paired with the ADHD group by age, gender and type of school (30 boys, 7 girls; 24 at public schools, 13 at private schools). The control group was a convenient sample recruited by the parents/caregivers of the ADHD group by asking classmates and neighbours to participate. We excluded children with hyperactivity and/or inattention indicators, based on the abbreviated Conners Rating Scale (CATRS-10)[25], and other developmental problems (e.g. convulsions, diseases) based on a health questionnaire answered by their parents.

Sensory processing abilities were assessed using a version of the Sensory Profile[14] that was translated and adapted for Brazilians[26]. This parent-caregiver report is a measure of the children's responses to daily sensory events and detects behavioural responses that indicate over-responsivity (i.e. low neurological threshold) or under-responsivity (i.e. high neurological threshold).

The questionnaire contained 125 items divided into 14 sections, 9 factors and 4 response patterns. The 14 sections were divided into three categories: 1) Sensory Processing, 2) Modulation and 3) Behavioural and Emotional Responses. The 9 factors - Sensory Seeking, Emotionally Reactive, Low Endurance, Oral Sensory Sensitivity, Inattention/Distractibility, Poor Registration, Sensory Sensitivity, Sedentary, Fine Motor/Perceptual – were based on combined scores from specific items from different sections. The 4 response patterns - Low Registration, Sensation Seeking, Sensory Sensitivity, Sensation Avoiding – were combined scores from specific factors and sections.

The questionnaire used a 5-point Likert scale, corresponding to the frequency of each behaviour (1=Always to 5=Never), where a lower score indicated a higher frequency of undesirable behavioural responses to the sensory events.

Behavioural symptoms of the ADHD children were examined using the Child Behaviour Checklist (CBCL)[24] and the EACIP-P[25], a teacher-report questionnaire covering five main areas of behaviour: Hyperactivity/Conduct Problems (EACP-I), Independent Functioning (EACIP-II), Inattention (EACIP-III), Neuroticism/Anxiety (EACIP-IV) and Social Interaction (EACIP-V).

Procedures

All procedures in this study were approved by the ethics committee of UNIFESP (CEP 1555/09). Informed consent forms were obtained from the children and their parents/caregivers.

The Sensory Profile questionnaire was administered to both groups in a single interview after receiving the written consent of the parents or caregivers. Data for the ADHD group of children were collected at an outpatient unit associated with the UNIFESP, while the control group data were obtained at their homes or schools.

Data analysis

Since normal distribution was not confirmed for most variables, the non-parametric Mann Whitney test was used to compare the ADHD and control groups' scores, and the Kruskall-Wallis test was used to compare the ADHD-I, ADHD-HI and ADHD-C subtype scores. The magnitude effect (*Cohen d*) was also calculated to determine the strength of the observed differences between variables.

The relationship between SP impairments and behavioural symptoms of children with ADHD was analyzed using Pearson's correlation coefficient. Specifically, the correlation between the Sensory Profile and the CBCL scores, and between the

Sensory Profile and the EACI-P scores were analysed with a significance level of $p<0.05$.

Results

ADHD children scored significantly lower on most of the Sensory Profile sections, factors and response patterns, suggesting that they may have different patterns of sensory processing and modulation. The greatest amount of difficulty was found to be the adaptive responses to sensory events when compared to typically-developing children.

Significant differences, with moderate to large magnitude effect ($p \leq 0.001$, d=0.74 to 2.08), were found between the ADHD and control groups on 11 of the 14 Sensory Profile sections (Table 1).

Significant differences, with moderate to large magnitude effect ($p \leq 0.05$, d=0.58 to 2.46), were also observed on 7 of 9 the factors (Table 2). The analysis of response patterns also indicated lower ADHD-group scores for all four response patterns - Low Registration, Sensation Seeking, Sensory Sensitivity and Sensation Avoiding.

No significant differences were found between ADHD subtypes on the Sensory Profile sections, factors or response patterns, except for the multisensory section ($p=0.008$, d=1.22), in which ADHD-C (M=18.45, SD=4.25) scored lower than ADHD-I (M=22.88, SD=2.59) and ADHD- HI (M=23.14, SD=3.48).

Pearson's correlation analysis detected a moderately negative correlation ($p<0.05$, r=-0.34 to -0.49) between the ADHD group's CBCL and Sensory Profile scores. For instance, higher indicators of comorbidity disorders were associated with poorer responses on some sensory processing aspects (Table 3). This correlation was verified with: a) Affective Disorder and auditory processing; visual processing; emotional/social responses; items indicating thresholds for response; Emotionally Reactive; and Low Registration; b) Anxiety Disorder and touch processing; emotional/social responses; and Sensory Sensitivity; c) Attention Disorder and vestibular processing; emotional/social responses; d) Oppositional Defiant Disorder and emotional/social responses; and Emotionally Reactive; e) Conduct Disorder and auditory processing; multisensory processing; emotional/social responses; and Inattention/ Distractibility.

A moderate significant negative correlation ($p<0.05$, r=-0.34 to -0.61) was also found between the EACI-P and Sensory Profile scores, suggesting

Table 1. Comparison of Sensory Profile section scores among ADHD children and control children.

	Control		ADHD		U	p-value	Cohen d
	M	SD	M	SD			
Sections							
Sensory Processing							
A. Auditory Processing	31.70	6.11	21.59	5.66	177.00	0.000	1.71
B. Visual Processing	39.78	4.08	33.14	7.59	304.00	0.000	1.08
C. Vestibular Processing	45.95	4.98	37.27	3.85	124.00	0.000	1.95
D. Touch Processing	78.16	7.11	67.43	11.55	302.50	0.000	1.11
E. Multisensory Processing	31.54	8.73	20.30	4.36	49.00	0.000	1.62
F. Oral Processing	47.86	7.95	43.05	10.10	511.50	0.061	0.52
Sensory Modulation							
G. Sensory Processing related to endurance/tone	43.24	2.78	39.08	5.30	329.00	0.000	0.98
H. Modulation related to body position and movement	40.70	5.01	34.46	5.48	270.00	0.000	1.18
I. Modulation of movement affecting activity level	21.70	3.23	19.41	4.51	507.00	0.054	0.58
J. Modulation of sensory input affecting emotion responses	15.16	3.57	12.84	2.58	388.50	0.001	0.74
K. Modulation of visual input affecting emotion/activity level	10.32	2.29	9.54	2.36	550.50	0.135	0.33
Behavioural and Emotional Responses							
L. Emotional/ Social Responses	68.11	6.98	51.95	8.43	86.50	0.000	2.08
M. Behaviour outcomes Sensory Processing	24.35	3.89	17.35	4.95	197.00	0.000	1.06
N. Items indicating Thresholds for Response	13.57	1.61	10.84	1.80	189.00	0.000	1.59

Table 2. Comparison of Sensory Profile factor and pattern scores among ADHD children and control children

	Control		ADHD				
	M	**DP**	**M**	**DP**	**U**	**p-value**	**Cohen d**
Factors							
1. Sensory Seeking	55.24	11.82	36.92	9.78	171.00	0.000	1.68
2. Emotionally Reactive	62.24	7.63	43.11	9.61	68.50	0.000	2.2
3. Low Endurance	43.24	2.78	39.08	5.30	329.00	0.000	0.98
4. Oral Sensory Sensitivity	35.51	6.95	34.11	8.20	624.00	0.512	0.18
5. Inattention/ Distractibility	27.24	5.61	14.68	4.52	76.00	0.000	2.46
6. Poor Registration	33.49	2.99	31.59	3.47	460.00	0.014	0.58
7. Sensory Sensitivity	18.16	2.70	17.49	3.00	603.00	0.355	0.23
8. Sedentary	12.30	3.46	14.14	5.60	500.00	0.045	0.38
9. Fine Motor/Perceptual	13.95	1.75	9.95	3.32	220.50	0.000	1.5
Patterns							
Low Registration	119.97	6.78	109.76	11.61	294.00	0.000	1.07
Sensation Seeking	95.95	15.81	71.35	14.56	184.50	0.000	1.61
Sensory Sensitivity	160.49	19.89	130.92	21.68	213.00	0.000	1.42
Sensation Avoiding	98.81	9.83	74.59	13.87	98.00	0.000	2.01

that increased signs of behavioural impairment at school were associated with worse responses on some aspects of the SP (Table 4). This correlation was found between: a) EACI-P I (hyperactivity/ conduct problems) and touch processing; and Sensation Avoiding; b) EACI-P II (independent functioning) and behaviour outcomes sensory processing; Fine Motor/Perceptual; c) EACI-P III (inattention) and auditory processing; behaviour outcomes sensory processing; items indicating Thresholds for Response; Inattention/Distractibility, Fine Motor/Perceptual; and Sensation Avoiding; d) EACI-P IV (neuroticism/anxiety) and Thresholds for Response items; e) EACI-P V (socialization problems) and modulation of movement affecting activity level; emotional/social responses; items indicating Threshold for Response; Emotionally Reactive; Sedentary; and Sensation Avoiding items.

Discussion

Sensory Profile abilities of ADHD children were assessed according to their response to daily sensory events. In addition, the possible relationship between sensory processing impairments and behavioural symptoms presented by ADHD children was also analyzed.

Our results indicated significant differences on 11 of the Sensory Profile's 14 sections, on which ADHD children scored lower. These results are consistent with those reported by authors who have used the same instrument. Dunn and Bennett[10] found significant differences in all 14 sections, suggesting that ADHD children had more sensory processing impairments than their control group. However, they only analyzed Sensory Profile sections and many of their ADHD children were under medication. Yochman et al.[4] also found differences in 11 sections and worse ADHD group responses, except for vestibular processing, tone/endurance, and emotional response.

Others authors have also reported similar findings to our own, such as significant differences between ADHD and control groups for auditory, visual, touch and oral processing, indicating that ADHD children may have sensory processing difficulties related to these systems[4,9,13]. In our study, however, there was only a significant difference between groups for the oral processing system.

In regard to Sensory Profile factors, we found significant differences between ADHD and the control group scores in 7 out of 9 factors, the exceptions being oral sensitivity and sensory sensitivity. Yochman et al.[4] also found significant differences in 6 out of 9 factors with ADHD children

Table 3. Correlations between Sensory Profile scores and CBCL scores among children with ADHD.

	Affective		Anxiety		Somatic		Attention		Oppositional Defiant			
	Pearson	p-value	Pearson	p- value	Pearson	p- value	Pearson	p-value	Pearson	p- value	Pearson	p-value
Sections												
Sensory Processing												
A. Auditory Processing	–0.35	0.031	–0.21	0.213	–0.10	0.569	–0.32	0.057	–0.29	0.084	–0.40	0.014
B. Visual Processing	–0.36	0.029	–0.32	0.051	–0.02	0.887	–0.04	0.825	–0.02	0.928	–0.04	0.803
C. Vestibular Processing	–0.24	0.159	–0.12	0.497	–0.08	0.646	–0.44	0.007	–0.31	0.066	–0.24	0.158
D. Touch Processing	–0.32	0.051	–0.33	0.049	–0.02	0.888	–0.08	0.644	–0.20	0.247	–0.30	0.068
E. Multisensory Processing	–0.16	0.333	–0.19	0.250	–0.17	0.308	–0.24	0.158	–0.31	0.064	–0.36	0.028
F. Oral Processing	0.00	0.990	–0.17	0.328	0.07	0.690	–0.13	0.444	–0.13	0.452	–0.06	0.726
Sensory Modulation												
G. Endurance/Tone	–0.27	0.105	–0.10	0.565	–0.20	0.244	–0.25	0.133	–0.10	0.559	–0.17	0.319
H. Position and Movement Modulation	–0.31	0.060	–0.10	0.545	–0.02	0.909	–0.31	0.058	–0.07	0.668	–0.28	0.099
I. Movement affecting Activity Level	0.06	0.721	–0.02	0.926	–0.07	0.699	0.08	0.640	0.12	0.481	–0.07	0.699
J. Sensory affecting Emotion Responses	0.03	0.861	–0.04	0.820	0.21	0.212	0.22	0.184	0.12	0.480	0.15	0.381
K. Visual affecting Emotion/ Activity Level	0.11	0.505	0.13	0.431	–0.05	0.774	0.11	0.529	0.01	0.951	–0.12	0.476
Behavioural and Emotional Responses												
L. Emotional/ Social Responses	–0.49	0.002	–0.38	0.019	–0.09	0.596	–0.33	0.044	–0.44	0.007	–0.36	0.029
M. Behaviour outcomes Sensory Processing	–0.04	0.821	0.01	0.964	0.09	0.586	–0.13	0.433	–0.08	0.628	–0.24	0.148
N. Thresholds for Response	–0.33	0.046	–0.07	0.695	–0.03	0.859	–0.09	0.608	0.16	0.330	–0.14	0.394
Factors												
1. Sensory Seeking	–0.06	0.706	0.09	0.594	–0.03	0.876	–0.15	0.389	–0.05	0.747	–0.30	0.069
2. Emotionally Reactive	–0.41	0.012	–0.28	0.088	–0.14	0.399	–0.29	0.079	–0.35	0.032	–0.24	0.153
3. Low Endurance	–0.27	0.105	–0.10	0.565	–0.20	0.244	–0.25	0.133	–0.10	0.559	–0.17	0.319
4. Oral Sensory Sensitivity	–0.01	0.945	–0.26	0.128	0.12	0.468	–0.12	0.486	–0.12	0.483	–0.02	0.902
5. Inattention/ Distractibility	–0.29	0.083	–0.18	0.299	0.07	0.696	–0.25	0.135	–0.17	0.315	–0.34	0.042
6. Poor Registration	–0.29	0.077	–0.05	0.778	–0.06	0.741	0.02	0.886	0.12	0.482	–0.05	0.781
7. Sensory Sensitivity	–0.20	0.243	–0.37	0.026	0.07	0.702	–0.31	0.065	–0.19	0.269	0.05	0.765
8. Sedentary	0.08	0.645	–0.01	0.966	–0.14	0.425	0.10	0.545	0.21	0.212	0.05	0.753
9. Fine Motor/Perceptual	–0.21	0.208	–0.04	0.812	0.11	0.529	–0.02	0.895	–0.03	0.837	–0.26	0.127
Patterns												
Low Registration	–0.34	0.043	–0.10	0.542	–0.20	0.245	–0.22	0.186	–0.06	0.746	–0.17	0.320
Sensation Seeking	–0.16	0.336	0.02	0.909	–0.02	0.890	–0.22	0.195	–0.07	0.695	–0.31	0.064
Sensory Sensitivity	–0.19	0.272	–0.32	0.057	0.08	0.656	–0.28	0.091	–0.24	0.151	–0.20	0.228
Sensation Avoiding	–0.27	0.112	–0.20	0.241	–0.12	0.477	–0.21	0.215	–0.19	0.260	–0.23	0.168

Table 4. Correlation between ADHD children's Sensory Profile and EACI-P scores.

	EACIP-I		EACIP-II		EACI-PIII		EACIP-IV		EACIP-V	
	Pearson	**p-value**	**Pearson**	**p-value**	**Pearson**	**p-value**	**Pearson**	**p-value**	**Pearson**	**p- value**
Sections										
Sensory Processing										
A. Auditory Processing	–0.17	0.320	0.19	0.271	–0.38	0.023	–0.20	0.260	–0.33	0.052
B. Visual Processing	–0.17	0.330	0.25	0.150	–0.21	0.237	–0.11	0.532	–0.23	0.186
C. Vestibular Processing	0.03	0.887	0.00	0.984	0.00	0.999	0.33	0.049	0.01	0.966
D. Touch Processing	–0.34	0.046	0.29	0.093	–0.27	0.113	–0.07	0.691	–0.26	0.136
E. Multisensory Processing	–0.31	0.068	0.23	0.179	–0.10	0.550	0.05	0.785	–0.13	0.445
F. Oral Processing	0.01	0.942	–0.05	0.788	0.19	0.269	0.08	0.649	–0.08	0.644
Sensory Modulation										
G. Endurance/Tone	–0.07	0.673	0.16	0.370	–0.09	0.623	–0.19	0.275	–0.27	0.119
H. Position and Movement Modulation	–0.29	0.088	0.19	0.285	–0.30	0.078	0.04	0.828	–0.18	0.312
I. Movement affecting Activity Level	–0.22	0.204	–0.12	0.480	–0.23	0.185	–0.04	0.819	–0.46	0.006
J. Sensory affecting Emotion Responses	0.08	0.653	0.00	0.989	0.24	0.171	–0.06	0.724	0.07	0.685
K. Visual affecting Emotion/ Activity Level	0.23	0.178	–0.04	0.822	0.23	0.183	0.22	0.210	0.13	0.443
Behavioural and Emotional Responses										
L. Emotional/ Social Responses	–0.22	0.208	0.02	0.910	–0.23	0.183	–0.22	0.214	–0.34	0.047
M. Behaviour outcomes Sensory Processing	–0.23	0.188	0.47	0.004	–0.51	0.002	–0.07	0.704	–0.26	0.137
N. Thresholds for Response	–0.22	0.195	0.31	0.067	–0.38	0.025	–0.40	0.017	–0.34	0.045
Factors										
1. Sensory Seeking	–0.29	0.092	0.21	0.218	–0.27	0.115	0.11	0.543	–0.12	0.491
2. Emotionally Reactive	–0.26	0.136	0.04	0.808	–0.27	0.117	–0.25	0.148	–0.46	0.006
3. Low Endurance	–0.07	0.673	0.16	0.370	–0.09	0.623	–0.19	0.275	–0.27	0.119
4. Oral Sensory Sensitivity	0.04	0.831	–0.08	0.645	0.23	0.182	0.04	0.799	–0.04	0.832
5. Inattention/ Distractibility	–0.14	0.410	0.17	0.330	–0.39	0.022	–0.06	0.743	–0.23	0.189
6. Poor Registration	–0.01	0.934	0.01	0.975	–0.02	0.927	–0.11	0.538	–0.11	0.545
7. Sensory Sensitivity	0.02	0.925	0.00	0.999	0.06	0.745	0.21	0.233	0.03	0.875
8. Sedentary	–0.20	0.261	–0.16	0.369	–0.22	0.204	–0.10	0.581	–0.50	0.002
9. Fine Motor/Perceptual	–0.09	0.620	0.56	0.000	–0.42	0.011	–0.14	0.422	–0.10	0.555
Patterns										
Low Registration	–0.07	0.689	0.14	0.422	–0.08	0.642	–0.20	0.244	–0.27	0.115
Sensation Seeking	–0.31	0.073	0.22	0.213	–0.30	0.082	0.09	0.611	–0.15	0.401
Sensory Sensitivity	–0.05	0.760	0.03	0.849	0.00	0.985	0.02	0.910	–0.18	0.290
Sensation Avoiding	–0.34	0.047	0.12	0.484	–0.45	0.007	–0.24	0.168	–0.61	0.000

scoring lower except for Low Endurance, Poor Registration and Sensory Sensitivity. However, their sample consisted only of preschoolers aged 4-6. Several functions are still being developed at this age and some symptoms may yet change as the brain develops.

