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The immediate effect of two mobilization with movement techniques on dorsiflexion and dynamic balance, in futsal players with chronic ankle instability: A randomized controlled trial

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Abstract

Background: Chronic ankle instability (CAI) may compromise the mechanical (e.g. dorsiflexion range of motion – DFROM) and functional (dynamic balance) integrity of the ankle joint. Mobilization with movement (MWM) has been described as a useful resource to manage these impairments. Since, the talocrural and tibiofibular joints seem to be involved in the development of deficits in these subjects, it appears to be relevant when applying MWM techniques in both joints. **Aim:** To analyse the immediate effect of two MWM techniques on DFROM and dynamic balance, in futsal players with CAI. Also, to assess the immediate impact of the application of both MWM techniques, with the order inverted, on the outcomes in study. **Methods:** A randomized controlled trial, that included 18 volunteer male senior futsal amateur athletes with CAI, aged between 18 and 35, was performed. Participants were randomly allocated into two experimental groups (MWM1, n=7; MWM2, n=5), that received two MWM techniques, with the order inverted, and a Placebo group (n=6), submitted to a placebo procedure. Later, both experimental groups were merged into an Intervention group (n=12). Before and immediately after the intervention, the DFROM and dynamic balance were measured through the Weight-Bearing Lunge Test and the anterior (ANT), the posteromedial (PM) and the posterolateral (PL) reach directions of the Star Excursion Balance Test (SEBT), respectively. Independent samples t test was used to compare the quantitative data between groups, with a significance set of 0.05. **Results:** There were no significant differences on the DFROM and the SEBT reach directions between MWM1 and MWM2 groups. When considering the difference variable [post-intervention (–) pre-intervention], the DFROM increased in the Intervention group, in opposite to the Placebo group (p=0.001). Also, the PM (p=0.031) and PL (p=0.020) reaches increased further in the Intervention group, when compared to the Placebo group. The same was not observed on the ANT reach direction. **Conclusion:** The application of both techniques seems to immediately improve the DFROM and dynamic balance, namely on the PM and PL reach directions. Nevertheless, the order of application of the two MWM techniques seems to have no immediate influence on the outcomes in study.

Key words: sport; chronic ankle instability; mobilization with movement; range of movement; dynamic balance

Resumo

Introdução: A instabilidade crónica do tornozelo (ICT) pode comprometer a integridade mecânica (p. ex. amplitude de movimento de dorsiflexão – AMDF) e funcional (p. ex. equilíbrio dinâmico) da articulação do tornozelo. A mobilização com movimento (MCM) tem sido descrita como um recurso útil na sua gestão. Visto que, a articulação talocrural e tibioperonial parecem estar envolvidas no desenvolvimento destes défices, a aplicação de técnicas de MCM poderá ser relevante. **Objetivo:** Analisar o efeito imediato de duas técnicas de MCM na AMDF e no equilíbrio dinâmico, em jogadores de futsal com ICT. Assim como, avaliar o impacto imediato da inversão da ordem de aplicação, de ambas as técnicas de MCM, nas variáveis supracitadas. **Métodos:** Estudo randomizado controlado que incluiu 18 jogadores séniores masculinos amadores de futsal, com ICT, com idades compreendidas entre os 18 e os 35 anos. Os participantes foram alocados aleatoriamente em dois grupos experimentais (MWM1, n=7; MWM2, n=5), sujeitos a duas técnicas de MCM, com a ordem invertida, e no Grupo Placebo (n=6), submetidos a um procedimento placebo. Posteriormente, os dois grupos experimentais fundiram-se no Grupo Intervenção (n=12). Antes e imediatamente após a intervenção, a AMDF e o equilíbrio dinâmico foram avaliados através do "Weight-Bearing Lunge Test" e do alcance obtido nas direções anterior (ANT), posteromedial (PM) e posterolateral (PL) do "Star Excursion Balance Test" (SEBT). O teste t para amostras independentes foi utilizado para a comparação dos dados quantitativos, entre grupos, com um nível de significância de 0.05 **Resultados:** Não se observaram diferenças significativas na AMDF, nem no alcance em nenhuma direção do SEBT, entre os grupos MWM1 e MWM2. Relativamente à variável diferença [pós-intervenção (-) pré-intervenção], a AMDF aumentou no Grupo Intervenção, contrariamente ao Grupo Placebo (p=0.001). Adicionalmente, o alcance nas direções PM (p=0.031) e PL (p=0.020) aumentou mais no Grupo Intervenção, quando comparado com o Grupo Placebo. O mesmo não foi observado no alcance na direção ANT. **Conclusão:** A aplicação das duas técnicas parece ter um efeito positivo, no imediato, na AMDF e no equilíbrio dinâmico, nomeadamente no alcance nas direções PM e PL. Não obstante, a ordem de aplicação das duas técnicas de MCM parece não ter influência, no imediato, nas variáveis em estudo.

Palavras-chave: desporto, instabilidade crónica do tornozelo; mobilização com movimento; amplitude de movimento; equilíbrio dinâmico.

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1. Introduction

Futsal is a sport played worldwide, at an amateur, semi-professional, and professional level (Fédération Internationale de Football Association, 2015). This sport is characterized as a multiple-sprints sport, where locomotor activity changes every three seconds, and it requires high physical, technical, and tactical demands, in tight spaces. Thus, it is essential that futsal players acquire multiple capacities such as endurance, leg power, repeated sprint ability and agility (Fédération Internationale de Football Association, 2015; Krutsch et al., 2020).

As in all high demanding sports, futsal players face injuries throughout the season. Ankle sprains were considered the injury with the highest incidence (48,8%), according to a study that included Portuguese futsal players (Manuel Serrano, Shahidian, da Cunha Voser, & Leite, 2013). The combined motion of excessive inversion and internal rotation of the rear foot on the tibia is described as the most common mechanism of injury (Fong, Ha, Mok, Chan, & Chan, 2012; Mok et al., 2011), compromising predominantly the lateral ligaments of the ankle, such as, the anterior talofibular and the calcaneofibular ligaments (Hertel & Corbett, 2019; Tiemstra, 2012). Nevertheless, other potential injuries must be considered, such as the high ankle sprain, an injury to the anterior inferior tibiofibular ligament and tibiofibular syndesmosis.

After an ankle sprain, subjects quickly develop common clinical signs and symptoms, such as pain, swelling, inflammation, diminished ankle range of motion, and alterations in sensorimotor function, which are usually resolved in a short period of time (Hertel & Corbett, 2019; Miklovic, Donovan, Protzuk, Kang, & Feger, 2018; Tiemstra, 2012; Van Dijk & Vuurberg, 2017). However, there is no such thing as a simple ankle sprain, and a recent model, proposes that this primary injury to the lateral ankle ligaments may lead to a collection of interrelated pathomechanical, sensory-perceptual, and motor behavioural impairments that influence subject's clinical outcomes, ranged from a fully successful recovery (coper) to an unsatisfactory outcome (chronic ankle instability – CAI) (Hertel & Corbett, 2019; Van Dijk & Vuurberg, 2017). In fact, Doherty et al., (2015) described in a prospective study that about 40% of acute ankle sprains resulted in CAI. This condition is characterized by repetitive episodes or perception of the ankle ´giving way' or feeling of instability, recurrent ankle sprains, persistency of symptoms from the first ankle sprain, and diminished self-reported function that persist for more than one year after the initial injury (Delahunt et al., 2018; Hertel & Corbett, 2019; Van Dijk & Vuurberg, 2017). The perpetuation of the aforementioned symptoms may contribute to ongoing disability (Van Dijk & Vuurberg, 2017).

Several authors have documented a decrease in dorsiflexion range of motion (DFROM) during functional tasks and weight-bearing measurements in CAI subjects (Hoch, Staton, Medina McKeon, Mattacola, & McKeon, 2012). These alterations in ankle motion may be due to arthrokinematic and osteokinematic restrictions of the ankle joint or due to several impaired domains of somatosensation (active and passive joint position sense; force sense; cutaneous sensation; sensory integration) (Hertel & Corbett, 2019). Consequently, the normal transmission of afferent information available to the sensorimotor system can be impaired and negatively influence specific aspects of dynamic balance (Hoch et al., 2012). In other words, the aforementioned impairments may compromise the mechanical and functional integrity of the joint and consequently its sensorimotor control (Delahunt et al., 2018; Munn, Sullivan, & Schneiders, 2010; Van Dijk & Vuurberg, 2017).

Multiple manual therapy techniques have been described as useful resources to manage these impairments (Weerasekara et al., 2018), such as mobilization with movement (MWM) (Hoch & McKeon, 2010; Westad, Tjoestolvsen, & Hebron, 2019). MWM was initially created by Brian Mulligan and is defined as the application of a sustained passive accessory movement to a joint, while the subject actively performs a movement or task that was previously identified as being painful or limited (Mulligan, 2010). The literature described promising results, after applying ankle dorsiflexion MWM techniques, such as improved DFROM (Cruz-Díaz, Lomas Vega, Osuna-Pérez, Hita-Contreras, & Martínez-Amat, 2015; Hing, Bigelow, & Bremner, 2009; Marrón-Gómez, Rodríguez-Fernández, & Martín-Urrialde, 2015; Vicenzino, Branjerdporn, Teys, & Jordan, 2006; Vicenzino, Paungmali, & Teys, 2007) and dynamic balance (Cruz-Díaz et al., 2015; Powden, Vallandingham, & Gaven, 2019), in subjects with CAI. Most of the previous studies on CAI have applied ankle dorsiflexion MWM techniques to the talocrural joint (Cruz-Díaz et al., 2015; Marrón-Gómez et al., 2015). However, Mulligan (2010) proposed that the tibiofibular joint is also compromised in ankle sprains, suggesting that the application of a posterior and cephalad glide at the fibula may be more appropriate, not only in acute or subacute status, but also to increase DFROM in subjects with CAI.

