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Original Article

The Effect of Ankle Taping and Balance Exercises on Postural Stability Indices in Healthy Women

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Abstract. [Purpose] The purpose of this study was to compare the effect of ankle taping and balance exercises on postural stability indices in healthy women. [Subjects and Methods] Thirty healthy female students were randomly assigned into two equal groups: ankle taping and balance exercise. The balance exercise group performed balance exercises for 6 weeks, with 3 sessions per week and each session lasting 40 minutes. Ankle joint taping was performed for 6 weeks and was renewed three times a week. Before and after the interventions, overall, anteroposterior, and mediolateral stability indices were measured with a Biodex Balance System in bilateral and unilateral stance positions with the eyes open and closed. [Results] In the taping group during bilateral standing with the eyes closed, the overall stability index changed from 6±1.4 to 4.8±1.3, anteroposterior stability index changed from 4.2±1.27 to 3.4±0.97, and mediolateral stability index changed from 3.2±0.75 to 2.7± 0.7. In the balance exercise group during bilateral standing with the eyes closed, the overall stability index changed from 5.7±1.69 to 4.5±1.94, anteroposterior stability index changed from 4.1±1.61 to 3±1.21, and mediolateral stability index changed from 3.5±1.4 to 2.2± 1.3. No significant difference was seen between the two groups regarding any study variables. [Conclusion] The results showed that compared with the taping technique, balance training increases postural stability in the majority of the studied balance situations.
Key words: Balance exercise, Taping, Biodex

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INTRODUCTION

The position of the body in relation to space is determined by visual, vestibular, and somatosensory functions[1)]. The ability to control the body in space is a complex interaction between musculoskeletal and neural systems. This set of systems is called the postural control system[1)]. Postural control involves the control of body position in space for the dual purposes of postural stability and postural orientation. Balance is a complex process involving the reception and interpretation of information about body movement, integration of sensorimotor information, and execution of appropriate movement to achieve the goal of upright postural control[2)]. A defect in each of these three aspects of data processing, i.e., sensory input (somatosensory, vision, and vestibular), sensorimotor integration, and motor output, can lead to imbalance[1)]. A reduction in joint position sense can cause recurrent ankle sprains[3)], knee ligaments sprain[4)], and degenerative joint diseases[5)].

The somatosensory system signals two types of information to the CNS. One of them is the movement of body parts in relation to a supporting surface, and the other one is the relative position of the body parts to each other. somatosensory inputs originate from pressure receptors in the skin, deep tendon sensory receptors, and joint receptors (especially the foot and ankle)[1)]. The postural control system should be regulated to ensure it functions properly, which is done by the feedback and feed forward systems. Sensory inputs adjust these mechanisms[6)]. Sensory inputs in the sole of the foot send information about the supporting surface. Proprioceptors send the position of the limbs and the relative position of head to the body, and at the same time, visual detection of movement in space can signal the head position related to the horizon line[7)].

Several types of exercise have been proposed to improve proprioception. Bouët and Gahery stated that balance exercises improve neuromuscular relations and reduce proprioception errors. They believe that those who have more proprioception difficulty may benefit more from exercise therapy[8)]. Rozzi et al. showed that balance exercises improve balance in patients with ankle instability and normal subjects. They related these findings to improvement of balance in the ankle joint and improvement of general balance[9)]. Lentell et al. showed that proprioception deficit and anatomical instability are two factors affecting functional stability. Proprioception data play a fundamental role both in local and general stability[10)]. Tropp et al. showed that proprioception reduces after joint damage, so increas-

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ing a patient's joint motion sense and dynamic stability are important for fast recovery[11].

Taping is another technique to enhance proprioception. Improvement in proprioception leads to better function and reduction of disability. Kinesio taping is being used to prevent injuries and to help injuries to heal[12]. It can also improve efficiency in sport, improve lymph and venous circulation, decrease edema, stimulate the mechanoreceptors and increase awareness of a subject with regard to ankle position, reduce pain, and improve muscle performance[12]. Taping improves dynamic stability by increasing sensory input, decreasing the delay in postural reflexes, and increasing stability[13]. Proprioception is the most important part of motor systems. It is an essential part of motor control and plays a very important role in joint dynamics[13]. The lateral ligaments and joint capsule of the ankle joint are full of proprioceptors, and any malfunctioning of these receptors reduces the joint kinesthesia. So decreasing input from these receptors to higher control centers leads to improper muscle response and changes in joint movement direction[14]. Taping has been shown to be able to control the center of pressure sway speed and lead to better performance in maintaining stability when a perturbation is applied[15]. Previous studies have shown that taping facilitates the neuromuscular reflexes[15, 16]. This capability is the result of increasing sensory input caused by direct contact between the tape and skin[17]. While other techniques like bracing do not increase sensory feedback, a previous study showed that taping can improve joint position sense in a non-weight-bearing position[18]. Heitkamp et al. showed that taping can improve proprioception[19]. Robbins et al. reported that taping has a positive effect on the position sense of the ankle joint[20].