Our study also found that ADHD children experienced major difficulties showing significance in all four Sensory Profile response patterns: Sensation Avoiding, Sensory Seeking, Sensory Sensitivity and Poor Registration. This dimension was previously analyzed only by Dove and Dunn[8], who compared typically developing and specific learning disability children (the latter, with and without ADHD) and found that the clinical group obtained low Sensory Profile scores for Sensory Seeking, Sensation Avoiding and Poor Registration. However, there was no specific comparison between the ADHD children and controls.

Cheung and Siu[15] specifically analyzed scores on each Sensory Profile item and found that the ADHD group scored lower than the controls. However, since they did not analyze the scores obtained for sections, factors and response patterns, these dimensions could not be compared with our results.

This study found that ADHD children had significant Sensory Processing impairments on dimensions such as emotional/social responses (section L) or Emotional Reactivity (factor 2), containing items related to self-esteem, frustration tolerance, irritability, anxiety and other emotional aspects. Some authors suggest that these behaviours may be associated with ADHD children's executive function deficits, impeding adequate performance of daily tasks and social skills[27]; but may also be the result of inadequate sensory modulation of sensory system inputs[14].

Sensory processing impairments were also observed on dimensions such as vestibular processing (section D), modulation of body position and movement (section G) and Sensory Seeking (factor 1), particularly for items concerning under-responsivity to vestibular and proprioceptive systems, showing excessive body movement and continuous stimulus seeking. These results pose the question of whether ADHD symptoms, such as constantly seeking body movement and stimuli, as described by the DSM-IV[23] and explained by inhibitory control deficits, may not also be influenced by the children seeking vestibular and proprioceptive sensory stimuli as a behavioural response to these children's high thresholds for these systems.

Our results also showed impairment on auditory-processing items (section A), which reflect overly responsive behaviours but also under-responsivity. It is important to consider that some of the issues regarding Sensory Profile auditory processing are already described in DSM-IV (e.g. distracted or has trouble functioning if there is a lot of noise around). However, assessment of auditory processing can help in understanding the basis of the behaviour of distractibility. Furthermore, our results suggest that a low threshold for sensory stimuli could contribute to distractibility in relation to an auditory stimulus in some ADHD children, whereas a high threshold could contribute to inattentive behaviour in others.

Therefore, from the Sensory modulation perspective, inattention could be present in individuals with under-responsivity (i.e. high threshold) who require more intense stimuli. Distractibility could be present both in under-responsive individuals who tend to seek stimuli in order to be organized, and in over-responsive (i.e. low threshold) individuals, who respond to all stimuli, with both types presenting higher activity levels.

Significant impairments were also observed in all four-response patterns. According to Dove and Dunn[8], each response pattern may have different repercussions for learning. In the presence of Sensory Seeking, the individual may seek movements and constant stimuli to obtain more sensory input (e.g. does not sit still, moves a lot on the seat). In the presence of Sensation Avoiding, the individual displays the need to avoid and aversion to sensory experiences (e.g. is disturbed by noise in the class whenever others bump into his/her desk). Whenever there is Poor Registration, the individual tends to respond slowly to the stimuli (e.g. does not retain information given by teachers, does not apprehend details in order to complete the required tasks). Lastly, in the presence of Stimuli Sensitivity, the individual easily responds to any stimuli (e.g. does not concentrate on the proposed task, does not finish what he/she has started, being distracted by other stimuli).

CBCL and EACI-P scores showed moderate negative correlation with Sensory Profile scores, suggesting that the increased presence of behavioural-symptom indicators were associated with worse responses for some aspects of the Sensory Processing. This correlation was found between: Auditory processing and Affective Disorder, Conduct Disorder (CBCL), and inattention (EACI-P); Vestibular processing and Attention Disorder (CBCL); Multisensory processing and Conduct Disorder (CBCL); Fine Motor/Perceptual and independent functioning and inattention (EACI-P);

touch processing and Sensory Sensitivity, and Anxiety Disorder (CBCL) and hyperactivity/conduct problems (EACI-P); Sensation Avoiding and hyperactivity/conduct problems, inattention, socialization problems (EACI-P); Thresholds for Response and neuroticism/anxiety and socialization problems (EACI-P); and, Modulation of movement affecting activity level and socialization problems (EACI-P).

Mangeot et al.[9] also found a higher correlation between the Short Sensory Profile's Tactile Sensitivity and the CBCL's Aggressive Behaviour and Somatic Complaints items. The relationship between sensory over-responsivity and anxiety was also analyzed by Reynolds and Lane[28], who found that ADHD children with over-responsivity were more susceptible to show anxiety than children without over-responsivity or control children.

According to Roberts et al.[29], different abilities and expression of behaviours relate to the individual's self-regulation, which refers to one's ability to regulate responses to specific stimuli, involving physiological, emotional and behavioural factors, and their interdependencies. Therefore, the ability to process sensory information is one of the factors that may influence individual differences in terms of self-regulation.

From the Sensory Modulation perspective, there is an interaction between the external dimension corresponding to culture, environment, relationships and tasks, and the internal dimension, which includes sensation, emotion and attention[30]. Thus, behaviour is generated based on an adequate interaction of such dimensions, so the presence of sensory modulation difficulties could cause emotional states including depression, anxiety, fear, aggressiveness and emotional lability[14,30], in addition to attentional states such as distractibility, impulsiveness and hyperactivity[9,30].

Our findings did not indicate significant differences between ADHD subtypes on Sensory Profile scores, except for multisensory processing (section E). Engel-Yeger and Ziv-On[6] compared Sensory Processing between ADHD subtypes using the abbreviated version - Short Sensory Profile[16] - and also found no significant differences between groups. As in the case of our own study, differences might not have been found due to the small number of subjects in each ADHD subtype group, as well as the concomitance of several comorbidities associated with ADHD, thus impeding a more specific analysis of Sensory Processing in ADHD subjects.

Conclusion and limitations

Previous studies[4,6,9,10,15] have suggested that ADHD children's Sensory Processing and Modulation patterns are significantly different to those of typically developing children. Our results reproduce previous findings while extending comprehension of this pattern in ADHD, since i) our sample members were not on medications, so our Sensory Processing analysis was free of the effects of medication; ii) the sample age range was broader; iii) SP scale sections, factors and response patterns were analyzed, and iv) impairment of SP abilities in ADHD was discussed.

Furthermore, the present study's findings suggest that ADHD children may have sensory modulation impairments which may contribute to behaviour and learning inappropriate responses displayed by children with ADHD, suggesting the importance of considering and studying SP difficulties and the possible contribution to the symptomatology of ADHD. In clinical practice, this discussion is relevant because it suggests the possibility of considering and including sensory strategies and resources when treating the symptoms of children with ADHD.

Our results should be interpreted in light of certain limitations, since the small number of ADHD subtype subjects prevented effective comparison of their sensory-processing abilities. Future research requires a larger sample to investigate sensory modulation differences between ADHD subtypes. Another limitation was the extent of comorbidities in ADHD children hindering more specific SP analysis. It also might be of interest to analyze the degree to which the sensory processing symptoms improve when affected by medication.

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Content validation of a clinical assessment instrument for stair ascent and descent in individuals with hemiparesis

Validação de conteúdo do instrumento de avaliação clínica da subida e descida de escadas em indivíduos com hemiparesia

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ABSTRACT | Background: Among the current instruments used to assess stair ambulation, none were observed that specifically evaluated the quality of movement or biomechanical strategies adopted by stroke patients. **Objective:** To evaluate the content validity of a clinical instrument designed to identify the qualitative and kinematic characteristics and strategies adopted by stroke patients during stair ascent and descent. **Method:** The first developed version, which comprised 80 items, had its content evaluated by an expert panel, which was composed of 9 well-known national and international professionals who are involved in stroke rehabilitation. The content validity index (CVI) and modified Kappa coefficients were employed for the statistical analyses. The items that demonstrated a CVI ≥ 0.80 and Kappa ≥ 0.75 were considered valid. **Results:** The content validation was performed in three stages. The final version of the instrument consisted of 38 items, which were divided into descriptive (8 items), a General Characteristics Domain (16 items) and adopted strategies (14 items) during stair ascent and descent. The total scores ranged from zero to 70 and zero to 74 for ascent and descent, respectively. Lower scores corresponded with better performance. **Conclusion:** Despite the satisfactory results obtained during the process of content validation, other psychometric properties of the instrument are necessary and must be evaluated.

Keywords: physical therapy; stroke; evaluation; biomechanics.

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RESUMO | Contextualização: Dentre os instrumentos existentes que avaliam a subida e descida de escadas, não foi encontrado nenhum específico sobre a qualidade de movimento e as estratégias biomecânicas adotadas por indivíduos com hemiparesia devido ao Acidente Vascular Encefálico (AVE). **Objetivo:** Avaliar a validade de conteúdo do instrumento de avaliação das características cinemáticas qualitativas e das estratégias adotadas na subida e descida de escadas por indivíduos com hemiparesia devido ao AVE. **Metódo:** A primeira versão do instrumento foi desenvolvida com um total de 80 itens e foi submetida a um comitê constituído por oito especialistas nacionais e internacionais para validação de conteúdo. A análise estatística foi realizada por meio do Índice de Validade de Conteúdo (IVC) e do Coeficiente Kappa Modificado, sendo considerados válidos os itens que apresentaram IVC ≥ 0,80 e Kappa ≥ 0,75. **Resultados:** Foram realizadas três etapas de validação de conteúdo, e a versão final do instrumento apresenta 38 itens divididos em Itens Descritivos (oito itens), Domínio de Características Gerais da Subida e Descida de Escadas (16 itens) e Domínio de Estratégias Adotadas para Subida e Descida de Escadas (14 itens). O escore total para a subida de escada pode variar entre 0 e 70 pontos e, para a descida, entre 0 e 74 pontos. A pontuação mínima corresponde ao melhor desempenho, e a máxima, ao pior desempenho no teste. **Conclusão:** Apesar dos resultados satisfatórios obtidos no processo de validação de conteúdo, as demais propriedades psicométricas devem e serão mensuradas futuramente.

Palavras-chave: fisioterapia; acidente vascular encefálico; avaliação; biomecânica.

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Introdução

A habilidade de subir e descer escadas é considerada como um indicador chave da independência funcional[1-7]. Os indivíduos com hemiparesia devido ao Acidente Vascular Encefálico (AVE) relatam dificuldade em desempenhar essa atividade mesmo após um ano do episódio[8-11]. E apesar das características cinemáticas da marcha de indivíduos com hemiparesia ser bastante descrita na literatura[12-15], não foi encontrado um instrumento completo e abrangente de avaliação da subida/descida de escadas para essa população.

A avaliação da atividade de subir/descer escadas na população com hemiparesia é abordada de forma isolada em diversos instrumentos que mensuram, separadamente, itens como o tempo total para subir/descer[3,16], a cadência[7], o uso do corrimão[17-19], o tipo de passo[17-19], a necessidade ou não de auxílio externo[4,17-22], a dificuldade[4,23,24], o uso de dispositivo auxiliar[4], entre outros. Contudo, essas características não eram avaliadas conjuntamente por nenhum outro instrumento ainda. Embora existam instrumentos que avaliem as características cinemáticas qualitativas da marcha[25] e de testes como o TUG (Timed Up and Go)[26,27], nenhum instrumento disponível avalia as estratégias utilizadas para subida/descida de escadas. Assim, por meio do instrumento desenvolvido[28], será possível identificar, além dos itens descritivos (como cadência, necessidade de auxílio) e características gerais (como uso de dispositivo auxiliar, corrimão), as estratégias adotadas por indivíduos com hemiparesia que conseguem subir/descer escadas com/sem auxílio externo (órteses e/ou ajuda de outra pessoa). A análise do desempenho da atividade será feita através de vídeo e trará subsídios mais consistentes para identificar os principais déficits nessa tarefa e guiar as melhores estratégias para a reabilitação motora do AVE.

A primeira versão do instrumento totalizou 80 itens descritos em três domínios: características gerais, desempenho funcional, estratégias adotadas na subida e na descida de escadas. Cada item foi desenvolvido a partir de uma extensa pesquisa bibliográfica, da opinião de especialistas da área e da análise cinemática qualitativa da subida/descida de escadas[28]. Entretanto, para serem passíveis de aplicação, todos os itens e o instrumento como um todo foram avaliados e validados por um comitê de especialistas[29,30].

A validação de conteúdo permite certificar se o instrumento mede o que propõe, verificando se os itens construídos refletem adequadamente o domínio de conteúdo de interesse, se as dimensões de escala estão de acordo com cada item proposto e se condizem com o índice de objetivos específicos traçados[29,31]. Os aspectos de validade de conteúdo incluem propriedade, clareza e abrangência de itens, que são classificados mediante a avaliação dos itens do instrumento por um grupo de especialistas com experiência anterior ou reconhecida competência atual nas áreas do estudo, denominados juízes ou peritos[29,32-34]. Apesar da grande importância, o processo de validação de conteúdo de instrumentos desenvolvidos originalmente é pouco descrito na literatura, sendo mais frequente o relato da tradução e da adaptação transcultural de instrumentos. Diante disso, o objetivo deste estudo foi validar o conteúdo do instrumento desenvolvido para avaliar as características cinemáticas qualitativas e as estratégias adotadas na subida e descida de escadas por indivíduos com hemiparesia.

Método

As etapas para o desenvolvimento e a validação de um instrumento englobam quatro fases distintas: planejamento, construção, análise quantitativa, validação[29]. As fases de planejamento e construção do instrumento, descritas no estudo de Natalio et al.[28], foram constituídas de uma extensa revisão bibliográfica, da opinião de especialistas e da análise cinemática qualitativa da subida/descida de escadas por indivíduos com hemiparesia devido ao AVE. Neste trabalho será descrita a validação de conteúdo. Este projeto foi aprovado segundo parecer número 42/2008 do Comitê de Ética em Pesquisa com Seres Humanos da Universidade do Estado de Santa Catarina (UDESC), Florianópolis, SC, Brasil.

Participantes

Seguindo o protocolo de Polit et al.[33], foram convidados a participar oito pesquisadores, brasileiros e canadenses, com reconhecido histórico científico na área de reabilitação motora de indivíduos com hemiparesia e com conhecimento da biomecânica da subida e descida de escadas. O tempo de experiência dos participantes variou entre 8 e 25 anos, sendo que, dos sete pesquisadores que aceitaram participar, dois eram mestres e cinco doutores na área de domínio do estudo. Os especialistas consideraram ter conhecimento muito bom ou excelente acerca da hemiparesia, da reabilitação motora e da biomecânica da subida e descida de escadas. Na primeira fase de validação de conteúdo sete especialistas responderam no prazo determinado, sendo quatro brasileiros e três canadenses. Na segunda e na terceira

fases participaram cinco especialistas, sendo dois brasileiros e três canadenses.

Procedimentos

Foram realizadas três fases de validação de conteúdo, nas quais a primeira versão e a versão modificada do instrumento foram submetidas à avaliação de validade de conteúdo por um comitê de sete especialistas com representatividade e reconhecimento na área de interesse desta pesquisa. Para tanto, foi elaborado, nas línguas portuguesa e inglesa, o questionário de validação de conteúdo, que avaliou a consistência, a representatividade, a relevância e a clareza de cada item desenvolvido[26,27,32-35].

