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Original articles

Impact of cervical pain, neck mobility, and body mass index on teachers' postural control

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ABSTRACT

Purpose: to analyze the impact of neck pain, neck mobility, and body mass index on teachers' postural control.

Methods: a cross-sectional study with 54 state public school teachers, 68.5% (n = 37) being females, with a mean age of 46.5 ± 9.3 years. Data were collected with the following instruments: Craniocervical Dysfunction Index (Brazilian version), force platform in bipedal and semi-tandem stance, visual analog scale, cervical mobility index, and body mass index. Data were analyzed with nonparametric statistics and multiple linear regression; the significance level was set at $p<0.05$, with 95% confidence intervals.

Results: teachers with neck pain and severely impaired neck mobility had greater postural control changes in the semi-tandem stance. In the bipedal stance, those with mild mobility changes and neck pain had a smaller total displacement. Obese teachers had a smaller movement amplitude in the anteroposterior and mediolateral directions.

Conclusion: teachers presented with neck pain and severely impaired neck mobility had a worse postural control. Obese teachers had a smaller total amplitude in both movement directions.

Keywords: Neck Pain; Postural Balance; Obesity; Faculty

Study conducted at Universidade Pitágoras and Universidade Estadual de Londrina, Parana, Brasil.

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INTRODUCTION

Cervical pain affects approximately 50% of the adult population in some phase of life and is one of the most common musculoskeletal dysfunctions[1,2]. Neck (or cervical) pain helps develop biomechanical changes that impair the cervical spine regarding joint positioning, which in turn affects postural control[3]. Like the visual and vestibular sensory systems, cervical somatosensory systems receive information on posture and send it to cortex regions, triggering efferences necessary to zygapophyseal joints and neck muscles to protect joint movements and maintain postural control[3]. However, when it is not maintained, these alterations of postural control, sometimes manifest as cervical kinesthesia, leading to compensatory body posture because of difficulties positioning the head and eyes to maintain balance[3].

Posture can be influenced by physiological changes (such as the aging process, chronic diseases, and pharmacological interactions), and by the work setting (as people take wrong postures often due to changes in the work process). Such changes result from social transformations and educational reforms that influence the teaching activity – e.g., cuts in financial resources and an excessive commitment to quality education and productive results, even when there is mass production and scarcity of material and human resources, devaluing teachers[4-7].

Changes imposed on the teachers' work make them have an excessive workload; thus, they remain long hours in the same position, decrease their physical activity, increase sedentarism, and possibly increase obesity[8,9]. An increased body mass index (BMI) changes the mechanics of step and plantar pressure when standing, thus overloading the plantar region, which can cause structural changes in the feet and lower limbs[10,11].

Such structural changes can change postural control[10,11], which is mostly assessed with the force platform. Data acquired in this instrument can be visualized in a statokinesigram (with a postural control map in the anteroposterior [AP] direction vs the mediolateral [ML] direction) or a stabilogram (temporal postural control series in each of the said directions). The stabilometric measure commonly used in postural assessment is the center of pressure (COP)[12].

Few resources are available to assess craniocervical disorders. Hence, the validation of the Craniocervical Dysfunction Index (CDI – Brazilian version) provides health professionals with a detailed and early investigation of such disorder, assessing cervical pain, muscle tension, and joint sounds during cervical spine movements, the amplitude of movement, pain during movement, and craniocervical posture[13]. They can be related to metabolic changes, interfering with BMI or functional structures, causing postural instability.

Teachers' quality of life can be directly affected by the impact of musculoskeletal dysfunction of the cervical spine, increasing obesity, and postural control changes. Thus, it is important to assess cervical pain and mobility and the interference of obesity with the postural control of elementary and middle school teachers. Hence, this study aimed to analyze the impact of cervical pain, neck mobility, and BMI on teachers' postural control.

METHODS

This cross-sectional study is part of a research project named PRÓ-MESTRE – Health, Lifestyle, and Work of Teachers in the Public Health Network of Londrina. Its objective is to assess the health, lifestyle, and work of state public school teachers[14,15]. The project was approved by the Human Research Ethics Committee of the *Universidade Estadual de Londrina*, Brazil (protocol no. 45285015.1.0000.0108) (CAAE: 33857114.4.0000.5231). All participants were initially informed of the research objectives and procedures and signed an informed consent form.

The broad research project was conducted in three stages – the present study belongs to the third one. Data were collected between September 2015 and June 2017. The teachers were invited to participate in auditory, vestibular, vocal, postural control, and cervical mobility assessments, as well as related factors, such as physical activity and metabolic and circulatory changes.

The inclusion criteria were as follows: teachers of both sexes; aged 18 to 60 years; working in public elementary and high schools, responsible for at least one school subject; teaching for more than 12 months; who were not on a leave of absence of more than 30 days in the last 12 months. The exclusion criteria were the following: having physical or sensory limitations that prevented them from verifying postural control and taking the balance tests (e.g., inability to understand and respond to simple verbal commands and/or incapacity to use required postures); severely impaired visual and/or hearing acuity and incapacity to perform activities of daily living; orthopedic disorders, limited movements, or lower limbs prostheses; self-reported central vestibular dysfunction; self-reported consumption of alcoholic beverages within 24 hours of the assessment or drugs that affected the central nervous system (such as tranquilizers and antidepressants) or the vestibular system within 48 hours of the assessment; patients who underwent vestibular rehabilitation after medical discharge.

Initially, 88 teachers were invited and agreed to be assessed. However, 10 participants were excluded for being above 60 years old; 11 for being on a leave of absence for more than 30 days in the previous year; three for reporting alcohol ingestion in the previous 24 hours; one for having severe visual impairment; one for having a severely diminished eyesight (who was reportedly waiting for a cornea transplant); and six for not attending assessments after having scheduled them three times to different days and hours. Thus, 54 teachers were included in the cervical mobility, cervical pain, BMI, and postural control assessments.

The statistical power of the sample was calculated based on a post hoc test, using GPower software 3.1.9.2 for Windows[16]. The means and standard deviations of total displacement in the semi-tandem stance were used regarding the groups without cervical pain (9.44 ± 10.8; n = 35) and with cervical pain (19.7 ± 16.5; n = 19) in a two-tailed test, with α = 0.05. The resulting statistical power was 70%.

Clinical information

The participants' clinical information necessary to the research included age, sex, dizziness, tinnitus, and so forth, according to Miller's medical history protocol[17]. Routine audiological assessments were conducted at the Department of Audiology at the Speech-Language-Hearing Clinic (UNOPAR). Moreover, cervical pain was assessed with a visual analog scale (VAS), CDI (Brazilian version), cervical mobility, BMI, and postural control.

