Changes in Postural Sway After a Single Global Postural Reeducation Session in University Students: A Randomized Controlled Trial

Carlos Lozano-Quijada, PT, PhD,[a] Emilio J. Poveda-Pagán, PT, PhD,[a] José V. Segura-Heras, PhD,[b] Sergio Hernández-Sánchez, PT, PhD,[a] and María J. Prieto-Castelló, PT, PhD[c]

Abstract

Objective: The purpose of this study was to assess the effectiveness of a single session of global postural reeducation (GPR) in postural sway in young adult university students who use data visualization screens.

Methods: A randomized controlled trial with 2 parallel groups was performed. Sixty-four subjects were randomized in the experimental group (12 men and 20 women) who underwent the GPR session, and a control group (13 men and 19 women) that did not receive any intervention was included. Center of pressure (COP) was assessed using a stabilometric platform, with eyes open and eyes closed before, immediately after, 48 hours after, and 7 days after intervention in both groups.

Results: In the interaction of time and gender, statistically significant differences were found for the area covered by COP (P = .020) and for the standard deviation (SD) in the mediolateral axis (P = .035). Considering the complete interaction time, gender, and group, statistically significant differences were found (P = .015) for the anteroposterior rate covered by COP and the SD in the anteroposterior axis (P = .033). In eyes closed condition, the intersubject analysis showed statistically significant differences for the interaction between group and gender for the variable mediolateral SD (P = .043). Considering the interaction of time with group, statistically significant differences were found for full length covered by COP (P = .017).

Conclusions: Changes in postural sway were observed after a single GPR session, mainly at 48 hours, with different behaviors between men and women. (J Manipulative Physiol Ther 2017;xx:1-10)

Key Indexing Terms: *Postural Balance; Posture; Musculoskeletal Manipulations; Muscle Stretching Exercise*

Introduction

Computers, mobile devices, and tablets are omnipresent in modern society, especially in the world of young adults. The use of mobile devices increases the weight that the neck has to bear because of the forward head posture, which depends on the increased bending angle the head must be held at to view the screen.[1] This forward head posture has an effect on the longitudinal axis of the subject by moving it forward.[2] These changes in cervical alignment cause an increase in the stress on the neck muscles,[1] generating muscle fatigue and changes in postural control.[3,4] Individuals in a seated position in front of a computer increase their forward head posture by approximately 10%.[5] In this posture, the lower cervical vertebrae are flexed in a forward glide, and the upper cervical vertebrae are extended.[6,7] A high prevalence of low-level discomfort in legs, head and neck, back, and shoulders in relation to high exposure to data visualization screens (DVSs) was also reported by adolescents.[8]

In the sit-to-stand task, neck proprioception plays an important contribution in regulating postural control and movement patterns.[9] The neural control mechanisms involved in maintaining balance in the sitting and standing tasks are different. In the standing task, postural performance is worse,

[a] Center for Translational Research in Physiotherapy, Department of Pathology and Surgery, Physiotherapy Area, Miguel Hernandez University of Elche, Alicante, Spain.
[b] Center of Operations Research, Miguel Hernandez University of Elche, Alicante, Spain.
[c] Faculty of Medicine, Legal and Forensic Medicine Division, Miguel Hernández University of Elche, Alicante, Spain.
Corresponding author: Emilio J. Poveda-Pagán, PT, PhD, Center for Translational Research in Physiotherapy, Department of Pathology and Surgery, Miguel Hernandez University of Elche, Crta, Valencia s/n 03550 Sant Joan, Alicante, Spain. (e-mail: *ejpoveda@goumh.umh.es*).
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and more neuromuscular activity would be required to maintain balance. In the standing position, the time that balance can be maintained using passive joint stiffness and reflex modulation is briefer, and an intermittent control by means of central neuronal commands produces a greater anticipatory muscle torque.[10]

To evaluate the evolution of postural disorders, the measurement of center of pressure (COP) using a stabilometric platform allows for comparison among different subjects when performing the measurements under the same conditions every time.[11] The measurement of postural sway using COP can be used to detect improvements in postural balancing after proprioception training.[12] It is a tool to assess the effects of chronic lumbar pain[13] and to quantify possible changes in the musculoskeletal activity after treatment with a manual therapy.[14-16]

There are different manual techniques based on treating and balancing the muscle chains tensions that provoke the biomechanical alterations that affect spinal stability.[17-22] The global postural reeducation (GPR)[19,20,22-27] technique describes 2 main master chains, the anterior master chain and the posterior master chain, as well as other secondary chains. Souchard[26] suggested slow stretching of all muscle chains to correct the tendency in the seated position to shorten the anterior chain at the spine level and upper limbs and the posterior chain at the lower limbs. These chains can be lengthened using different groups of postures from GPR treatment. The inverse myotatic reflex[19] and Hooke's physics law and Young's module[2,26] applied to the muscle and tendon tissues justify the low-intensity stretching exercises to avoid tissue damage. Stretching is held for a prolonged time, thus allowing an increased elongation of the shortened muscles.[26]