To our knowledge, there are no studies that compare the application of these two ankle dorsiflexion MWM techniques, with glides applied at the talus and fibula. Since both the talocrural and tibiofibular joints seem to be involved in the development of deficits in subjects with CAI, it appears to be relevant to apply both MWM techniques (Hing, Hall, Rivett, Vicenzino, & Mulligan, 2015; Mulligan, 2010). Furthermore, the research group was curious about the cumulative effect of these techniques. However, without knowing which technique to apply first, it would not make sense. Hereupon, we decided to explore the effects of applying these glides on two relevant impairments, identified in this subjects, DFROM and dynamic balance. Therefore, the goal of the present study was to analyse the immediate effect of two MWM techniques on the DFROM and dynamic balance, in futsal players with CAI. Also, to assess the immediate impact of the application of both MWM techniques, with the order inverted, on the outcomes in study. Although the research group does not acknowledge the order effect, we believe that the application of both MWM techniques may improve the DFROM and dynamic balance.

2. Methods

2.1. Design

The research methodology was quantitative, with a randomized controlled trial study design. Consenting participants were randomly allocated into three groups: two experimental groups – MWM1 e MWM2, and a Placebo group. Afterwards, both experimental groups were merged into an Intervention group. The MWM1 and MWM2 groups received two ankle dorsiflexion MWM techniques, in partial weight-bearing. In both groups' glides were applied at the fibula and talus. The glide application order distinguished the groups from one another.

The Placebo group performed the same number of sets and repetitions of lean/lunge forward into dorsiflexion, without any glide applied. The participants were blinded as to whether they were receiving the MWM's techniques or the placebo procedure.

2.2. Participants

The target population were male senior futsal athletes aged between 18 and 35 from Portugal's amateur futsal teams. All volunteer athletes (convenience non-probabilistic sampling process) were selected according to the criteria for CAI, adapted from the International Ankle Consortium (Table 1) (Gribble et al., 2013).

Table 1 – Inclusion and exclusion criteria (adapted from Gribble et al., [2013]).

Inclusion criteria	Exclusion criteria
A history of at least one significative ankle sprain: Initial sprain must have occurred at least 12 months prior to study enrolment; – Was associated with inflammatory symptoms; – Created at least one interrupted day of desired physical activity; – The most recent injury must have occurred more than 3 months prior to study enrolment. A history of the previously injured ankle joint "giving way" and/or recurrent sprain and/or "feelings of instability": – Participants should report at least two episodes of "giving way" in the 12 months	A history of previous surgeries to the musculoskeletal structures (i.e., bones, joint structures, nerves) in either lower extremity. A history of bilateral ankle sprain. A history of a fracture in either lower extremity requiring realignment. Acute injury to musculoskeletal structures of other joints of the lower extremity in the previous 3 months that impacted joint integrity and function (i.e., sprains, fractures), resulting in at least one interrupted day of desired physical activity. Have conditions for which manual therapy is generally contraindicated (such as the presence of a tumour, fracture, rheumatoid arthritis, osteoporosis, prolonged history of steroid use, or severe vascular disease).

prior to study enrolment, to account for the seasonal nature of futsal; – Recurrent sprain was defined as two or more sprains to the same ankle. Self-reported ankle instability should be confirmed with the Ankle Instability Instrument: answer "yes" to at least 5 yes/no questions.	Receiving concurrent physiotherapy treatment in the last 3 months. Inability to read Portuguese.

2.3. Instruments

2.3.1. Sample selection and characterization

The questionnaire (Appendix I) ensured the eligibility of the participants, guaranteed that the inclusion and exclusion criteria were respected, and characterized the sample (i.e., age). The Ankle Instability Instrument (AII) (Appendix II), developed by Docherty, Gansneder, Arnold, & Hurwitz (2006), is a self-reported assessment tool for functional ankle instability including twelve items, which also helped to guarantee the defined criteria (Gribble et al., 2013). This tool was adapted to the Portuguese population by Silva et al., (2018), suggesting good internal consistency with a Kuder–Richardson coefficient of 0.79 (95% CI = 0.71-0.85).

2.3.2. Weight-Bearing Lunge Test

The DFROM was measured by the Weight-Bearing Lunge Test (WBLT). This instrument is probably the most widely used measurement method to assess DFROM (Cejudo, Sainz de Baranda, Ayala, & Santonja, 2014). A millimetre measuring tape 150-centimetre long, with a longitudinal line drawn in the middle, was placed on the ground perpendicular to a wall. On this wall, a similar measuring tape was placed as a continuation of the ground line (adapted from Langarika-Rocafort, Emparanza, Aramendi, Castellano, & Calleja-González (2017)), as demonstrated in Figure 1. In the present study, this instrument has demonstrated excellent test-retest reliability (intraclass correlation coefficient – ICC = 0.984).

2.3.3. Star Excursion Balance Test

The dynamic balance was measured by the anterior ANT), posteromedial (PM) and posterolateral (PL) reach directions of the Star Excursion Balance Test (SEBT) (van Lieshout et al., 2016). This test has been used effectively to screen for deficits in dynamic balance among groups with lower extremity conditions, such as CAI (Gribble, Hertel, & Plisky, 2012). For ease of quantification of each reach distance, the lines of the SEBT directional components were simulated by three 150 centimetres measuring tapes fixed on the ground in the shape of a "Y" (posterior tapes positioned 135 degrees from the anterior) (Figure 2). In the present study, this instrument has demonstrated excellent test-retest reliability (ICC = AP – 0.934; PM – 0.964; PL – 0.914).

2.4. Procedures

2.4.1. Pilot study

The pilot study was conducted to standardize and verify the possible need of adjustments in the Selection and Characterization Questionnaire, as well as data collection procedures. A test-retest reliability study was also performed for the WBLT and SEBT. The measurements were made with 11 participants with the same characteristics of the final sample (n=11), as described above. No adjustments were required.

2.4.2. Data Collection

The recruitment of the sample was conducted by telephonic invitation to 23 clubs of the "Associação de Futebol do Porto" to determine if they would be willing to participate. The teams that accepted the invitation were visited by the researchers. An Eligibility and Characterization Questionnaire was distributed individually to the participants. Thereafter, the volunteers, who according to the questionnaire met the inclusion criteria, answered the AII to define the final sample. Finally, an appointment for data collection was scheduled.

The procedures, measurements and interventions described below were performed on the participating teams' sports hall. To avoid inter-rater error and ensure that the participants conditions were similar, the same researcher performed the same tasks throughout the whole study. The researchers registered the test results, before and after the interventions, on separate sheets, so that they did not know the prior scores obtained. At the beginning of each testing session, several anatomical reference points were marked with a non-permanent pen. Also, each participant watched two exemplifying videos of the WBLT and the SEBT.

Anthropometric and body composition measurements were assessed in all participants. Height (m) and body mass (kg) were measured respectively using a seca 222 stadiometer with a precision of 1.0 mm and a seca 760 scale with a precision of 1.0 kg (seca – Medical Scales and Measuring Systems, Hamburg, Germany). The dominant limb was defined as the one that kicks a ball (van Melick, Meddeler, Hoogeboom, Nijhuis-van der Sanden, & van Cingel, 2017). Lower limb length was also measured. The participants were placed on a treatment table in the supine position with their pelvis and lower extremities in relaxed neutral alignment. Afterward, the participant lifted the hips off the table and returned them to the starting position. Then, the researcher passively straightened his legs to equalize the pelvis (Plisky, Rauh, Kaminski, & Underwood, 2006). The participants' lower limb length was then measured in centimetres from the anterior superior iliac spine to the most distal portion of the medial malleolus with a measuring tape (Farahmand et al., 2019). The average of the two measurements was recorded (Beattie, Isaacson, Riddle, & Rothstein, 1990).

Before and after the intervention protocol, the participants performed the WBLT and the SEBT (in this order for all participants).

Before the WBLT, the most distal point of the heel and the anterosuperior edge of the patella of all participants were marked with a non-permanent pen (participants in supine position). Therefore, participants, barefoot, positioned their test foot, so that the centre of their heel and first toe were aligned with the centre line of the ground line. Then, they were instructed to lunge towards the wall, flexing the knee, ankle and hip, of the tested leg, to touch the anterosuperior edge of the patella on the wall, while keeping their heel in contact with the floor. The aim was to find the maximum distance from the wall to the heel of the tested foot, while touching the wall with the knee without raising the heel (Figure 1). During the test, participants were allowed to put the non-tested leg in a comfortable position and place their hands on the wall to maintain their balance There were no restrictions on the number of attempts, but on each attempt, the participants had to remove their knee from the wall (Langarika-Rocafort et al., 2017). After maximal DFROM was found, the following measurements were taken (Figure 1): a) Heel-wall distance (HW): the distance between the wall and the most distal point of the heel; b) Ground-Knee distance (GK): the distance between the ground and the anterosuperior edge of the patella.

The trigonometric angle (TA) was calculated using a simple trigonometric function (Langarika-Rocafort et al., 2017; Pope, Herbert, & Kirwan, 1998):

$$TA = 90 - \text{arctangent}\,(GK/HW)$$

A higher TA value represented a higher DFROM.

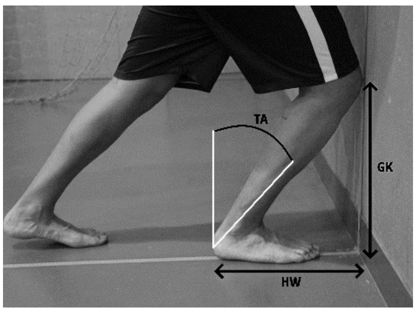

Figure 1- Weight-Bearing Lunge Test. TA: trignometric angle; HW: heel-wall distance; GK: ground-knee distance.

The SEBT was performed with the participants, barefoot, with both hands placed on the hips, on single leg stance, with their big toe of their ipsilesional limb on the point of interception of the three measuring tapes. The participants were asked to reach as far as possible with the free limb in the ANT, PM, and PL directions (always in this order), making a light touch on the centre of the tape with their big toe and return to the initial position (Figure 2). Every participant completed 4 practice and 3 trials attempts, in each of the 3 directions, with 2 minutes of recovery between reach directions (Robinson & Gribble, 2008). If the participants, throughout the trial, lifted or shifted any part of their stance foot, removed one or both hands from their hips, used their reaching leg for a substantial amount of support, lost their balance, or rested their reaching foot on the ground, at any time, the trial was discarded and repeated (Gribble et al., 2012; Plisky et al., 2006). Reach distances were registered by having one of the researchers place a mark on the tape that corresponded to the touchdown point. During the 4 practice trials, the marks were not recorded, but during the 3 test trials the marks of previous trials remained. The greatest distance of 3 trials was registered in centimetres (Plisky et al., 2006).