Postural control assessment

Postural control was assessed with the ground vertical force of reaction on a force platform (BIOMEC400, EMG System of Brazil, SP, Brazil), sample at 100 Hz. All force signals were filtered with a second-order 35-Hz low-pass Butterworth filter and converted into COP data, using MATLAB routines (The MathWorks, Natick, MA, USA)[16]. The following data on postural control parameters were extracted: COP ellipse area (95% confidence) (A-COP, in cm^2), COP velocity (VEL) in both movement directions (AP and ML, in cm/s)[17], total displacement (D-TOTAL, in cm), and amplitude of displacement (AMP, in cm) in both directions[18-20].

Participants first got familiarized with the equipment and protocol until they felt comfortable with the test. Balance was assessed with a standardized protocol: barefoot, arms by their sides or parallel to the trunk (PA), in bipedal stance[21]; and in semi-tandem (ST) on the platform, the right ankle 2.5 cm away from the posterior hallux[22]. The two stances (PA and ST) were assessed on a rigid surface and then on a foam surface.

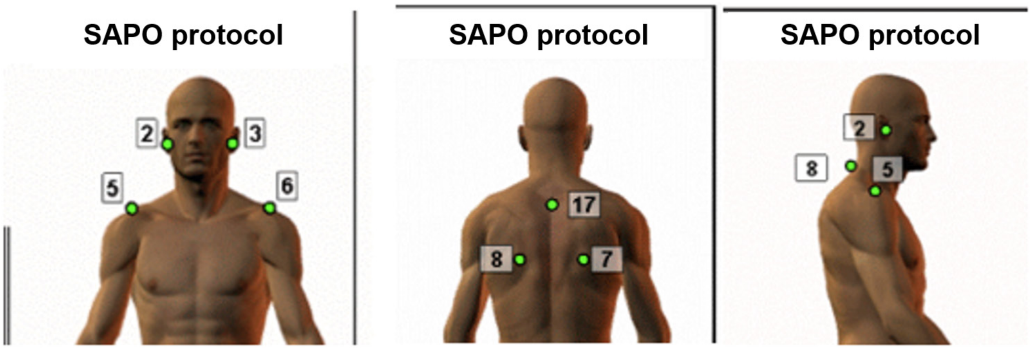
The test used the experimental protocol with eyes open, asking participants to fix their eyes on a target (black cross, 14.5 cm high x 14.5 cm across x 4 cm deep) on the wall, placed 2 m away from them at eye level[21]. Three 30-second attempts were made, with 30-second intervals between them[19]. The mean of the three measures was used for subsequent analysis[21], which was based on the difference between the means obtained on foam and rigid surfaces, in both stances (PA and ST).

Cervical Mobility Index and CDI (Brazilian version)

The cervical mobility index corresponds to item "A" in CDI (Brazilian version), which is based on the Cervical Mobility Index described by Wallace and Klineberg[6]. The amplitude of cervical spine movement was assessed with a flexometer manufactured by Sanny. During the assessment, it was verified whether they had any joint sounds, which may help the evaluator to identify functional impairments or joint degeneration. Each movement (flexion, extension, rotation, and lateral flexion) scored 0, 1, or 5 (respectively normal, mild, or severe), according to the patient's active amplitude of movement[6].

The pain was assessed during neck flexion, extension, rotation, and lateral inclination. Muscle pain was analyzed by palpating the trapezius, sternocleidomastoid, occipital, masseter, and mandible muscles.

Craniocervical posture was analyzed through photographs, in biophotogrammetric analysis with SAPO® (0.68) (free software that furnishes linear and angular measures), taking anterior, right and left lateral, and posterior pictures, after marking the anatomical points defined in clinical relevance, scientific basis, and applicability[12,23,24]. Styrofoam balls were placed on the temporomandibular joint region, the base of the scapula, the acromion, and C6/C7 (Figure 1).



Source: http://www.repositorio.unesp.br/bitstream/handle/11449/119092/fonseca_mop_tcc_prud.pdf?sequence=1

Figure 1. Anatomical reference points in the SAPO protocol

Participants stood in front of the symmetrograph, 3 meters away from the camera. The program analyzes not only the angles and measures in photographs, but also enables one to freely measure the distances necessary in the assessment. After marking points 2, 5, 8, and 18 as reference anatomical points, the program observed the distance between the posterior part of the trunk (vertical alignment) and the horizontal line, traced across the largest concavity of the cervical lordosis curve; this distance was assessed according to CDI (Brazilian version).

CDI classifies dysfunctions according to the score and level of dysfunction. Scores range from 0 to 25 points, classified as 0 (no dysfunction), 1-4 (mild dysfunction), 5-9 (moderate dysfunction), and 10-25 (severe dysfunction). The levels are classified as level 0 (no dysfunction), level 1 (mild dysfunction), and level 2 (moderate dysfunction); severe dysfunction is subdivided into three levels: level 3 (10-13 points), level 4 (15-17 points), and level 5 (20-25 points)[6].

Statistical analysis

Data were statistically analyzed with the Statistical Package for the Social Sciences, version 20.0 (SPSS, UK), with a 95% confidence index and 5% significance level ($p < 0.05$) in all tests. The parametric distribution of data was verified with the Shapiro-Wilk test; without the assumption of normality, the Mann-Whitney and Kruskal-Wallis tests with Dunn post hoc were used for the continuous variables. The effect size of nonparametric tests was also calculated. Mann-Whitney used the following equation: $r = Z / \sqrt{n}$, in which "r" is the correlation coefficient, "Z" is the standardized U value, and "n" is the number of observations[25]. Kruskal-Wallis used the estimated square epsilon (E_r^2) with the equation: $E_r^2 = H/(n^2 - 1)/(n + 1)$; "$E_r^2$" is the coefficient, whose value ranges from 0 (no relationship) to 1 (perfect relationship); "H" is the valued obtained in Kruskal-Wallis, and "n" is the number of observations[26-27]. The effect sizes followed the classification by Cohen (1988)[7]. The Spearman correlation test analyzed the correlation between COP variables and VAS, Mobility Index, and BMI. The Spearman correlation was classified as follows: values below 0.4 were considered weak, and between 0.4 and 0.5 were considered moderate[28]. The chi-square test analyzed the association between categorical variables. A multiple linear regression analysis was performed to verify possible predictors for each COP variable. It included VAS cervical score, cervical pain, and BMI; BMI classification and mobility were transformed into dummy variables to enter the model.

RESULTS

Altogether 54 teachers were assessed, with a mean age of 46.5 ± 9.3 years; 68.5% (n = 37) were females, and 31.5% (n = 17) were males. Cervical pain was self-reported by 35.2% (n = 19), while 20.4% (n = 11) had great movement difficulties, and 30.8% (n = 17) were obese. CDI detected mild dysfunction in 57.4%, and 55.6% had a low level of physical activity, verified with the International Physical Activity Questionnaire (IPAQ)[29].