It is common in clinical practice to perform manual therapy sessions at weekly intervals. We hypothesize that the musculoskeletal changes after a GPR session can be reflected in the displacement and the area covered by COP[27,28] along the interval of 1 week. In addition, we expect that there would be differences between men's and women's responses after the session. Therefore, the purpose of this study was to investigate these effects in university students who use DVSs to analyze how long the changes remain. The secondary aim was to assess potential differences by gender in COP behavior.

Methods

Design

A randomized controlled trial with 2 parallel groups (experimental and control) was designed. Written informed consent was obtained from the participants before data collection. The study was approved by the Miguel Hernández University (UMH) Research Ethics Committee (DPC-CLQ-001-12) and conformed to the Declaration of Helsinki. The study was registered in clinicaltrials.gov (NCT02175667).

Setting and Participants

The study was conducted between July and October of 2014 at the Miguel Hernandez University physiotherapy research center. The study population comprised healthy volunteer university students ranging from 19 to 35 years of age. Inclusion criteria to participate were being a university student and remaining seated or standing in front of a DVS (tablet, computer, and smartphone) for at least 4 hours a day. Exclusion criteria were participants who had been diagnosed with a severe comorbid disorder or who had undergone surgery in the 6 months prior to the recruitment. Those with some type of musculoskeletal injury or disability or who were scheduled to undertake physiotherapy treatment or training during the study period were also excluded.

Randomization and Interventions

Participants were recruited during June/July 2014 by a researcher who did not perform the intervention. To recruit the sample, we first obtained permission from professors teaching different courses at the Campus of Health Sciences of the Miguel Hernandez University to access the students in one of their classes. After a short presentation about the study's aims and having obtained the participants' cooperation, the volunteers were randomly assigned to the groups by the same researcher by uniform distribution (0,1) using Microsoft Excel 2013. All participants underwent a baseline postural sway measurement. Then, each subject of the experimental group was treated with GPR by an experienced physiotherapist to correct specific compensations in each muscle chain.[26,29] The procedure (45 minutes) consisted of 4 phases of treatment and 3 positions of GPR[26,29-32] (Fig 1) as follows:

First phase (5–6 min). Participant in supine position; physiotherapist begins with specific work of diaphragmatic breathing and soft cervical traction (stretching muscles involved in breathing).

Second phase (25 min). "Open hip angle with upper limbs in adduction" posture. Participant in supine position with upper limbs at 45° of abduction and flexed, abducted, and laterally rotated hips, with the soles of the feet touching each other to stretch the anterior muscle chain (diaphragm, pectoralis minor, scalene, sternocleidomastoid, intercostalis, iliopsoas, arm flexors, forearm pronators, and hand flexors). The pelvis is kept in retroversion with an initial traction of the sacrum, while the lumbar spine remains stabilized, and the lower limbs are extended as much as possible while maintaining the corrections. The physiotherapist stretches superior shoulder muscle chain (upper

