



Research Article

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Immediate Effect of Bilateral Talocrural Joint Manipulation on Postural Balance in Healthy Subjects

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The aim of this study was to assess the immediate effect of bilateral talocrural joint manipulation on the postural balance of healthy subjects. Ninety healthy subjects (21 males and 69 females) were included in this study. The mean age, height and body weight of the subjects were 22.21 years, 165.1 cm and 62.58 Kg, respectively. Following collection of anthropometric data, the subjects were allocated randomly into an experimental group (receiving real talocrural joint manipulation), a placebo group and a control group. Before and after manipulation, the subjects performed two postural balance tasks, in quiet standing position (eyes open and eyes closed) on a force platform. The stabilometric data were recorded for 60 seconds in each condition. Sway area, medio-lateral (ML) and antero-posterior (AP) velocities and median frequency were calculated from the center of pressure (COP) displacements. The results showed that in the experimental group the COP sway velocity decreased in both directions of movement (AP and ML) and in both visual tasks (eyes open and eyes closed). In general, the placebo and control groups had similar postural balance across balance parameters. Significant effect of the bilateral talocrural joint manipulation was found on main balance parameter like COP velocity in the anteroposterior and mediolateral directions. These results have some much implications for manual therapy rehabilitation of individuals with ankle instability.

Keywords: Posture; Manual therapy; Physical Therapy; Rehabilitation**Introduction**

Balance is the ability to maintain equilibrium by positioning the centre of gravity over the base of support of body. It is carried out by a complex process involving afferents from the sensory system, integration of efferents by central nervous system and afferent being sent to an intact musculoskeletal system [1].

Static position sense, or the perception of a stationary joint angle, depends on afferent information from joint receptors along with signals from muscle spindles and Golgi tendon organs [2]. Ruffini receptors and Pacinian corpuscles are both classified as dynamic receptors; however, Ruffini receptors have also been described as static receptors based on their low-threshold, slow-adapting characteristics. It has been suggested that these types of receptors are stimulated when a joint is moved near the end range of motion [3]. Therefore, it is suggested that good proprioception is of concern in promoting of dynamic joint and of functional stability in sports, activities of daily living and occupational tasks.

The ankle joints also play an important role in maintaining postural stability [4]. Loss of postural control has been consistently observed in patients with chronic ankle instability [5] and after an acute ankle sprain [6], which can present poor proprioception and/or poor muscular capacity to protect the joint and physical performance. Ankle manipulation has excellent potential to assist in the treatment of a variety of foot disorders related to postural instability. The understanding of the techniques of ankle manipulation as well as of the recommendations for its use can be a clinical valuable tool for the rehabilitation programs. Some scientific evidences has showed positive effects of joint mobilization on functional balance performance related to changes in sensorimotor system function [7,8]. However, functional tests can measure balance deficit indirectly through the recorded time-limit of physical performance (i.e., one aspect of physical condition

or muscular capacity of individual), while centre of pressure (COP) parameters from a force platform can directly analyze balance deficits related to proprioception and postural adjustments (feedback and feedforward) of the neuromuscular system [9]. This is further supported by a recent study [10] suggesting that clinical functional tests such as time-limit to stand one leg and laboratory-based measures from COP parameters may capture different aspects of balance.

Another aspect of these two studies [7,8] was reporting the results with only massage and simple joint mobilization on intervention process. Few studies has investigated the caudal talocrural joint manipulation from high-velocity and low-amplitude caudal thrust. Comparing with placebo, López-Rodríguez et al. [11] that investigated the caudal talocrural joint manipulation in athletic individuals with grade II ankle sprain showed better balance related to load support at foot level. Although these effects support, at least, positive results on postural system regulation, it is unclear still whether there is an immediate (acute session) effect on postural stability after therapeutic ankle manipulation during a standing position with two different conditions (eyes open and eyes closed) on a force platform measurement.

Postural stability has traditionally been examined by spatial

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measures of the center of pressure (COP), where greater COP movements are considered signs of postural instability. COP parameters are defined as the coordinates of the resultant force applied through the feet on a force plate along anteroposterior (AP) and mediolateral (ML) orthogonal axes [12]. The stabilometric parameters that are most commonly reported in the literature describe the statistical properties of the COP trajectory, which is considered a stationary signal, in the time and frequency domains [13,14]. The most commonly used COP parameters are mean velocity and sway area, with the mean velocity considered the most reliable [15,16].

Although one study found that talocrural joint manipulation immediately affects on postural stability [7], a similar effect was not observed in another study [12]. These discrepancies in the results may be related to methodological differences regarding protocol or equipment (functional performance, balance scale, force platform baropodometer, functiona), patient age (adults versus elderly) and patient activity level (athletes and non-athletes). The aim of this study was thus to assess immediate effect of bilateral talocrural joint manipulation on the postural balance of healthy subjects during a standing position in two tasks (eyes open and eyes closed) on a force platform, which is of concern to determine the effects of intervention on biomechanical and neuromuscular strategies of postural control.