The comparison between groups with and without cervical pain indicated a D-TOTAL difference in the semi-tandem stance (p = 0.008; *r* = 0.3). Those who reported cervical pain had greater postural sway (Table 1). The Kruskal-Wallis test found a Mobility Index difference in D-TOTAL in the semi-tandem stance (p = 0.037; E_r^2 = 0.12) (Table 2); the Dunn post hoc showed that severe mobility difficulties in the semi-tandem stance were worse in the assessment process (severe vs normal: adjusted p = 0.024; severe vs mild: adjusted p = 0.017). The analysis of the cervical mobility index subgroup found a difference in the mild group regarding A-COP in the bipedal stance (p = 0.037; r = 0.36); the cervical pain group had a smaller A-COP in this stance (Table 3). CDI data indicated a significant difference and a moderate effect size in the mild dysfunction group regarding VEL ML (p = 0.028; *r* = 0.4) and D-TOTAL (p = 0.002; *r* = 0.5) in the semi-tandem stance. Those who reported cervical pain had higher values in these COP variables (Table 4).

Table 1. Comparison between the groups with and without cervical pain and variables of the center of pressure

COP variables	Cervical pain (n = 19)	No cervical pain (n = 35)	p (Mann-Whitney test)
Bipedal stance			
A-COP (cm²)	2.38 [1.64-1.33][a]	2.73 [1.22-4.68]	p = 0.553
VEL AP (cm/s)	0.33 [0.21-0.44]	0.40 [0.27-0.61]	p = 0.282
VEL ML (cm/s)	0.46 [0.36-0.67]	0.42 [0.26-0.61]	p = 0.404
D-TOTAL (cm)	20.76 [14.42-26.71]	20.30 [14.68-32.55]	p = 0.817
AMP-AP (cm)	0.96 [0.44-1.39]	0.90 [0.52-1.54]	p = 0.867
AMP-ML (cm)	1.10 [0.76-1.19]	0.92 [0.64-1.31]	p = 0.630
Semi-tandem stance			
A-COP (cm²)	1.87 [1.04-3.91]	2.55 [0.69-5.15]	p = 0.572
VEL AP (cm/s)	0.10 [-0.09-0.20]	0.09 [0.22-0.26]	p = 0.846
VEL ML (cm/s)	0.45 [0.33-0.55]	0.38 [0.21-0.47]	p = 0.111
D-TOTAL (cm)	17.59 [10.79-23.06]	9.45 [2.90-14.63]	**p = 0.008*** **_r_ = 0.3**
AMP-AP (cm)	0.82 [0.43-1.29]	0.79 [0.33-1.61]	p = 0.926
AMP-ML (cm)	0.38 [0.11-0.72]	0.35 [0.07-0.65]	p = 0.802

Legenda: COP (centro de pressão); n (número de participantes); [a] (mediana e intervalo interquartil [25-75%]); A-COP (área do centro de pressão); VEL AP (velocidade no sentido anteroposterior); VEL ML (velocidade na direção mediolateral); D-TOTAL (deslocamento total); AMP-AP (amplitude no sentido anteroposterior); AMP-ML (amplitude na direção mediolateral); *(diferença estatisticamente significante);

Table 2. Comparison between the cervical mobility index and variables of the center of pressure

COP variables	Normal (n = 11)	Mild difficulty (n = 32)	Severe difficulty (n = 11)	p Kruskal-Wallis
Bipedal stance				
A-COP (cm^2)	2.32 [0.46-4.56][a]	2.86 [1.80-4.85]	2.33 [1.49-3.50]	p = 0.454
VEL AP (cm/s)	0.40 [0.30-0.69]	0.37 [0.23-0.60]	0.40 [1.13-0.52]	p = 0.887
VEL ML (cm/s)	0.39 [0.26-0.54]	0.45 [0.28-0.61]	0.53 [0.37-0.73]	p = 0.434
D-TOTAL (cm)	18.11 [14.88-26.83]	20.90 [14.61-29.80]	22.70 [11.84-35.14]	p = 0.952
AMP-AP (cm)	0.78 [0.22-1.33]	1.01 [0.55-1.60]	0.84 [0.32-1.26]	p = 0.440
AMP-ML (cm)	0.87 [0.47-1.38]	1.03 [0.70-1.33]	1.07 [0.70-1.15]	p = 0.756
Semi-tandem stance				
A-COP (cm^2)	1.97 [0.40-4.22]	1.91 [0.87-4.66]	2.58 [1.06-6.75]	p = 0.759
VEL AP (cm/s)	0.09 [0.04-0.32]	0.11 [0.09-0.19]	0.07 [0.03-0.27]	p = 0.753
VEL ML (cm/s)	0.35 [0.20-0.49]	0.41 [0.22-0.47]	0.50 [0.38-0.55]	p = 0.174
D-TOTAL (cm)	9.71 [3.09-17.92]	10.81 [3.90-16.74]	22.90 [12.40-27.77]	**p = 0.037*** **E_r^2 = 0.12**
AMP-AP (cm)	0.75 [0.05-1.57]	0.76 [0.38-1.52]	1.01 [0.33-1.65]	p = 0.840
AMP-ML (cm)	0.11 [0.09-0.60]	0.38 [0.08-0.69]	0.34 [0.12-1.55]	p = 0.572

Captions: COP (center of pressure); n (number of participants); [a] (median and interquartile range [Q_1-Q_3]); A-COP (area of the center of pressure); VEL AP (anteroposterior velocity); VEL ML (mediolateral velocity); D-TOTAL (total displacement); AMP-AP (anteroposterior amplitude); AMP-ML (mediolateral amplitude); *(statistically significant difference)

Table 3. Analysis of subgroups of the cervical mobility index and their relationship with cervical pain and variables of the center of pressure

