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Influence of Talocrural Joint Mobilization on Balance and Proprioception of Adults with Limited Ankle Joint Dorsiflexion

The purpose of this study was to assess the changes in balance and proprioception of adults with limited ankle joint dorsiflexion, after the application of talocrural joint mobilization. The subjects of this study included 23 college students in their twenties with limited ankle joint dorsiflexion. The students were randomly assigned to the ankle joint mobilization group (AJMG, n=12) and the control group (CG, n=11). After 2 weeks of intervention using grade III talocrural joint mobilization in the anterior-posterior movement, the balance and proprioception of the subjects were assessed. Static/dynamic balance capabilities and ankle proprioception were analyzed using paired t-test and independent t-test. The dynamic balance and proprioception of AJMG were significantly improved after intervention ($p<.05$), In the comparison between the groups after the intervention, the dynamic balance and proprioceptive sense of AJMG were significantly improved compared to the control group ($p<.05$). This study suggests that AJMG can help improve the dynamic balance and proprioception.

Key words: *Dorsiflexion; Talocrural Joint Mobilization; Balance; Proprioception*

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INTRODUCTION

The key functions of the ankle joint in the human body include balance adjustment in case of posture changes, shock absorption while walking, and provision of momentum for lower limb movement. For the ankle joint to properly function, it requires an adequate range of motion, strength, and proprioceptive sense [1]. Furthermore, the ankle is an important joint in the human body for walking as it acts as a shock absorber and provides a stable surface for weight-bearing posture and lower limb movement. The movement of the ankle while walking increases energy efficiency for humans to walk more easily - for this, a sufficient range of motion and strength in the ankle joint are required [2].

A limited range of motion in the ankle joint is the key cause of restriction in daily activities and structural defects [3]. Reduced flexibility and range of motion of the ankle are the result of musculoskeletal changes accompanied by aging, causing a negative effect on the balancing ability of the elderly population [4]. Moreover, with age, the ability to maintain balance becomes worse, nerve reflection becomes slower, and peripheral circulation, cardiac output, and lung capacity decrease [4, 5]. Lastly, reduced proprioceptive sense is associated with reduced balancing ability and increased falls [6]. Posture control is the maintenance of appropriate balance between the human body and the environment, and postural orientation and stability are its key components [7].

Joint mobilization is an intervention method used to treat joint disabilities disabilities (i.e., low mobility of joint or joint pain), and is one of the physiotherapy methods based on the knowledge of anatomy, kinesiology, and pathology of the nerve root and skeletal muscle [8]. Among multiple passive movement techniques, joint mobilization is performed based on osteokinematic motion regardless of arthrokinematic principles, and its purpose is to maintain normal range of motion regardless of the articular surface movement [8].

Although there have been several studies that have observed the changes in balance and proprioception

due to limited ankle joint movement, most of these studies have focused on utilization of passive stretching and active movement, or active movement and passive joint mobilization [9-13]. Therefore, this study aimed to observe the changes in balance and proprioceptive sense after the application of joint mobilization in adults with limited ankle joint movement, in order to provide fundamental data for physiotherapy interventions.

METHODS

Subjects

This study was performed on a cohort of 23 college students in their twenties with limited ankle joint dorsiflexion. The students were divided into the ankle joint mobilization group (AJMG, n=12) and control group (CG, n=11). The following were the selection criteria: subjects who had no experience of ankle sprain in the past year; subjects who had no issue with walking, and subjects who had one ankle with limited movement and experienced pain due to an ankle sprain with $\leq 10^{\circ}$ dorsiflexion (with knee joint bent) [14]. The following subjects were excluded from the study: subjects who had mental conditions that might hamper the intervention, subjects with neurological symptoms, and subjects who were pregnant. All participants were instructed about potential risks and experimental design, and were provided with an informed consent form to sign prior to participation, with the knowledge that they could withdraw at any time. The Ethics Committee of Namseoul University in Korea approved the study. The IRB approval number is Research NSUIRB-201812-004.