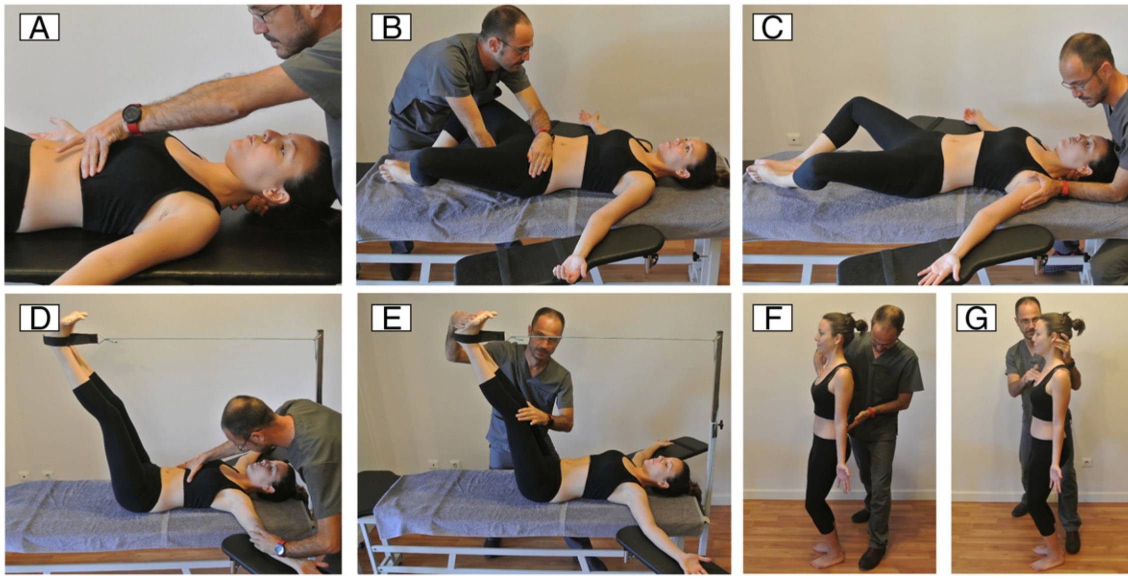

Fig 1. *Global postural reeducation session. A, Work of diaphragmatic breathing and soft cervical traction. B, Traction of the sacrum in posture "open hip angle with upper limbs in adduction." C, Work of superior shoulder muscle chain. D, Work of the anterointernal shoulder chain in posture "closed hip angle with upper limbs in abduction." E, Specific work of the lower limb. F, Thoracic and lumbar corrections in posture "standing in the center." G, Final cervical corrections.*

trapezius, elevator scapulae) with upper limbs into adduction (to adduction from 45° to 0°), emphasizing the diaphragmatic breathing and cervical traction.

Third phase (10–15 min). "Closed hip angle with upper limbs in abduction" posture. Participant in supine position with stabilized occipital, lumbar, and sacral spine, and 90° hip flexion on the lower limbs to stretch the posterior muscle chain (suboccipitalis, erector spinae, gluteus maximus, hamstrings, triceps surae, and foot intrinsic muscles). In this posture, the physiotherapist stretches anterointernal muscle chain (major pectoralis and subscapular) with 45° of abduction to 130° to 140° in the upper limbs. Furthermore, the physiotherapist makes all the lower limb corrections while performing gradual knee extension.

Fourth phase (3–5 min). "Standing in the center" posture. With the participant standing with an open hip angle and slightly flexed knees, the physiotherapist makes final corrections for postural integration for the whole stretching while the participant extends the knees, maintaining the correct posture of the spine and upper and lower limbs.

After the treatment session, participants had 5 minutes to rest in the sitting position, and the measurements were repeated. The participants from the control group underwent the exact same measurements, but instead of receiving treatment between the baseline and immediately after, they remained seated for 45 minutes on a stable seat.

Outcomes Measures and Follow-Up

Measures. The postural sway variables considered for this study were the measurement of the length of displacement of COP (length) and the area covered by the COP (area). COP was also analyzed in the mediolateral position (X_{mean}) and anteroposterior position (Y_{mean}), mediolateral rate movement (DeltaX) and anteroposterior rate movement (DeltaY), as well as the mediolateral and anteroposterior standard deviations (SDs; SDX and SDY, respectively).[12]

Measurement Systems. For postural sway measurements, the Freemed (Rome, Italy) pressure platform was used along with the FreeStep software version 1.0.3 (Rome, Italy). The total surface of the platform is 555 × 420 mm, 8 mm thick, with an active measurement surface of 400 × 400 mm. All measurements were conducted during 90 seconds with a measuring frequency of 100 Hz.[33,34] Because of the contrasted reliability of the platform,[12] a single measure was taken for each test.

Weight was measured using Seca brand scales, model 762. Height was measured with a Seca brand measure, model 216.

Measurement Conditions. The conditions for measurement were reproduced exactly for each trial: The participants had to be barefoot and with their feet at a 15° angle from the sagittal plane and heels separated by 2 cm.[11,35] The postural sway was assessed for 90 seconds, first with eyes open (EO) and then with eyes closed (EC). Between each measurement, a 1-minute rest period was allowed; the participant remained seated. For the EO measure, the participant was