COP variables	Normal			Mild			Severe		
	No pain (n = 10)	Neck pain (n = 1)	p-value†	No pain (n = 18)	Neck pain (n = 14)	p-value	No pain (n = 7)	Neck pain (n = 4)	p-value
Bipedal stance									
A-COP (cm^2)	1.73 [0.39-3.21][a]	6.13	p = 0.114	3.51 [2.31-5.45]	2.07 [1.54-3.15]	**p = 0.037*** ***r* = 0.36**	2.28 [0.34-3.74]	2.46 [1.96-4.20]	p = 0.521
VEL AP (cm/s)	0.35 [0.28-0.52]	0.69	p = 0.341	0.49 [0.20-0.65]	0.32 [0.24-0.44]	p = 0.270	0.44 [0.22-0.57]	0.31 [0.17-0.44]	p = 0.392
VEL ML (cm/s)	0.38 [0.25-0.45]	1.08	p = 0.182	0.44 [0.25-0.64]	0.45 [0.30-0.63]	p = 0.864	0.55 [0.11-0.76]	0.53 [0.41-0.72]	p = 0.837
D-TOTAL (cm)	17.83 [13.89-23.92]	48.26	p = 0.194	22.81 [13.33-34.57]	19.41 [16.55-24.08]	p = 0.382	24.11 [8.98-35.14]	18.00 [11.34-35.98]	p = 0.831
AMP-AP (cm)	0.76 [0.13-1.44]	1.21	p = 0.527	1.08 [0.59-1.69]	0.96 [0.45-1.48]	p = 0.635	0.89 [0.56-1.46]	0.66 [0.10-1.14]	p = 0.394
AMP-ML (cm)	0.75 [0.42-1.22]	1.95	p = 0.111	0.94 [0.72-1.40]	1.11 [0.61-1.22]	p = 0.608	0.94 [0.34-1.23]	1.07 [0.86-1.16]	p = 0.669
Semi-tandem stance									
A-COP (cm^2)	2.17 [0.27-4.81]	1.97	p = 1.000	2.37 [1.08-5.24]	1.64 [0.77-3.92]	p = 0.362	2.58 [0.50-8.05]	2.66 [1.40-9.46]	p = 0.831
VEL AP (cm/s)	0.37 [0.15-0.47]	0.80	p = 0.117	0.10 [0.04-0.22]	0.13 [0.09-0.20]	p = 0.955	0.17 [0.03-0.40]	0.11 [0.03-0.17]	p = 0.114
VEL ML (cm/s)	0.29 [0.19-0.44]	0.82	p = 0.112	0.39 [0.20-0.44]	0.43 [0.24-0.55]	p = 0.342	0.50 [0.28-0.61]	0.48 [0.41-0.56]	p = 0.914
D-TOTAL (cm)	7.09 [4.43-14.86]	66.92	p = 0.126	7.04 [2.90-12.56]	13.99 [8.84-17.72]	p = 0.058	14.11 [8.42-27.77]	23.59 [22.82-42.66]	p = 0.201
AMP-AP (cm)	0.61 [0.02-1.61]	1.41	p = 0.752	0.84 [0.32-1.67]	0.62 [0.39-1.23]	p = 0.582	1.02 [0.33-1.71]	1.01 [0.34-2.34]	p = 0.757
AMP-ML (cm)	0.28 [0.11-0.48]	0.72	p = 0.206	0.43 [0.27-0.68]	0.35 [0.25-0.75]	p = 0.676	0.52 [0.11-1.55]	0.33 [0.17-2.33]	p = 0.762

Captions: COP (center of pressure); n (number of participants); † (p-value with the Mann-Whitney test); [a] (median and interquartile range [Q_1-Q_3]); A-COP (area of the center of pressure); VEL AP (anteroposterior velocity); VEL ML (mediolateral velocity); D-TOTAL (total displacement); AMP-AP (anteroposterior amplitude); AMP-ML (mediolateral amplitude); *(statistically significant difference).

Table 4. Analysis of data from the Craniocervical Dysfunction Index, cervical pain, and variables of the center of pressure

COP Variables	No dysfunction (n = 5)	Mild dysfunction (n = 31)			Moderate dysfunction (n = 13)			Severe dysfunction, level 3 (n = 5)		
	No pain (n = 5)	No pain (n = 19)	With pain (n = 12)	p-value†	No pain (n = 8)	With pain (n = 5)	p-value	No pain (n = 3)	With pain (n = 2)	p-value
Bipedal stance										
A-COP (cm²)	1.14 [0.01-3.63][a]	2.76 [1.80-5.04]	2.29 [1.64-4.68]	0.646	3.09 [0.49-5.38]	2.55 [2.01-3.82]	0.876	3.35 [2.28-5.72]	1.15 [0.36-1.37]	0.200
VEL AP (cm/s)	040 [0.35-0.63]	0.35 [0.16-0.63]	0.36 [0.26-0.49]	0.984	0.38 [0.29-0.57]	0.21 [-0.06-0.38]	0.268	0.55 [0.51-0.59]	0.43 [0.31-0.33]	0.200
VEL ML (cm/s)	0.43 [0.32-0.62]	0.41 [0.22-0.60]	0.48 [0.34-0.65]	0.326	0.43 [0.27-0.67]	0.60 [0.08-0.73]	0.530	0.57 [0.30-0.90]	0.41 [0.27-0.34]	0.800
D-TOTAL (cm)	18.82 [17.83-33.92]	19.33 [10.92-33.41]	19.56 [17.31-27.04]	0.734	21.52 [11.10-28.63]	12.10 [1.06-31.61]	0.755	30.19 [16.59-34.60]	22.33 [15.57-17.92]	0.800
AMP-AP (cm)	0.74 [0.55-1.31]	0.79 [0.47-1.43]	1.02 [0.66-1.58]	0.412	1.41 [0.69-1.77]	0.96 [0.40-1.30]	0.268	1.55 [0.73-1.74]	0.07 [-0.08-0.18]	0.200
AMP-ML (cm)	0.86 [0.01-3.63]	0.91 [0.65-1.30]	1.15 [0.77-1.40]	0.411	0.76 [0.54-1.12]	1.07 [0.20-1.09]	1.000	1.36 [1.14-1.53]	0.86 [0.40-0.89]	0.400
Semi-tandem stance										
A-COP (cm²)	2.63 [-0.13-6.77]	2.01 [0.40-4.90]	1.89 [0.96-3.95]	1.000	4.22 [0.73-5.54]	1.87 [1.10-7.38]	0.755	2.69 [1.32-16.76]	1.29 [0.35-1.58]	0.400
VEL AP (cm/s)	-0.02 [-0.34-0.39]	0.08 [-0.10-0.12]	0.13 [-0.06-0.25]	0.269	0.12 [0.06-0.49]	-0.03 [-0.39-1.14]	0.106	0.25 [0.15-0.36]	0.13 [0.04-0.15]	0.400
VEL ML (cm/s)	0.35 [0.22-0.63]	0.34 [0.18-0.43]	0.51 [0.34-0.64]	**0.028*** ***r* = 0.4**	0.43 [0.30-0.50]	0.41 [0.14-0.48]	0.432	0.51 [0.32-0.55]	0.50 [0.31-0.43]	1.000
D-TOTAL (cm)	4.48 [-11.18-23.82]	4.89 [2.07-11.83]	17.25 [17.83-20.73]	**0.002*** ***r* = 0.5**	12.27 [8.79-28.48]	23.06 [2.58-36.48]	0.530	14.59 [3.52-26.79]	17.24 [8.80-17.05]	1.000
AMP-AP (cm)	0.47 [-0.54-1.72]	0.75 [0.37-1.60]	0.74 [0.36-1.27]	0.889	1.30 [0.35-1.72]	1.17 [0.30-2.98]	0.876	1.24 [1.19-2.94]	0.65 [0.33-0.63]	0.800
AMP-ML (cm)	0.44 [-0.01-1.29]	0.11 [-0.20-0.56]	0.46 [0.16-0.83]	0.205	0.50 [0.04-1.47]	0.25 [-0.13-1.69]	0.753	0.42 [0.27-1.82]	-0.09 [-0.25-0.11]	0.200

Captions: COP (center of pressure); n (number of participants); [a] (median and interquartile range [Q_1-Q_3]); † (Mann-Whitney test with Fisher exact test p-value); *r* (Mann-Whitney test effect size); A-COP (area of the center of pressure); VEL AP (anteroposterior velocity); VEL ML (mediolateral velocity); D-TOTAL (total displacement); AMP-AP (anteroposterior amplitude); AMP-ML (mediolateral amplitude); *(statistically significant difference)

Concerning BMI, a difference with a small effect size was found in the obesity group in bipedal stance regarding AMP-AP ($p = 0.003$; $E_r^2 = 0.02$) and AMP-ML ($p = 0.030$; $E_r^2 = 0.01$), as shown in Table 5. The obesity group had a smaller amplitude in both directions. The chi-square test found no association between cervical pain and BMI ($p > 0.05$).