Balance exercises and taping can both improve postural control by improving proprioception inputs, but comparing the effects of these treatments to select the best strategy to manage proprioception deficit is a challenge. This study evaluated dynamic stability, while many other studies have measured static stability, and so their results cannot be generalized to dynamic stability. Since many daily activities are link to dynamic stability, the study of balance in these situations is of more importance. Both taping and balance exercises have effects on dynamic balance, so this study compared the effects of ankle taping and balance exercise on postural stability indices in healthy women.

SUBJECTS AND METHODS

This study was a single-blinded randomized controlled trial. Thirty female students from Zahedan University of Medical Sciences participated in this study and were divided into two groups. Subjects were randomly divided into the two groups by lottery conducted by clinical therapists. There were 15 subjects in each group. Subjects were not informed about the basics of the study. They just knew that we were comparing the effects of ankle taping and balance exercise, both of which can improve balance. The administrator and participants were informed about the grouping data. But the physiotherapist who assessed the subjects, measured the outcome, and analyzed the data was blinded about the grouping. Balance exercises were performed for six weeks, three days a week, with each session lasting forty minutes. Data were recorded before and after finishing the protocol.

In this study, thirty healthy female students were selected through simple non-probability sampling method. Before entering the study, they were tested for the health of the muscle and ligaments around the ankle joint by anterior and posterior drawer tests and joint glides. The inclusion criteria for this study were having no pain in the ankle joint; not being involved in any sports activity in the period of this study; healthy sensory motor function in the lower limbs; no history of neuromuscular disease, vertigo or any uncorrected visual problems, any kind of ankle injury or lower limb surgery, taking sedative medication, cardiovascular, neurologic, or pulmonary disease, balance problems, rheumatoid disease, and psychological disease; and a body mass index of between 17 and 25. Exclusion criteria included ankle pain, allergy to tape, and not completing all interventional sessions. Those subjects who were eligible to take part in the study signed an informed consent before entering the study. This study was approved by the Scientific and Ethics committee of the School of Rehabilitation Sciences of Zahedan University of Medical Sciences, and the rights of the subjects were respected throughout the study.

In order to apply the inclusion and exclusion criteria, all cases were subjected to an interview and assessment. The heights of the subjects were measured by a meter with 1 cm accuracy, and a digital scale was used to measure the body weights of the subjects (in order to calculate BMI). A Biodex Balance System was used to measure balance indices. It has reliability and validity for measuring balance indices[21, 22].

The overall stability index (OSI), anteroposterior stability index (APSI), and mediolateral stability index (MLSI) were recorded with a Biodex Balance System (SD 950-340, Biodex Medical Systems, Inc., Shirley, NY, USA).

The Biodex system has a circular deck with a 55 cm diameter located 20 cm above the floor inside its body, which is able to tilt 20 degrees from the horizontal position to all sides. The overall stability index shows the variance in plate deviation from the horizontal plane. The anteroposterior and mediolateral indices show the deviation of the plate from the horizontal position in the sagittal and frontal planes, respectively. The scores for the indices show the level of deviation from the horizontal position, so the lower scores indicate better balance[22].

The subjects stood on the balance board without shoes and stockings. The right heel was placed at the intersection of the lines from E and 9. The left heel was placed on the intersection of the lines from F and 12. The feet were 20 degrees out toed. The hands were laid one across the other on the thorax. The difficulty level of the test in the double leg standing position with the eyes open and closed was decreased from level 6 to level 3. In other words, the difficulty level in a 20-second trial changed from six to three. The trial began with level six and finished in level three. In the single leg standing positions with the eyes closed and open, the difficulty level changed from eight to five gradually in accordance with previous method[22].