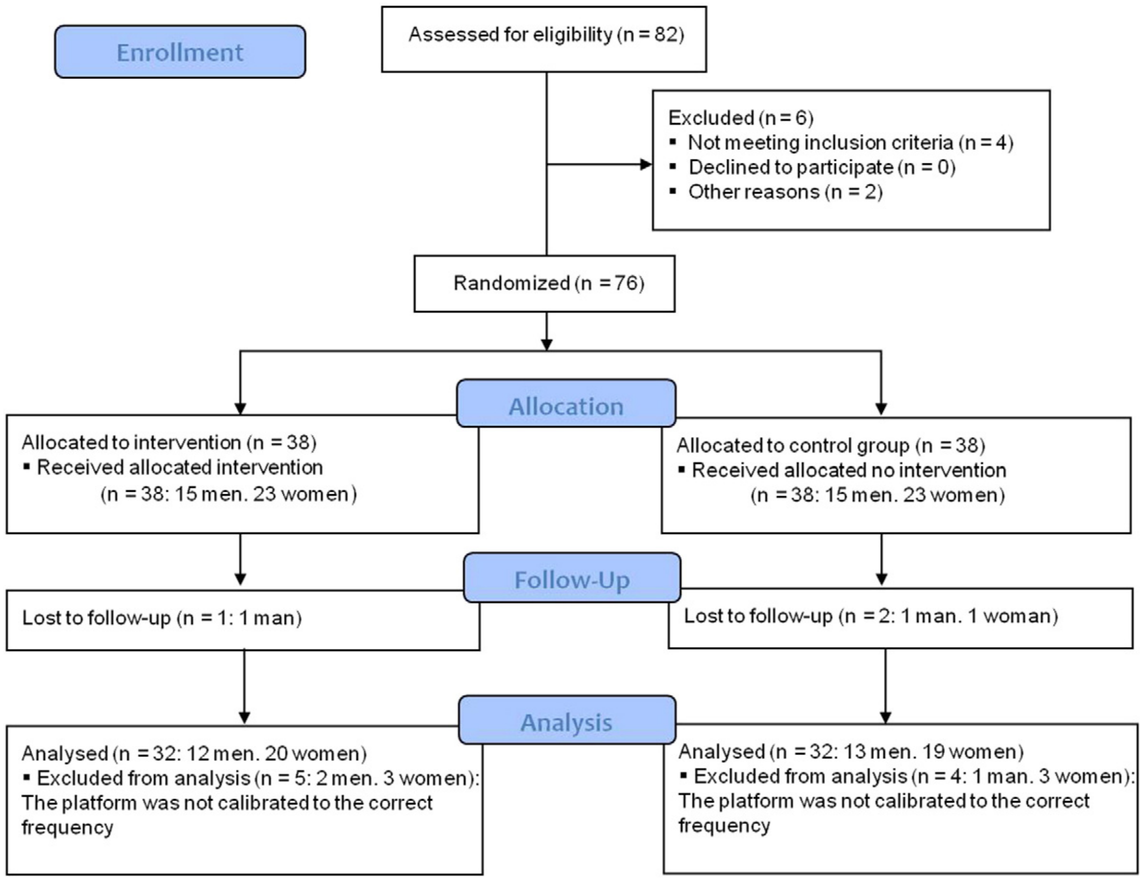

Fig 2. *CONSORT 2010 flow diagram.*

asked to look at a white dot (2 cm in diameter) placed 2 m away at eye level. For the EO and EC measurements, the participants were asked to stand in a relaxed posture with arms hanging by their sides, and they were asked to count out loud.[11] For the follow-up, the measurements were repeated 3 times after intervention (immediately after, 2 days later, and 7 days later) to assess the effects of GPR after 1 week. All the measures were taken in the same laboratory and in the afternoon to avoid any influence of time of day.[36]

Sample Size. The main aim was to compare, by gender, the results between the experimental and control groups during a specific period (3 time points), using repeated measures analysis of variance with 2 intersubject factors (2 × 2), expecting a medium effect size (f = 0.25). Considering a type I error of 5% and a 95% power, as well as minimum correlation of 0.6 between the measures, at least a total sample size of 48 individuals would be necessary (12 per cell). The G*Power 3.1 statistical package was used for this calculation.

Statistical Analysis. Descriptive statistics are presented using mean and SDs for continuous variables. Differences between groups are expressed as mean differences with 95% confidence intervals. The Kolmogorov-Smirnov test was used to check the normal distribution of quantitative variables. For the anthropometric variables, Student's t test for independent samples was used in continuous variables. A general linear model for repeated measures was used to assess the effect of gender and experimental group as intersubject factors, and time as the intrasubject factor (analysis of variance). The Bonferroni test was used for paired comparisons, and significance was determined with α = 0.05. Data were analyzed using SPSS for Windows (version 21; SPSS, Inc., Chicago, Illinois).

Results

A total of 82 participants were recruited (Fig 2), of which 76 met the inclusion criteria, and 64 (39 women and 25 men) completed the final analysis process. Mean age was 22 years (SD 3.7; range 19-35 years); mean height 169.2 cm (SD 10; range 151–193 cm); mean weight 66 kg (SD 14.1; range 42–111 kg); body mass index mean 22.9 (SD 3.2; range 17–32.8). The 95% confidence intervals for the anthropometric variables between the control group and the experimental group were age (−0.5 to 3.1), height (−1.7 to 8.2), weight (1.4–15.1), and body mass index (0.3–3.4).