Table 5. Comparison between categories of body mass index and variables of the center of pressure

COP Variables	Well-nourished (n = 28)	Overweight (n = 16)	Obese (n = 10)	p Kruskal-Wallis
Bipedal stance				
A-COP (cm^2)	2.83 [1.83-5.13][a]	2.42 [1.25-3.33]	1.82 [0.13-2.73]	p = 0.062
VEL AP (cm/s)	0.40 [0.31-0.59]	0.31 [0.12-0.44]	0.38 [0.07-0.67]	p = 0.335
VEL ML (cm/s)	0.42 [0.30-0.57]	0.51 [0.39-0.67]	0.50 [0.43-0.85]	p = 0.491
D-TOTAL (cm)	18.82 [15.21-30.19]	21.05 [12.10-27.15]	20.76 [12.84-35.44]	p = 0.819
AMP-AP (cm)	1.33 [0.79-1.68]	0.73 [0.44-1.03]	0.25 [-058.-0.93]	**p = 0.003*** **E_r^2= 0.02**
AMP-ML (cm)	1.13 [0.83-1.42]	0.79 [0.64-1.12]	0.86 [0.15-1.10]	**p = 0.030*** **E_r^2= 0.01**
Semi-tandem stance				
A-COP (cm^2)	2.12 [1.32-4.90]	1.84 [0.73-6.61]	1.17 [0.77-2.58]	p = 0.156
VEL AP (cm/s)	0.11 [0.01-0.19]	0.19 [0.10-0.37]	0.16 [0.07-0.22]	p = 0.595
VEL ML (cm/s)	0.42 [0.32-0.49]	1.28 [1.11-1.58]	1.07 [1.04-1.28]	p = 0.879
D-TOTAL (cm)	10.83 [4.14-17.64]	13.63 [5.50-24.12]	9.96 [1.90-28.75]	p = 0.730
AMP-AP (cm)	0.89 [0.47-1.60]	0.82 [0.43-1.72]	0.35 [0.12-1.02]	p = 0.138
AMP-ML (cm)	0.44 [0.14-0.72]	0.16 [0.09-0.60]	0.77 [0.51-1.17]	p = 0.268

Captions: COP (center of pressure); n (number of participants); [a] (median and interquartile range [Q_1-Q_3]); A-COP (area of the center of pressure); VEL AP (anteroposterior velocity); VEL ML (mediolateral velocity); D-TOTAL (total displacement); AMP-AP (anteroposterior amplitude); AMP-ML (mediolateral amplitude); *(statistically significant difference)

The data also indicate a weak correlation in semi-tandem stance between VAS and D-TOTAL (r s: 0.367; p = 0.007) and between BMI and D-TOTAL (r s: 0.304; p = 0.027). In other words, as pain intensity or movement difficulties increase, total displacement also increases. There was also a weak correlation in the bipedal stance regarding AMP-AP (r s: -0.299; p = 0.033) and AMP-ML (r s: -0.340; p = 0.015). That is, in this case, as BMI increases, the amplitude in both directions decreases. There was no correlation between BMI and VAS for cervical pain.

Concerning multiple linear regression results after the model application was regressed, the bipedal stance variables were not considered predictors of A-COP, VEL AP, VEL ML, or D-TOTAL. On the other hand, BMI, obesity, and overweight were predictors of AMP-AP, while only obesity was a predictor of AMP-ML. In the semi-tandem stance, no predictors of VEL AP, VEL ML, or AMP-ML were found. On the other hand, severe mobility and obesity were predictors of A-COP, while cervical pain, severe mobility, and obesity were predictors of D-TOTAL. These data are shown in Table 6.

Table 6. Analysis of the multiple linear regression for variables of the center of pressure

COP Variables	R^2	Predictor	B (95% CI)	β	F	t	p-value
Bipedal stance							
A-COP	0.07	No	-	-	0.47	-	0.845
VEL AP	0.06	No	-	-	0.42	-	0.879
VEL ML	0.04	No	-	-	0.71		0.656
D-TOTAL	0.02	No	-	-	0.13	-	0.995
		BMI	0.13 (0.04 –0.22)	0.762		3.05	0.004*
AMP-AP	0.35	Obesity	-2.63 (-3.74 -1.15)	-0.601	10.14	-4.77	0.001*
		Overweight	-1.03 (-1.63 -0.43	-0.802		-3.47	0.001*
AMP-ML	0.08	Obesity	-0.50 (-0.92 -0.07	-0.323	5.69	-2.38	0.021*
Semi-tandem							
A-COP	0.19	Obesity	-4.67 (-7.43 -1.91	-0.541	7.18	-3.40	0.001*
		Severe mobility	3.39 (0.74 –6.04)	0.340		2.57	0.013*
VEL AP	0.04	No	-	-	0.71	-	0.661
VEL ML	0.04	No	-	-	0.67	-	0.696
D-TOTAL	0.18	Cervical pain	9.91 (2.38 –17.45)	0.338	6.70	2.64	0.011*
		Severe mobility	10.82 (1.75 – 19.89)	0.307		2.40	0.020*
AMP-AP	0.09	Obesity	-0.82 (-1.47 -0.17	-0.357	3.75	-2.54	0.014*
AMP-ML	0.03	No	-	-	0.81	-	0.578

Captions: COP (center of pressure); R^2 (adjusted R square value; when multiplied by 100, it represents a percentage of the variability explained by the model); B (non-standardized coefficient value); 95% CI (lower and upper limits of the 95% confidence interval); β (standardized coefficient); F (ANOVA F statistics); t (t statistics, which must be different from 0); A-COP (area of the center of pressure); VEL AP (anteroposterior velocity); VEL ML (mediolateral velocity); D-TOTAL (total displacement); AMP-AP (anteroposterior amplitude); AMP-ML (mediolateral amplitude); BMI (body mass index); *(statistically significant)

DISCUSSION

Studies demonstrate that cervical pain increasingly impacts the socioeconomic life of the general population, particularly the professionals addressed in this study. It can have a disabling effect on them, due to changes in cervical spine mobility and postural control, thus decreasing physical activity, and possibly increasing BMI[1,2,4,6,30-32]. Most teachers assessed in this study were females (68.5%), 35.2% of the sample reported cervical pain, 20.4% had mobility difficulties, and 30.8% were obese. As in this study, there is a consensus in the literature that head and neck pain predominates in women. Even though such pain did not predominate in some studies analyzed, it is among those that most impair performance, possibly increasing the risk of occupational diseases[22,23,32-35].