Materials and Methods

Subjects

Ninety healthy subjects (21 males and 69 females) were recruited voluntarily and by convenience to participate of this study. The subjects characteristics were in mean age 22.21 years (SD 2.42), height 165.1 cm (SD 0.7) and body weight 62.58 Kg (SD 12.70). An orthopedic physician examined all subjects before each trial to ensure that they had no musculoskeletal injuries, neuromuscular disorders, lower extremity injuries, spine pathology, balance problems or pain. Subjects reporting an acute ankle sprain within the past 6 months, a previous history of lower extremity surgeries or a fracture within the past 6 months were also excluded from the study.

Following the collection of anthropometric data, the subjects were allocated randomly by using a computer software into an experimental group, a placebo group and a control group (Table 1). All subjects were informed about the experimental protocol and the potential risks of the study and gave written consent before their participation. The protocol and the consent form had been previously approved by the local Ethics committee (UNICID, SP).

Procedure and data collection

The bilateral talocrural joint manipulation procedure in the experimental group was similar to that described by López-Rodríguez et al. [11]. A trained therapist applied a high-velocity, low-amplitude caudal thrust directed at the talocrural joint in the following manner: with the patient in the supine position, the therapist wrapped his or her hands around the leg with the fingers at the level of the neck of the talus and then applied caudal traction, increasing the dorsiflexion at the talocrural joint. In the placebo group, the positioning of the physical therapist and the subjects remained the same, but the handgrip was such that neither therapeutic traction nor joint manipulation occurred: the volunteers feet were simply held bilaterally for 20 seconds and then repositioned on the table. For both intervention and placebo groups the same therapist applied the technique to avoid possible bias. In the control group, after the first data recording, the volunteers remained

lying on the table for one minute and stabilometric data recording recommenced.

Stabilometric data collection

Before testing, all subjects were familiarized with the balance protocol. Two conditions were tested during quiet standing: (i) eyes open and eyes closed in pre-manipulation of talocrural joint; (ii) eyes open and eyes closed after manipulation of talocrural joint occurred. These two conditions were performed before the (pre) and immediately after (post) the manipulation without any resting time. The order of the trials was randomized for each subject. Another investigator trained conducted all balance evaluation on the force platform (e.g. evaluator blind to intervention). The participant remained with arms alongside the body and gaze fixed on a circular target (5 cm in diameter) at the height of the glabellum attached to a pedestal at a distance of 1.5 meters from the volunteer. The stabilometric data were recorded for 60 seconds at a sampling frequency of 100 Hz in each trial, with the feet close together on a BIOMECH 400 16-bit force plate (EMG System do Brasil). This platform features load cells with an internal circuit that changes electrical resistance upon the application of a force; the device's accuracy is 0.5 % and its dimensions are 500 × 500 mm.

The data analyses were performed using Matlab 7.1 software (The Math Works, Inc. Natick, MA, USA). The COP data were low-pass filtered at 10 Hz with a Butterworth filter. After filtering, the COP sway area was calculated, as well as the mean velocity and frequency of the COP data in the anteroposterior and mediolateral directions. The COP excursion was defined as the maximum displacement of the COP in each direction (i.e., the distance between the farthest points in the COPap and COPml directions). The CoP area was estimated by fitting an ellipse to the CoP data (AP versus ML) that encompasses 95% of the data [17]. The COP velocity was calculated as the total COP displacement divided by the measurement time. The frequency of the COP displacement is the frequency below which 80% of the COP spectral power occurs [18,19]. The power spectral density of the COP data was estimated by the Welch periodogram method with a resolution of 0.039 Hz. The validity and reliability of all these parameters computed with this BIOMECH 400 force platform have been accepted for both young adults and elderly subjects as reported by a recent study [17].

Statistical analyses

The statistical data was analyzed in SPSS 16.0 for Windows (SPSS Inc., Chicago, IL, USA); the Shapiro-Wilk test was used to check for normal data distribution. Since the data were not normally distributed, the Kruskal-Wallis test was used to test the homogeneity of stabilometric parameters (sway area, velocity and median frequency) between the three groups (experimental, placebo and control) before manipulation of the talocrural joint. The manipulation effect of the talocrural joint in the two conditions visual (eyes open and eyes closed)

	Experimental Group (n = 30)	Placebo Group (n = 30)	Control Group (n = 29)
Gender	5 M / 25 F	7 M / 23 F	8 M / 21 F
Age (yrs)	22.20 ± 2.64	22.07 ± 2.69	22.45 ± 1.93
Body weight (Kg)	61.42 ± 8.91	61.06 ± 11.36	65.12 ± 16.89
Height (m)	1.64 ± 0.07	1.65 ± 0.08	1.67 ± 0.08

The data are presented in mean values with Standard deviation (±).
M: male; F: female

Table 1: Characteristics of subjects.

conditions was determined by the Wilcoxon test for each group of subjects (experimental, placebo and control) with an alpha level of 0.05.