Table 1. *Eyes Open—Mean (SD) for Postural Sway Variables for Each Group, Mean (SD) Difference Within Groups, and Mean (95% CI) Differences Between Groups*

	Groups								Differences Within Groups						Differences Between Groups		
	Baseline		Day 0		Day 2		Day 7		Day 0 Minus Baseline		Day 2 Minus Baseline		Day 7 Minus Baseline		Day 0 Minus Baseline	Day 2 Minus Baseline	Day 7 Minus Baseline
Outcome	Exp (n = 32)	Con (n = 32)	Exp (n = 32)	Con (n = 32)	Exp (n = 32)	Con (n = 32)	Exp (n = 32)	Con (n = 32)	Exp	Con	Exp	Con	Exp	Con	Exp-Con	Exp-Con	Exp-Con
Area (mm^2)	71.2 (70.7)	55.4 (40.7)	85 (75.2)	91.9 (111.9)	66.8 (89.7)	97.5 (101.5)	66.7 (56.4)	78.2 (70.1)	13.9 (63.5)	36.5 (107)	-4.4 (69.2)	42.1 (101.3)	-4.5 (63)	22.8 (65.1)	-22.6 (-66.6 to 21.4)	-46.4 (-89.8 to -3.1)	-27.3 (-59.3 to 4.8)
Length (mm)	7391 (2308.5)	6862 (1828.4)	6896.4 (2119.3)	6751.8 (1941.5)	6933.2 (2317.1)	6703.1 (1772.2)	6881.6 (2047.5)	7012.2 (1933.2)	-494.6 (2008.1)	-110.2 (1788.8)	-457.8 (1701.2)	-158.9 (1291.9)	-509.4 (1841.3)	150.3 (1402.1)	-384.4 (-1334.7 to 565.9)	-298.9 (-1053.7 to 456)	-659.6 (-1477.5 to 158.2)
DeltaX (mm)	9.1 (4.9)	8.1 (2.7)	9.2 (3.9)	10.4 (6.1)	8.9 (3.4)	10.6 (5.1)	9.5 (3.9)	9.4 (3.4)	0.1 (4.1)	2.3 (5.4)	-0.2 (4.3)	2.5 (4.7)	0.4 (4.6)	1.2 (3.1)	-2.2 (-4.6 to 0.2)	-2.8 (-5 to -0.5)	-0.8 (-2.8 to 1.1)
DeltaY (mm)	11.9 (5.3)	11.6 (4.7)	12.7 (6)	12.9 (7.3)	11.5 (7.7)	13.6 (9.1)	11.9 (5.8)	11.9 (6.2)	0.7 (5.9)	1.3 (7.1)	-0.4 (6.5)	2 (8.6)	0 (7.7)	0.3 (5.6)	-0.5 (-3.8 to 2.7)	-2.3 (-6.2 to 1.5)	-0.3 (-3.7 to 3.1)
X_{mean} (mm)	-1.1 (6.1)	0.2 (5.3)	-0.8 (5.1)	1.7 (5.8)	-0.6 (4.8)	0.2 (5.5)	-0.2 (4.8)	0.4 (4.2)	0.3 (5.9)	1.5 (5.7)	0.5 (5.5)	-0.1 (6.4)	0.9 (7)	0.2 (5)	-1.2 (-4.1 to 1.7)	0.5 (-2.5 to 3.5)	0.8 (-2.3 to 3.8)
Y_{mean} (mm)	-17 (12.3)	-16.6 (9.6)	-16.5 (10.1)	-14.4 (9.9)	-16.1 (10.5)	-14.9 (9.2)	-15.6 (13.3)	-14.3 (10.4)	0.5 (8.3)	2.2 (7.3)	0.9 (8.4)	1.7 (6.6)	1.4 (8.6)	2.4 (6.9)	-1.7 (-5.7 to 2.2)	-0.8 (-4.6 to 3)	-1 (-4.9 to 2.9)
SDX (mm)	1.5 (0.8)	1.3 (0.5)	1.6 (0.8)	1.6 (0.9)	1.4 (0.5)	1.7 (0.9)	1.6 (0.7)	1.6 (0.7)	0.1 (0.8)	0.4 (0.8)	-0.1 (0.7)	0.5 (1)	0.1 (0.7)	0.3 (0.7)	-0.3 (-0.7 to 0.1)	-0.6 (-1 to -0.1)	-0.2 (-0.6 to 0.1)
SDY (mm)	(2) 1	2 (0.9)	2.4 (1.3)	2.3 (1.4)	2 (1.4)	2.4 (1.5)	2 (1.1)	2.2 (1.1)	0.3 (1.2)	0.3 (1.4)	0 (1.1)	0.4 (1.5)	-0.1 (1.5)	0.2 (1.1)	0 (-0.6 to 0.7)	-0.4 (-1.1 to 0.2)	-0.2 (-0.9 to 0.4)

Area, area covered by center of pressure; *Baseline,* before intervention; *CI,* confidence interval; *Con*, control; *Day 0,* immediately after intervention; *Day 2,* 2 days after intervention; *Day 7,* 7 days after intervention; *DeltaX,* rate covered by the center of pressure in mediolateral direction; *DeltaY,* rate covered by the center of pressure in anteroposterior direction; *Exp*, experiment; *Length,* length covered by center of pressure; *SD,* standard deviation; *SDX,* standard deviation in mediolateral direction; *SDY,* standard deviation in anteroposterior direction; X_{mean}, mean mediolateral position; Y_{mean}, mean anteroposterior position.