Reach distances were measured from the intersection of the three tapes to the marked point of maximum reach and normalized to limb length, using the following formula (Gribble & Hertel, 2003):

$$\text{Normalized score (\%)} = (\text{excursion distance/limb length}) * 100$$

This normalization method accounts for limb-length differences in individuals, allows comparisons between the right and left limbs and between participants (Gribble & Hertel, 2003). A higher normalized score was associated with a higher dynamic balance.

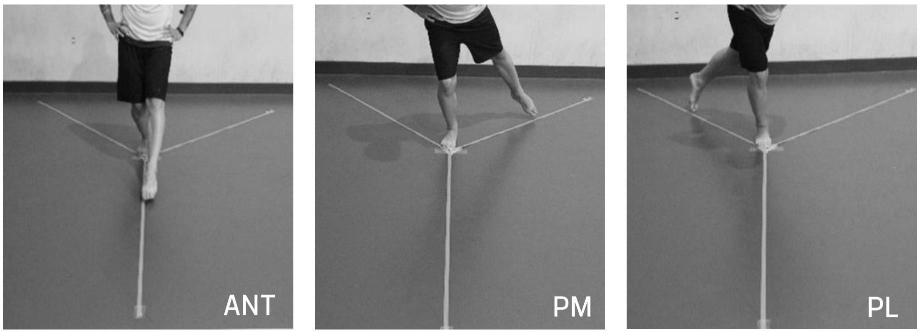

Figure 2 – Star Excursion Balance Test. ANT: anterior reach direction; PM: posteromedial reach direction; PL: posterolateral reach direction.

2.4.3. Intervention Protocol

Participants were divided into two experimental groups – MWM1 e MWM2, and a Placebo group. Later, both experimental groups were merged into an Intervention group. The MWM1 and MWM2 groups received, two ankle dorsiflexion MWM techniques, with glides applied at the talus and fibula. The difference between the experimental groups, was the order of application of the glides.

The MWM technique with the glide applied on the talus was performed with the participants in partial weight-bearing, half kneeling, barefoot, on a treatment table. A treatment belt was looped around the participant's distal lower leg, at a right angle to the lower leg, and around the researcher's hips. The researcher fixated the talus with the webspace of both hands to prevent movement of the talus anteriorly. Afterwards, an anterior glide was applied on the tibia by the treatment belt while the participant lunged forward over his foot into dorsiflexion, as described by, Hing, Hall, Rivett, Vicenzino, & Mulligan (2015) (Figure 3-A). Three sets of 10 repetitions were completed. Participants were also instructed that if they felt pain at any moment, performing the technique, they should notify the researcher immediately (Hing et al., 2015).

The MWM technique with the glide applied at the distal tibiofibular joint was performed in the same position as described for the talus technique. The researcher fixated the tibia with one hand posteriorly and cupped the distal end of the fibula (lateral malleolus) with the thenar eminence. After, they applied a posterior and cephalad glide while the participant lunged forward over his foot into dorsiflexion, as described by Hing et al. (2015) (Figure 3-B). Once more, three sets of 10 repetitions were performed and the participant was advised to report any kind of pain to the therapist immediately.

The Placebo group participants performed the same number of sets and repetitions of lean/lunge forward into dorsiflexion, without any glide application, in the same position.

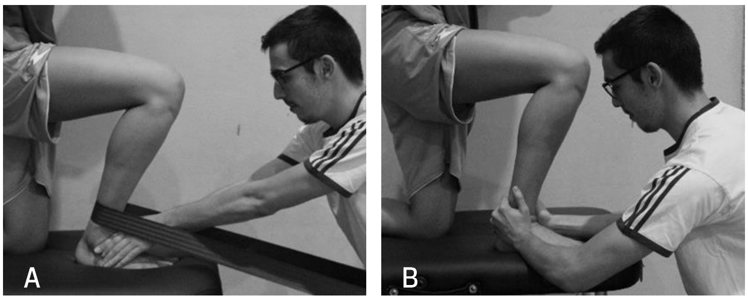

Figure 3 – Application of two ankle dorsiflexion mobilization with movement techniques. A: glide applied at the talocrural joint; B: glide applied at the distal tibiofibular joint

2.5. Ethics approval and consent to participate

The Health School of the Porto Polytechnic's Research Ethics Committee previously approved the present study (registration nº E0027 in 31/10/2019). All participants provided their written informed consent (Appendix III) in compliance with the Declaration of Helsinki, and their anonymity and the confidentiality of their data were guaranteed. After the study, all the participants had the opportunity to receive the experimental protocol.

2.6. Statistical analysis

IBM's Statistical Package for the Social Science® software version 26.0 (IBM Corporation, Armonk NY, United States of America) was used for descriptive and inferential data analysis, with significance set at 0.05. The Shapiro-Wilk test was used to test the normality of the data. Mean (±standard deviation) was used to describe the distribution of quantitative variables. Independent samples t-test was used to compare the quantitative data between groups, to verify the immediate effect of the two MWM techniques (MWM1 vs. MWM2) and the impact of performing them in a different order (Placebo vs. Intervention group) in all variables (Marôco, 2018).

3. Results

3.1. Sample characterization

The final sample was randomly divided into two experimental groups (MWM1 and MWM2) and a Placebo group (Figure 4). The MWM1 group included 7 participants (23.14±6.20 years of age), and the MWM2 group 5 participants (23.20±3.83 years of age). Later, these groups were merged into an Intervention group with 12 participants (23.17±5.13 years of age). The Placebo group included 6 participants (25.00±5.25 years of age). Age and anthropometric data were similar between the MWM1 and MWM2 groups and between the Intervention and Placebo groups (Table 2).

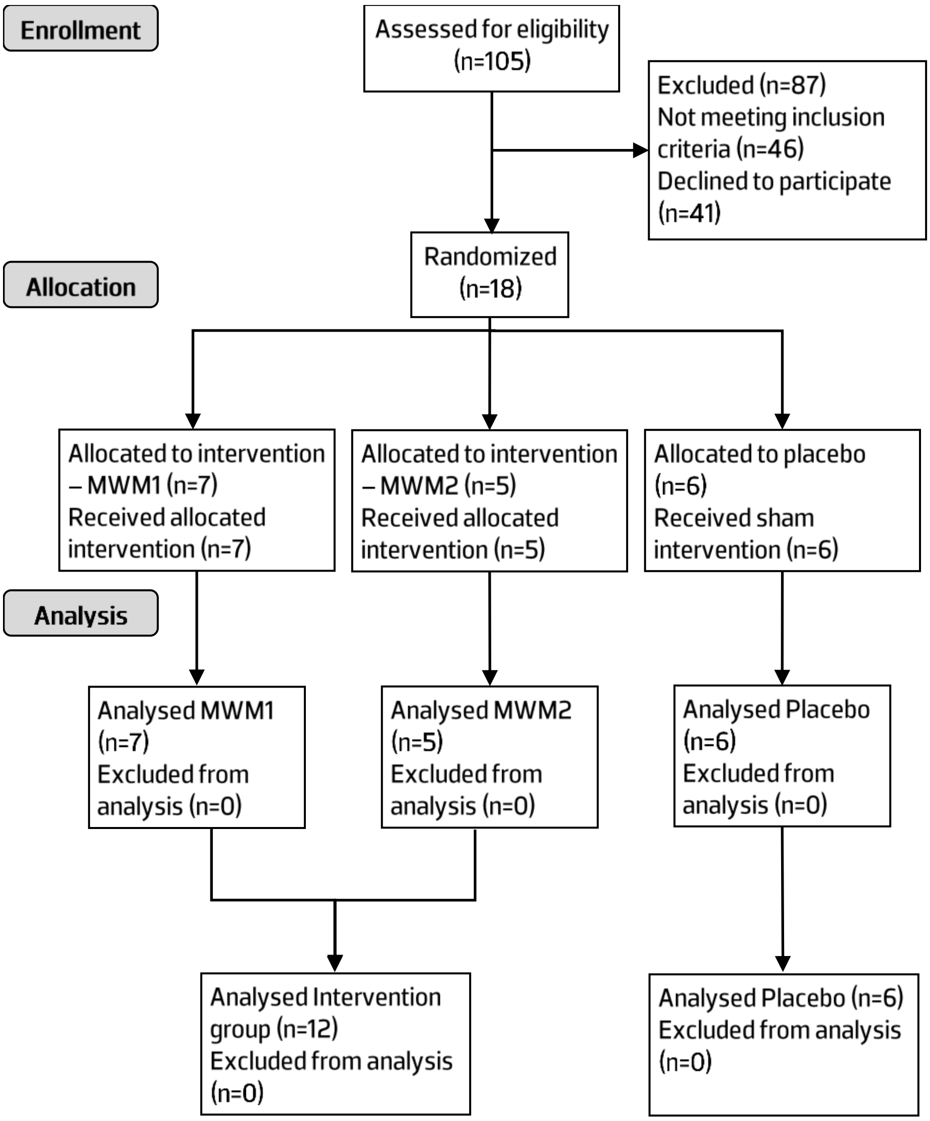

Figure 4 – Sample flow diagram, from amateur futsal players of "Associação de Futebol do Porto".

Table 2 – Sample characterization: sociodemographic and anthropometric data. Data is presented as mean (±standard deviation). p values reflect the between-groups comparison.

Variable		Age (years)	Body mass (kg)	Height (m)	BMI (kg/m^2)
Intervention group (n=12)		23.17±5.13	77.88±10.88	1.72±0.07	26.24±3.01
	MWM1 group (n=7)	23.14±6.20	78.03±10.67	1.72±0.09	26.50±2.90
	MWM2 group (n=5)	23.20±3.83	77.68±12.43	1.73±0.03	25.87±3.46
Placebo group (n=6)		25.00±5.25	80.15±13.41	1.75±0.05	26.20±3.14
Between-groups comparison (*p* value)	**MWM1 vs. MWM2**	0.986	0.959	0.747	0.738
	Placebo vs. Intervention	0.488	0.704	0.488	0.980

MWM: mobilization with movement; BMI: body mass index.