Análise estatística

A validade de conteúdo do instrumento desenvolvido foi analisada estatisticamente pelo Índice de Validade de Conteúdo (IVC). Para o cálculo do IVC cada item foi classificado em uma escala de quatro pontos (1=não relevante, 2=pouco relevante, 3=bastante relevante, 4=altamente relevante). Para cada item, o IVC foi calculado como o número de especialistas que forneceram a classificação de 3 ou 4 dividido pelo número total de especialistas. O Coeficiente Kappa Modificado foi utilizado para verificar o grau de concordância de relevância do IVC e foi calculado a partir das instruções de Polit et al.[33].

Considerando que, na primeira fase de validação de conteúdo, participaram sete especialistas, o valor aceitável do IVC para cada item variou entre 1,00 e 0,71, e o valor do Kappa Modificado, entre 1,00 e 0,65. Na segunda e na terceira fases, foram considerados aceitáveis os itens que apresentaram IVC entre 1,00 e 0,80 e Kappa Modificado entre 1,00 e 0,76, visto que, nessa etapa, participaram cinco especialistas[31]. Como o IVC considera o número de especialistas consultados para cada etapa, a diferença no número de especialistas nas diferentes fases de validação de conteúdo deste presente estudo não influenciou no resultado estatístico obtido.

Resultados

A primeira versão do instrumento foi desenvolvida com um total de 80 itens divididos em três domínios: características gerais (seis itens), desempenho funcional (23 itens), estratégias adotadas para a subida (25 itens) e descida (26 itens). O domínio de desempenho funcional apresenta 18 itens comuns para a subida e a descida de escadas, além de dois itens referentes à subida e três itens referentes à descida de escadas. No domínio de estratégias adotadas, 25 itens foram idênticos para a subida e descida, mas foram avaliados separadamente nas diferentes fases de validação de conteúdo[28].

Primeira fase de validação de conteúdo

Na primeira fase de validação de conteúdo, os domínios desenvolvidos foram considerados satisfatórios (IVC entre 0,71 e 1,00)[33] para a avaliação da subida e descida de escadas, sendo que o Domínio de Estratégias Adotadas, tanto para a subida como para a descida, demonstrou necessidade de correções mais importantes.

A maioria dos itens do Domínio de Características Gerais obteve escores satisfatórios (Tabela 1). Todos os itens desse domínio foram mantidos na segunda versão do instrumento, sendo que os dois primeiros itens que avaliavam, respectivamente, o número de degraus e o uso de órteses foram transferidos para um domínio descritivo, sem pontuação específica. Já os

Tabela 1. Resultado da primeira fase de validação de conteúdo dos itens do domínio de características gerais.

ITENS	Características gerais								RESULTADO
	Consistência		Represent.**		Relevância		Clareza		
	IVC*	Kappa	IVC*	Kappa	IVC*	Kappa	IVC*	Kappa	
1. Número de degraus	0,86	0,85	0,71	0,65	0,86	0,85	1,00	1,00	Mudança de domínio
2. Uso de órteses	0,86	0,85	0,86	0,85	1,00	1,00	1,00	1,00	Mudança de domínio
3.1 Nível de confiança	0,71	0,65	0,86	0,85	0,86	0,85	**0,43**	**0,41**	Corrigido
3.2 Nível de confiança com corrimão	0,71	0,65	0,86	0,85	0,86	0,85	0,71	0,65	Corrigido
3.3 Nível de confiança sem corrimão	0,71	0,65	0,86	0,85	0,86	0,85	0,71	0,65	Corrigido
4. Graduação funcional	**0,57**	**0,56**	0,71	0,65	0,86	0,85	0,86	0,85	Corrigido

*IVC: Índice de validade de conteúdo; **Representatividade/Relevância em relação ao domínio de interesse.

itens que avaliam o nível de confiança e a graduação funcional tiveram sua redação alterada para melhor compreensão.

A Tabela 2 apresenta os escores dos itens comuns do Domínio de Desempenho Funcional para subida e descida de escadas. Os dois primeiros itens, que avaliam a cadência de subida e descida de escadas, foram transferidos para o domínio descritivo (sem pontuação), e o item 9, que avalia o membro inferior que inicia o movimento, foi alterado para o domínio que avalia separadamente a subida e a descida. Os itens 2 e 8 foram mantidos sem necessidade de correção, e os itens 4, 6, 7 e 16 foram excluídos.

No Domínio de Desempenho Funcional – itens referentes à subida de escada, o item 1, que avalia a necessidade de auxílio na transição chão-escada, foi excluído, apesar de apresentar valores de IVC e Kappa próximos dos aceitáveis para características como relevância e clareza (IVC=0,71 e Kappa=0,65), visto que, segundo os especialistas, esse item avalia aspectos não relacionados exclusivamente ao desempenho na escada, como no caso da marcha em nível plano. No mesmo domínio, o item 2, que avalia a colisão do pé com o degrau, não alcançou escores aceitáveis para as características de consistência (IVC=0,57 e Kappa=0,56) e de clareza (IVC=0,28 e Kappa=0,26), necessitando de modificações.

No Domínio de Desempenho Funcional – itens referentes à descida de escada, foi excluído o item 1, que avalia a necessidade de auxílio na transição patamar-degrau devido aos baixos valores de IVC e Kappa para a maioria das características analisadas. O item 2, que avalia a necessidade de auxílio na transição último degrau-chão teve sua escrita alterada, a fim de melhor adequá-lo à avaliação da descida de escada, visto que apresentou valores baixos de IVC e Kappa para consistência e representatividade (IVC=0,57 e Kappa=0,56). O item 3 referente à

Tabela 2. Resultado da primeira fase de validação de conteúdo dos itens do Domínio de Desempenho Funcional – Itens comuns para subida e descida de escada.

Desempenho funcional: itens comuns subida e descida									
Itens	**Consistência**		**Represent.****		**Relevância**		**Clareza**		**Resultado**
	IVC*	**Kappa**	**IVC***	**Kappa**	**IVC***	**Kappa**	**IVC***	**Kappa**	
A. Cadência Subida	0,71	0,65	0,86	0,85	0,86	0,85	0,86	0,85	Mudança de domínio
B. Cadência Descida	0,71	0,65	0,86	0,85	0,86	0,85	0,86	0,85	Mudança de domínio
1. Auxílio externo	0,86	0,85	0,86	0,85	1,00	1,00	0,86	0,85	VALIDADO
2. Corrimão	0,71	0,65	0,86	0,85	0,86	0,85	0,86	0,85	Corrigido
3. Intensidade uso corrimão	0,86	0,85	0,71	0,65	0,71	0,65	**0,43**	**0,41**	Corrigido
4. Posição MMSS	0,71	0,65	0,71	0,65	**0,57**	**0,56**	**0,57**	**0,56**	EXCLUÍDO
5. Posição MS parético	0,86	0,85	**0,57**	**0,56**	**0,57**	**0,56**	**0,57**	**0,56**	Corrigido
6. Reações de equilíbrio	**0,57**	**0,56**	**0,57**	**0,56**	**0,57**	**0,56**	**0,43**	**0,41**	EXCLUÍDO
7. Balanço MMSS	0,71	0,65	**0,57**	**0,56**	**0,57**	**0,56**	**0,43**	**0,41**	EXCLUÍDO
8. Tipo de passo	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	VALIDADO
9. MI que inicia movimento	0,71	0,65	1,00	1,00	1,00	1,00	1,00	1,00	Mudança de domínio
10. Tempo de apoio	0,86	0,85	1,00	1,00	0,86	0,85	0,86	0,85	VALIDADO
11. Velocidade relativa MMII	**0,57**	**0,56**	0,71	0,65	0,86	0,85	0,86	0,85	Corrigido
12. Estratégia de realização	**0,57**	**0,56**	0,71	0,65	0,86	0,85	**0,43**	**0,41**	Corrigido
13. Estratégia de posição dos pés	0,71	0,65	0,86	0,85	0,86	0,85	0,71	0,65	Corrigido
14. Apoio dos pés	**0,57**	**0,56**	0,71	0,65	0,71	0,65	**0,43**	**0,41**	Corrigido
15. Contato inicial do pé	**0,43**	**0,41**	0,86	0,85	0,86	0,85	0,71	0,65	Corrigido
16. Apoio plantar	**0,57**	**0,56**	**0,57**	**0,56**	**0,57**	**0,56**	**0,57**	**0,56**	EXCLUÍDO

*IVC: Índice de validade de conteúdo; **Representatividade/Relevância em relação ao domínio de interesse.

descida, que avalia a segurança no alcance do degrau inferior com o pé, não obteve escore satisfatório para a característica de representatividade (IVC=0,57 e Kappa=0,56) e teve sua redação corrigida. Além disso, foi realizada a alteração na ordem dos itens 2 e 3 desse domínio.

Em relação aos domínios desenvolvidos na primeira versão, de acordo com a sugestão de um dos especialistas, os itens do Domínio de Desempenho Funcional foram incluídos no Domínio de Características Gerais. Assim, a segunda versão do instrumento foi subdividida em Domínio de Características Gerais e Domínio de Estratégias Adotadas.

Os itens do Domínio de Estratégias Adotadas para subida e descida de escadas foram avaliados como pouco suficientes por dois dos sete especialistas. Como esse domínio foi avaliado de forma semelhante por todos os especialistas tanto para a subida como para a descida de escadas, e pelo fato de ser um domínio longo, optou-se pela união dos dois (subida e descida) no que tange ao *layout* do instrumento.

Os itens que não alcançaram níveis aceitáveis em todas as características analisadas (consistência, representatividade, relevância e clareza) pelo IVC e pelo Coeficiente Kappa Modificado foram excluídos:

- Tronco: rotação de tronco e pelve na fase de transição ($0,57 \leq IVC \leq 0,71$);
- Quadril: adução ($0,43 \leq IVC \leq 0,57$);
- Joelho: rotação interna ($0,43 \leq IVC \leq 0,57$); rotação externa ($0,28 \leq IVC \leq 0,57$); varismo (IVC=0,43); valgismo (IVC=0,43);
- Estabilidade articular: foram excluídos todos os itens tanto para subida como para descida (IVC=0,43).

Em relação à pontuação desse domínio, verificou-se a necessidade de padronização da pontuação para todos os segmentos avaliados, sendo mantida apenas uma descrição de pontuação: (0) não apresenta desvio ou esse desvio é muito leve; (1) desvio moderado; (2) desvio severo, dificultando consideravelmente a realização da tarefa.

Segunda fase de validação de conteúdo

A segunda versão do instrumento foi submetida novamente à avaliação do comitê de especialistas com um total de 39 itens, sendo que, desses, apenas quatro não necessitaram de avaliação sobre a validade de conteúdo, porque já haviam alcançado valores aceitáveis de IVC e Kappa na primeira fase de validação. Assim, na segunda fase de validação de conteúdo, foram reavaliados 35 itens.

Como pode ser observado na Tabela 3, que descreve a segunda etapa de validação dos itens do Domínio de Características Gerais, a maioria dos itens alcançou valores satisfatórios para IVC e Kappa, exceto os itens 5, 6 e 9 para a característica

Tabela 3. Resultado da segunda fase de validação de conteúdo dos itens do domínio de características gerais da subida e descida.

Itens	Características gerais								Resultado
	Consistência		Represent.**		Relevância		Clareza		
	IVC*	Kappa	IVC*	Kappa	IVC*	Kappa	IVC*	Kappa	
1.1 Nível de confiança	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	VALIDADO
1.2 Nível confiança com corrimão	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	VALIDADO
1.3 Nível confiança sem corrimão	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	VALIDADO
2. Graduação funcional	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	VALIDADO
4. Uso do corrimão	0,80	0,76	0,80	0,76	0,80	0,76	**0,60**	**0,54**	Corrigido
5. Intensidade uso corrimão	0,80	0,76	0,80	0,76	**0,60**	**0,54**			Corrigido
6. Posição MS parético	0,80	0,76	0,80	0,76	**0,60**	**0,54**	**0,60**	**0,54**	Corrigido
9. Velocidade MMII	1,00	1,00	0,80	0,76	**0,60**	**0,54**	0,80	0,76	Corrigido
10. Alinhamento corporal	0,80	0,76	0,80	0,76	0,80	0,76	0,80	0,76	Corrigido
11. Alinhamento dos pés	0,80	0,76	1,00	1,00	0,80	0,76	0,80	0,76	Corrigido
12. Apoio dos pés	0,80	0,76	0,80	0,76	0,80	0,76	**0,60**	**0,54**	Corrigido
13. Contato inicial do pé	0,80	0,76	0,80	0,76	0,80	0,76	0,80	0,76	Corrigido

*IVC: Índice de validade de conteúdo; **Representatividade/Relevância em relação ao domínio de interesse.

de relevância e os itens 4, 6, e 12 para a característica de clareza. Esses itens foram corrigidos e submetidos à terceira etapa de validação de conteúdo.

A Tabela 4 apresenta o resultado da avaliação da validade de conteúdo das características analisadas para cada um dos itens do Domínio de Características Gerais, itens referentes à subida de escadas. Os dois itens foram avaliados com adequados índices de validade de conteúdo, sendo que apenas o item 2, que avalia a colisão do pé com o degrau, foi considerado com déficits de clareza/possibilidade de compreensão (redação), necessitando de correção. Da mesma forma, é possível verificar que os itens do Domínio de Características Gerais – itens referentes à descida de escada, alcançaram índices adequados de validade de conteúdo, sendo que apenas o item 2, que analisa a segurança no alcance do degrau inferior com o pé durante a descida de escada, foi avaliado com baixos valores de IVC e Kappa para as características de relevância para a interpretação clínica, que pode ser feita com base na medida, e de clareza/possibilidade de compreensão (redação).

No Domínio de Estratégias Adotadas, todos os itens desenvolvidos para tronco/pelve, quadril, joelho, tornozelo alcançaram índices adequados de validade de conteúdo para todas as quatro características analisadas, com valores de IVC entre 0,80 e 1,00 e Kappa entre 0,76 e 1,00. O único item avaliado com escores inferiores foi o item que avalia a anteversão/retroversão de pelve, conforme Tabela 4. Ele foi, então, excluído da versão final do instrumento.

Terceira fase de validação de conteúdo

Ao todo, foram analisados, na terceira etapa de validação de conteúdo, dez itens do Domínio de Características Gerais: itens comuns à subida e descida de escadas, itens referentes à subida e à descida de escada. Conforme a Tabela 5, todos os itens submetidos a essa etapa foram validados com as devidas correções.

Discussão

A validade de conteúdo está relacionada à solidez da interpretação dos escores de um instrumento e indica em que grau esses escores medem o que pretendem medir[35,36]. No presente estudo foram realizadas três etapas de validação de conteúdo para que o conjunto final de itens obtivesse consenso entre os especialistas consultados. Segundo Benson e Clark[29], quando o acordo absoluto não é alcançado para um item, ele deve ser revisado até que um consenso seja obtido. Entretanto, alguns itens nunca alcançarão esse padrão apesar de diversas revisões e devem, consequentemente, ser excluídos do instrumento. Nesse contexto, a primeira fase de validação de conteúdo deste estudo possibilitou uma redução significativa no tamanho do instrumento, com a exclusão de 41 itens, sendo que, desses, 15 foram excluídos e outros 26 foram unidos no Domínio de Estratégias Adotadas da subida e descida de escadas. Dos 15 itens excluídos, seis pertenciam ao Domínio de Características Gerais e nove ao Domínio de Estratégias Adotadas. Os itens do Domínio de Características Gerais que não alcançaram índices satisfatórios de validade de conteúdo foram considerados insubsistentes com o Domínio de Conteúdo do Instrumento. Os nove itens excluídos do Domínio de Estratégias Adotadas avaliavam amplitudes de movimento e compensações consideradas como incompatíveis com a análise cinemática qualitativa. Nessa primeira etapa também foram realizadas alterações importantes em relação à redação dos itens para melhor compreensão e, por isso, o instrumento foi submetido à reavaliação de sua validade de conteúdo.

Os resultados do processo de validação de conteúdo foram determinados pelos IVC e Coeficiente Kappa Modificado. Segundo Polit et al.[33], podem ser considerados bons e excelentes os itens que

Tabela 4. Resultado da segunda fase de validação de conteúdo dos itens independentes para subida e descida.

Itens	Consistência		Represent.**		Relevância		Clareza		Resultado
	IVC*	Kappa	IVC*	Kappa	IVC*	Kappa	IVC*	Kappa	
Características gerais – Itens referentes à subida									
1. Membro que inicia subida	1,00	1,00	1,00	1,00	0,80	0,76	1,00	1,00	VALIDADO
2. Colisão do pé na subida	0,80	0,76	1,00	1,00	1,00	1,00	0,60	0,54	Corrigido
Características gerais – Itens referentes à descida									
1. Membro que inicia descida	1,00	1,00	1,00	1,00	0,80	0,76	1,00	1,00	VALIDADO
2. Segurança na descida	0,80	0,76	0,80	0,76	0,60	0,54	0,60	0,54	Corrigido
3. Necessidade de auxílio	0,80	0,76	1,00	1,00	0,80	0,76	0,80	0,76	Corrigido

*IVC: Índice de validade de conteúdo; **Representatividade/Relevância em relação ao domínio de interesse.

Tabela 5. Resultado da terceira fase de validação de conteúdo.