Results and Discussion

To analyse the effect of talocrural joint manipulation, it was necessary to verify whether the stabilometric data presented significant differences between groups (experimental, placebo, control) before the intervention. There were no significant differences in the values for sway area, velocity and median frequency in the COPap and COPml displacement between the groups in both balance experimental condition (eyes open and eyes closed) (Table 2).

In relation to interventions effects on balance after the manipulation, experimental group reduced in mean 0.4 cm/s the sway COP velocity values in the two directions (AP and ML) in both tested conditions (Table 3). The median frequency was significantly lower in the experimental group after manipulation at the eyes open condition only. These results support the improve of postural stability on experimental

manipulation group. In general, similar postural balance results were found between placebo and control groups across balance parameters. Interestingly, the control group poored the balance of 0.34 cm² from sway COP area results for eyes open condition (Table 3).

The results of the present study are in agreement with previous studies, despite the protocols and sample differences. Similar effects have been described after caudal talocrural joint manipulation [11] and an association of massage and mobilization of the feet and ankles [7,8]. Apparently, high-velocity and low-amplitude caudal thrust directed at the talocrural joint helps to improve the balance by stimulating the afferents inputs arising of mechanoreceptors in the ankle ligaments and capsule. These changes were only observed in the experimental group and demonstrate that change occurs in sensorimotor system function following joint mobilization. Muscle spindles play a large role in kinesthesia and provide information about muscle length changes, while joint receptors respond primarily at the end ranges of movement [20]. Thus, stimulating the mechanoreceptors of the ankle joint by this type of manipulation may lead to an increase in neuromuscular activity

	Experimental Group	Placebo Group	Control Group	P-Value
Eyes Open				
Area (cm ²)	1.55 ± 0.80	1.37 ± 0.90	1.47 ± 0.64	0.27
Velocity COPap(cm/s)	0.66 ± 0.11	0.64 ± 0.08	0.69 ± 0.12	0.12
Velocity COP ml (cm/s)	0.58 ± 0.09	0.54 ± 0.08	0.56 ± 0.09	0.21
Median Frequency COPap(Hz)	0.15 ± 0.06	0.15 ± 0.06	0.17 ± 0.06	0.48
Median Frequency COPml (cm)	0.22 ± 0.08	0.26 ± 0.09	0.23 ± 0.07	0.31
Eyes Closed				
Area (cm ²)	2.61 ± 2.32	1.66 ± 0.76	2.19 ± 1.11	0.38
Velocity COPap(cm/s)	0.83 ± 0.17	0.78 ± 0.16	0.67 ± 0.17	0.11
Velocity COP ml (cm/s)	0.65 ± 0.13	0.60 ± 0.11	0.64 ± 0.10	0.13
Median Frequency COPap(Hz)	0.19 ± 0.08	0.21 ± 0.05	0.21 ± 0.06	0.49
Median Frequency COP ml (cm)	0.22 ± 0.06	0.26 ± 0.08	0.22 ± 0.06	0.28

Mean and standard deviation (SD) values of the variables sway area of COP, velocity and frequency in both directions (AP and ML). The Kruskal-Wallis test was performed to compare the stabilometric parameters between the three groups (experimental, placebo and control groups) before talocrural joint manipulation. $P > 0.05$: no significant difference between-group.

Table 2: Comparison between the three groups on postural stability task during the two conditions (eyes open and eyes closed) before manipulation of joint.