Cervical dysfunctions can change the proprioceptive and somatosensory systems, impairing neuromuscular and postural control, and thus causing imbalance[36]. This was demonstrated in the present study, as teachers who had cervical pain also had greater D-TOTAL than those without such pain, corroborating the study by Soares et al. The postural control assessment indicated a greater displacement in the cervical pain group[37].

Given the complexity of postural control, cervical pain affects the whole body. It can impair the function of deep muscles, such as joint and tendon mechanoreceptors, interfering with cervical spine mobility and stability through changes in the information sent to the central nervous system and the vestibular and visual systems[38]. These information changes interfere with postural control, causing the person with pain to increasingly lose postural control – which also agrees with the data in this study.

Postural control depends on both internal and external factors, and the capacity to maintain postural control depends on genetic factors, age, positioning of the center of mass, flexibility, and visual control[39]. The foam used in the assessments is an external factor that affects postural control, disturbing the posture and requiring neutralizing reactions to the stimuli. Not only foam but also other internal and external disturbances affect balance, forcing the body and its systems to master postural control[40].

Besides the surfaces, the bipedal and semi-tandem stances challenge individuals in postural control assessment. The absence of D-total differences in the bipedal stance may be due to the larger base of support, as the less demanding task ensures functional adaptations that diminish postural sway. In its turn, the semi-tandem stance poses a greater challenge: since the base of support is smaller, body instability increases, and so does the postural imbalance. Hence, standing on foam in a semi-tandem stance requires attention. Continuous muscle action may interfere with this task, and the metabolic level may increase, likewise increasing body sway and specific modulations of the neuromotor system to regulate postural control[40,41].

Thus, this study showed that cervical pain and limited cervical spine mobility, associated with a smaller base of support in the semi-tandem stance (which increases task demand), increased body sway in the group with severe mobility difficulties, in contrast with the bipedal stance, which is less difficult and more stable.

Furthermore, the analysis of A-COP in the group with mild cervical mobility difficulties showed they had a smaller area in the bipedal stance. This agrees with the position analysis and demonstrates better performance in more stable stances, with a larger base of support, and milder mobility difficulties – unlike the subgroups with medium and severe cervical spine mobility difficulties in the semi-tandem stance[20,42].

The analysis of the subgroup with mild mobility difficulties indicates better performance in the position with a lower degree of lesion of the neck proprioceptor stimuli and less interference of disturbances with cervical sensorimotor control. This leads to the hypothesis that the person had a mild dysfunction, without intense constant pain or the perception of pain. Participants seldom reported this finding; instead, it was verified in the detailed CDI assessment. Structural and functional cervical impairment and mechanoreceptor activation may be absent or diminished – thus, the reflex of these changes on postural control may likewise be reduced, decreasing postural control.

Few studies have addressed postural control in obese teachers. Nonetheless, this is a greatly important topic because teachers have been working harder, often seated, which limits periodical physical activity. After the COVID-19 pandemic, teachers are more sedentary, as the working hours are often longer than the established limits either because they had to be in social isolation or had to readapt to new technologies and telework. This limited their physical activity, social interaction, and nutrition and increased postural impairment due to the lack of an adequate work setting. These circumstances increase obesity, also affecting posture and postural control[43-46].

Most studies demonstrate a greater postural control imbalance in the obese population, as increased body mass changes the weight load on the forefoot and hindfoot, changing the person's balance. Almost all participants were assessed with open and closed eyes, which demonstrates the importance of sight as a source of proprioception in balance control[47,48]. However, the study by Sasaki et al. reported no change in postural dynamics with eyes open or closed, suggesting that the absence of sight did not have any effect on postural control[49].

High body mass increases plantar shear strength in standing posture. Despite the predominance of females in the assessments in the present study, the results agree with another one conducted on males, whose results did not indicate changes in postural control. This may have happened because such participants adapted more easily and flexibly to acute external stimuli on static posture[50].

Data in the present study differ from those found by other authors. One of the main problems of postural control regulation is maintaining the center of mass on the foot triangle, which is done by the COP, as pressure on the heel changes. However, when the ankle and foot joint sway, neural responses are adjusted in the calf muscles, calcaneal tendon, toe flexors, and opposed hip and trunk muscles to maintain balance[10,11]. Hence, smaller AP and ML amplitudes found in this study concerning BMI in the bipedal stance lead to the analysis of balance in relation to the base of support.

Increased body mass alone does not fully explain postural sway. On the other hand, a high BMI increases not only the plantar region in both AP and ML directions but also deformities in medial sectional and longitudinal plantar arches. Tactile perception also increases due to high plantar pressure, which suggests that mechanoreceptor sensitivity decreases as sensory feedback increases. Another factor is that young individuals have greater activation sensitivity in the neuromuscular system and can easily detect changes in stimuli and thus adapt the functions with compensations. Moreover, obese individuals may concentrate more to keep postural control during the assessment, using the proprioceptive, visual, and vestibular systems. Hence, they compensate for the decreased sensitivity of plantar mechanoreceptors, preventing the decrease in standing postural control[50].

When the base of support increases, so does the area of mass in which the body can move without losing balance. In the case of overweight, the mass in joint regions (including the ankle) increases, expanding the base of support. Thus, the muscles involved, whether weak or strong, are recruited to neutralize external forces. As the increased base of support, muscle and joint structures, and systems involved in balance (including sight) readapt, obese individuals have body adaptations that help maintain postural control[47].

Another hypothesis that agrees with the results of this study is that postural control changes may be different in static assessment. Therefore, assessments must include dynamic tasks, such as gait, to analyze whether the adaptation to external stimuli interferes with postural control in the obese population[50].

This topic is little discussed, though greatly important to teachers' health, especially because they are the basis of all education. All kinds of professionals who are in the learning process need special attention not to impair the quality of their education. Regarding this study, some limitations must be pointed out. Postural control assessments were performed with eyes open, but other sensory conditions might have resulted in different findings – although the participants' occupational activities are carried out with eyes open. Another limitation was the scarcity of studies reporting teachers' postural control variables.

CONCLUSION

In the semi-tandem stance, teachers with cervical pain and severe neck mobility impairment had a greater postural imbalance. BMI was not directly related to cervical pain. CDI (Brazilian version) was compared with cervical pain and COP variables, indicating a greater displacement velocity in the semi-tandem stance. Further studies addressing obese teachers and cervical pain are needed to confirm these findings.