Intervention

The experiments were performed after randomly dividing the subjects into either the ankle joint mobilization group (AJMG) or the control group (CG). Joint mobilization was performed alongside general physiotherapy once every day for 30 minutes, at a frequency of 3 sessions per week for a 2-week period. The subjects were given information regarding the intervention and assessment procedures before they were conducted. Measurement of the variables in this study and data collection were performed solely by the investigator. An assistant investigator was also present in case of unforeseen emergency circumstances during the measurement.

Ankle joint mobilization Group (AJMG)

Ankle joint mobilization group was performed with the subject in a supine position on top of a mat, with the lower limb aligned and a towel placed underneath the subject's knees to prevent the knee from becoming entirely flattened. Ankle joint mobilization was applied on the talocrural joint with the strength of the Maitland mobilization grade III [13], in the AP (anterior-posterior) movement at 2 Hz frequency for four sets of one-minute sessions. The intervention was applied while making sure that the degree of pain remained below the VAS(visual analogue scale) score of 3 [9, 15, 16].

Control Group (CG)

Similarly, the subjects in the control group received the intervention in a supine position on top of a mat, with the lower limb aligned and a towel placed underneath the subject's knees to prevent the knee from becoming entirely flattened. Ankle joint mobilization was applied on the talocrural joint with the strength of the Maitland mobilization grade I [15], in the AP (anterior-posterior) movement at 0.5 Hz frequency for four sets of one-minute sessions.

Measurement method

Balance Ability

Static Balance Ability

In order to assess the balanced ability of the study subjects, a Balanced Scorecard (BT-4; Hur Lab, Kkoarla, and Finland) was used to assess the ability to balance static and dynamic abilities. BT-4 has a sampling rate of 100 Hz and a strain gauge at the apex point of each side in the form of a rectangle. The test protocol, using the 30s Rombergs (Romberg 30s), once opened its eyes and once closed its eyes for 30 seconds each. The main measurement result value is C90 Area. C90 Area refers to the area (mm2) where the COP (center of pressure) moves at the pressure center, and the area appears narrower with a good static balance [17].

Dynamic Balance Ability

Among different assessment tools, the Limits of Stability (LOS) test was used. The position of the feet was identical to that in the assessment for static balance ability. The subjects stood straight on a platform. Without moving their feet away from the platform, the subjects were asked to lean over for 8 seconds in 4 different directions (anterior, posterior, right, and

left) and the maximal range of movement was calculated. The key measurement variable was the maximum degree, and this value was greater in the individuals with better dynamic balance ability.

Proprioception

Proprioceptive senses of the ankle - plantar flexion and dorsiflexion - were assessed using an isokinetic equipment called CSMi (Humac co, USA). The subjects sat on a chair, and the foot being assessed was placed on top of a measurement table. The talocrural joint and knee joint were positioned so that they were parallel to one another, and the lower limbs and feet were fixed using a strap. The subjects were asked to remember the joint position by maintaining the assessment angle for 10 seconds, and then were asked to replicate the position by themselves. The angular speed of the isokinetic equipment was set at 180°/sec, and the mean value of three assessments were calculated. The smaller the error range, the improved ability of proprioception.

The subjects were blindfolded so they could not simply replicate the position by visualization [18].

Data Analysis

Statistical analyses were statistical processed using SPSS version 20.0. Descriptive statistics were used to identify the general characteristics of the subjects, normal distribution of the data was determined by the Shapiro-Wilk test, and t-test was performed for the group's prior homogeneity check. Pre-post-comparative comparisons of static and dynamic balance capabilities, ankle proprioception under intervention were conducted using a paired t-test. Independent t-test was used to compare the difference between static balanced, dynamic balance capabilities and ankle proprioception before and after intervention between groups. The statistical significance level was set to .05.