	Eyes Open (Mean ± SD)		P-Value	Eyes Closed (Mean ± SD)		P-Value
	T1	T2		T1	T2	
Experimental group						
Area (cm ²)	1.55 ± 0.80	1.72 ± 1.01	0.19	2.61 ± 2.32	2.09 ± 1.08	0.22
Velocity COPap (cm/s)	0.66 ± 0.11	0.62 ± 0.09	<0.001*	0.83 ± 0.17	0.78 ± 0.17	0.001*
Velocity COPml (cm/s)	0.58 ± 0.09	0.54 ± 0.09	<0.001*	0.65 ± 0.13	0.61 ± 0.13	0.001*
Median Frequency COPap (Hz)	0.15 ± 0.06	0.16 ± 0.05	0.53	0.19 ± 0.08	0.19 ± 0.07	0.64
Median Frequency COPml (Hz)	0.22 ± 0.08	0.18 ± 0.06	0.01*	0.22 ± 0.06	0.21 ± 0.07	0.31
Placebo group						
Area (cm ²)	1.37 ± 0.90	1.32 ± 0.73	0.88	1.66 ± 0.76	1.72 ± 0.82	0.27
Velocity COPap (cm/s)	0.64 ± 0.08	0.62 ± 0.09	0.06	0.78 ± 0.16	0.75 ± 0.14	0.12
Velocity COPml (cm/s)	0.54 ± 0.08	0.52 ± 0.08	0.06	0.60 ± 0.11	0.59 ± 0.09	0.11
Median Frequency COPap (Hz)	0.15 ± 0.06	0.16 ± 0.05	0.34	0.21 ± 0.05	0.20 ± 0.05	0.48
Median Frequency COPml (Hz)	0.26 ± 0.09	0.22 ± 0.07	0.03*	0.26 ± 0.08	0.24 ± 0.09	0.06
Control group						
Area (cm ²)	1.47 ± 0.64	1.81 ± 0.93	0.004*	2.19 ± 1.11	2.48 ± 1.76	0.38
Velocity COPap (cm/s)	0.69 ± 0.12	0.66 ± 0.10	0.08	0.67 ± 0.17	0.66 ± 0.17	0.14
Velocity COPml (cm/s)	0.56 ± 0.09	0.55 ± 0.09	0.19	0.64 ± 0.10	0.64 ± 0.14	0.13
Median Frequency COPap (Hz)	0.17 ± 0.06	0.15 ± 0.07	0.34	0.21 ± 0.06	0.21 ± 0.06	0.49
Median Frequency COPml (Hz)	0.23 ± 0.07	0.19 ± 0.06	0.01*	0.22 ± 0.06	0.23 ± 0.05	0.88

Means and standard deviation (SD) values are presented.

* Significant differences between times measures from Wilcoxon test in each group from each COP parameter analysis.

Table 3: The influence of manipulation of the talocrural joint, in the time 1 and 2 (T1 and T2) on COP parameters for two conditions (eyes open and eyes closed).

and enhanced joint stability through co-activation of the musculature surrounding the joint. This hypothesis can be further supported from a combination of diminished proprioception and increasing muscle weakness when related as possible causes of chronic ankle instability [21]. Moreover, the effects of lateral ankle ligament anesthesia on time-to-boundary measures of single limb postural control in healthy adults are similar to deficits found in individuals with chronic ankle instability [22,23].

Postural balance control depends on the integrity of the visual, vestibular and mechanoreceptor feedback regarding the lower limbs. Any malfunction or improper feedback from these receptors would cause inappropriate motor reaction and poor balance control [19]. Parameters that describe well COP excursions are frequently used to measure stability and discriminate pathological mechanisms. This is possible since the COP signal is proportional to ankle torque, a combination of descending motor commands as well as mechanical properties of the surrounding musculature. Thus, the results obtained by means of stabilometric recording demonstrated that talocrural joint manipulation produces an immediate effect on the velocity of body sway in quiet standing in both conditions (eyes open and eyes closed). According to a recent review of the test-retest reliability of COP measures in bipedal static task conditions, the reliability of the eyes closed condition is greater than that of the eyes open condition, and the mean velocity is one of the most commonly used (and the most reliable) COP parameter [16]. This parameter was also the most sensitive to discriminate the manipulation effects in the two directions (AP and ML) in both conditions. A recent study [17] also pointed out the reliability of this parameter for both young adults and elderly subjects, both healthy, during a challenging balance tasks such as unipedal condition.

The manipulation of the talocrural joint can provide mechanical benefits for postural control. Therefore, manipulation interventions can be combined with lower limb proprioceptive training programs and other rehabilitation strategies such as balance training. Such a combination of therapies may lead to greater improvement in self-reported function and changes in static postural control. In addition, clinical measurements of stabilometric parameters can be used to track progress during the rehabilitation process.

Finally, the overall results of this study cannot necessarily be generalized to all subjects, since they may not represent the full heterogeneity of balance status among the patients with ankle disorders. Another limitation is the use of standing position on a force platform that not reveal all functionality of limb, although the use of the two conditions of postural control assessment (eyes open and eyes closed). Furthermore, a complementary analysis of muscular activity using electromyography simultaneous to force platform parameters computation and time reaction would be relevant to help interpret the results.

In conclusion, the significant effect of the bilateral talocrural joint manipulation was found on main balance parameter like COP velocity in the anteroposterior and mediolateral directions. These results have some much implications for manual therapy rehabilitation of individuals with ankle instability.

Clinical Messages

- Immediate bilateral talocrural joint manipulation is efficient to improve the postural balance.

- Improper feedback from the ankle joint receptors could cause inappropriate motor reaction and poor balance control.

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