REFERENCES

1. Delfino PD, Rampim DB, Alfieri FM, Tomikawa LCO, Fadel G, Stump PRNAG et al. Cervicalgia: reabilitação. Acta Fisiátr. 2012;19(2):73-81. https://doi.org/10.5935/0104-7795.20120014.
2. Soares JC, Weber P, Trevisan ME, Trevisan CM, Rossi AG. Correlação entre postura da cabeça, intensidade da dor e índice de incapacidade cervical em mulheres com queixa de dor cervical. Fisioter. Pesqui. 2012;19(1):68-72. https://doi.org/10.1590/S1809-29502012000100013.
3. Reis FJJ, Mafra B, Mazza D, Marcato G, Ribeiro M, Absalão T. Assessment of sensorimotor disturbance in mechanical neck pain: a review. Fisioter Mov. 2010;23(4):617-26. https://doi.org/10.1590/S0103-51502010000400012.
4. Weber P, Corrêa ECR, Ferreira FS, Soares JC, Bolzan GP, Silva AMT. Frequência de sinais e sintomas de disfunção cervical em indivíduos com disfunção temporomandibular. J Soc Bras Fonoaudiol. 2012;24(2):134-9. https://doi.org/10.1590/S2179-64912012000200008.
5. Junior PF, Barela JA. Alterações no funcionamento do sistema de controle postural de idosos. Uso da informação visual. Rev Port Cien Desp. 2006;6(1):94-105. https://doi.org10.5628/rpcd.06.01.94.
6. Wallace C, Klineberg IJ. Management of craniomandibular disorders. Part 1: a craniocervical dysfunction index. J Orofac Pain. 1993;7(1):83-8. PMID: 8467302.
7. Cardoso JP, Ribeiro IQB, Araújo TM, Carvalho FM, Reis EJFB. Prevalência de dor musculoesquelética em professores. Rev Bras Epidemiol. 2009;12(4):604-14. https://doi.org/10.1590/S1415-790X2009000400010.
8. Gil AWO, Silva RA, Oliveira MR, Carvalho CE, Oliveira DAAP. Comparison of postural control in five tasks of balance and relation of risk of falls between older and young adult women. Fisioter Pesqui. 2017;24(2):120-6. https://doi.org/10.1590/1809-2950/15804424022017.
9. Oliveira MR, Vieira ER, Gil AWO, Fernandes KBP, Teixeira DC, Amorim CF et al. One-legged stance sway of older adults with and without falls. PLoS One. 2018;13(9):e0203887. https://doi.org/10.1371/journal.pone.0203887.
10. Filippin NT, Barbosa VLP, Sacco ICN, Costa PHL. Efeitos da obesidade na distribuição de pressão plantar em crianças. Braz J Phys Ther. 2007;11(6):495-501. https://doi.org/10.1590/S1413-35552007000600012.
11. Carneiro JAO, Almeida DS, Vilaça KHC, Pfrimer K, Santos-Pontelli TEG, Carneiro AAO et al. Influência da obesidade e da força de preensão palmar no equilíbrio postural estático de idosas ativas. Motriz. 2012;18(3):432-40. https://doi.org/10.1590/S1980-65742012000300003.
12. Duarte MF, Sandra MSF. Revisão sobre posturografia baseada em plataforma de força para avaliação do equilíbrio. Braz J Phys Ther. 2010;14(3):183-92. https://doi.org/10.1590/S1413-35552010000300003.
13. Dias ACM, Doi MY, Mesas AE, Fillis MMA, Branco-Barreiro FCA, Marchiori LLM. Translation to Brazilian Portuguese and Cultural Adaptation of the Craniocervical Dysfunction Index. Int Arch of Otorhinolaryngol. 2018;22(03):291-6. https://doi.org/10.1055/s-0037-1621743.
14. Birolim MM, Mesas AE, González AD, Santos HG, Haddad MCFL, Andrade SM. Trabalho de alta exigência entre professores: associação com fatores ocupacionais conforme o apoio social. Ciênc Saúde Coletiva. 2019;24(4):1255-64. https://doi.org/10.1590/1413-81232018244.08542017.
15. Fillis MMA, Andrade SM, González AD, Melanda FN, Mesas AE. Frequência de problemas vocais autorreferidos e fatores ocupacionais associados em professores da educação básica de Londrina, Paraná, Brasil. Cad. Saúde Pública. 2016;32(1):e00026015. https://doi.org/10.1590/0102-311X00026015.
16. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods. 2007;39(2):175-91. https://doi.org/10.3758/bf03193146.
17. Miller MH. A integração dos achados audiológicos. In: Katz J, editor. Tratado de audiologia clínica, 3ª ed. São Paulo: Manole; 1999. p.268-70.

18. Silva RA, Vieira ER, Carvalho CE, Oliveira MR, Amorim CF. Age-related differences on low back and postural control during one-leg stance: A case-control study. Eur Spine J. 2016;25(4):1251-7. https://doi.org/10.1007/s00586-015-4255-9.

19. Silva RA, Bilodeau M, Parreira RB, Teixeira DC, Amorim CF. Age-related differences in time-limit performance and force platform-based balance measures during one-leg stance. J Eletromyogr Kinesiol. 2013;23(3):634-9. https://doi.org/10.1016/j.jelekin.2013.01.008.

20. Paillard T, Noé F. Techniques and methods for testing the postural function in healthy and pathological subjects. Biomed Res Int. 2015;1-15. https://doi.org/10.1155/2015/891390.

21. Oliveira MR, Silva RA, Dascal JB, Teixeira DC. Effect of different types of exercise on postural balance in elderly women: A randomized controlled trial. Arch Gerontol Geriatr. 2014;59(3):506-14. https://doi.org/10.1016/j.archger.2014.08.009.

22. Glaucia LVS, Iris LS, Fabricio C, Heron B. Incidence of work-related musculoskeletal disorders of teachers of a higher education institution of Belém/PA. Fisioter Brasil. 2009;10(4):263-9.

23. Souza JA, Pasinato F, Basso D, Corrêa ECR, Silva AMT. Biofotogrametria confiabilidade das medidas do protocolo do software para avaliação postural. (SAPO). Rev. Bras. Cineantropom. Desempenho Hum. 2011;13(4):299-305. https://doi.org/10.5007/1980-0037.

24. Suaide ALAP. Desenvolvimento e validação de uma ferramenta computacional para mensuração das curvaturas da coluna vertebral [Dissertation]. São Paulo (SP): Universidade de São Paulo, Instituto de Psicologia; 2008.

25. Fritz CO, Morris PE, Richler JJ. Effect size estimates: current use, calculations, and interpretation. J Exp Psychol Gen. 2012;141(1):2-18. https://doi.org/10.1037/a0024338.