Table 2. *Eyes Closed—Mean (SD) for Postural Sway Variables for Each Group, Mean (SD) Difference Within Groups, and Mean (95% CI) Differences Between Groups*

	Groups								Differences Within Groups						Differences Between Groups		
	Baseline		Day 0		Day 2		Day 7		Day 0 Minus Baseline		Day 2 Minus Baseline		Day 7 Minus Baseline		Day 0 Minus Baseline	Day 2 Minus Baseline	Day 7 Minus Baseline
	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp	Con	Exp-Con	Exp-Con	Exp-Con
Outcome	(n = 32)	(n = 32)	(n = 32)	(n = 32)	(n = 32)	(n = 32)	(n = 32)	(n = 32)									
Area (mm^2)	79.9 (90.8)	88.8 (83.1)	96.8 (77.9)	160.8 (209.9)	99.5 (124.6)	134.8 (212.9)	87.8 (76.8)	135.3 (169.2)	16.9 (67.8)	72 (153.7)	19.7 (63.3)	46 (156.7)	8 (61.5)	46.5 (152.5)	-55.1 (-114.4 to 4.3)	-26.3 (-86 to 33.4)	-38.6 (-96.7 to 19.5)
Length (mm)	6445.2 (1645.4)	6483 (1476.8)	6307.9 (1744.1)	6625 (1639.7)	6565.8 (1663)	5907.7 (1630.3)	6401 (1792.2)	6487.9 (1786.4)	-137.3 (1287.9)	142 (1233.6)	120.6 (1536.6)	-575.4 (1517.9)	-44.2 (1186.3)	4.8 (1380.9)	-279.3 (-909.5 to 350.9)	696 (-67.3 to 1459.2)	-49 (-692.3 to 594.3)
DeltaX (mm)	11.2 (4.1)	11.1 (4)	11.9 (4.3)	13.4 (7.7)	11.4 (3.4)	13.6 (7.3)	11.3 (3.4)	13.6 (6.2)	0.7 (4)	2.3 (5.9)	0.2 (3.9)	2.5 (6.4)	0.1 (4)	2.6 (5.4)	-1.7 (-4.2 to 0.8)	-2.3 (-4.9 to 0.4)	-2.4 (-4.8 to -0.1)
DeltaY (mm)	13.3 (7.2)	13.5 (5.8)	13.5 (5.6)	16.4 (9.8)	13.4 (5.5)	16 (12.4)	13.6 (7.1)	16.8 (10.4)	0.2 (4.2)	2.9 (8.2)	0.1 (4.4)	2.6 (9.9)	0.2 (4.6)	3.3 (9)	-2.7 (-5.9 to 0.6)	-2.4 (-6.3 to 1.4)	-3.1 (-6.7 to 0.5)
X_{mean} (mm)	0.5 (5.7)	1.4 (5.1)	-0.1 (5.5)	2.3 (5.3)	0.1 (4.9)	0.8 (4.6)	-0.1 (5.7)	0.8 (4.4)	-0.6 (5.8)	0.9 (6.5)	-0.3 (5.6)	-0.5 (5.2)	-0.5 (6.1)	-0.6 (5)	-1.5 (-4.6 to 1.6)	0.2 (-2.5 to 2.9)	0.1 (-2.7 to 2.9)
Y_{mean} (mm)	-14.3 (9)	-14.2 (10.5)	-15 (10)	-14.5 (12.3)	-15.1 (11.4)	-13.7 (11.5)	-12.9 (11.7)	-15.6 (10.1)	-0.7 (6.2)	-0.3 (9.1)	-0.8 (9.4)	0.6 (8.8)	1.4 (8.5)	-1.4 (7.6)	-0.5 (-4.4 to 3.4)	-1.4 (-5.9 to 3.2)	2.8 (-1.3 to 6.8)
SDX (mm)	1.6 (0.6)	1.7 (0.7)	2 (0.8)	2.1 (1.4)	1.8 (0.7)	2 (1.2)	1.8 (0.7)	2.2 (1.1)	0.3 (0.7)	0.4 (1.1)	0.2 (0.7)	0.3 (1.1)	0.2 (0.8)	0.5 (0.9)	-0.1 (-0.6 to 0.4)	-0.1 (-0.6 to 0.3)	-0.4 (-0.8 to 0.1)
SDY (mm)	2.2 (1.4)	2.4 (1.2)	2.2 (1.1)	2.9 (2)	2.3 (1.5)	2.7 (2.3)	2.3 (1.3)	2.7 (1.8)	0 (0.9)	0.5 (1.7)	0.1 (0.9)	0.3 (1.9)	0.1 (0.7)	0.3 (1.8)	-0.5 (-1.2 to 0.2)	-0.2 (-0.9 to 0.6)	-0.2 (-0.9 to 0.4)