Itens	Consistência		Represent.**		Relevância		Clareza		Resultado
	IVC*	Kappa	IVC*	Kappa	IVC*	Kappa	IVC*	Kappa	
Características gerais da subida e descida									
Uso do corrimão	1,00	1,00	1,00	1,00	1,00	1,00	0,80	0,76	VALIDADO
- Tempo de uso do corrimão	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	VALIDADO
- Posição dos MMSS	0,80	0,76	0,80	0,76	0,80	0,76	0,80	0,76	VALIDADO
- Simetria tempo de apoio	0,80	0,76	0,80	0,76	1,00	1,00	0,80	0,76	VALIDADO
- Alinhamento corporal	0,80	0,76	1,00	1,00	1,00	1,00	0,80	0,76	VALIDADO
- Alinhamento dos pés	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	VALIDADO
- Apoio dos pés	1,00	1,00	1,00	1,00	1,00	1,00	0,80	0,76	VALIDADO
Características gerais – Itens referentes à subida									
- Colisão do pé na subida	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	VALIDADO
Características gerais – Itens referentes à descida									
- Dificuldade na descida	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	VALIDADO
- Necessidade de auxílio	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	VALIDADO

*IVC: Índice de validade de conteúdo; **Representatividade/Relevância em relação ao domínio de interesse.

apresentarem valores de IVC e Kappa Modificado superiores a 0,70. Assim, considerando a versão final do instrumento, verifica-se que, do total de 38 itens, seis foram validados na primeira etapa de validação de conteúdo, 22 na segunda e dez na terceira e última fase. Apesar disso, na primeira fase de validação, 57,5% dos itens alcançaram índices aceitáveis (acima de 0,70) de validade de conteúdo e do Coeficiente Kappa Modificado para a característica de consistência; 56,2% para representatividade; 50% para relevância e 32,5% para clareza, mas correções foram sugeridas pelos especialistas, justificando uma nova avaliação para eles. Na segunda fase de validação 81,6% dos itens alcançaram índices aceitáveis (acima de 0,70) para as características de consistência e representatividade; 65,8% para relevância e 71% para clareza. Todos os últimos dez itens submetidos à terceira avaliação alcançaram índices aceitáveis e foram considerados validados nos aspectos avaliados.

A versão final do instrumento de avaliação clínica da subida e descida de escada para indivíduos com hemiparesia apresenta um total de 38 itens divididos em oito itens descritivos, 16 itens do Domínio de Características Gerais da subida e descida de escadas e 14 itens do Domínio de Estratégias Adotadas para subida e descida de escadas (Anexo 1). Cada item é avaliado por meio de uma escala categórica ordinal, que varia de zero a dois pontos, correspondendo, respectivamente, ao melhor desempenho e ao pior desempenho. O escore total do instrumento deverá ser calculado separadamente para subida (0 a 70 pontos) e descida (0 a 74 pontos) de escadas. Devido ao formato extenso do instrumento, os principais itens de cada domínio estão apresentados no Anexo 1 deste artigo, sendo que o instrumento como um todo poderá ser obtido por meio de contato com as autoras.

Os 38 itens que constituem a versão final do instrumento apresentaram adequada validade de conteúdo para a avaliação das características cinemáticas qualitativas e das estratégias adotadas na subida e descida de escadas por indivíduos com hemiparesia. Entretanto, novos estudos de análise das demais propriedades psicométricas, como confiabilidade inter e intraexaminadores, consistência interna, validade de critério e de construto, são necessários e serão realizados futuramente.

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Anexo 1. Principais itens de cada Domínio do Instrumento de Avaliação Clínica da Subida e Descida de Escadas em Indivíduos com hemiparesia.

DOMÍNIO DE ITENS DESCRITIVOS (sem pontuação)

Número de degraus da escada: ( ) 4 ( ) 5 ( ) 6

Cadência de Subida: _____degraus/minuto **Cadência de Descida:** _____degraus/minuto

Uso de órteses: ( ) Sem órtese ( ) Com órtese Tipo de órtese:_____

Graduação Funcional (este item deve ser preenchido após a conclusão da análise da subida e descida de escada)
(0) A tarefa é completada sem dificuldade ou com leve dificuldade.
(1) A tarefa ou certas etapas são realizadas com dificuldade significativa, ou pode ter havido necessidade de assistência por parte do examinador entre 25 e 50% da tarefa.
(2) A tarefa é completada com assistência do examinador em mais de 50% da tarefa.

I – DOMÍNIO DE CARACTERÍSTICAS GERAIS (com pontuação)

ITENS COMUNS	Subida	Descida
1 - Necessidade de auxílio externo (Dispositivos auxiliares de marcha e/ou auxílio de uma pessoa) (0) Não necessita de auxílio externo. (1) Necessita de dispositivos auxiliares de marcha. (2) Necessita de auxílio de uma pessoa.	**0 1 2**	**0 1 2**
2– Uso do corrimão e dos membros superiores (0) Não faz uso do corrimão. (1) Usa apenas uma das mãos para apoiar no corrimão. (2) Usa as duas mãos para apoiar no corrimão.	**0 1 2**	**0 1 2**

ITENS REFERENTES À SUBIDA

12 – Membro inferior que inicia o movimento
(0) Membro inferior parético.
(1) Misto (alterna entre membro inferior parético e não parético).
(2) Membro não parético.

13 – Colisão do pé com o degrau durante a subida de escada
(0) Alcança o degrau superior sem colidir o pé.
(1) Colisão do pé com o degrau superior é observada, MAS sem perda de equilíbrio.
(2) Colisão do pé com o degrau superior é observada, e ocorre desequilíbrio.

ITENS REFERENTES À DESCIDA

14 – Membro inferior que inicia o movimento
(0) Membro inferior não parético.
(1) Misto (alterna entre membro inferior parético e não parético).
(2) Membro parético.

15 – Dificuldade no alcance do degrau inferior com o pé durante a descida de escada
(0) Alcança o degrau inferior sem ou com leve dificuldade.
(1) Alcança o degrau inferior com moderada dificuldade, interferindo pouco na realização da atividade.
(2) Alcança o degrau inferior com severa dificuldade, interferindo muito na realização da atividade.

II – DOMÍNIO DE ESTRATÉGIAS ADOTADAS (com pontuação)

Para essa avaliação, utilizar a seguinte pontuação:
(0) **Não apresenta desvio** ou esse desvio é **muito leve.**
(1) Apresenta **desvio moderado.**
(2) Apresenta **desvio severo,** dificultando consideravelmente a realização da tarefa.

Estratégias	SUBIDA		DESCIDA	
	Fase de Balanço	Fase de Apoio	Fase de Balanço	Fase de Apoio
1. Flexão/extensão de tronco	(-) 2 1 0 1 2 (+) Flexão Extensão	(-) 2 1 0 1 2 (+) Flexão Extensão	(-) 2 1 0 1 2 (+) Flexão Extensão	(-) 2 1 0 1 2 (+) Flexão Extensão
2. Inclinação lateral de tronco	(-) 2 1 0 1 2 (+) Direita Esquerda	(-) 2 1 0 1 2 (+) Direita Esquerda	(-) 2 1 0 1 2 (+) Direita Esquerda	(-) 2 1 0 1 2 (+) Direita Esquerda

Anexo 1. Continuação...

II – DOMÍNIO DE ESTRATÉGIAS ADOTADAS (com pontuação)				
3. Inclinação lateral de pelve	(-) 2 1 0 1 2 (+) Direita Esquerda	(-) 2 1 0 1 2 (+) Direita Esquerda	(-) 2 1 0 1 2 (+) Direita Esquerda	(-) 2 1 0 1 2 (+) Direita Esquerda
4. Rotação de tronco e pelve	(-) 2 1 0 1 2 (+) Direita Esquerda	(-) 2 1 0 1 2 (+) Direita Esquerda	(-) 2 1 0 1 2 (+) Direita Esquerda	(-) 2 1 0 1 2 (+) Direita Esquerda
As estratégias a seguir avaliam o MEMBRO INFERIOR AFETADO				
5. Flexão de quadril	(-) 2 1 0 1 2 (+) Redução Excesso		(-) 2 1 0 1 2 (+) Redução Excesso	
6. Abdução de quadril	(-) 2 1 0 1 2 (+) Redução Excesso		(-) 2 1 0 1 2 (+) Redução Excesso	
7. Rotação interna de quadril	0 1 2 (+) Excesso	0 1 2 (+) Excesso	0 1 2 (+) Excesso	0 1 2 (+) Excesso

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Cervical and shoulder postural assessment of adolescents between 15 and 17 years old and association with upper quadrant pain

Rodrigo M. Ruivo[1], Pedro Pezarat-Correia[1], Ana I. Carita[2]

ABSTRACT | **Background:** There is sparse literature that provides evidence of cervical and shoulder postural alignment of 15 to 17-year-old adolescents and that analyzes sex differences. **Objectives:** To characterize the postural alignment of the head and shoulder in the sagittal plane of 15 to 17-year-old Portuguese adolescents in natural erect standing and explore the relationships between three postural angles and presence of neck and shoulder pain. **Method:** This cross-sectional study was conducted in two secondary schools in Portugal. 275 adolescent students (153 females and 122 males) aged 15 to 17 were evaluated. Sagittal head, cervical, and shoulder angles were measured with photogrammetry and PAS software. The American Shoulder and Elbow Surgeons Shoulder Assessment (ASES) was used to assess shoulder pain, whereas neck pain was self-reported with a single question. **Results:** Mean values of sagittal head, cervical, and shoulder angles were 17.2±5.7, 47.4±5.2, and 51.4±8.5°, respectively. 68% of the participants revealed protraction of the head, whereas 58% of them had protraction of the shoulder. The boys showed a significantly higher mean cervical angle, and adolescents with neck pain revealed lower mean cervical angle than adolescents without neck pain. 53% of the girls self-reported regular neck pain, contrasting with 19% of the boys. **Conclusions:** This data shows that forward head and protracted shoulder are common postural disorders in adolescents, especially in girls. Neck pain is prevalent in adolescents, especially girls, and it is associated with forward head posture.

Keywords: adolescents; cervical; photogrammetry; rehabilitation; posture; shoulder.

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Introduction

Posture has been defined as the alignment of the body segments at a particular time[1] and is an important health indicator[2]. It must correspond to a specific body position in space which minimizes anti-gravity stresses on body tissues[3]. Inadequate posture consists of poor interrelations between parts of the body[4]. These imperfect interrelations cause muscle tension and shortening, which makes appropriate joint movements more difficult to achieve[5] and may cause pain.

Epidemiological studies have shown a high prevalence of spinal postural deviations in children and adolescents[6,7], with forward head posture (FHP) and protracted shoulder (PS) posture being two of the most common postural deviations[7]. FHP is commonly defined as the protrusion of the head in the sagittal plane so that the head is placed anterior to the trunk[8]. It can occur because of anterior translation of the head, lower cervical flexion or both, and it is claimed to be associated with an increase in upper cervical extension[8]. It is associated with shortening of the upper trapezius, the posterior cervical extensor muscles, the sternocleidomastoid muscle and the levator scapulae muscle[9]. It is thought that adolescents or patients with neck pain (NP) have a more forward head posture, thus a smaller craniovertebral (CV) angle in standing, than age-matched pain-free participants[10]. PS is a forward displacement of the acromion with reference to the 7th cervical spinous process, frequently associated with a protracted, anterior tilted and internally rotated scapula and with a tightness of the pectoralis minor muscle[11].

To study the misalignments outlined above, the photographic measurement of sagittal postures of cervical spine and shoulder is becoming more widespread, with several studies confirming the high reliability of photogrammetry[2,9,12-14]. To assist with

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posture assessment from digitized images, specific software has been developed such as PAS/SAPO (Postural Assessment Software)[12].

Based on the knowledge that the current literature is still sparse in the characterization of the postural alignment of adolescents in a large sample size and that there is no concrete information on the relationship between neck and shoulder pain and sagittal posture of the spine in a standing position, we defined the following objectives for this study: 1) to characterize the postural alignment of the head and shoulders in the sagittal plane of 15 to 17-year-old Portuguese adolescents in natural erect standing; 2) to find the relationship (if any) between the postural angles studied and neck and shoulder pain; and 3) to analyze sex differences in the postural angles and neck and shoulder pain.

The findings of this study may give researchers further information about cervical and shoulder postural alignment of a specific age group and will help to evaluate the relationship between neck and shoulder pain and posture. Moreover, the results may help to improve the management of patients with neck pain. This study has the advantage of having evaluated a far larger sample than other studies[6,15] and analyzed sex differences.

Method

Participants

This cross-sectional study was conducted in two public secondary schools, Lumiar Secondary School and Padre Antonio Vieira Secondary School, located in the city of Lisbon, Portugal. Male and female adolescent students between the ages of 15 and 17 years were eligible to participate. The justification of the ages is to avoid the effects of the pubertal growth spurt. Participants were excluded if they had visual deficits, diagnosed balance disorders, musculoskeletal pathologies (e.g. history of shoulder surgery, cervical or thoracic fracture), were non-ambulatory, displayed functional or structural scoliosis, or had excessive thoracic kyphosis. Given these criteria, a total of 275 adolescent students (146 females and 129 males) aged 15, 16, or 17 years old [15.76±1.08 y] from 17 different classes (nine from the 10th grade, seven from the 11th grade, and one from the 12th grade) were evaluated and included in the study.

The participation of all students was voluntary, and written informed consent was obtained from all participants, and their parents or legal guardians. The study was approved by the Research Ethic s Committee of the Faculty of Human Kinetics from Universidade de Lisboa, Lisbon, Portugal (approval number: 5/2013).

Procedures

Posture alignment assessment

Standing cervical and shoulder posture was measured with photogrammetry and PAS software. When compared to radiographs using the LODOX, the photographs provide valid and reliable indicators of the spine[6]. Also the software PAS has proven to be valid and reliable[12]. Three angles of measurement were used – sagittal head angle (HT), cervical angle (CV), and shoulder angle (SH) (Figure 1) – and obtained in the sagittal view as follows:

Sagittal head angle - The angle formed at the intersection of a horizontal line through the tragus of the ear and a line joining the tragus of the ear and the lateral canthus of the eye.

Cervical angle - The cervical angle is highly reliable to assess the forward head position[4]. It is the angle formed at the intersection of a horizontal line through the spinous process of C7 and a line to the tragus of the ear. In this study, if the angle was less than 50°, the participant was considered to have forward head posture. The selection of 50° as a reference angle was guided by the studies of Diab and Moustafa[16] and Yip et al.[17], with the latter reporting 55.02±2.86 as a normal range. As is well known,

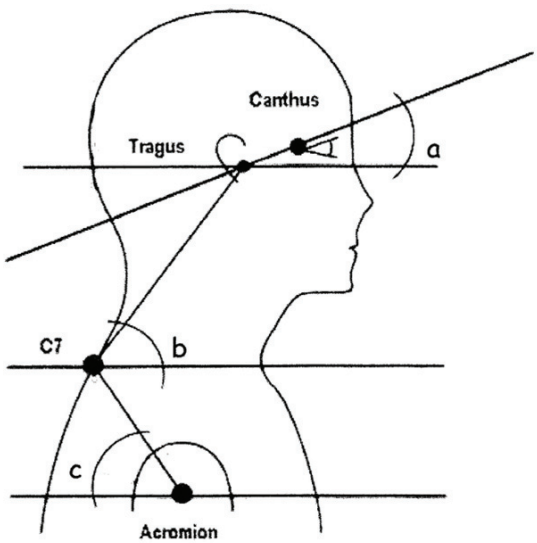

Figure 1. Adhesive marker placement and postural angles. a sagittal head; b cervical angle; c shoulder angle.

subjects with FHP have a significantly smaller cervical angle when compared with normal subjects[18].

Shoulder angle - The angle formed at the intersection of the line between the midpoint of the humerus and spinous process of C7 and the horizontal line through the midpoint of the humerus. In the present study, we considered 52° as the reference angle based on Thigpen et al.[19] who evaluated 310 participants in a standing position and reported 2.6°±15.3 as a normal range, and Brink et al.[20], who evaluated 15 to 17 year-olds and reported a mean shoulder angle value of 51.35°±17.2°, and based on the premise that subjects with protracted shoulder have a significantly smaller shoulder angle when compared with normal subjects[15]. We considered an individual to have PS if the angle was less than 52°.

All measurements were taken by the same researcher who was experienced in the assessment of postural alignment. The photographing took place in the gymnasium of the 2 secondary schools with the areas arranged identically. Landmarks were placed on the floor to ensure the same positioning of all subjects in front of the camera and to ensure that the subject was aligned perpendicular to the camera. A landmark was placed in front of a white wall to ensure a contrast of the subjects against the background. One Canon Power Shot A4000 IS was supported on a Manfrotto tripod, model 055 CLB, three meters away from the line marking the position of the subject. The height of the tripod was adjusted so the middle of the objective lens was 130 cm above the ground. A calibration board was placed in the field of view and aligned with the subject to allow referencing of horizontal and vertical axes from the photographs. The calibration board also displayed each subject's identification number. For positioning, the adolescent was instructed to stand comfortably in a normal standing position and to look straight ahead. Marks on the floor ensured that all subjects were in the same place.

Before photographing, the researcher put reflective markers (styrofoam balls with 20 mm diameter) on the following anatomical points on the right side of the subject´s body: tragus of the ear, lateral canthus of the eye, spinous process of C7, and midpoint of the humerus. With these markers we were able to calculate the sagittal head angle, cervical angle, and shoulder angle.