3.2. MWM1 group vs. MWM2 group

At the pre- and post-intervention assessment, and in the difference variable [post-intervention (-) pre-intervention], the DFROM, the ANT reach (%), the PM reach (%) and the PL reach (%) were similar between MWM1 and MWM2 groups (Table 3).

Table 3 – Ankle dorsiflexion range of motion (expressed as °) and dynamic balance (expressed as %), at the pre- and post-intervention assessment, in MWM1 and MWM2 groups. Data are presented as mean (± standard deviation). p values reflect the comparison between groups at the pre- and post-intervention assessment, as well as in the difference variable [post-intervention (–) pre-intervention].

Group	Pre-intervention	Post-intervention	Post-intervention (–) pre-intervention	Between-groups comparison		
				Pre-intervention (*p* value)	Post-intervention (*p* value)	Post-intervention (–) pre-intervention (*p* value)
DFROM						
MWM1 (n=7)	40.38±6.34	41.49±6.17	1.11±0.61	0.729	0.947	0.204
MWM2 (n=5)	39.34±1.32	41.30±1.82	1.96±1.21			
ANT reach (%)						
MWM1 (n=7)	64.28±5.61	63.26±7.77	-1.02±7.32	0.691	0.248	0.450
MWM2 (n=5)	65.52±4.46	67.32±3.26	1.80±3.64			
PM reach (%)						

MWM1 (n=7)	97.38±9.80	104.95±8.18	7.57±4.78	0.759	0.699	0.997
MWM2 (n=5)	95.51±10.58	103.10±7.57	7.59±8.99			
PL reach (%)						
MWM1 (n=7)	87.38±9.68	96.52±10.08	9.14±6.90	0.917	0.827	0.815
MWM2 (n=5)	87.98±9.63	97.94±11.68	9.96±3.35			

DFROM: dorsiflexion range of motion; MWM: mobilization with movement; ANT: anterior; PM: posteromedial; PL: posterolateral.

3.3. Intervention group vs. Placebo group

At the pre- and post-intervention assessment, there were not significant differences between the Intervention and Placebo groups. However, when considering the difference variable [post-intervention (–) pre-intervention], a significant difference between the groups was found on the DFROM (p=0.001), the PM (p=0.031) and PL reach (p=0.020). Opposite to the Placebo group, DFROM increased in the Intervention group. Also, the PM and PL reaches increased further in the Intervention group, when compared to the Placebo group (Table 4).

Table 4 - Ankle dorsiflexion range of motion (expressed as °) and dynamic balance (expressed as %), at the pre- and post-intervention assessment, in the Intervention and Placebo groups. Data is presented as mean (± standard deviation). *p* values reflect the comparison between groups at the pre- and post-intervention assessment, as well as in the difference variable [post-intervention (–) pre-intervention].

Group	Pre-intervention	Post-intervention	Post-intervention (–) pre-intervention	Between-groups comparison		
				Pre-intervention (*p* value)	Post-intervention (*p* value)	Post-intervention (–) pre-intervention (*p* value)
DFROM						
Intervention (n=12)	39.95±4.78	41.41±4.69	1.46±0.96	0.914	0.465	0.001
Placebo (n=6)	40.21±4.56	39.61±5.06	-0.60±0.94			
ANT reach (%)						
Intervention (n=12)	64.79±4.98	64.95±6.41	0.15±6.01	0.723	0.886	0.811
Placebo (n=6)	63.67±8.33	64.46±7.24	0.79±2.78			

PM reach (%)						
Intervention (n=12)	96.60±9.70	104.18±7.63	7.58±6.47	0.083	0.654	0.020
Placebo (n=6)	105.56±9.65	106.06±9.45	0.50±2.12			
PL reach (%)						
Intervention (n=12)	87.63±9.22	97.11±10.28	9.48±5.50	0.586	0.560	0.031
Placebo (n=6)	90.57±13.11	93.29±17.16	2.72±6.20			

DFROM: dorsiflexion range of motion; MWM: mobilization with movement; ANT: anterior; PM: posteromedial; PL: posterolateral.

4. Discussion

The results revealed that the order of application of both ankle dorsiflexion MWM techniques, with glides applied at the talus and fibula, does not seem to have any significant influence on DFROM or dynamic balance, in futsal players with CAI. A recent systematic review with meta-analysis, that also included other mobilization techniques, described that in these individuals, MWM and Maitland mobilizations may moderately improve maximum DFROM (assessed through the WBLT) and dynamic balance (measured by the SEBT or the Y-Balance Test) (Powden et al., 2019). Nevertheless, this review indicated that MWM led to higher improvements on dynamic balance when compared to Maitland mobilizations (Powden et al., 2019). Furthermore, the evidence described that either ankle dorsiflexion MWM technique, with the glide applied at the talus or at the fibula, are aimed to restore DFROM (Hing et al., 2015; Mulligan, 2010; Vicenzino et al., 2006) and dynamic balance (Cruz-Díaz et al., 2015). Despite the potential improvements in the outcomes throughout the application of both techniques, the order seems to have no influence. Thus, the researchers hypothesized that perhaps the most important aspect is to mobilize the ankle joint, regardless of the order.

Whereas no significant differences were found between MWM1 and MWM2, both groups were merged into a single Intervention group. This group allowed the researchers to assess the immediate effect of both ankle dorsiflexion MWM techniques, in futsal players with CAI, on DFROM and dynamic balance. It seems that both MWM techniques have a significant positive effect on the DFROM, the PM and the PL reach directions of the Intervention group, when compared to the Placebo group. Contrarily, they do not seem to have any significant effect on the ANT reach direction. Regarding the effect on DFROM, the results of the present study suggest that immediately after the application of both MWM techniques, an improvement on DFROM seems to be observed. Nevertheless, the mechanisms of action underpinning MWM techniques are not completely understood. Originally, Mulligan (2010) described it through a mechanical model and suggested that MWM techniques could correct minor bony incongruities (positional faults) which presumably occur after an injury. This positional faults were hypothesized to lead to pain and impairment through abnormal joint mechanics and ensuing damages to soft tissues (Vicenzino, Hing, Hall, & Rivett, 2011). Hereupon, it was recommended that the MWM techniques would help the return to the normal joint biomechanics and consequently decrease the symptoms substantially (Mulligan, 2010). This mechanical model was studied and there is some preliminary radiologic support that described the existence of an anteriorly positioned fibula (Hubbard, Hertel, & Sherbondy, 2006) and talus (Wikstrom & Hubbard, 2010), in individuals with CAI. However, to date there is limited research of

MWM effects on positional faults and, there is no concrete evidence to support or refute that the positional fault hypothesis explains the mechanisms by which MWM produces its clinical effects on pain, impairments and disability (Vicenzino et al., 2011). Recently, it has been proposed that the interaction of both biomechanical and neurophysiological mechanisms may be implicated on the mechanisms of action of MWM. MWM is dependent on the application of a non-painful manual contact with a specific direction, amount of force and application point (Hing et al., 2015). In addition, preliminary data indicated that the proprioceptive input to the central nervous system from the researcher's hands and/or the belt, might stimulate some mechanoreceptors. This proprioceptive feedback, combined with the mechanical stimulus to the talus and/or to the fibula from the technique, associated with the active motion, could potentially contribute to the improvements on DFROM (Baeske, 2015; Bialosky et al., 2018; Vicenzino et al., 2011). As far as we are aware, no studies have analysed the impact of both techniques on DFROM in subjects with CAI. In parallel, several authors described that talocrural MWM significantly increased DFROM based on a single treatment (Cruz-Díaz et al., 2015; Hoch & McKeon, 2010; Marrón-Gómez et al., 2015). Hoch & McKeon (2010) analysed three preliminary investigations that applied similar MWM techniques, with the glide applied at the talus, that resulted in DFROM improvements ranging from 16% to 26% (Collins, Teys, & Vicenzino, 2004; Reid, Birmingham, & Alcock, 2007; Vicenzino et al., 2006). Up-to-date studies showed similar results, after single and multiple interventions (Cruz-Díaz et al., 2015; Marrón-Gómez et al., 2015). Marrón-Gómez et al. (2015), showed a significant immediate improvement in DFROM compared to a placebo intervention, that was maintained for two days. Cruz-Díaz et al. (2015), combined a three-week intervention and showed significant short- and long-term (6 months) improvements for DFROM, compared to placebo and no treatment control. Contrarily, Gilbreath, Gaven, Van Lunen, & Hoch (2014), administrated 3 intervention sessions over one week, without any effect on DFROM. However, none of the aforementioned studies included the standardized inclusion and exclusion criteria endorsed by the International Ankle Consortium, in 2013, different criteria were applied, such as the presence of a determined DFROM asymmetry, what could have originated higher improvements after mobilization. On the other hand, fewer researchers have explored the application of the fibula glide. Kumari, Nijhawan, & Paresh (2014) compared the administration of the distal tibiofibular MWM technique, in weight-bearing, combined with conventional treatment (talocrural joint MWM, strength and flexibility exercises), with the administration of conventional treatment. The authors reported significant improvements on DFROM with the distal tibiofibular joint MWM technique over conventional therapy alone. These findings may be due to the characteristics of their sample, namely subjects with post-acute lateral ankle sprain.

Concerning the effects of both dorsiflexion MWM techniques on dynamic balance, the results of the present study showed significant improvements on the PM an PL reach directions of the SEBT, which may possibly indicate a positive effect on dynamic balance. The available literature underlying the mechanisms by which MWM has influence on dynamic balance, in subjects with CAI, is limited. On the whole, the current model explains that a specific mechanical perturbation, may evoke neurophysiological mechanisms in the sensory, motor and sympathetic systems (Paungmali, O'Leary, Souvlis, & Vicenzino, 2003; Vicenzino et al., 2011). The articular stretching performed in the capsule and ligaments of the ankle, due to joint mobilization, appears to effectively promote the activity of mechanoreceptors, which increase their sensory output, through the activation of gamma motor neurons by tissue traction, which may improve postural control (Riemann & Lephart, 2002). In agreement, Cruz-Díaz et al. (2015) demonstrated a short- and long-term effect (6 months) on dynamic postural control when compared to placebo and no treatment control, after a three-week weight-bearing MWM intervention period, with the application of the talus glide. But the results were observed in all three directions of the SEBT (Cruz-Díaz et al., 2015). Thus, a recent Systematic Review and Meta-Analysis, that also included other mobilization techniques, referred that the reach directions that improved more by a joint mobilization intervention designed to increase DFROM, were the PM an PL reach directions (Powden et al., 2019). Further, it described that improvements on dynamic balance were greater at follow up than immediately after application. Also, mobilization techniques that used multiple intervention sessions produced more robust improvements than single interventions (Powden et al., 2019). This may suggest that improvements on dynamic balance could require multiple sessions and time to manifest.