Area, area covered by center of pressure; *Baseline,* before intervention; *CI,* confidence interval; *Con*, control; *Day 0,* immediately after intervention; *Day 2,* 2 days after intervention; *Day 7,* 7 days after intervention; *DeltaX,* rate covered by the center of pressure in mediolateral direction; *DeltaY,* rate covered by the center of pressure in anteroposterior direction; *Exp*, experiment; *Length,* length covered by center of pressure; *SD,* standard deviation; *SDX,* standard deviation in mediolateral direction; *SDY,* standard deviation in anteroposterior direction; X_{mean}, mean mediolateral position; Y_{mean}, mean anteroposterior position.

For a simpler representation, only time and group factors are shown in Table 1 (EO) and Table 2 (EC). All the considered interactions for the complete factorial model are shown in the online supplementary files for EO condition (Supplementary Table 1, available online) and EC condition (Supplementary Table 2, available online), and individual patient data are presented in Supplementary Table 3 (available online).

In EO condition, the intersubject analysis for all variables did not show any statistically significant differences. However, some variables presented *P* values close to the α considered: Area (*P* = .096), DeltaX (*P* = .084), and SDX (*P* = .071). Considering the interaction of time and group, statistically nonsignificant differences were found for any variable. Only SDX is close to the α considered (*P* = .079). In the interaction of time and gender, statistically significant differences were found for the variables of area (*P* = .020) and SDX (*P* = .035). Considering the complete interaction time, gender, and group, statistically significant differences were found for DeltaY (*P* = .015) and SDY (*P* = .033).

In the EC condition, the intersubject analysis showed statistically significant differences for the interaction between group and gender for the variable SDX (*P* = .043). When considering the interaction of time with group, statistically significant differences were found for length (*P* = .017). No statistically significant differences were found for the interaction between time and gender, and for the interaction between time, gender, and group, although the values were close to α considered for DeltaX (*P* = .065) and Y_{mean} (*P* = .089).

Discussion

Supporting the hypothesis that GPR session has effects on postural sway, some differences were found between the GPR group and the control group in our study, mainly on the length covered by COP and anteroposterior shifting. Moreover, some behavioral differences appeared when gender was considered.

In comparison with our study, Lopez et al[37] also found a decrease in anteroposterior shifting, but this was found after 4 weeks of a manual osteopathic intervention on healthy older adult participants. Alburquerque-Sendín et al[15] did not consider their results as sufficient to support the improvement of stability despite having found statistically significant anteroposterior differences after a talocrural manipulation in young healthy participants.

Although Souchard and Ollier[28] and Pastor[27] mentioned the possibility of using the stabilometric platform to assess postural changes, we have not found any other clinical trials that assess the effect of a specific GPR treatment for postural correction using COP measures. Nevertheless, postural corrections applied with corsets in patients with scoliosis have shown changes in postural balancing, but on an unstable surface.[38] Reid et al[16] found no differences in postural balance after applying Maitland's spinal manipulation treatment for 12 weeks on participants with cervicogenic dizziness, but they found changes in cervical articulation range and head position. There is no conclusive evidence that manual therapeutic interventions exert any immediate or long-term effects on COP excursions in healthy individuals.[14] The stabilometry is probably more appropriate to assess changes in subjects with pain[13] or in older subjects.[39-41] Other authors proposed different instruments to assess the postural effect of a GPR session. Bezerra et al[42] proposed the use of morphologic segments of the participants' images to diagnose posture problems, assess physiotherapy treatment evolution, and thus reduce diagnostic errors resulting from subjective analysis. Oliveri et al[22] analyzed the short-term effects of a single session of GPR using transcranial magnetic stimulation in healthy subjects. They found significant differences in the stimulation of areas where brain activity belongs to the muscles that had been treated.