To enable precise positioning of the markers we instructed the subjects to wear tight shorts and sleeveless t-shirts and to tie their hair back when needed. The procedure was always performed by the same researcher, who was blinded to the subjects' condition. Each person was asked to look straight ahead and to march on the spot five times before each picture was taken[21] to capture the participant's natural head-on-trunk and shoulder alignment. Each picture was taken within five seconds of the marching sequence, in a lateral view, with the right side of the subject photographed for the right hand-dominant participants and the left side for the left-hand dominant participants. The dominant arm was defined as the most used in daily activities. The photographic analysis was subsequently performed using PAS, which determined the coordinates of the anatomical points on the photographs. The zoom was standardized at 200% and the angles were measured in degrees. One researcher undertook all scanning and digitizing to eliminate inter-examiner error. The data were submitted to descriptive statistical analysis, and quantitative values for head and upper member angles were obtained. PAS has already been shown to be valid and reliable[12].

Self-assessment of shoulder pain and function and neck pain

The American Shoulder and Elbow Surgeons Shoulder Assessment (ASES) form was translated and cross-culturally adapted to the Portuguese language. This Portuguese version was then used to record the presence of shoulder pain and function in the subjects. The questionnaire addressed self-evaluation of pain using a visual analog scale and activities of daily living questionnaire. A high total score indicates low perceived pain and low dysfunction in activities of daily living. After the postural assessment and administration of the ASES questionnaire, the students were asked to answer yes or no to the following question: do you feel neck pain regularly? With this question we also wanted to address neck pain as an outcome measure.

Reliability study

A separate preparatory study to confirm the inter- and intra-rater reliability of computerized photogrammetry using the PAS was performed. The study sample consisted of 17 subjects from the 10th grade. Three physical therapists (all men from 26 to 32 years old), who had used the PAS/SAPO before but were not regular users, were invited to participate as raters. Each student was photographed in the same conditions as detailed before in the main study, and pictures were taken of the participants in random order. Using the PAS, the three raters took the measurements, which were then used to calculate the inter-rater reliability. These procedures were repeated one week later by therapist A, and the results were compared to assess the intra-rater reliability.

Statistical analysis

All statistical analyses were performed using specific software (SPSS version 20), and the α value was defined in 0.05. Intra-rater reliability was assessed using type 2.1 intraclass correlation coefficient (ICC), whereas the inter-rater reliability was assessed using ICC(3.1).

The Shapiro-Wilk test was used to assess normality. To analyze differences between sexes and between patients with and without neck pain (NP) in the three postural angles and ASES scores, the independent-samples t-test was applied. A chi-square test was used to assess the relationship between the forward head and cervical pain. Relationships between the three postural angles and ASES were examined by calculating Spearman's rho correlation coefficient (r_s).

Results

Reliability study

The reliability of the photographic measurement is shown in Table 1. A total of 17 subjects (14 females and 3 males) aged 15 to 17 years were recruited for the reliability study. The ICC (2.1) values for the shoulder angle and for the cervical angle reported good reliability, with 0.78 and 0.66 respectively, whereas the values for the HT angle (0.83) revealed very good intra-rater reliability. All the ICC (3.1) values for the three angles, in the inter-rater reliability, reported a very good reliability, with the SEMs of the photographic measurement ranging between 1.64 and 2.35.

Experimental study

Sample

A total of 275 adolescents, 153 girls and 122 boys (age 15±1 year), participated in the study. Sex and descriptive values for the three postural angles and ASES scores are described in Table 2.

Bearing in mind the reference values outlined before, of the 275 adolescents studied, 188 (68%) had forward head (FH) with a cervical angle less than 50°, while 131 (58%) had a shoulder angle less than 52°, revealing a PS. These values are shown in Figure 2.

Sex, neck pain, postural angles and ASES

The examination of the head and shoulder posture measurements to identify the effect of sex and NP on postural angles and ASES scores using the t-test is reported in Table 2. Significant differences were observed between boys and girls with respect to the HT angle and the CV angle, with the boys reporting a higher mean value (18.4±6.03 vs 16.15±5.31, and 48.43±4.91 vs 46.55±5.24, respectively).

105 adolescents (38.2%) of the 275 reported having NP regularly. The overall NP group showed a significantly lower mean CV angle (46.5±5.6 vs 47.9±4.79), whereas no statistically significant difference was found between patients and pain-free participants for the HT angle (t=1.76, *P*>.05) and SH angle (t=–1.2, *P*>.05). When trying to associate CV and neck pain using chi squared test for forward head and cervical pain, it was clear that neck pain was more prevalent in adolescents with FH than adolescents without FH (29.8% vs 8.4%).

When introducing the sex item, 53% of the girls (n=81) reported NP regularly, contrasting with 19.7% of the boys (n=24). Girls with NP also reported

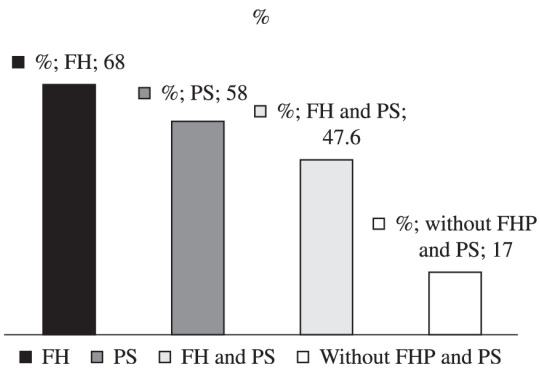

Figure 2. Percentage of students experiencing forward head and/or protracted shoulder (PS).

Table 1. Intra-rater and inter-rater reliability findings: ICC and SEM values for all angles.

Measurement	Intra-rater reliability			Inter-rater reliability		
	ICC (95% CI)	SEM	MDC	ICC (95% CI)	SEM	MDC
Sagitall Head Angle	0.83 (0.60-0.94)	2.72	7.54	0.88 (0.75-0.95)	2.35	6.51
Cervical Angle	0.66 (0.26-0.87)	3.54	9.81	0.87 (0.74-0.95)	1.85	5.13
Shoulder Angle	0.78 (0.49-0.92)	4.03	11.18	0.96 (0.92-0.99)	1.64	4.55

ICC - Intraclass correlation coefficient; SEM - standard error of measurement.

Table 2. Descriptive values for the postural angles and ASES scores (n=275) and effect of gender and neck pain in postural angles and ASES scores.

	Overall					Females	Males		
	All (n=275)	**No NP (n=170)**	**NP (n=105)**	**t**	**p**	**All (n=153)**	**All (n=122)**	**t**	**p**
Sagittal head tilt angle	17.2±5.7	17.6±5.7	16.4±5.7	1.76	0.008	16.15±5.3	18.4±6.03	–3.3	0.001
Cervical angle	47.4±5.174	47.96±4.79	46.46 ±5.6	2.358	0.019 *	46.55±5.2	48.43±4.91	–3.05	0.002*
Shoulder angle	51.4±8.548	50.95 ±8.18	52.24±9.13	–1.219	0.224	51.09±8.27	51.88±8.92	–0.765	0.445
ASES Scores (right)	93.3±9.53	95.06±6.68	90.46±12.40	3.99	0.000*	92.31±10.7	94.55±7.59	3.136	0.053
ASES Scores (left)	91.6± 9.38	93.13±7.75	89.10±11.14	3.52	0.000*	90.46±9.99	93.01±8.37	1.252	0.025*

	Females				Males			
	No NP (n=72)	**NP (n=81)**	**t**	**p**	**No NP (n=98)**	**NP (n=24)**	**t**	**p**
Sagittal head tilt angle	16.5±5.1	15.8±5.5	0.67	0.5	18.5±6.0	18.1±6.3	0.3	0.76
Cervical angle	47.38±4.76	45.8±5.6	1.86	0.0048*	48.38±4.79	48.63±5.5	–0.221	0.825
Shoulder angle	50.72±7.72	51.4±8.78	–0.52	0.603	51.12±8.4	55.02±9.89	–1.944	0.054
ASES Scores (right)	94.92±5.85	89.98±13.33	2.91	0.004*	95.16±7.25	92.07±8.57	1.800	0.074*
ASES Scores (left)	92.53±6.96	88.62±11.8	2.45	0.015*	93.56±8.29	90.76±8.51	1.479	0.142

ASES - American shoulder and elbow surgeons shoulder assessment; NP - neck pain; *Statistically significant difference (p<0.05).

Table 3. Spearman's rho correlations between ASES and the cervical and shoulder angle.

n=275	ASES right	ASES left	Sagittal Head Angle	Cervical Angle	Shoulder Angle
ASES right		0.853* p=0.00	0.031 p=0.592	0.141* p=0.02	-0.001 p=0.0981
ASES left	0.85* p=0.00		0.050 p=0.410	0.141* p=0.004	0.02 p=0.698
Sagittal Head Angle	0.031 p=0.592	0.050 p=0.410		0.07 p=0.245	-0.156 *p=0.010
Cervical Angle	0.141*p=0.02	0.141* p=0.004	0.07 p=0.245		0.057 p=0.293
Shoulder Angle	0.001*p=0.0981	0.02 p=0.698	-0.156 *p=0.010	0.057 p=0.293	

*Correlation is significant at the 0.05 level (2-tailed).

a significantly lower cervical angle than the girls without NP (45.81±5.6 Vs 47.38±4.76°).

Spearman's rho correlation coefficients among the ASES and CV and SH angle are presented in Table 3. None of variables presented a high (r>0.8) and statistically significant correlation other than the expected ASES (right) and ASES (left) (r=0.853).

Discussion

Reliability study

The present study demonstrated very good reliability for the intra-rater measurements for the HT angle and good reliability for the cervical and

shoulder angle in the normal standing posture. With this data, we can suggest that the participants' upper quadrant standing posture did not change significantly over repeated testing. Regarding the inter-rater measurements in the same image for all the variables studied, the very good reliability values are in accordance with the values found by Falla et al.[18].

Experimental study

Descriptive statistics

A large percentage of the subjects revealed some degree of postural abnormality in the cervical and/or shoulder region, with 68% and 58% of the students showing FH and PS, respectively, and 48% of the total sample showing both misalignments.

The incorrect use of heavy backpacks[22], psychosocial factors such as depression or stress[23], the lack of ergonomic school furniture[24], and the extended hours in incorrect postures in school and in front of computers and television[20] may be responsible for this finding.

Specifying the angles studied, we chose HT, CV, and SH angles because they are the most commonly cited in the literature, enabling the comparison of results. These analyses are reliable and help us to characterize a patient's posture in terms of head and shoulder position[8].

The HT angle measures the alignment of the upper cervical spine[25]. The overall mean HT angle registered (17.2°) is similar to a study by Chansirinukor et al.[15] with adolescents (13-16 years old) in standing position, which reported a mean HT angle of 16.3°. De Wall et al.[26] recommended that a suitable HT angle would be 15° above horizontal.

For the CV angle, a smaller angle indicates a more forward head posture[16]. The mean CV angle obtained (47.4°) was similar to the mean reported by van Niekerk et al.[6] who evaluated 40 adolescents aged 16 to 17 years. In another study with 94 students aged 15 to17 years, Brink et al.[20] found a smaller CV angle of 39.27° (7.9), which was considered the cause of upper quadrant pain.

The SH angle is an angle that provides a measurement of the shoulder position. The mean SH angle obtained (51°) is the same as the one found by Brink et al.[20] and very similar to the one found by van Niekerk et al.[6] (50°). Both studies evaluated adolescents. A smaller angle indicates a PS.

Effect of postural angles in pain

In an overall view, 105 (38%) participants reported feeling NP regularly. This finding is concurrent with other studies that found a high prevalence of self-reported upper quadrant pain among adolescents[27], with the shoulder and neck regions becoming more and more cited as the areas of greatest discomfort[28]. Hakala et al.[29] in a study with adolescents reports NP is common in adolescents, with around one in four reporting NP at least weekly.

This NP can be associated with musculoskeletal disorders, with several studies associating an excessive FH position with NP[8,10,17,30]. For example, Chiu et al.[30] found that approximately 60% of individuals with NP had FHP. The assumption that greater neck flexion is worse is based on the biomechanical principle relating an increased lever arm (from head center of mass to head/neck and neck/thorax axes of rotation) with increased gross moment. Johnson[31] suggested that prolonged FHP might increase loading to the non-contractile structures and abnormal stress on the posterior cervical structures and cause myofascial pain.

In this study, 68% of the students showed FH, which could predispose then to regular neck pain. Our results confirmed that the adolescents with NP showed a significantly lower CV angle than those without NP (46.5° vs 48.0°). The interdependence between the NP and the CV angles was confirmed with the NP being more prevalent in adolescents with FH than adolescents without FH (29.8% vs 8.4%).

This high prevalence of adolescents with FH and NP can be a reflection of modern Portuguese society, with information technology having a tremendous impact on the life of adolescents through daily use of internet, computers, and console games and with obesity on the rise.

Effect of sex on the postural angles and pain

Girls showed a lower resting CV angle than boys (46.5° vs 48.4°), which is in accordance with Hakala et al.[29], who found females had 2-3° more neck flexion than males in a study of standing cervical habitual posture in adolescents. Also in adults, significant sex differences in CV angle have been observed previously, with women having a more forward head position than men[29]. This posture of greater flexion in females can be attributable to psychosocial issues, such as stress, or partly associated with the development of secondary sex characteristics in females.

Contrary to the current study, two studies with small samples reported no sex differences for cervical habitual posture in adolescents and pre-adolescents[2,6]. More research is required to clarify the role of sex in cervical posture.

Regarding shoulder posture, we found similar mean values in boys and girls. This is in accordance with Raine and Twomey[33], who also reported this

similarity in all age groups studied, including the 17-29 age group.

Regarding NP, 52.9% of the girls reported regular NP, contrasting with 19% of the boys. This result is in accordance with previous cross-sectional studies that showed a greater female predisposition to musculoskeletal pain[34]. The reasons for this remain speculative, but we can hypothesize that this result may have been influenced by differences in musculoskeletal systems, such as the fact that girls revealed a significantly lower mean CV angle. Other explanations may be related to differences in behavioral factors, with boys having the tendency to deny pain and girls to overestimate their symptoms at puberty and to have more study-related stress.

Limitations

The study aimed to minimize errors and bias by recruiting a large sample, setting careful positioning and testing procedures, and blinding the digitization procedure. However it still has some limitations such as the fact that it describes only the alignment of the spine and the shoulder girdle at rest. Therefore the findings cannot be generalized to alignment during functional tasks, especially when the upper limb is moving or loaded.

Another limitation refers to the fact that we have only evaluated the dominant-side. To be more complete, postural alterations could be observed in a non-dominant side as well.

It should also be highlighted that future studies need to characterize the entire spine given the potential influence postures at the lumbar spine have on head position. Also some other variables such as anthropometric variables (e.g. height), degree of thoracic kyphosis or physical activity level must be taken into account.

Conclusion

The results of the present study showed that the photographic measurement is a reliable tool to assess the standing sagittal posture of the cervical spine and shoulder. It also showed that forward head and protracted shoulder are common postural disorders in adolescents. 68% and 58% of the adolescents revealed anteriorization of the head and protraction of the shoulder, respectively. The subjects with neck pain had a more forward head posture. Sex was also found to have an important effect on posture and neck pain, with girls revealing a lower cervical angle and more neck pain.

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Assessment of the measurement properties of quality of life questionnaires in Brazilian women with breast cancer

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ABSTRACT | **Background:** There are several questionnaires available to assess quality of life in breast cancer, however the choice of the best questionnaire often does not take into account the adequacy of these questionnaires' measurement properties. **Objective:** To test the measurement properties of two generic quality of life questionnaires and one quality of life questionnaire specific for women with breast cancer. **Method:** We assessed 106 women after surgery for breast cancer. The assessment included application of the SF-36, WHOQOL-bref, and FACT-B+4 questionnaires as well as the Global Perceived Effect and Pain Numerical Rating scales. The participants were interviewed on three occasions to investigate internal consistency, floor and ceiling effects, construct validity, reproducibility, and responsiveness. **Results:** Most of the instruments' domains showed adequate internal consistency (Cronbach's alpha varying from 0.66 to 0.91). Reliability varied from poor to substantial ($ICC_{2,1}$ between 0.39 and 0.87) and agreement varied from negative to very good. The SF-36 presented doubtful agreement and showed floor and ceiling effects in three domains. The domains of the generic questionnaires presented moderate to good correlation with the FACT-B+4 (Pearson varying from 0.31 to 0.69). The internal responsiveness varied from small to large (ES varying from –0.26 to 0.98) and external responsiveness was found in only some of the instruments' domains. **Conclusions:** Most of the measurement properties tested for the WHOQOL-bref and FACT-B+4 were adequate as was their ability to assess quality of life in women with breast cancer. The SF-36 showed inadequacy in agreement and floor and ceiling effects and should not be used in women with breast cancer.

Keywords: breast cancer; questionnaires; quality of life; reliability and validity; physical therapy.