On the other hand, the present study could not find any effect of MWM on the ANT reach direction of the SEBT, besides the improvements observed on DFROM. Previous research supports the existence of a correlation between the maximum weight-bearing DFROM and performance on the ANT and PL reach directions (Basnett et al., 2013; Hoch, Staton, & McKeon, 2011; Hoch et al., 2012). However, the evidence available is conflicting, with some authors not finding any correlation on the ANT (Doherty et al., 2015), PM or PL reach directions (Hoch et al., 2012). In fact, there may be other variables influencing SEBT reach distances, such as strength, neuromuscular control, and motion of the lower extremity (Gribble & Hertel, 2003; Hoch, Gaven, & Weinhandl, 2016; Hubbard, Kramer, Denegar, & Hertel, 2007; McCann et al., 2017). Strength of the hip musculature has been shown to have strong relationships with reach distances of the SEBT, particularly in the PM and PL directions (Hubbard et al., 2007). This may support our results, since our study included futsal players that allegedly have higher levels of strength in lower extremities due to the characteristics of the sport (Fédération Internationale de Football Association, 2015). Moreover, the SEBT requires neuromuscular control through proper joint positioning and strength, in surrounding musculature to create and maintain the necessary positions throughout the test (Gribble & Hertel, 2003). Hoch, Gaven, & Weinhandl (2016), suggested that subjects with CAI may rely on alternative strategies to achieve greater reach distances. Furthermore, it is inferred that weight-bearing DFROM is not only related to maximum reach distances but also many kinematic variables which possibly contribute to ANT reach performance. The strongest predictors of maximal ANT reach direction of the SEBT were the combination of frontal plane motion of the trunk, hip, and ankle (Hoch et al., 2016). This research did not analyse kinematic predictors, but future studies should continue to investigate changes in motor control strategies during the SEBT by examining the range of motion contributions from distal and proximal joints using, not only laboratory measures like 3-dimensional motion analysis, but also clinical tests such as the WBLT.

Methodological considerations

Mechanical instability measures were not included, such as changes in ankle mobility or the presence of mechanical laxity. Once Brown, Padua, Marshall, & Guskiewicz (2009, 2011) reported that mechanical ankle instability groups had more self-reported disability, and no differences in the number of episodes of "giving way", than the functional ankle instability groups. These reports may suggest that mechanical ankle instability groups had similar functional instability, when compared to the functional ankle instability groups. Therefore, it seems that this information may support the strength of the contribution of functional ankle instability measures, to define CAI, instead of mechanical instability measures (Brown et al., 2009, 2011; Gribble et al., 2013).

The evidence describes several valid and reliable methods to assess DFROM (Langarika-Rocafort et al., 2017). In the present study, the DFROM was determined through an angle calculated using a trigonometric formula. This method tends to overestimate the actual DFROM by approximately 10 degrees (Montgomery, Nelson, Norton, & Deuster, 1989). This is because, the axis of ankle rotation is not at the posterior aspect of the heel, which was the point of reference used in the calculations. Nevertheless, as the magnitude of this overestimation was considered relatively constant between individuals, the simple calculated angle was used in an uncorrected form as an index of the true value (Pope et al., 1998). No direct comparisons to normative values should be considered.

Limitations of the present study

Our study had some limitations and the external validity of the study results may have been influenced negatively by the reduced *n* sample. Also, neither the present study nor the literature allowed us to know whether one of the techniques may have had a superior effect over the results.

In addition, overpressure was not applied with a belt on the distal tibiofibular MWM technique, which may improve the results according to Hing et al. (2015). They suggest the application of overpressure with a belt or the load of the therapist body, as a progression, when maximal DFROM is achieved (Hing et al., 2015).

Future investigations

The present study only evaluated the limb classified as having CAI. In the Doherty et al. (2015) study, CAI participants exhibited bilateral deficits in dynamic balance when compared with lateral ankle sprain coopers motion during the SEBT on the uninvolved limb. Which led us think that it is of clinical importance to design further rehabilitation and research programs respecting the bilateral nature of these deficits in mind. Furthermore, only the immediate effect of one MWM intervention was assessed, while other studies carried out additional interventions and measured its short- and long-term effects, displaying positive results (Cruz-Díaz et al., 2015; Terada, Pietrosimone, & Gribble, 2013). For example, Cruz-Díaz et al. (2015) revealed positive outcomes on DFROM and dynamic balance, for MWM compared to the control group in a 6 month follow up. Therefore, the investigators should consider that for clinical integration, further research is needed to determine the long-term effects of MWM interventions. Also, other intervention variables to improve the DFROM and dynamic balance, in these individuals should be explored, such as optimal treatment guidelines, length of effects or the description of other complementary kinematic strategies, once the evidence available is conflicting.

5. Conclusion

In the present study, the application of two ankle dorsiflexion MWM techniques seems be effective to improve immediately the DFROM, in futsal players with CAI. Conflicting results were observed regarding its effect on dynamic balance, where both MWM techniques only appear to be effective on the PM and PL reach directions. Nevertheless, the order of application of the two MWM techniques seems to have no immediate influence on the outcomes in study. To sum up, applying both ankle dorsiflexion MWM techniques, whether through a biomechanical or neuroscience paradigm, may be beneficial to provide the most effective outcome in individuals with CAI.

6. Bibliographic references

Baeske, R. (2015). Mobilisation with movement: a step towards understanding the importance of peripheral mechanoreceptors. *Physical Therapy Reviews*, *20*(5–6), 299–305. https://doi.org/10.1080/10833196.2015.1121014

Basnett, C. R., Hanish, M. J., Wheeler, T. J., Miriovsky, D. J., Danielson, E. L., Barr, J. B., & Grindstaff, T. L. (2013). Ankle dorsiflexion range of motion influences dynamic balance in individuals with chronic ankle instability. *International Journal of Sports Physical Therapy*, *8*(2), 121–128. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/23593550

Beattie, P., Isaacson, K., Riddle, D. L., & Rothstein, J. M. (1990). Validity of derived measurements of leg-length differences obtained by use of a tape measure. *Physical Therapy*, *70*(3), 150–157. https://doi.org/10.1093/ptj/70.3.150

Bialosky, J. E., Beneciuk, J. M., Bishop, M. D., Coronado, R. A., Penza, C. W., Simon, C. B., & George, S. Z. (2018). Unraveling the mechanisms of manual therapy: Modeling an approach. *Journal of Orthopaedic and Sports Physical Therapy*, *48*(1), 8–18. https://doi.org/10.2519/jospt.2018.7476

Brown, C. N., Padua, D. A., Marshall, S. W., & Guskiewicz, K. M. (2009). Variability of motion in individuals with mechanical or functional ankle instability during a stop jump maneuver. *Clinical Biomechanics*, *24*(9), 762–768. https://doi.org/10.1016/j.clinbiomech.2009.07.001

Brown, C. N., Padua, D. A., Marshall, S. W., & Guskiewicz, K. M. (2011). Hip kinematics during a stop-jump task in patients with chronic ankle instability. *Journal of Athletic Training*, *46*(5), 461–470. https://doi.org/10.4085/1062-6050-46.5.461

Cejudo, A., Sainz de Baranda, P., Ayala, F., & Santonja, F. (2014). A simplified version of the weight-bearing ankle lunge test: Description and test-retest reliability. *Manual Therapy*, *19*(4), 355–359. https://doi.org/10.1016/j.math.2014.03.008

Collins, N., Teys, P., & Vicenzino, B. (2004). The initial effects of a Mulligan's mobilization with movement technique on dorsiflexion and pain in subacute ankle sprains. *Manual Therapy*, *9*(2), 77–82. https://doi.org/10.1016/S1356-689X(03)00101-2

Cruz-Díaz, D., Lomas Vega, R., Osuna-Pérez, M. C., Hita-Contreras, F., & Martínez-Amat, A. (2015). Effects of joint mobilization on chronic ankle instability: A randomized controlled trial. *Disability and Rehabilitation*, *37*(7), 601–610. https://doi.org/10.3109/09638288.2014.935877

Delahunt, E., Bleakley, C. M., Bossard, D. S., Caulfield, B. M., Docherty, C. L., Doherty, C., … Gribble, P. A. (2018). International Ankle Consortium Rehabilitation-Oriented Assessment. *British Journal of*

Sports Medicine, *0*(0), 1–2. https://doi.org/10.1136/bjsports-2018-099935

Docherty, C. L., Gansneder, B. M., Arnold, B. L., & Hurwitz, S. R. (2006). Development and reliability of the ankle instability instrument. *Journal of Athletic Training*, *41*(2), 154–158.