26. Tomczak A, Tomczak E. The need to report effect size estimates revisited. An overview of some recommended measures of effect size. Trends Sport Sci. 2014;1(21):19-25.

27. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. New York: Routledge, 1988.

28. Portney LG. Correlation. In: Portney LG, editor. Foundations in clinical research: applications to evidence-based practice. 4th ed. Philadelphia: FA Davis; 2020. p. 428-39.

29. Zbrońska I, Mędrela-Kuder E. The level of physical activity in elderly persons with overweight and obesity. Rocz Panstw Zakl Hig. 2018;69(4):369-73. https://doi.org/10.32394/rpzh.2018.0042.

30. Oliveira RAR, Moreira OC, Andrade Neto F, Amorim W, Costa EG, Marins CB. Prevalência de sobrepeso e obesidade em professores da Universidade Federal de Viçosa. Fisioter Mov. 2011;24(4):603-12. https://doi.org/10.1590/S0103-51502011000400003.

31. Carvalho AJFP, Alexandre NMC. Sintomas osteomusculares em professores do ensino fundamental. Rev bras fisioter. 2006;10(1):35-41. https://doi.org/10.1590/S1413-35552006000100005.

32. Safiri S, Kolahi AA, Hoy D, Buchbinder R, Mansournia MA, Bettampadi D et al. Global, regional, and national burden of neck pain in the general population, 1990-2017: systematic analysis of the Global Burden of Disease Study 2017. BMJ. 2020;368:m791. https://doi.org/10.1136/bmj.m791.

33. Fejer R, Kyvik KO, Hartvigsen J. The prevalence of neck pain in the world population: a systematic critical review of the literature. Eur Spine J. 2006;15(6):834-48. https://doi.org/10.1007/s00586-004-0864-4. PMID: 15999284.

34. Borges MC, Borges CS, Silva AGJ, Castellano LRC, Cardoso FAG. Evaluation of quality of life and the physiotherapy treatment in patients with chronic neck pain. Fisioter Mov. 2013;26(4):873-81. https://doi.org/10.1590/S0103-51502013000400016.

35. Temesgen MH, Belay GJ, Gelaw AY, Janakiraman B, Animut Y. Burden of shoulder and/neck pain among school teachers in Ethiopia. BMC Musculoskelet Disord. 2019;20(1):1-9. https://doi.org/10.1186/s12891-019-2397-3.

36. Freitas Júnior P, Barela JA. Alterações no funcionamento do sistema de controle postural de idosos. Uso da informação visual. Rev Port Cien Desp. 2006;6(1):94-105. https://doi.org/10.5628/rpcd.06.01.94.

37. Soares JC, Weber P, Trevisan ME, Trevisan CM. Influência da dor no controle postural de mulheres com dor cervical. Rev bras cineantropom desempenho hum. 2013;15(3):371-81. https://doi.org/10.5007/1980-0037.2013v15n3p371.

38. Knapstad MK, Goplen FK, Ask T, Skouen JS, Nordahl SHG. Associations between pressure pain threshold in the neck and postural control in patients with dizziness or neck pain – A cross-sectional study. BMC Musculoskelet Disord. 2019;20(1):520-8. https://doi.org/10.1186/s12891-019-2922-4. PMID: 31707980.

39. Stawicki P, Wareńczak A, Lisiński P. Does regular dancing improve static balance? Int J Environ Res Public Health. 2021;18(10):50-6. https://doi.org/10.3390/ijerph18105056. PMID: 34064678.

40. Sozzi S, Schieppati M. Balance adaptation while standing on a compliant base depends on the current sensory condition in healthy young adults. Front Hum Neurosci. 2022;16:839799. https://doi.org/10.3389/fnhum.2022.839799.

41. Mademli L, Mavridi D, Bohm S, Patikas DA, Santuz A, Arampatzis A. Standing on unstable surface challenges postural control of tracking tasks and modulates neuromuscular adjustments specific to task complexity. Sci Rep. 2021;11(1):6122. https://doi.org/10.1038/s41598-021-84899-y.

42. Peng B, Yang L, Li Y, Liu T, Liu Y. Cervical proprioception impairment in neck pain-pathophysiology, clinical evaluation, and management: a narrative review. Pain Ther. 2021;10(1):143-64. https://doi.org/10.1007/s40122-020-00230-z. PMID: 33464539.

43. Marchiori LLM, Marchiori GM, Rodrigues ML, Carlos P, Cordova NM, Santos MCM et al. Is remote and distance teaching during the COVID-19 pandemic related to the university professors' weight gain, body mass index changes, hearing complaints, and self-perception of voice? Rev. CEFAC. 2021;23(5):e4521. https://doi.org/10.1590/1982-0216/20212354521.

44. Marchiori LLM, Marchiori GM, Carlos P, Benites SL, Mendes MSB, Ciquinato DSA. Do body mass index levels correlate with tinnitus among teachers? Int Arch Otorhinolaryngol. 2021;26(01):63-8. https://doi.org/10.1055/s-0040-1722251.

45. Rocha SV, Cardoso JP, Santos CA, Munaro HLR, Vasconcelos LRC, Petroski EL. Overweight/obesity in teachers: prevalence and associated factors. Rev bras cineantropom desempenho hum. 2015;17(4):450-9. https://doi.org/10.5205/1981-8963-v12i10a237489p2573-2582-2018.

46. Belzunegui-Eraso A, Erro-Garcés A. Teleworking in the context of the Covid-19 crisis. Sustainability. 2020;12(9):1-18. https://doi.org/10.3390/su12093662.

47. Lee JJ, Hong DW, Lee AS, Soh Y, Yang M, Choi KM et al. Relationship between obesity and balance in the community-dwelling elderly population: a cross-sectional analysis. Am J Phys Med Rehabil. 2020;99(1):65-70. https://doi.org/10.1097/phm.0000000000001292. PMID: 31464747.

48. Aleixo AA, Guimaraes EL, Walsh IAP, Pereira K. Influence of overweight and obesity on posture, overall praxis and balance in schoolchildren. Rev Bras Crescimento Desenvolv Hum. 2012;22(2):239-45. https://doi.org/10.7322/jhgd.157754.
49. Sasaki O, Gagey PM, Ouaknine AM, Martinerie J, Le Van Quyen M, Toupet M et al. Nonlinear analysis of orthostatic posture in patients with vertigo or balance disorders. Neurosci Res. 2001;41(2):185-92. https://doi.org/10.1016/s0168-0102(01)00276-0.
50. Jeong H, Johnson AW, Feland JB, Petersen SR, Staten JM, Bruening DA. Added body mass alters plantar shear stresses, postural control, and gait kinetics: implications for obesity. PLoS One. 2021;16(2):e0246605. https://doi.org10.1371/journal.pone.0246605. PMID: 33544773.

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