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Introduction

Breast cancer is a significant public health issue in Brazil, and it is considered the second most common cause of death among women[1]. After surgical treatment, the patient experiences severe physical and motor consequences that negatively influence the clinical condition. Some examples of these changes are limitation of the upper limb movements, pain and functional impairment, paresthesia, postural asymmetries, fibrosis of the glenohumeral joint, and lymphedema[2-5]. Some studies show the correlation between the treatment of breast cancer and functional impairment and demonstrate that the measurement of quality of life related to health becomes important to understand how the functional impairment interferes, in general, in the daily activities of the women diagnosed with breast cancer[6-9].

Quality of life (QoL) assessment consists basically of questionnaires, most of which have been created in English and are aimed toward English-speaking populations[10-12]. The number of instruments available to assess QoL in cancer patients has increased and today there are several breast cancer-specific questionnaires in the literature[12,13]. The Functional Assessment of Cancer Therapy - Breast plus Arm Morbidity (FACT-B+4) is a QoL questionnaire specific for women with breast cancer. The FACT-B+4 has been already tested in the Brazilian population and showed appropriate internal consistency, reproducibility, and construct validity[14] compared with other specific QoL questionnaires.

Additionally, generic questionnaires can be proposed for this assessment. The Medical Outcomes

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Study 36 - Item Short-Form Health Survey (SF-36) and World Health Organization Quality of Life - bref (WHOQOL-bref) questionnaires have been used to assess general QoL in Latin America[15-20]. However, measurement properties are not always tested in most instruments, taking into account the language and target population. To date, no published studies have completely tested the measurement properties of QoL assessment questionnaires in Brazilian-Portuguese and applied them to women with breast cancer.

Considering the choice of the most appropriate questionnaire for women with breast cancer, the aim of the present study is to test the measurement properties of the SF-36 and WHOQOL-bref compared to the FACT-B+4. The secondary objectives are to determine the preference and acceptance of the QoL questionnaire and assess its ease of comprehension. The hypothesis of this study is that the generic questionnaires available for general clinical purposes will be acceptable and will have good clinimetric results for the population of women with breast cancer when compared to the FACT-B+4.

Method

Sample

The study included 106 women who underwent breast cancer surgery, constituting a convenience sample that was assessed between 27 March and 28 November 2012. The inclusion criteria were: women aged 18 years or more with a primary diagnosis of breast cancer at any stage of the disease, submitted to breast cancer surgery in the last 5 years, discharged from hospital (to avoid immediate postoperative adaptations and consequent influence on the QoL), having received or currently receiving treatment with radiotherapy, chemotherapy, and/or hormone therapy, and recruited at Hospital do Câncer AC Camargo – Fundação Antônio Prudente, in the city of São Paulo, SP, Brazil. The exclusion criteria were: breast cancer as a secondary diagnosis and inability to read, write or speak fluently in Portuguese.

The participants who agreed to participate signed an informed consent form prior to data collection. The study was approved by the Research Ethics Committee of Universidade Cidade de São Paulo (UNICID), São Paulo, SP, Brazil (protocol 13616825) and by the Human Research Ethics Committee of Fundação Antônio Prudente – Hospital do Câncer AC Camargo, São Paulo, SP, Brazil (protocol 1627/11).

Assessment instruments

Assessment sheet

An assessment sheet was used to gather sociodemographic, clinical data, and clinical characteristics of the cancer. Some data were obtained directly from the patient's electronic medical records.

Medical Outcomes Study 36 – Item Short - Form Health Survey (SF-36)

The SF-36[21], adapted to Brazilian-Portuguese[22], is a generic QoL questionnaire composed of 11 questions with 36 items divided into eight dimensions: physical functioning (questions 3 to 12), role limitations due to physical health (role-physical - questions 13 to 16), role limitations due to emotional problems (role-emotional - questions 17 to 19), bodily pain (questions 21 and 22), general health perceptions (questions 1 and 33 to 36), vitality (questions 23, 27, 29 and 31), social functioning (questions 20 and 32), mental health (questions 24 to 26, 28 and 30), and one extra question (question 2) not included in the total score. The score for each dimension varies from 0 to 100, with zero being the worst possible health condition and 100 being the best possible health condition[22]. The score was calculated according to the scoring rules of the RAND 36 Health Survey item 1.0, in two phases: 1) all of the items were scored on a scale of 0 to 100; and 2) the mean of the items of each dimension were calculated to create the eight scores of the scale. Any unanswered questions were not included in the calculation. At last, the scores for each dimension represent the mean of all answered items[23].

World Health Organization Quality of Life – bref (WHOQOL-bref)

The WHOQOL-bref questionnaire is an abbreviated version of the WHOQOL-100[24] that has been adapted to Brazilian-Portuguese[25]. It contains 26 questions, including 2 general questions, and the remaining 24 questions representing each of the 24 aspects of the original instrument. It is divided into four domains: physical health (questions 3, 4, 10 and 15 to 18), psychological (questions 5, 6, 7, 11, 19 and 26), social relationships (questions 20 to 22), and environment (questions 8, 9, 12 to 14 and 23 to 25). The WHOQOL-bref scores are calculated according to an algorithm[26] that considers the number of answered questions in each of the domains and standardizes the scores of all domains from zero to 100, with zero being the worst possible health

condition and 100 being the best health condition. The algorithm inverts the score values for questions 3, 4, and 26 to calculate the final score[25,27,28].

Functional Assessment of Cancer Therapy – Breast plus Arm Morbidity (FACT-B+4)

The breast cancer-specific questionnaire FACT-B+4 consists of 36 questions, 27 of which refer to overall QoL and 9 to specific problems of patients with breast cancer[29]. In 2001, a four-question subscale was added to the FACT-B questionnaire to assess arm morbidity in patients submitted to breast surgery[30]. The FACT-B+4 has been adapted into Brazilian-Portuguese[31]. It is divided into six scales with independent scores: physical well-being ranging from 0 to 28 (questions GP1 to GP7), social/family well-being ranging from 0 to 28 (questions GS1 to GS7), emotional well-being ranging from 0 to 24 (questions GE1 to GE6), functional well-being ranging from 0 to 28 (questions GF1 to GF7), breast cancer subscale ranging from 0 to 36 (questions B1 to B9) and arm subscale ranging from 0 to 20 (questions B3 and B10 to B13). The answers are presented on a five-point Likert scale. The score is calculated separately for each scale by adding up the points for each question. The values for some questions (GP1 to GP7, GE1, GE3 to GE6, B1 to B3, B5 to B8, B10 to B13) are inverted in the calculation of the final score. When there were any unanswered questions, the mean of the answered questions was considered for that scale. The results are added to obtain the final total score ranging from 0 to 164. The higher the score is, the better the patient's QoL[29,30].

Global Perceived Effect scale (GPE)

For this research, the GPE scale[32] was adapted to assess the patient's level of perception of recovery since the day of diagnosis with breast cancer. The guiding question was "Compared to when you received your diagnosis, how would you describe your quality of life these days?". It is an 11-point numerical scale (–5 to 5), with –5 being vastly worse; 0 being no change; and 5 being complete recovery. The higher the score is, the better the recovery from the condition[32].

Pain Numerical Rating scale (PNR)

The five-point adapted PNR scale[33] was used to verify the patient's degree of understanding regarding the QoL questionnaires. The guiding question is: "Did you understand what was asked in the questionnaire?" The minimum value is 0, meaning "I did not understand anything", and the maximum value is 5, meaning "I understood perfectly and did not have any questions"[33].

Procedures

The researcher collected the participants' sociodemographic and clinical data and administered the QoL questionnaires at baseline. After that, the participants were informed of the subsequent days when the questionnaires would be administered over the phone, i.e. 48 hours and 30 days after the first session. The 48-hour interval between the first and second session was established to avoid significant changes in the patient's QoL, thus allowing the evaluation of the test-retest reproducibility of the questionnaire. The 30-day interval between the first and third session was established to allow sufficient time for changes in QoL and thus test the responsiveness of the questionnaires[34].

Statistical analysis

The assessments of the measurement properties, described in detail in Table 1, were conducted according to procedures recommended by Maher et al.[11] and Terwee et al.[34].

Results

A total of 111 eligible women were invited to take part in the study: 5 women declined to answer the questionnaires and 106 women agreed to participate. Of the 106 participants, 99 responded to the second assessment session after 48 hours and 94 responded to the third assessment session after 30 days. These drop outs were caused by side effects of chemotherapy, pneumonia associated with hospital stay, low immunity, infection, necrosis of surgical wound, and second surgery. Table 2 shows the clinical and demographic characteristics, and Table 3 shows the scores for the QoL questionnaires applied in the three assessment sessions. The postoperative period ranged from 3 days to 4 years.

Regarding acceptance and preference for the questionnaire that best represented QoL, 53.8% of the participants chose the FACT-B+4 (Table 2). Regarding ease of comprehension of the questionnaires, the means were similar (Table 3).

In the assessment of the internal consistency, Cronbach's alpha for all of the instruments was adequate, with the exception of: the social functioning dimension of the SF-36; the social relationships domain of the WHOQOL-bref, with the highest

Table 1. Measurement properties tested.

	Measurement properties
Internal consistency	The homogeneity of the items of the questionnaire was tested using Cronbach's alpha[11,35] and Cronbach's alpha if an item deleted. The Cronbach alpha values are considered adequate when equal to or greater than 0.70 and less than 0.95[11,35].
Reproducibility	The term reproducibility incorporates two measurement properties: reliability and agreement. Reliability was tested using Type 2,1 Intraclass Correlation Coefficient ($ICC_{2,1}$) with 95% confidence intervals (CIs). An ICC of less than 0.40 represents poor reliability; between 0.40 and 0.75 represents moderate reliability; between 0.75 and 0.90, substantial reliability; and greater than 0.90, excellent reliability. Agreement was measured using the following measurements: Standard Error of the Measurement (SEM)[36] and Smallest Detectable Change (SDC)[11,35]. The SEM was calculated by the ratio of the standard deviation of the mean difference to the square root of two. The percentage of the SEM related with the total score of the questionnaire can be interpreted as follows: ≤5%: very good; >5% and ≤10%: good; >10% and ≤20%: doubtful and >20%: negative[37]. The SDC was calculated using the formula $SDC=1.645 \times \sqrt{2} \times SEM$, with 90% CI, which reflects the smallest detectable change in an individual's score. Thus, it can be interpreted that values above the SDC describe a change in the individual's score above the error of the measurement[35].
Construct validity	We correlated the domains with the most similarities, e.g. the SF-36 dimensions physical functioning, role-physical, role-emotional, and social functioning with the FACT-B+4 scales functional well-being, physical well-being, emotional well-being, and social/family well-being, respectively, and the WHOQOL-bref domains physical health, psychological, and social relationships with the FACT-B+4 scales physical well-being, emotional well-being, and social/family well-being, using Pearson's correlation test (r). When $r<0.30$, the correlation was considered weak, when $r\geq0.30$ and <0.60 the correlation was considered moderate and when $r\geq0.60$ the correlation was considered good[36]. It is expected that the generic quality of life questionnaires SF-36 and WHOQOL have a positive correlation with the FACT-B+4 with $r\geq0.60$, assuming that the construct of the evaluated domains of the three questionnaires were similar.
Responsiveness	The analysis of the responsiveness was based on the participants who showed clinical changes, considering a two-point change (negative or positive) in the GPE scale. The internal responsiveness was assessed by calculating the effect size (ES: mean of difference between initial assessment and 30-day follow-up, divided by the standard deviation of the initial assessment) with 84% CI. We chose 84% CI to allow a direct comparison of the ES of different instruments since CIs that do not exceed 84% are equivalent to Z scores at 95%[38,39]. A value for ES ≤0.20 represents a change of approximately 1/5 of the standard deviation at the beginning of treatment and it is considered small. A value of 0.50 is considered moderate and a value ≥0.80 is considered large[40]. The external responsiveness was measured by two tests: 1) Pearson's Correlation test to determine the correlation between the initial and 30-day assessments of the dimensions of the SF-36[22], WHOQOL-bref[25], FACT-B+4[29] and the GPE scale[32] assessed on the 30-day assessment session. This type of responsiveness test compares the instruments' sensitivity to change in relation to a global measurement of quality of life; and 2) the construction of ROC (Receiver-Operator Characteristics) curves using the differences between the initial and 30-day assessments of the SF-36, WHOQOL-bref, FACT-B+4 and the GPE scale dichotomized in patients who changed their quality of life status. The cut-off point to categorize change was based on the number of women who changed their quality of life considering a two-point variation in the GPE scale assessed in the 30-day assessment session. The analysis was based on the area under the curve (AUC) and values of 0.70[35] or more were considered responsive. This type of responsiveness measures the questionnaire's ability to distinguish patients who changed quality of life status from those who did not[11,35].
Floor and ceiling effects	These measurements were calculated by the percentage of patients who achieved the maximum score (ceiling) or the minimum score (floor). These effects are considered when 15% of respondents reach the ceiling or floor scores, leading to implications on the questionnaire's reproducibility and responsiveness[11,35].

value of Cronbach's alpha if item deleted reached when question 21 was deleted; and the emotional well-being scale and breast cancer subscale of the FACT-B+4, with no change when using Cronbach's alpha if item deleted (Table 4).

Considering reliability, the SF-36 had six dimensions with moderate reliability, the WHOQOL-bref had substantial reliability in all domains, and the FACT-B+4 had five scales with moderate reliability (Table 4). In most dimensions of the SF-36, agreement was classified between doubtful and negative; the

Table 2. Characteristics of study participants.

Variables	Baseline (n=106)
Age (years), mean (SD)	49.2 (9.6)
Height (m), mean (SD)	1.6 (0.1)
Weight (Kg), mean (SD)	71.2 (13.3)
BMI (kg/m^2), mean (SD)	27.3 (4.3)
Marital status, n (%)	
single	27 (25.5)
married	61 (57.5)
divorced	13 (12.3)
widow	5 (4.7)
Educational level, n (%)	
Primary education	12 (11.3)
Secondary education	24 (22.7)
Tertiary education	70 (66)
Postoperative date (weeks), mean (SD)	32.7 (50.2)
Metastasis[1], n (%)	26 (24.5)
Type of surgery, n (%)	
Radical Mastectomy	15 (14.2)
Modified Radical Mastectomy	68 (64.2)
Quadrantectomy	23 (21.7)
Axillary dissection[2], n (%)	94 (88.7)
Type of axillary dissection[1] n (%)	
Sentinel node	24 (22.6)
Partial axillary dissection	22 (20.8)
Total axillary dissection	47 (44.3)
Lymphedema, n (%)	18 (17)
Fibrous cord, n (%)	31 (29.2)
Breast reconstruction[1], n (%)	58 (54.7)
Type of reconstruction[1], n (%)	
Silicone	34 (32.1)
Tissue expander	23 (21.7)
None	48 (45.3)
Questionnaire that best represented the QoL[1], n (%)	
SF-36	14 (13.2)
WHOQOL-bref	34 (32.1)
FACT-B+4	57 (53.8)

BMI (body mass index), QoL (quality of life), SF-36 (Medical Outcomes Study 36 – Item Short-Form Health Survey), WHOQOL-bref (World Health Organization Quality of Life – bref), FACT-B+4 (Functional Assessment of Cancer Therapy – Breast plus Arm Morbidity). [1]Missing data (%): Metastasis (2.8), Type of axillary dissection (0.9), Breast reconstruction (0.9), Type of reconstruction (0.9), Questionnaire that best represented the QoL (0.9); [2]Patients who did not undergo axillary dissection (11.3%).

WHOQOL-bref had good agreement in all domains; and the agreement levels of the FACT-B+4 varied from very good to doubtful (Table 4). Regarding the floor or ceiling effects, values above 15% were only found in three dimensions of the SF-36, with floor effect in the role-physical and role-emotional dimensions and ceiling effect in the role-emotional and social functioning dimensions (Table 4).

For the construct validity, the correlations between the scales of the FACT-B+4 and the SF-36 varied from good to moderate (correlation between role-physical dimension of the SF-36 and physical well-being scale of the FACT-B+4: r=0.31, p=0.001; correlation between role-emotional dimension of the SF-36 and emotional well-being scale of FACT-B+4: r=0.41, p=0.000; correlation between physical functioning dimension of the SF-36 and functional well-being scale of FACT-B+4: r=0.39, p=0.000). The association of the scales of the FACT-B+4 and WHOQOL-bref showed good correlation (correlation between physical health domain of the WHOQOL-bref and physical well-being scale of FACT-B+4: r=0.69, p=0.000; correlation between social relationships domain of the WHOQOL-bref and social/family well-being scale of FACT-B+4: r=0.62, p=0.000; correlation between psychological domain of the WHOQOL-bref and emotional well-being scale of FACT-B+4: r=0.61, p=0.000).

In the assessment session after 30 days, 62 patients had changes <2 points and 32 patients had clinical changes ≥2 points in the GPE scale. The analysis of responsiveness considered the data from these 32 patients. Regarding internal responsiveness, the SF-36 showed moderate ES in all dimensions except physical functioning and general health perceptions, which had small ES, and bodily pain, which had large ES. The WHOQOL-bref showed small ES in all domains, except physical health, with moderate ES. The FACT-B+4 showed moderate ES in all scales except social/family well-being, emotional well-being, and functional well-being, which had small ES. With 84% CI, there was no difference between similar domains, i.e. in all comparisons there was overlapping between the CIs. For example, the role-physical dimension of the SF-36 presented ES=0.29 with 84% CI of 0.04 to 0.54 which overlapped the CI of the physical health domain of the WHOQOL-bref, with ES=0.53 and 84% CI of 0.24 to 0.80, and of the physical well-being scale of the FACT-B+4, with ES=0.33 and 84% CI of 0.02 to 0.63.