RESULTS

The dynamic balance and proprioception of AJMG were significantly improved after intervention ($p<.05$),

Table 1. Demographics of participants

	AJMG (n=12)	CG (n=11)	p
Gender (male/female)	7/5	7/4	N/A
Side (left/right)	4/8	3/8	N/A
Age (yrs)	22.47±2.17	20.85±4.24	.23
Height (cm)	165.35±7.87	167.61±9.30	.51
Weight (kg)	61.08±10.39	62.94±11.75	.09

AJMG: ankle joint mobilization group, CG: control group

Table 2. Changes in outcome measure variables between pre- and post-interventions

Variable	Group	Pre (M±SD)	Post (M±SD)	p
Static balance ability	AJMG	8.10±.88	9.18±.63	.09
(C90 Area, unit: mm2)	CG	8.88±.89	8.27±.85	.23
Dynamic balance ability	AJMG †	313.25±140.10	368.79±164.30	.00*
(LOS, unit: degrees)	CG	312.47± 87.35	331.34± 83.85	.32
Proprioception	AJMG †	2.07±031	1.07±0.82	.02*
(unit: degrees)	CG	2.19±0.85	2.08±1.07	.12

*p<.05, AJMG: ankle joint mobilization group, CG: control group, LOS: Limits of Stability
† p<.05, The values in the AJMG were significant differently to the CG

but there was no significant change in static balance. The static/dynamic balance and proprioception of CG did not change significantly after intervention. In the comparison between the groups after the intervention, the dynamic balance and proprioception of AJMG were significantly improved compared to the control group ($p<.05$) however, the static balance was not significantly different between the two groups. This study suggests that AJMG can help improve the dynamic balance and proprioception.

DISCUSSION

A limited range of motion in the ankle is a general cause of hindrance in daily activities [3]. This study assessed the changes in balance and proprioception of 23 college students in their twenties with limited ankle joint dorsiflexion, after the application of ankle joint mobilization intervention for 3 weeks.

There were significant differences in dynamic balance ability and proprioception of the subjects in the AJMG between before and after the intervention. Similarly, compared to the control group (CG, mobilization grade [1], there were significant differences in both dynamic balance ability and proprioception in the AJMG.

Hoch et al. (2012) reported that 12 adults (6 males and 6 females) with chronic ankle instability exhibited significantly improved dynamic balance and range of motion in the ankle after 2 weeks of ankle joint mobilization [19]. Similarly, a study by Shih et al. (2018) demonstrated that there were significant differences in the range of motion in the ankle, posterolateral balance performance, and Cumberland Ankle Instability Tool (CAIT) score in a cohort of subjects with functional ankle instability, after applying ankle joint mobilization for 4 weeks [20]. Vaillant et al. (2009) also showed that one-time application of plantar massage and ankle joint mobilization in a cohort of 28 elderly subjects resulted in significant differences in the One Leg Balance test and Timed Up and Go test [21]. Similar to these previous studies, our study also demonstrated an increased dynamic balance ability after 2 weeks of ankle joint mobilization. Ankle joint mobilization inducing structural changes of the talocrural joint and consequently increased delivery of somatosensory information - for improvement of the range of motion in the ankle and balance - to the central nervous system (CNS) likely resulted in an improved balance ability of the subjects [9, 19, 21-23].

A previous study mentioned that performing balance training - which involves stimulation of proprioception - on top of a balance pad could improve balance ability [24]. Moreover, Hyndman et al. (2009) reported that proprioceptive stimulatory training can result in significant reduction of motion-based fluctuation in different directions - such as anterior, posterior, and lateral (side) directions [25]. Similarly, in our study, application of joint mobilization resulted in an improved dynamic balance ability. The joint position sense collects information from mechanoreceptors, such as receptors of nearby ligaments and articular capsules, skin receptors, muscle spindles, and golgi tendon organs [26, 27]. Therefore, application of joint mobilization may have stimulated ligaments or articular capsules which are non-contractile structures, consequently improving the joint position sense [28-30].

Despite these intriguing findings, our study has several limitations. This study was based on a cohort of adults in their twenties, and therefore it is difficult to generalize the findings to all age groups. In addition, the short intervention period (2 weeks), limited number of subjects, and uncontrolled daily activities aside from the intervention, are all potential limitations which should be resolved in future studies.

CONCLUSION

This study assessed the changes in balance and proprioception of 23 college students in their twenties with limited ankle joint dorsiflexion, after the application of ankle joint mobilization intervention for 2 weeks.

The dynamic balance and proprioception of AJMG were significantly improved after intervention , In the comparison between the groups after the intervention, the dynamic balance and proprioception of AJMG were significantly improved compared to the control group. application of joint mobilization for adults with limited ankle joint dorsiflexion can improve their balance and proprioception.

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