Doherty, C., Bleakley, C., Hertel, J., Caulfield, B., Ryan, J., & Delahunt, E. (2015). Recovery from a First-Time Lateral Ankle Sprain and the Predictors of Chronic Ankle Instability. *American Journal of Sports Medicine*, *44*(4), 995–1003. https://doi.org/10.1177/0363546516628870

Farahmand, B., Ebrahimi Takamjani, E., Yazdi, H. R., Saeedi, H., Kamali, M., & Bagherzadeh Cham, M. (2019). A systematic review on the validity and reliability of tape measurement method in leg length discrepancy. *Medical Journal of the Islamic Republic of Iran*, *33*, 46. https://doi.org/10.34171/mjiri.33.46

Fédération Internationale de Football Association. (2015). Futsal FIFAS's Development Programmes and Guidelines. Zurich. Retrieved from https://resources.fifa.com/image/upload/futsal-fifa-s-development-programmes-and-guidelines-2831350.pdf?cloudid=yvjybimaeii6ky8zdwpe

Fong, D. T. P., Ha, S. C. W., Mok, K. M., Chan, C. W. L., & Chan, K. M. (2012). Kinematics analysis of ankle inversion ligamentous sprain injuries in sports: Five cases from televised tennis competitions. *American Journal of Sports Medicine*, *40*(11), 2627–2632. https://doi.org/10.1177/0363546512458259

Gilbreath, J. P., Gaven, S. L., Van Lunen, B. L., & Hoch, M. C. (2014). The effects of Mobilization with Movement on dorsiflexion range of motion, dynamic balance, and self-reported function in individuals with chronic ankle instability. *Manual Therapy*, *19*(2), 152–157. https://doi.org/10.1016/j.math.2013.10.001

Gribble, P. A., Delahunt, E., Bleakley, C., Caulfield, B., Docherty, C., Fourchet, F., … Wikstrom, E. (2013). Selection Criteria for Patients With Chronic Ankle Instability in Controlled Research: A Position Statement of the International Ankle Consortium. *Journal of Orthopaedic & Sports Physical Therapy*, *43*(8), 585–591. https://doi.org/10.2519/jospt.2013.0303

Gribble, P. A., & Hertel, J. (2003). Considerations for normalizing measures of the Star Excursion Balance Test. *Measurement in Physical Education and Exercise Science*, *7*(2), 89–100. https://doi.org/10.1207/S15327841MPEE0702_3

Gribble, P. A., Hertel, J., & Plisky, P. (2012). Using the star excursion balance test to assess dynamic postural-control deficits and outcomes in lower extremity injury: A literature and systematic review. *Journal of Athletic Training*, *47*(3), 339–357. https://doi.org/10.4085/1062-6050-47.3.08

Hertel, J., & Corbett, R. O. (2019). An updated model of chronic ankle instability. *Journal of Athletic*

Training, *54*(6), 572–588. https://doi.org/10.4085/1062-6050-344-18

Hing, W., Bigelow, R., & Bremner, T. (2009). Mulligan's Mobilization with Movement: A Systematic Review. *Journal of Manual & Manipulative Therapy*, *17*(2), 39E-66E. https://doi.org/10.1179/jmt.2009.17.2.39e

Hing, W., Hall, T., Rivett, D. A., Vicenzino, B., & Mulligan, B. (2015). The Mulligan Concept of Manual Therapy: Textbook of Techniques. In *The Mulligan Concept of Manual Therapy: Textbook of Techniques* (p. 505). Churchill Livingstone Elsevier.

Hoch, M. C., Gaven, S. L., & Weinhandl, J. T. (2016). Kinematic predictors of star excursion balance test performance in individuals with chronic ankle instability. *Clinical Biomechanics*, *35*, 37–41. https://doi.org/10.1016/j.clinbiomech.2016.04.008

Hoch, M. C., & McKeon, P. O. (2010). The effectiveness of mobilization with movement at improving dorsiflexion after ankle sprain. *Journal of Sport Rehabilitation*, *19*(2), 226–232. https://doi.org/10.1123/jsr.19.2.226

Hoch, M. C., Staton, G. S., & McKeon, P. O. (2011). Dorsiflexion range of motion significantly influences dynamic balance. *Journal of Science and Medicine in Sport*, *14*(1), 90–92. https://doi.org/10.1016/j.jsams.2010.08.001

Hoch, M. C., Staton, G. S., Medina McKeon, J. M., Mattacola, C. G., & McKeon, P. O. (2012). Dorsiflexion and dynamic postural control deficits are present in those with chronic ankle instability. *Journal of Science and Medicine in Sport*, *15*(6), 574–579. https://doi.org/10.1016/j.jsams.2012.02.009

Hubbard, T. J., Hertel, J., & Sherbondy, P. (2006). Fibular position in individuals with self-reported chronic ankle instability. *Journal of Orthopaedic and Sports Physical Therapy*, *36*(1), 3–9. https://doi.org/10.2519/jospt.2006.36.1.3

Hubbard, T. J., Kramer, L. C., Denegar, C. R., & Hertel, J. (2007). Correlations among multiple measures of functional and mechanical instability in subjects with chronic ankle instability. *Journal of Athletic Training*, *42*(3), 361–366. Retrieved from www.journalofathletictraining.org

Krutsch, W., Mayr, H. O., Musahl, V., Della, F., Tscholl, P. M., & Jones, H. (2020). *Injury and Health Risk Management in Sports*. *Injury and Health Risk Management in Sports*. https://doi.org/10.1007/978-3-662-60752-7

Kumari, N., Nijhawan, A. M., & Paresh, P. (2014). Efficacy of Weight Bearing Distal Tibiofibular Joint Mobilization With Movement (Mwm) in Improving Pain, Dorsiflexion Range and Function in Patients With Postacute Lateral Ankle Sprain. *International Journal of Physiotherapy and Research*, *2*(3), 542–548.

Langarika-Rocafort, A., Emparanza, J. I., Aramendi, J. F., Castellano, J., & Calleja-González, J. (2017).

Intra-rater reliability and agreement of various methods of measurement to assess dorsiflexion in the Weight Bearing Dorsiflexion Lunge Test (WBLT) among female athletes. *Physical Therapy in Sport*, *23*, 37–44. https://doi.org/10.1016/j.ptsp.2016.06.010

Manuel Serrano, J., Shahidian, S., da Cunha Voser, R., & Leite, N. (2013). Incidence and injury risk factors in portuguese futsal players. *Revista Brasileira de Medicina Do Esporte*, *19*(2), 123–129. https://doi.org/10.1590/S1517-86922013000200011

Marôco, J. (2018). *Análise Estatística com o SPSS Statistics* (7ª Edição). ReportNumber.

Marrón-Gómez, D., Rodríguez-Fernández, Á. L., & Martín-Urrialde, J. A. (2015). The effect of two mobilization techniques on dorsiflexion in people with chronic ankle instability. *Physical Therapy in Sport*, *16*(1), 10–15. https://doi.org/10.1016/j.ptsp.2014.02.001

McCann, R. S., Crossett, I. D., Terada, M., Kosik, K. B., Bolding, B. A., & Gribble, P. A. (2017). Hip strength and star excursion balance test deficits of patients with chronic ankle instability. *Journal of Science and Medicine in Sport*, *20*(11), 992–996. https://doi.org/10.1016/j.jsams.2017.05.005

Miklovic, T. M., Donovan, L., Protzuk, O. A., Kang, M. S., & Feger, M. A. (2018). Acute lateral ankle sprain to chronic ankle instability: a pathway of dysfunction. *The Physician and Sportsmedicine*, *46*(1), 116–122. https://doi.org/10.1080/00913847.2018.1409604

Mok, K. M., Fong, D. T. P., Krosshaug, T., Engebretsen, L., Hung, A. S. L., Yung, P. S. H., & Chan, K. M. (2011). Kinematics analysis of ankle inversion ligamentous sprain injuries in sports: 2 cases during the 2008 beijing olympics. *American Journal of Sports Medicine*, *39*(7), 1548–1552. https://doi.org/10.1177/0363546511399384

Montgomery, L. C., Nelson, F. R. T., Norton, J. P., & Deuster, P. A. (1989). Orthopedic history and examination in the etiology of overuse injuries. *Medicine and Science in Sports and Exercise*, *21*(3), 237–243. https://doi.org/10.1249/00005768-198906000-00001

Mulligan, B. R. (2010). *Manual Therapy NAGS, SNAGS, MWMS etc* (6 ed.). Wellington, New Zealand: Bateson Publishing Ltd.

Munn, J., Sullivan, S. J., & Schneiders, A. G. (2010). Evidence of sensorimotor deficits in functional ankle instability: A systematic review with meta-analysis. *Journal of Science and Medicine in Sport*, *13*(1), 2–12. https://doi.org/10.1016/j.jsams.2009.03.004

Paungmali, A., O'Leary, S., Souvlis, T., & Vicenzino, B. (2003). Hypoalgesic and Sympathoexcitatory Effects of Mobilization With Movement for Lateral Epicondylalgia. *Physical Therapy*, *83*(4), 374–383. https://doi.org/10.1093/ptj/83.4.374

Plisky, P. J., Rauh, M. J., Kaminski, T. W., & Underwood, F. B. (2006). Star excursion balance test as a predictor of lower extremity injury in high school basketball players. *Journal of Orthopaedic* *and Sports Physical Therapy*, *36*(12), 911–919. https://doi.org/10.2519/jospt.2006.2244

Pope, R., Herbert, R., & Kirwan, J. (1998). Effects of ankle dorsiflexion range and pre-exercise calf muscle stretching on injury risk in Army recruits. *Australian Journal of Physiotherapy*, *44*(3), 165–172. https://doi.org/10.1016/S0004-9514(14)60376-7

Powden, C. J., Vallandingham, R. A., & Gaven, S. L. (2019). Changes in Dorsiflexion and Dynamic Postural Control After Mobilizations in Individuals With Chronic Ankle Instability: A Systematic Review and Meta-Analysis. *Journal of Athletic Training*, *54*(4), 403–417. https://doi.org/10.4085/1062-6050-380-17

Reid, A., Birmingham, T. B., & Alcock, G. (2007). Efficacy of mobilization with movement for patients with limited dorsiflexion after ankle sprain: a crossover trial. *Physiotherapy Canada*, *59*(3), 166–172. https://doi.org/10.2310/6640.2007.00016

Riemann, B. B. L., & Lephart, S. M. S. (2002). The sensorimotor system, part II: the role of proprioception in motor control and functional joint stability. *Journal of Athletic Training*, *37*(1), 80–84. Retrieved from http://www.ncbi.nlm.nih.gov/pmc/articles/pmc164312/

Robinson, R. H., & Gribble, P. A. (2008). Support for a Reduction in the Number of Trials Needed for the Star Excursion Balance Test. *Archives of Physical Medicine and Rehabilitation*, *89*(2), 364–370. https://doi.org/10.1016/j.apmr.2007.08.139

Silva, D. C., Paulo Vilas-boas, J., Carvalho Mesquita, C., Maia, J., Santos, R., André Teixeira Peixoto, T., … Sousa, A. S. (2018). Cross-cultural adaptation and measurement properties of the Portuguese version of the Ankle Instability Instrument. *Trends in Sport Sciences*, *4*(25), 187–194. https://doi.org/10.23829/TSS.2018.25.4-3