In the external responsiveness assessment using ROC curve analysis, all dimensions of the SF-36 were responsive, except for physical functioning,

Table 3. Scores of quality of life questionnaires and scales used in the study in the three assessment sessions, in mean and standard deviation.

Variables	Baseline (n=106)	48 hr after baseline (n=99)	30 days after baseline (n=94)
SF-36 - Dimensions			
Physical functioning (0-100)	70.0 (36.2)[1]	70.0 (25)[1]	75.0 (31.2)[1]
Role-physical (0-100)	0.0 (25)[1]	0.0 (0.0)[1]	0.0 (56.2)[1]
Role-emotional (0-100)	66.6 (100)[1]	33.3 (100)[1]	100.0 (66.7)[1]
Bodily pain (0-100)	61.0 (20.7)	62.0 (20.3)	64.8 (18.0)
General health perceptions (0-100)	68.0 (19.2)	70.3 (19.0)	72.1 (18.3)
Vitality (0-100)	65.3 (25.9)	61.4 (23.3)	71.2 (22.7)
Social functioning (0-100)	62.5 (37.5)[1]	62.5 (25.0)[1]	75 (28.1)[1]
Mental health (0-100)	72.0 (28.0)[1]	68.4 (18.0)	69.6 (16.3)
WHOQOL-bref - Domains			
Physical health (0-100)	50.6 (17.2)	60.3 (16.4)	63.1 (16.2)
Psychological (0-100)	67.4 (16.8)	70.8 (20.8)[1]	68.6 (15.9)
Social relationships (0-100)	66.7 (19.7)	65.9 (17.9)	66.6 (18.7)[1]
Environment (0-100)	68.9 (12.7)	67.8 (12.8)	67.2 (12.5)[1]
FACT-B+4 - Scales			
Physical well-being (0-28)	21.0 (7.2)[1]	21.0 (8.0)[1]	23.0 (7.3)[1]
Social/family well-being (0-28)	22.0 (7.2)[1]	19.8 (8.0)[1]	21.0 (8.0)[1]
Emotional well-being (0-24)	20.0 (6.0)[1]	20.0 (5.0)[1]	20.0 (5.0)[1]
Functional well-being (0-28)	17.8 (5.7)	17.1 (4.9)	18.0 (7.0)[1]
Breast cancer subscale (0-36)	22.3 (5.7)	23.0 (7.0)[1]	25.0 (7.2)[1]
Arm subscale (0-20)	14.1 (4.3)	14.9 (3.9)	15.6 (3.7)
FACT-B+4 total score (0-164)	101.2 (17.6)	100.3 (19.1)	103.5 (19.0)
GPE (–5 a +5)	2.6 (2.3)	2.6 (2.4)	2.6 (2.4)
PNR			
SF-36 (1-5)	4.5 (0.7)	4.6 (0.6)	4.6 (0.6)
WHOQOL-bref (1-5)	4.6 (0.6)	4.6 (0.5)	4.6 (0.5)
FACT-B+4 (1-5)	4.6 (0.5)	4.7 (0.5)	4.7 (0.5)

SF-36 (Medical Outcomes Study 36 – Item Short - Form Health Survey), WHOQOL-bref (World Health Organization Quality of Life – bref), FACT-B+4 (Functional Assessment of Cancer Therapy – Breast plus Arm Morbidity), GPE (Global Perceived Effect scale), PNR (Pain Numerical Rating scale). [1]Data expressed as median and interquartile range.

role-physical, and role-emotional. In the WHOQOL-bref, all domains had values above 0.70. The physical well-being, functional well-being, and total score scales of the FACT-B+4 were responsive. The Pearson correlation analysis showed a significant and moderate correlation in the dimensions bodily pain, general health perceptions, vitality, and mental health of the SF-36. The WHOQOL-bref showed significant good and moderate correlation for the domains psychological and social relationships, respectively. The FACT-B+4 showed a moderate correlation for the functional well-being and total score scales of the FACT-B+4 (Table 5).

Discussion

Most of the domains of the SF-36, WHOQOL-bref, and FACT-B+4 showed acceptable values for the measurement properties. All instruments showed good comprehension represented by similar means. With regard to the questionnaire which best-represented QoL, 53.8% of the participants chose the FACT-B+4, possibly due to the fact that

Table 4. Values of internal consistency, reproducibility and floor or ceiling effects.

Instruments	Internal consistency	Reproducibility			Floor or ceiling effects	
	Cronbach's alpha (Cronbach's alpha if an item was deleted)	Reliability$ICC_{2,1}$ (95% CI)	Agreement SEM (%)	Agreement SDC	Floor (%)	Ceiling (%)
SF-36 - Dimensions						
Physical functioning (0-100)	0.88 (0.85-0.87)	0.77 (0.68 to 0.84)	11.28 (11.28)	26.24	0.0	6.6
Role-physical (0-100)	0.91 (0.87-0.89)	0.55 (0.40 to 0.68)	23.24 (23.24)	54.06	68.9	13.2
Role-emotional (0-100)	0.88 (0.77-0.91)	0.39 (0.21 to 0.54)	34.52 (34.52)	80.30	33	44.3
Bodilypain (0-100)	0.76 (-)[1]	0.58 (0.42 to 0.70)	15.17 (15.17)	35.28	0.9	5.7
General health perceptions (0-100)	0.70 (0.56-0.69)	0.74 (0.63 to 0.82)	8.82 (8.82)	20.51	0.0	7.5
Vitality (0-100)	0.82 (0.75-0.80)	0.73 (0.62 to 0.81)	10.66 (10.66)	24.81	0.0	1.9
Social functioning (0-100)	0.56 (-)[1]	0.52 (0.37 to 0.66)	16.73 (16.73)	38.91	0.9	17
Mental health (0-100)	0.82 (0.77-0.81)	0.71 (0.60 to 0.78)	10.37 (10.37)	24.12	0.0	0.0
WHOQOL-bref - Domains						
Physical health (0-100)	0.83 (0.76-0.84)	0.80 (0.72 to 0.87)	7.39 (7.39)	17.18	0.0	0.9
Psychological (0-100)	0.78 (0.74-0.80)	0.87 (0.81 to 0.91)	6.06 (6.06)	14.10	0.0	0.9
Social relationships (0-100)	0.68 (0.47-0.78)	0.76 (0.66 to 0.82)	9.46 (9.46)	22.01	0.9	5.7
Environment (0-100)	0.75 (0.70-0.75)	0.80 (0.71 to 0.87)	5.77 (5.77)	13.43	0.0	0.0
FACT-B+4 - Scales						
Physical well-being (0-28)	0.75 (0.68-0.76)	0.62 (0.50 to 0.73)	2.97 (10.60)	6.93	0.0	3.8
Social/family well-being (0-28)	0.85 (0.80-0.88)	0.76 (0.60 to 0.86)	2.46 (8.78)	5.73	0.0	10.4
Emotional well-being (0-24)	0.67 (0.57-0.67)	0.72 (0.61 to 0.80)	1.79 (7.45)	4.19	0.0	11.3
Functional well-being (0-28)	0.84 (0.80-0.85)	0.62 (0.50 to 0.73)	3.25 (11.60)	7.57	0.9	1.9
Breast cancer subscale(0-36)	0.66 (0.60-0.67)	0.71 (0.60 to 0.80)	2.94 (8.16)	6.87	0.0	0.0
Arm subscale (0-20)	0.84 (0.79-0.85)	0.75 (0.65 to 0.82)	2.02 (10.10)	4.71	0.9	9.4
FACT-B+4 total score (0-164)	0.88 (0.87–0.89)	0.86 (0.80 to 0.90)	7.07 (4.31)	16.48	0.0	0.0

ICC (Intraclass Correlation Coefficient), CI (confidence interval), SEM (standard error of the measurement), SDC (smallest detectable change), SF-36 (Medical Outcomes Study 36 – Item Short - Form Health Survey), WHOQOL-bref (World Health Organization Quality of Life – bref), FACT-B+4 (Functional Assessment of Cancer Therapy – Breast plus Arm Morbidity). [1]Insufficient number of items for calculating Cronbach's alpha if an item was deleted.

this instrument included specific questions to breast cancer and upper limb limitations.

In our study, the SF-36 showed adequate Cronbach's alpha in all dimensions except social functioning. Similar studies with different samples were found in the literature. In a population of Chinese medical students, Cronbach's alpha ranged from 0.63 to 0.82, with the lowest value in the social functioning dimension. This result may be due to the fact that the items of this dimension are not sensitive to cultural variations and may need to be adapted to the characteristics of the target population[41]. In Chinese patients with chronic diseases, Cronbach's alpha ranged from 0.54 to 0.93, with the lowest values in the dimensions bodily pain (0.54) and social functioning (0.62)[42]. In contrast, in a study with a population of 50 healthy individuals and 80 patients with chronic disease, Cronbach's alpha ranged from 0.72 to 0.89[43].

Moderate reliability was found in all dimensions of the SF-36 except role-emotional, which had poor reliability, making it impossible to obtain similar results among the participants of this study. Other studies found in the literature show substantial to excellent reliability. In a population of Chinese patients with chronic disease, ICC values ranged from 0.83 to 0.96[42]. In a sample of 130 Arabic individuals, ICC ranged from 0.95 to 0.98[43]. However, both of these studies may have overestimated the results because they did not report the type of ICC used.

Table 5. Internal and external responsiveness.

Instruments	Internal responsiveness	External responsiveness	
	ES (84% CI) (n=32)	AUC[1] (95% CI) (n=32)	r (p) (n=32)
SF-36 - Dimensions			
Physical functioning (0-100)	0.11 (–0.23 to 0.45)	0.49 (0.28 to 0.70)	0.17 (0.35)
Role-physical (0-100)	0.29 (0.04 to 0.54)	0.49 (0.27 to 0.71)	–0.04 (0.81)
Role-emotional (0-100)	0.26 (0.01 to 0.52)	0.58 (0.35 to 0.80)	0.08 (0.68)
Bodily pain (0-100)	0.98 (0.68 to 1.27)	0.71 (0.52 to 0.89)	0.37 (0.03)**
General health perceptions (0-100)	–0.26 (–0.52 to –0.01)	0.71 (0.52 to 0.89)	0.42 (0.01)**
Vitality (0-100)	0.39 (0.13 to 0.65)	0.75 (0.58 to 0.92)	0.36 (0.38)**
Social functioning (0-100)	0.41 (0.16 to 0.67)	0.71 (0.50 to 0.92)	0.34 (0.06)
Mental health (0-100)	0.36 (0.14 to 0.58)	0.86 (0.68 to 1.00)	0.53 (0.00)*
WHOQOL-bref - Domains			
Physical health (0-100)	0.53 (0.24 to 0.80)	0.73 (0.54 to 0.92)	0.27 (0.14)
Psychological (0-100)	0.02 (–0.11 to 0.17)	0.88 (0.76 to 0.99)	0.61 (0.00)*
Social relationships (0-100)	0.12 (–0.06 to 0.30)	0.80 (0.65 to 0.95)	0.44 (0.01)**
Environment (0-100)	0.00 (–0.19 to 0.21)	0.71 (0.52 to 0.89)	0.32 (0.07)
FACT-B+4 - Scales			
Physical well-being (0-28)	0.33 (0.02 to 0.63)	0.73 (0.54 to 0.90)	0.33 (0.06)
Social/family well-being (0-28)	–0.11 (–0.28 to a 0.05)	0.60 (0.40 to 0.79)	0.30 (0.90)
Emotional well-being (0-24)	0.17 (–0.08 to 0.44)	0.58 (0.37 to 0.78)	0.22 (0.22)
Functional well-being (0-28)	0.07 (–0.18 to 0.32)	0.86 (0.72 to 0.99)	0.59 (0.00)*
Breast cancer subscale (0-36)	0.37 (0.13 to 0.60)	0.51 (0.28 to 0.74)	–0.03 (0.86)
Arm subscale (0-20)	0.36 (0.11 to 0.60)	0.45 (0.23 to 0.66)	–0.25 (0.17)
FACT-B+4 total score (0-164)	0.22 (–0.01 to 0.47)	0.71 (0.51 to 0.91)	0.40 (0.02)**

SF-36 (Medical Outcomes Study 36 – Item Short - Form Health Survey), WHOQOL-bref (World Health Organization Quality of Life – bref), FACT-B+4 (Functional Assessment of Cancer Therapy – Breast plus Arm Morbidity), ES (Effect size), AUC (area under the curve), CI (Confidence interval). [1]Cutoff for improvement ≥2 in the Global Perceived Effect scale; *Statistically significant correlations ($p<0.01$), **Statistically significant correlations ($p<0.05$).

That may be the reason why these studies found higher ICC values than those in our study. For agreement, the present study found high standard error of measurement (SEM) values (most of the dimensions showed values >10% and ≤20%) and smallest detectable change (SDC) ranging from 20.51 to 80.30, characterizing the SF-36 as having doubtful agreement.

We found the presence of floor effect in the dimensions role-physical and role-emotional and the presence of ceiling effect in the dimensions role-emotional and social functioning. These specific dimensions were probably unable to detect change in the patients' health condition, with implications on reproducibility and responsiveness. For construct validity, analyzed by the combination of dimensions from the SF-36 and the FACT-B+4, the results indicated a significant correlation in all dimensions except the social functioning dimension of the SF-36. No studies were found that conducted a similar correlation between these two questionnaires.

The assessment of the internal responsiveness showed that responsiveness ranged from small to large. Considering external responsiveness, the SF-36 was characterized as a responsive instrument. Furthermore, a significant correlation was found between the dimensions that had AUC values above 0.70. The SF-36 showed at least one dimension with inadequate values in all measurement properties

tested. This result implies that the SF-36 should not be used to evaluate QoL in patients with breast cancer.

The WHOQOL-bref presented adequate internal consistency in most of the domains, except for the social relationships domain. No studies were found on assessment of the measurement properties of the WHOQOL-bref in patients with breast cancer. In other populations, studies that tested the internal consistency of the WHOQOL-bref found similar values[25,28,44-46]. One study in which the internal consistency of the WHOQOL-bref was compared to that of the WHOQOL-100 found a higher Cronbach's alpha. Thus, the low value of the abbreviated questionnaire can be explained by the low number of questions in the social relationships domain given that Cronbach's alpha is dependent on the number of items of a scale[25,34].

Reliability was substantial in all domains of the WHOQOL-bref. These results are similar to those of one study[28], in which the values varied from substantial to excellent. However, this study[28] does not report the type of ICC used. For the agreement, good SEM values were found and an SDC of 13.43 to 22.01, characterizing the WHOQOL-bref as having good agreement.

There were no floor or ceiling effects. The construct validity presented a good correlation. No study was found that conducted a similar correlation between the two questionnaires. Internal responsiveness showed small responsiveness in most of the domains. A study with smokers also found small responsiveness for all domains except the psychological domain[44]. The assessment of the external responsiveness by the AUC showed responsiveness in all domains. However, only the psychological and social relationship domains showed significant correlation. After the analysis, the WHOQOL-bref can be used to assess QoL in patients with breast cancer given that the measurement properties were adequate and the instrument was able to detect clinical changes over time.

The FACT-B+4 showed adequate values for internal consistency, with the exception of the emotional well-being scale and the breast cancer subscale. Other studies found lower internal consistency values for the same scales, suggesting that there is no homogeneity in these scales. For example, in the original validation study of the arm subscale of the FACT-B+4, the internal consistency ranged from 0.62 to 0.83[30]; in a sample of breast cancer patients before surgery with upper limb lymphedema, the internal consistency varied from 0.52 to 0.92[47].

For reliability, most scales showed moderate reliability. Conflicting results were found in a sample of patients with lymphedema, with reliability ranging from 0.40 to 0.88[47], and the study did not report the type of ICC used. The agreement values for the scales of the FACT-B+4 were characterized between good and doubtful. For the FACT-B+4 total score, a very good agreement was observed. Floor or ceiling effects were not observed. In contrast, another study on women with breast cancer showed ceiling effects in the physical well-being and social/family well-being scales and the arm subscale[47]. For construct validity, the FACT-B+4 presented better correlation with the WHOQOL-bref, with good correlation between all scales.

The assessment of internal responsiveness showed small to moderate responsiveness. External responsiveness, based on the analysis of the AUC, was only found for the physical well-being, functional well-being, and total score scales. The correlation analysis showed moderate correlation for the functional well-being scale and total score.

The measurement of QoL is important to understand how functional impairment interferes in the daily activities of women undergoing treatment for breast cancer. Considering that the assessment of QoL is multidimensional[48,49], with different meanings depending on the variety of life contexts, maintenance of functional capacity, general satisfaction, personal fulfillment, and social interaction[48,49], physical therapists should investigate QoL with the goal of improving the treatment and monitoring the evolution of the clinical condition, which contributes to prevention interventions or treatment directions[6,50].