In the current study, the behavior with EO throughout time in the area covered by COP and in the mediolateral SD (SDX) was different between men and women, independent of group assignment. When the effect of the experimental and control groups was considered for EO, the difference in behaviors by gender throughout time was found in the anteroposterior axis for the DeltaY and SDY variables. In the interaction of group and gender, some differences between men and women also appear for EC. Several other studies have also found gender differences in postural sway.[39,41,43-48] Era et al[47] found differences in speed (correlated with length) for each of 5 age groups (7979 adults aged 30 years and over) and propose separate normative values for both genders. Kim et al[39] observed that gender differences persist even when data are normalized by subjects' height, but mainly in older adults, not in the young. Nevertheless, Chiari et al[48] found that the differences by gender did not persist when several anthropometric variables were controlled or feet position was standardized, and they concluded that most of the effects of gender on standing body sway resulted from biomechanical properties rather than neural control. In another study, Raffi et al[46] observed that there was a difference in the responses in postural sway and in muscular activity according to the gender of subjects when measured with electromyography in front of a visual stimulus. Koslucher et al[43,44] suggested in their studies on young adults that gender differences in the control of postural balance may be related to susceptibility to motion sickness, which is significantly greater in women. In our study, we hypothesize that this susceptibility may be related to the effects suffered by women after a manual therapy session, as women show more significant changes compared with men.

The interpretation of changes in postural sway in asymptomatic young adults may differ from those in other populations.[13,39-41] Different studies examined the functional aspects of motor and postural variability that show the magnitude of sway (area, length, displacement in X and Y axis) does not directly relate to stability.[49-52] Reducing the functional degrees of freedom can be a strategy to reduce the perturbations that are constantly acting on the body during the upright stance. In asymptomatic young adults, postural sway within the base of support may also be beneficial because these movements can be exploratory and provide sensory information about how their body interacts with the environment.[49,53] Hasson et al[54] observed that in a quiet stance, the alterations in muscular mechanical properties of plantar flexors had a predictive role in balance performance. This effect did not depend directly on age, but the plantar flexors show a decline in strength and volume with aging, and the authors suggest that other factors, such as age differences, reaction time, and sensory thresholds, may further explain balance degradation.

Only a few clinical trials have studied the 1-week follow-up after a manual therapy intervention. In our study, the most significant changes occurred at 48 hours. After 1 week, these changes tend to return to the baseline, but not completely. Oliveira-Campelo et al[55] with a similar follow-up (immediately, 24 hours, and 7 days after) analyzed the effects of different manual techniques on cervical ranges of motion and pressure pain sensitivity in subjects with latent trigger point of the upper trapezius muscle. They found that the effects of these techniques persisted after 1 week. In asymptomatic subjects with sacroiliac restriction, Grassi et al[56] obtained a positive influence on weight distribution among the feet of an asymptomatic population immediately and 1 week after a high-velocity, low-amplitude sacroiliac joint thrust. These data support the idea that a 1-week interval between sessions may be appropriate for GPR treatment.

Findings must be interpreted with caution because of some limitations. Our study was focused on asymptomatic university students with no significant musculoskeletal disabilities or pain,[14] and no blinded participants were treated in a single session. However, the strength of the current study is that the effects of a manual therapy on postural sway have been analyzed with a 1-week follow-up, including the effects based on gender and visual control.

Conclusions

A single session of GPR for university students who used DVSs produced some changes in postural sway, but these changes cannot be interpreted as an improvement or alteration in postural stability. After a single session of GPR, postural sway showed differences between men and women, suggesting that future studies should further explore the effects of manual therapy techniques according to the gender of subjects. The biggest differences in behavior between the groups were found at 48 hours, and the values then tended to return to the baseline further along the week.

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Contributorship Information

Concept development (provided idea for the research): C.L.Q., E.J.P.P., M.J.P.C.

Design (planned the methods to generate the results): C.L.Q., E.J.P.P., M.J.P.C.

Supervision (provided oversight, responsible for organization and implementation, writing of the manuscript): C.L.Q., E.J.P.P., M.J.P.C., S.H.S.

Data collection/processing (responsible for experiments, patient management, organization, or reporting data): C.L.Q., J.V.S.H.

Analysis/interpretation (responsible for statistical analysis, evaluation, and presentation of the results): C.L.Q., J.V.S.H.

Literature search (performed the literature search): C.L.Q., E.J.P.P., S.H.S.

Writing (responsible for writing a substantive part of the manuscript): C.L.Q., S.H.S., J.V.S.H.

Critical review (revised manuscript for intellectual content, this does not relate to spelling and grammar checking): C.L.Q., E.J.P.P., M.J.P.C., J.V.S.H., S.H.S.

Practical Applications

- Postural sway changes after a single GPR session.
- This study suggests that there is different behavior between men and women after a GPR session, and future studies should further explore by gender the effects of manual therapy techniques to control better these different effects after clinical sessions.
- The interval of 48 hours and 7 days could be considered while planning clinical sessions of GPR.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jmpt.2017.06.005.

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