Terada, M., Pietrosimone, B. G., & Gribble, P. A. (2013). Therapeutic interventions for increasing ankle dorsiflexion after ankle sprain: A systematic review. *Journal of Athletic Training*, *48*(5), 696–709. https://doi.org/10.4085/1062-6050-48.4.11

Tiemstra, J. (2012). Update on Acute Ankle Sprains. *American Academy of Family Physicians*, *85*(12), 1170–1176. Retrieved from https://www.aafp.org/journals/afp.html?cmpid=_van_188

Van Dijk, C. N., & Vuurberg, G. (2017). There is no such thing as a simple ankle sprain: Clinical commentary on the 2016 International Ankle Consortium position statement. *British Journal of Sports Medicine*, *51*(6), 485–486. https://doi.org/10.1136/bjsports-2016-096733

van Lieshout, R., Reijneveld, E. A. E., van den Berg, S. M., Haerkens, G. M., Koenders, N. H., de Leeuw, A. J., … Stukstette, M. J. (2016). Reproducibility of the modified star excursion balance test composite and specific reach direction scores. *International Journal of Sports Physical Therapy*, *11*(3), 356–365. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/27274422

van Melick, N., Meddeler, B. M., Hoogeboom, T. J., Nijhuis-van der Sanden, M. W. G. G., & van Cingel,

R. E. H. H. (2017). How to determine leg dominance: The agreement between self-reported and observed performance in healthy adults. *PLoS ONE*, *12*(12), e0189876. https://doi.org/10.1371/journal.pone.0189876

Vicenzino, B., Branjerdporn, M., Teys, P., & Jordan, K. (2006). Initial changes in posterior talar glide and dorsiflexion of the ankle after mobilization with movement in individuals with recurrent ankle sprain. *Journal of Orthopaedic & Sports Physical Therapy*, *36*(7), 464–471. https://doi.org/10.2519/jospt.2006.2265

Vicenzino, B., Hing, W., Hall, T., & Rivett, D. (2011). *Mobilisation with Movement: The art and science*. Elsevier Australia. Retrieved from https://espace.library.uq.edu.au/view/UQ:257033

Vicenzino, B., Paungmali, A., & Teys, P. (2007). Mulligan's mobilization-with-movement, positional faults and pain relief: Current concepts from a critical review of literature. *Manual Therapy*, *12*(2), 98–108. https://doi.org/10.1016/j.math.2006.07.012

Weerasekara, I., Osmotherly, P., Snodgrass, S., Marquez, J., de Zoete, R., & Rivett, D. A. (2018). Clinical Benefits of Joint Mobilization on Ankle Sprains: A Systematic Review and Meta-Analysis. *Archives of Physical Medicine and Rehabilitation*, *99*(7), 1395-1412.e5. https://doi.org/10.1016/j.apmr.2017.07.019

Westad, K., Tjoestolvsen, F., & Hebron, C. (2019). The effectiveness of Mulligan's mobilisation with movement (MWM) on peripheral joints in musculoskeletal (MSK) conditions: A systematic review. *Musculoskeletal Science and Practice*, *39*, 157–163. https://doi.org/10.1016/j.msksp.2018.12.001

Wikstrom, E. A., & Hubbard, T. J. (2010). Talar positional fault in persons with chronic ankle instability. *Archives of Physical Medicine and Rehabilitation*, *91*(8), 1267–1271. https://doi.org/10.1016/j.apmr.2010.04.022

7. Appendix

7.1. Appendix 1 – Eligibility and Characterization Questionnaire, Portuguese version

Efeito imediato de duas técnicas de mobilização com movimento na dorsiflexão e no equilíbrio dinâmico, em atletas de futsal, com instabilidade crónica do tornozelo: um estudo randomizado controlado

No âmbito da Unidade Curricular "Dissertação/Estágio com relatório final" do 2º ano do curso de Mestrado em Fisioterapia da Escola Superior de Saúde do Porto (ESS-P.PORTO) foi elaborado o seguinte questionário para selecionar os participantes para o estudo de investigação supracitado. Este estudo tem como objectivo analisar o efeito imediato de duas técnicas de mobilização com movimento na amplitude de movimento de dorsiflexão e no equilíbrio dinâmico, em jogadores de futsal com instabilidade crónica da tibiotársica.
O preenchimento deste questionário demorará no máximo 10 minutos.
Agradecemos desde já a sua disponibilidade.

Consentimento Informado

Estou informado de que o estudo de investigação anteriormente mencionado se destina à análise dos efeitos imediatos de duas técnicas de mobilização com movimento na minha amplitude de movimento de dorsiflexão e no meu equilíbrio dinâmico enquanto jogador de futsal.
É-me garantido que todos os dados relativos à minha identificação neste estudo são confidenciais e que será mantido o anonimato.
Sei que posso recusar-me a participar ou interromper a qualquer momento a minha participação no estudo, sem nenhum tipo de penalização por este facto.
Compreendi a informação que me foi dada.
Caso seja aceite como voluntário, aceito participar de livre vontade no estudo acima mencionado, e ser contactado telefonicamente para a realização do estudo.
Também autorizo a divulgação dos resultados obtidos no meio científico, garantindo o anonimato.

Concorda com o consentimento informado acima descrito? *

- Sim
- Não

Contacto telefónico

Caso cumpra os critérios de participação deste estudo de investigação, necessitamos de o contactar para proceder à realização do protocolo experimental. Deste modo, agradecemos que nos ceda o seu contacto telefónico e avance para a secção seguinte do questionário.

Número de Telemóvel *

Sua resposta

Dados Sociodemográficos

Nível competitivo a que pratica futsal: *

- ◯ Nacional
- ◯ Distrital

Idade: *

(anos)

Sua resposta

Habilitações literárias: *

- 4º Ano
- 9º Ano
- 12º Ano
- Formação profissional
- Licenciatura
- Mestrado
- Doutoramento

Historial Clínico

Teve pelo menos uma entorse do tornozelo há mais de um ano? *

- Sim
- Não

Historial Clínico A

Em que tornozelo? *

- Tornozelo Direito
- Tornozelo Esquerdo
- Ambos

Esse(s) episódio(s) impediu(ram) a sua participação em pelo menos um treino/jogo? *

- ◯ Sim
- ◯ Não

Teve duas ou mais entorses no mesmo tornozelo? *

- ◯ Sim, no tornozelo direito
- ◯ Sim, no tornozelo esquerdo
- ◯ Sim, em ambos
- ◯ Não

Historial Clínico B

Nos últimos 3 meses, teve alguma entorse no tornozelo? *

- ◯ Sim
- ◯ Não

Historial Clínico C

No último ano sentiu pelo menos dois episódios, em que o(s) seu(s) tornozelo(s) "falhou/falharam" (sensação de que ia ocorrer uma entorse mas não aconteceu), durante atividades como caminhar ou correr? *

- Sim, no tornozelo direito
- Sim, no tornozelo esquerdo
- Sim, em ambos os tornozelos
- Não

Alguma vez sentiu instabilidade no(s) tornozelo(s) (falta de confiança/medo de ter uma entorse)? *

- Sim, no tornozelo direito
- Sim, no tornozelo esquerdo
- Sim, em ambos os tornozelos
- Não

Historial Clínico D

Nos últimos 3 meses teve algum tipo de lesão no membro inferior que o tenha retirado do treino/jogo pelo menos um dia? *

- Sim
- Não

Historial Clínico E

Alguma vez fez uma fratura (partir um osso) nos membros inferiores? *

- Sim
- Não

Alguma vez foi submetido a alguma cirurgia no membro inferior? *

- Sim
- Não

Historial Clínico F

Que tipo de intervenção foi realizada? *

Sua resposta

Há quanto tempo? *

Sua resposta

Historial Clínico G

Está a receber ou recebeu nos últimos 3 meses algum tipo de intervenção em Fisioterapia no membro inferior? *

(Apenas considere lesões/condições que o tenham afastado pelo menos um dia do treino/jogo)

- Sim
- Não

Utiliza algum tipo de medida preventiva (incluindo ligaduras funcionais) no(s) tornozelo(s)? *

- Sim, no tornozelo direito
- Sim, no tornozelo esquerdo
- Sim, em ambos os tornozelos
- Não

Historial Clínico H

Toma alguma medicação? *

- Sim
- Não

Historial Clínico I

Por favor indique qual ou quais. *

Sua resposta

Historial Clínico J

Possui alguma patologia/doença diagnosticada? *

- ◯ Sim
- ◯ Não

Historial Clínico K

Por favor indique qual ou quais. *

Sua resposta

7.2. Appendix II – Ankle Instability Instrument, Portuguese version

ID:_____________

Este formulário será usado para categorizar a instabilidade do seu tornozelo. Por favor, preencha o formulário na totalidade. Se tiver alguma dúvida, por favor, pergunte ao investigador. Obrigado pela sua participação.

1. Alguma vez já torceu o seu tornozelo?

☐ Sim ☐ Não

2. Alguma vez consultou um médico por causa de uma entorse do tornozelo?

☐ Sim ☐ Não

2.1. Se sim, como é que o médico classificou a sua entorse mais grave do tornozelo?

☐ Ligeira (grau I) ☐ Moderada (grau II) ☐ Severa (grau III)

3. Alguma vez utilizou algum auxiliar de marcha (como muletas) por incapacidade de suportar o peso corporal devido a uma entorse do tornozelo?

☐ Sim ☐ Não

3.1. Se sim, na entorse mais grave do tornozelo, quanto tempo utilizou o auxiliar de marcha (muletas) referido anteriormente?

☐ 1 a 3 dias ☐ 4 a 7 dias ☐ 1 a 2 semanas ☐ 2 a 3 semanas ☐ > 3 semanas

4. Alguma vez teve a sensação de o seu tornozelo ceder/falhar?

☐ Sim ☐ Não

4.1. Se sim, quando foi a última vez que o seu tornozelo cedeu/falhou?

☐ < 1 mês atrás ☐ 1 a 6 meses atrás ☐ 6 a 12 meses atrás ☐ 1 a 2 anos atrás ☐ > 2 anos atrás

5.Alguma vez sentiu o seu tornozelo instável durante a marcha em superfície plana?