Some limitations can be suggested in this study. The inclusion criteria included the largest possible number of women with breast cancer regardless of their phase of treatment. The wide variety in the type of surgery and time since surgery may have become a limitation because a more homogeneous sample in regard to treatment phase or surgery type could have resulted in similar changes in QoL. However, the current sample was based on previous studies[51,52]. Another limitation was the 30-day interval for the responsiveness assessment. Perhaps if this follow-up time had been longer, greater clinical changes could have occurred and better results could have been found.

Most of the measurement properties tested for the WHOQOL-bref and FACT-B+4 were adequate as was their ability to assess QoL in women with breast cancer. The domains of WHOQOL-bref and

FACT-B+4 are interconnected in the measurement of QoL in the studied population. The SF-36 showed inadequacy in agreement and floor and ceiling effects and should not be used to assess QoL in women with breast cancer.

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BJPT Brazilian Journal of Physical Therapy

SCOPE AND POLICIES

The Brazilian Journal of Physical Therapy (BJPT) publishes original research articles on topics related to the areas of physical therapy and rehabilitation, including clinical, basic or applied studies on the assessment, prevention, and treatment of movement disorders.

Our Editorial Board is committed to disseminating quality scientific investigations from many areas of expertise.

The BJPT accepts the following types of study, which must be directly related to the journal's scope and expertise areas:

a) **Experimental studies:** studies that investigate the effect(s) of one or more interventions on outcomes directly related to the BJPT's scope and expertise areas. Experimental studies include single-case experimental studies, quasi-experimental studies, and clinical trials. The World Health Organization defines clinical trial as any research study that prospectively allocates human participants or groups of humans to one or more health-related interventions to evaluate the effect(s) on health outcome(s). Therefore, any study that aims to analyze the effect of a given intervention is considered as a clinical trial. Clinical trials include single-case studies, case series (a single group without a control group for comparison), non- randomized controlled trials and randomized controlled trials. Randomized controlled trials must follow the CONSORT (Consolidated Standards of Reporting Trials), recommendations, which are available at: http://www.consort-statement.org/consort-statement/overview0/. On this website, the author must access the CONSORT 2010 checklist, which must be completed and submitted with the manuscript. All manuscripts must also contain a CONSORT Statement 2010 Flow Diagram. From 2014, the entire submission process of experimental studies should address this recommendation.

b) **Observational studies:** studies that investigate the relationship(s) between variables of interest related to the BJPT' scope and expertise areas without direct manipulation (e.g. intervention). Observational studies include cross-sectional studies, cohort studies, and case-control studies.

c) **Qualitative studies:** studies that focus on understanding needs, motivations, and human behavior. The object of a qualitative study is guided by in-depth analysis of a topic, including opinions, attitudes, motivations, and behavioral patterns without quantification. Qualitative studies include documentary and ethnographic analysis.

d) **Literature reviews:** studies that analyze and/or synthesize the literature on a topic related to the scope and expertise areas of the BJPT. Critical or narrative reviews will only be published by invitation from the editors. Systematic reviews that include meta-analysis will have priority over other systematic reviews. Those that have an insufficient number of articles or articles with low quality and do not include an assertive and valid conclusion about the topic will not be considered for peer-review analysis.

e) **Methodological studies:** studies centered on the development and/or evaluation of psychometric properties and clinimetric characteristics of assessment instruments. They also include studies that aim to translate and/or cross-culturally adapt foreign questionnaires into Brazilian Portuguese. The authors' permission for translation and/or adaptation of the original instrument must be included in the submission process.

The EQUATOR Network website (http://www.equator-network.org/resource-centre/library-of-health-research-reporting) includes a full list of guidelines available for each type of study, such as the STROBE (STrengthening the Reporting of OBservational Studies in Epidemiology) for observational studies, the COREQ (Consolidated Criteria For Reporting Qualitative Research) for qualitative research, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) for systematic reviews and meta-analyses, and the GRRAS (Guidelines for Reporting Reliability and Agreement Studies) for reliability studies. We recommend that the authors check these guidelines and adhere to the appropriate checklist before submitting their manuscripts.

Studies that report electromyographic results must follow the ISEK (International Society of Electrophysiology and Kinesiology) Standards for Reporting EMG Data, available at http://www.isek-online.org/standards_emg.html.

Ethical and legal aspects

Submitting a manuscript to the BJPT implies that the article, in whole or in part, has not been published by another source of communication and that it is not being considered for publication by another journal.

The use of patient initials, names or hospital registration numbers must be avoided. Patients must not be identified in photographs, except with their express written consent attached to the original article at the time of submission.

Studies in humans must be in agreement with ethical standards and have the informed consent of the participants in accordance with National Health Council (NHC) Resolution 196/96 of the Brazilian Ministry of Health, which oversees the Human Research Ethics Code. Authors outside Brazil must follow the guidelines set forth by the Committee on Publication Ethics (COPE).

Animal experiments must comply with international guidelines (such as, the Committee for Research and Ethical Issues of the International Association for the Study of Pain [Pain, 16:109-110, 1983]).

For studies involving human and animal research, the manuscript must include the approval number given by the Research Ethics Committee. The study must be registered in the National Health Council of the university or hospital or by the National Health Council nearest to your area. The BJPT reserves the right not to publish manuscripts that do not adhere to the legal and ethical rules for human and animal research.

For clinical trials, any registration that satisfies the requirements of the International Committee of Medical Journal Editors (ICMJE), e.g. http://clinicaltrials.gov/ and/or http://www.anzctr.org.au will be accepted. The complete list of all clinical trial registries can be found at: http://www.who.int/ictrp/network/primary/en/index.html.

From 01/01/2014 the BJPT will effectively adopt the policy suggested by the International Society of Physiotherapy Journal Editors (ISPJE) and will require a prospective registration number (i.e., clinical trials that have begun the recruitment from this date must register the study BEFORE the recruitment of the first patient) by the time of the manuscript submission. For studies that have started recruitment up to 31/12/2013 retrospective registration will be accepted.

Authorship criteria

The BJPT accepts submissions of manuscripts with up to six (6) authors. The BJPT's authorship policy follows ICMJE requirements for Manuscripts Submitted to Biomedical Journals (www.icmje.org), which state that "authorship credit should be based on 1) substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; 2) drafting the article or revising it critically for important intellectual content; and 3) final approval of the version to be published." Conditions 1, 2, and 3 should all be met. Grant acquisition, data collection and/or general supervision of a research group do not justify authorship and must be recognized in the acknowledgements.

All authors are solely responsible for the content of the submitted manuscripts. All published material becomes property of the BJPT, which will retain the copyrights. Therefore, no material published in the BJPT may be reproduced without written permission from the editors. All authors of the submitted manuscript must sign a copyright transfer agreement form from the date of the acceptance of the manuscript.

The editors may consider, in exceptional cases, a request for submission of a manuscript with more than six (6) authors. The criteria for analysis include the type of study, potential for citation, methodological quality and complexity, among others. In these exceptional cases, the contribution of each author must be specified at the end of the text (after Acknowledgements and right before References), according to the guidelines of the International Committee of Medical Journal Editors and the Guidelines for Integrity in Scientific Activity widely disseminated by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq; http://www.cnpq.br/web/guest/diretrizes).

MANUSCRIPT FORM AND PRESENTATION

The BJPT accepts the submission of manuscripts with up to 3,500 words (excluding title page, abstract, references, tables, figures, and legends). Information contained in appendices will be included in the total number of words allowed.

The manuscript must be written preferably in English. Whenever the quality of the English writing hinders the analysis and assessment of the content, the authors will be informed.

It is recommended that manuscripts submitted in English be accompanied by certification of revision by a professional editing and proofreading service. This certification must be included in the submission. We recommend the following services, not excluding others:

- *American Journal Experts (www.journalexperts.com);*
- *Scribendi (www.scribendi.com);*
- *Nature Publishing Groups Language Editing* (https://languageediting.nature.com/login).

The manuscript must include a title and identification page, the abstract, and keywords before the body of the manuscript. References, tables, and figures and appendices should be inserted at the end of the manuscript.

Title and identification page

The title of the manuscript must not exceed 25 words and must include as much information about the study as possible. Ideally, the terms used in the title should not appear in the list of keywords. The identification page must also contain the following details:

- **Full title and short title** of up to 45 characters to be used as a legend on the printed pages;
- **Author**: author's first and last name in capital letters without title followed by a superscript number (exponent) identifying the institutional affiliation (department, institution, city, state, country). For more than one author, separate using commas;
- **Corresponding author**: name, full address, email, and telephone number of the corresponding author who is authorized to approve editorial revisions and provide additional information if needed.
- **Keywords:** up to six indexing terms or keywords in Portuguese and English.

Abstract

The abstract must be written in a structured format. A concise presentation not exceeding 250 words in a single paragraph, in English, must be written and inserted immediately after the title page. Do not include references, footnotes or undefined abbreviations.

Introduction

This part of the manuscript should give information on the subject of investigation, how it relates to other studies in the same field, and the reasons that justify the need for the study, as well as specific objective(s) of the study and hypotheses, if applicable.

Method

Clear and detailed description of the study participants and the procedures of data collection, transformation/reduction, and data analysis in order to allow reproducibility of the study. The participant selection and allocation process must be organized in a flowchart containing the

number of participants in each phase as well as their main characteristics (see model of CONSORT flow diagram).

Whenever relevant to the type of study, the author should include the calculation that adequately justifies the sample size for investigation of the intervention effects. All of the information needed to estimate and justify the sample size used in the study must be clearly stated.

Results

The results should be presented briefly and concisely. Pertinent results must be reported with the use of text and/or tables and/or figures. Data included in tables and figures must not be duplicated in the text.

Discussion

The purpose of the discussion is to interpret the results and to relate them to existing and available knowledge, especially the knowledge already presented in the Introduction. Be cautious when emphasizing recent findings. The data presented in the Methods and/or in the Results sections should not be repeated. Study limitations, implications, and clinical application to the areas of physical therapy and rehabilitation sciences must be described.

References

The recommended number of references is 30, except for literature reviews. Avoid references that are not available internationally, such as theses and dissertations, unpublished results and articles, and personal communication. References should be organized in numerical order of first appearance in the text, following the Uniform Requirements for Manuscripts Submitted to Biomedical Journals prepared by the ICMJE.

Journal titles should be written in abbreviated form, according to the List of Journals of Index Medicus. Citations should be included in the text as superscript (exponent) numbers without dates. The accuracy of the references appearing in the manuscript and their correct citation in the text are the responsibility of the author(s).

Examples: http://www.nlm.nih.gov/bsd/uniform_requirements.html.

Tables, Figures, and Appendices

A total of five (5) combined tables and figures is allowed. Appendices must be included in the number of words allowed in the manuscript. In the case of previously published tables, figures, and appendices, the authors must provide a signed permission from the author or editor at the time of submission.

For articles submitted in Portuguese, the English version of the tables, figures, and appendices and their respective legends must be attached in the system as a supplementary document.

- **Tables:** these must include only indispensable data and must not be excessively long (maximum allowed: one A4 page with double spacing). They should be numbered consecutively using Arabic numerals and should be inserted at the end of the text. Small tables that can be described in the text are not recommended. Simple results are best presented in a phrase rather than a table.
- **Figures:** these must be cited and numbered consecutively using Arabic numerals in the order in which they appear in the text. The information in the figures must not repeat data described in tables or in the text. The title and legend(s) should explain the figure without the need to refer to the text. All legends must be double-spaced, and all symbols and abbreviations must be defined. Use uppercase letters (A, B, C, etc.) to identify the individual parts of multiple figures.

If possible, all symbols should appear in the legends. However, symbols identifying curves in a graph can be included in the body of the figure, provided this does not hinder the analysis of the data. Figures in color will only be published in the online version. With regard to the final artwork, all figures must be in high resolution or in its original version. Low-quality figures may result in delays in the acceptance and publication of the article.

Acknowledgements: these must include statements of important contributions specifying their nature. The authors are responsible for obtaining the authorization of individuals/institutions named in the acknowledgements.

ELECTRONIC SUBMISSION

Manuscript submission must be done electronically via the website http://www.scielo.br/rbfis. Articles submitted and accepted in Portuguese will be translated into English by BJPT translators, and articles submitted and accepted in English will be forwarded to BJPT English proofreaders for a final review.

It is the authors' responsibility to remove all information (except on the title and identification page) that may identify the article's source or authorship.

When submitting a manuscript for publication, the authors must enter the author details into the system and attach the following supplementary documents:

1) Cover letter;
2) Conflict of interest statement;
3) Copyright transfer statement signed by all authors.
4) Other documents when applicable (e.g. permission to publish figures or excerpts from previously published materials, checklists, etc.).

THE REVIEW PROCESS

The submissions that meet the standards established and presented in accordance with the BJPT editorial policies will be forwarded to the area editors, who will perform an initial assessment to determine whether the manuscripts should be peer-reviewed. The criteria used for the initial analysis of the area editor include: originality, pertinence, clinical relevance, and methodology. The manuscripts that do not have merit or do not conform to the editorial policies will be rejected in the pre-analysis phase, regardless of the adequacy of the text and methodological quality. Therefore, the manuscript may be rejected based solely

on the recommendation of the area editor without the need for further review, in which case, the decision is not subject to appeal. The manuscripts selected for pre-analysis will be submitted to review by specialists, who will work independently. The reviewers will remain anonymous to the authors, and the authors will not be identified to the reviewers. The editors will coordinate the exchange between authors and reviewers and will make the final decision on which articles will be published based on the recommendations of the reviewers and area editors. If accepted for publication, the articles may be subject to minor changes that will not affect the author's style. If an article is rejected, the authors will receive a justification letter from the editor. After publication or at the end of the review process, all documentation regarding the review process will be destroyed.

AREAS OF EXPERTISE

1. Physiology, Kinesiology, and Biomechanics; 2. Kinesiotherapy/therapeutic resources; 3. Motor development, acquisition, control, and behavior; 4. Education, Ethics, Deontology, and Physical Therapy History; 5. Assessment, prevention, and treatment of cardiovascular and respiratory disorders; 6. Assessment, prevention, and treatment of aging disorders; 7. Assessment, prevention, and treatment of musculoskeletal disorders; 8. Assessment, prevention, and treatment of neurological disorders; 9. Assessment, prevention, and treatment of gynecological disorders; 10. Ergonomics/Occupational Health.

PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS DA REABILITAÇÃO MESTRADO E DOUTORADO

Recomendado pela CAPES – Conceito 5

O Programa de Pós-graduação em Ciências da Reabilitação tem como base a perspectiva apresentada no modelo proposto pela Organização Mundial de Saúde e propõe que as dissertações e trabalhos científicos desenvolvidos estejam relacionados com o desempenho funcional humano. Com a utilização de um modelo internacional, espera-se estimular o desenvolvimento de pesquisas que possam contribuir para uma melhor compreensão do processo de função e disfunção humana, contribuir para a organização da informação e estimular a produção científica numa estrutura conceitual mundialmente reconhecida. O Programa de Pós-graduação em Ciências da Reabilitação tem como objetivo tanto formar como aprofundar o conhecimento profissional e acadêmico, possibilitando ao aluno desenvolver habilidades para a condução de pesquisas na área de desempenho funcional humano.

O programa conta com parcerias nacionais e internacionais sedimentadas, e os seus laboratórios de pesquisa contam com equipamentos de ponta para o desenvolvimento de estudos na área de Ciências da Reabilitação.

Mais informações

Fone/Fax: (31) 3409-4781
www.eef.ufmg.br/mreab

Universidade Federal de São Carlos

Programa de Pós-Graduação em Fisioterapia

O Programa de Pós-Graduação em Fisioterapia tem como área de concentração: "Processos de Avaliação e Intervenção em Fisioterapia". Nosso objetivo é oferecer condições acadêmicas necessárias para que o aluno adquira um repertório teórico e metodológico, tornando-se apto a exercer as atividades de docente de nível universitário e iniciá-lo na carreira de pesquisador.
Os cursos de mestrado e doutorado (stricto sensu) foram os primeiros criados na área de fisioterapia do país.

Linhas de pesquisa do programa são:

- Instrumentação e Análise Cinesiológica e Biomecânica do Movimento
- Processos de Avaliação e Intervenção em Fisioterapia do Sistema Músculo-Esquelético
- Processos Básicos, Desenvolvimento e Recuperação Funcional do Sistema Nervoso Central
- Processos de Avaliação e Intervenção em Fisioterapia Cardiovascular e Respiratória

Recomendado pela CAPES – Conceito 6

Mais informações
Fone: (16) 3351-8448
www.ppgft.ufscar.br
e-mail ppg-cr@ufscar.br

O que é PEDro?

PEDro, Physiotherapy Evidence Database, é uma base de dados eletrônica gratuita de evidências relevantes em fisioterapia. PEDro permite acesso rápido a mais de 17.000 estudos clínicos aleatorizados, revisões sistemáticas e diretrizes de prática clínica em fisioterapia, fornecendo, quando possível, resumo e link para o texto completo de cada documento indexado.

Todos os estudos clínicos na PEDro são avaliados para fins de classificação de qualidade. Esses critérios de qualidade permitem aos usuários identificar de forma rápida os estudos que mais possivelmente contenham informações válidas e úteis para guiar a prática clínica.

PEDro é gratuita. E PEDro está disponível em português:

www.pedro.org.au/portuguese

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PHYSIOTHERAPY EVIDENCE DATABASE

CONHEÇA VISITE CONSULTE CONTRIBUA

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Original Articles

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