☐ Sim ☐ Não

6. Alguma vez sentiu o seu tornozelo instável durante a marcha em piso irregular?

☐ Sim ☐ Não

7. Alguma vez sentiu o seu tornozelo instável durante atividades recreativas ou desportivas?

☐ Sim ☐ Não

8. Alguma vez sentiu o seu tornozelo instável ao subir escadas?

☐ Sim ☐ Não

9. Alguma vez sentiu o seu tornozelo instável ao descer escadas?

☐ Sim ☐ Não

7.3. Appedix III – Informed Consent, Portuguese version

P.PORTO

ESCOLA SUPERIOR DE SAÚDE
POLITÉCNICO DO PORTO

TERMO DE CONSENTIMENTO INFORMADO

O termo de consentimento informado deve ser específico do Estudo de Investigação (o modelo deve ser adaptado ao estudo em causa, acrescentando outros dados consicerados pertinentes ou eliminando partes não aplicáveis).
Compete ao Investigador Principal, prestar aos Participantes do estudo as informações necessárias ao consentimento livre e esclarecido.

Declaração de Consentimento Informado

Conforme alei 67/98 de 26 de Outubro e a "Declaração de Helsínquia" da Associação Médica Mundial (Helsínquia 1964; Tóquio 1975; Veneza 1983; Hong Kong 1989; Somerset West 1996, Edimburgo 2000; Washington 2002, Tóquio 2004, Seul 2008, Fortaleza 2013) – quando se aplicar

Efeito imediato de duas técnicas de mobilização com movimento na dorsiflexão e no equilíbrio dinâmico, em atletas de futsal, com instabilidade crónica do tornozelo: um estudo randomizado controlado

DESIGNAÇÃO DO ESTUDO

Eu, abaixo-assinado ____

Fui informado de que o Estudo de Investigação acima mencionado se destina a analisar o **Efeito imediato de duas técnicas de mobilização com movimento na dorsiflexão e no equilíbrio dinâmico, em atletas de futsal, com instabilidade crónica do tornozelo: um estudo randomizado controlado.**

Sei que neste estudo está prevista a realização de **avaliação antropométrica (altura, peso e comprimento dos membros inferiores), avaliação de amplitude de dorsiflexão do tornozelo e desempenho no *Star Excursion Balance test*,** tendo-me sido explicado em que consistem e quais os seus possíveis efeitos.

Foi me garantido que todos os dados relativos à identificação dos Participantes neste estudo são confidenciais e que será mantido o anonimato.

Sei que posso recusar me a participar ou interromper a qualquer momento a participação no estudo, sem nenhum tipo de penalização por este facto.

Compreendi a informação que me foi dada, tive oportunidade de fazer perguntas e as minhas dúvidas foram esclarecidas.

Aceito participar de livre vontade no estudo acima mencionado. Também autorizo a divulgação dos resultados obtidos no meio científico, garantindo o anonimato.

Júlio Alexandre Carvalho Portela (alexandre95portela@gmail.com)
Mariana Rocha Maia (marianamaia131@gmail.com)

_____/______/______ DATA

____ ASSINATURA

SGS ESS.0004.MO.317.01

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7.4. Appendix V – Raw Data

Table 4 – Raw data from the characterization of the sample.

Subjects	Groups		Age (years)	Body mass (Kg)	Height (m)	BMI (Kg/m²)	Lower limb lenght (cm)
0	IG	MWM2	18	82.90	1.74	27.40	92.40
1	IG	MWM2	19	65.60	1.73	21.90	88.00
2	GP		25	87.7	87.70	1.75	28.60
3	IG	MWM2	21	84.60	1.77	27.00	88.00
4	IG	MWM1	21	68.30	1.64	25.40	85.00
5	PG		27	79.2	79.20	1.76	25.60
6	PG		34	101	101.00	1.84	30.00
7	PG		24	63.2	63.20	1.70	21.90
8	IG	MWM1	27	88.10	1.88	24.90	96.00
9	IG	MWM1	18	75.40	1.60	29.50	81.00
10	IG	MWM2	25	59.40	1.69	20.80	84.50
11	PG		19	79.3	79.30	1.69	27.80
12	IG	MWM2	28	71.00	1.71	24.30	90.00
13	IG	MWM1	24	75.80	1.70	26.20	87.50
14	IG	MWM1	35	77.10	1.69	27.00	86.50
15	IG	MWM2	24	90.50	1.74	29.90	91.00
16	IG	MWM1	18	95.90	1.77	30.60	88.50
17	PG		21	70.1	70.10	1.73	23.40

IG: Intervention Group; PG: Placebo Group; MWM: mobilization with movement.

Table 5 – Raw data from the Weight-Bearing Lunge Test.

Subjects		Ground-Knee distance (cm)	Hell-Wall distance (cm)	DFROM (°)	M1-M0 (°)
0	M0	43.60	34.00	37.95	1.54
	M1	42.60	35.10	39.49	
1	M0	41.30	33.90	39.38	1.72
	M1	40.00	34.90	41.10	
2	M0	46.20	28.60	31.76	-0.90
	M1	46.70	27.90	30.86	
3	M0	42.70	34.80	39.18	0.93
	M1	41.90	35.30	40.11	
4	M0	42.20	30.20	35.59	2.16
	M1	40.30	31.20	37.75	
5	M0	42.40	37.00	41.11	0.21
	M1	43.00	37.80	41.32	
6	M0	44.40	36.00	39.04	-2.17
	M1	46.80	35.10	36.87	
7	M0	38.10	36.90	44.08	-0.38
	M1	38.30	36.60	43.70	
8	M0	43.70	37.60	40.71	0.49
	M1	43.30	37.90	41.20	
9	M0	37.80	31.20	39.54	0.57
	M1	37.40	31.50	40.11	
10	M0	39.60	34.10	40.73	0.87
	M1	39.20	34.80	41.60	
11	M0	38.20	33.50	41.25	-0.79
	M1	39.40	33.60	40.46	
12	M0	42.70	33.60	38.20	2.91
	M1	40.80	35.60	41.11	
13	M0	39.70	33.40	40.07	1.02
	M1	39.10	34.10	41.09	
14	M0	31.90	43.20	53.56	0.87
	M1	31.40	43.90	54.43	
15	M0	41.80	35.90	40.66	3.54
	M1	39.60	38.50	44.19	
16	M0	45.50	30.50	33.84	0.95
	M1	45.20	31.40	34.79	
17	M0	38.40	37.10	44.01	0.46
	M1	38.10	37.40	44.47	

M0: pre-intervention; M1: post-intervention; DFROM: dorsiflexion range of motion.

Table 6 – Raw data from the Star Excursion Balance Test.

Subjects		ANT (cm)	ANT NS (%)	M1–M0 ANT (%)	PM (cm)	PM NS (%)	M1–M0 PM (%)	PL (cm)	PL NS (%)	M1–M0 PL (%)
0	M0	61.50	66.56	4.44	81.30	87.99	7.68	87.00	94.16	11.15
	M1	65.60	71.00		88.40	95.67		97.30	105.30	
1	M0	50.80	57.73	8.7	82.40	93.64	13.75	84.30	95.80	3.07
	M1	58.50	66.48		94.50	107.39		87.00	98.86	
2	M0	52.80	62.49	-3.20	78.90	93.37	13.96	99.30	117.51	2.25
	M1	50.10	59.29		90.70	107.34		101.20	119.76	
3	M0	55.50	63.07	3.52	64.70	73.52	7.39	68.60	77.95	19.32
	M1	58.60	66.59		71.20	80.91		85.60	97.27	
4	M0	57.50	67.65	-10.12	63.80	75.06	10.82	80.60	94.82	6.00
	M1	48.90	57.53		73.00	85.88		85.70	100.82	
5	M0	59.80	63.08	1.27	90.00	94.94	0.32	95.30	100.53	-0.32
	M1	61.00	64.35		90.30	95.25		95.00	100.21	
6	M0	47.10	50.37	4.28	62.70	67.06	-3.42	88.00	94.12	0.00
	M1	51.10	54.65		59.50	63.64		88.00	94.12	
7	M0	60.20	67.26	-0.89	88.00	98.32	1.90	96.60	107.93	-1.12
	M1	59.40	66.37		89.70	100.22		95.60	106.82	
8	M0	67.90	70.73	0.52	88.90	92.60	8.13	85.60	89.17	16.98
	M1	68.40	71.25		96.70	100.73		101.90	106.15	
9	M0	46.60	57.53	2.22	63.00	77.78	20.00	76.70	94.69	9.75
	M1	48.40	59.75		79.20	97.78		84.60	104.44	
10	M0	61.50	72.78	-4.14	85.00	100.59	12.43	89.00	105.33	8.88
	M1	58.00	68.64		95.50	113.02		96.50	114.20	
11	M0	55.50	62.71	3.39	75.50	85.31	-1.36	86.50	97.74	3.84
	M1	58.50	66.10		74.30	83.95		89.90	101.58	
12	M0	55.30	61.44	0.78	80.70	89.67	7.67	90.30	100.33	3.44
	M1	56.00	62.22		87.60	97.33		93.40	103.78	
13	M0	53.70	61.37	-1.49	90.00	102.86	5.83	94.50	108.00	6.40
	M1	52.40	59.89		95.10	108.69		100.10	114.40	
14	M0	61.00	70.52	4.16	73.50	84.97	7.75	97.90	113.18	3.12
	M1	64.60	74.68		80.20	92.72		100.60	116.30	
15	M0	58.00	63.74	4.40	80.20	88.13	14.62	90.80	99.78	-4.84
	M1	62.00	68.13		93.50	102.75		86.40	94.95	
16	M0	57.00	64.41	-11.19	75.00	84.75	-2.26	76.10	85.99	7.68
	M1	47.10	53.22		73.00	82.49		82.90	93.67	
17	M0	68.50	76.11	-0.11	94.00	104.44	4.89	104.00	115.56	-1.67
	M1	68.40	76.00		98.40	109.33		102.50	113.89	

M0: pre-intervention; M1: post-intervention; ANT: anterior reach; PM: posteromedial reach; PL: posterolateral reach; NS: normalized score.