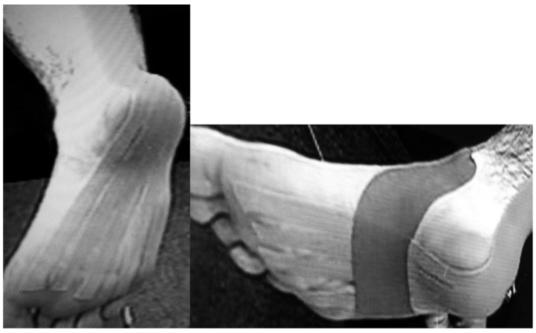

Fig. 1. Ankle joint taping

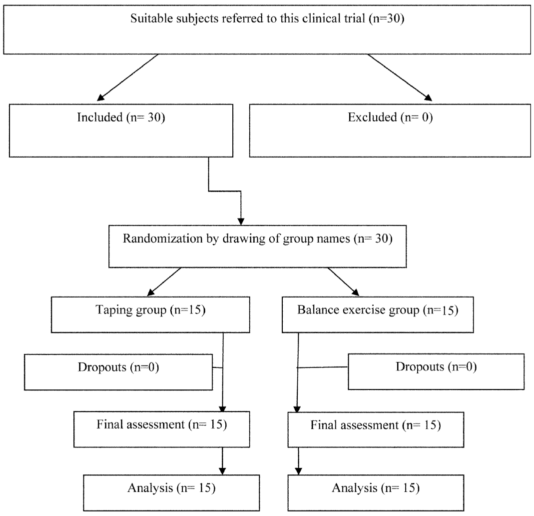

Fig. 2. Flow diagram of the progress through the phases of the randomized trial

The subjects became familiar with the testing protocol in a pretesting session. Dynamic postural stability test was performed in the double leg standing position with the eyes open and closed and in the single leg standing position with the eyes open and closed on the right and left legs. Each test included three trials that lasted 20 seconds with a 10-second interval between trials for rest. A mean score was calculated from the three test evaluations. There was five-minute rest period between tests.

The first group performed balance exercise for six weeks, 3 times a week, with each session lasting 40 minutes. Each session started with several minutes of slow walking and progressive stretching of the ankle, knee, and hip muscles, which was gradually increased in time and repetition. After that, balance exercises were performed. The session was finished with several minutes of slow walking. The balance exercises started with static exercises in the first week and progressed to dynamic exercises with the eyes closed and open plus crossed movement of the upper extremities in the sixth week. There were 10 repetitions for each exercise, and each exercise lasted 10 seconds. There were also 10 minutes of rest between exercises[23–27].

In the taping group, we used elastic tape (DARCO GmbH, Raisting, Germany) with a width of 5 cm (Fig 1). In order to confirm that there would be no allergic reaction to the tape, a piece of tape was applied to the skin of the calf for 24 hours. Ankle joint taping was performed for 6 weeks and was renewed three times a week. In a careful assessment, proper tension of the tape, correct cutting, and direction of tape application were taken into account for all subjects. The ankle joint was put into full dorsiflexion before taping. Taping was started from gastrocnemius muscle bulk and progressed toward the Achilles tendon; after passing the heel, it was cut into four divisions and attached to the dorsal aspect of the foot, the metatarsal area. A second length of tape was attached to the lateral malleolus in the ankle dorsiflexion position, passed over the lateral ligaments, passed under the foot to reach the medial malleolus, and passed across the medial ligaments of the ankle[15].

The sample size was determined based on a pilot study. Ten subjects were divided randomly into two equal groups, and the main part of study was conducted on them. The means and SDs for the parameters from this pilot study, with $\alpha = 0.05$ and 90% power were used to calculate the sample size.

Data analysis was performed with SPSS version 17. The assumption of a normal distribution was assessed using the K-S test. The assumption of equality of variances was tested using Levene's test. The paired t-test and independent samples t-test were used for within- and between-group comparisons. The α level was less than 5% for all tests.

RESULTS

Figure 2 presents the recruitment strategy and experimental plan. The pilot study showed that 15 subjects would be needed for each group (a total of 30 subjects). Ultimately, 30 subjects finished the study procedure.

The mean weight and height of the subjects in the taping group were 53.80±3.23 kg and 161.13±4.10 cm, respectively. The mean weight and height of the subjects in the balance exercise group were 52.87±6.41 kg and 161.20±5.63 cm, respectively. The subjects was between 19 and 22 years of age. All data had a normal distribution.

The means and SDs of the OSI, APSI, and MLSI for all testing positions were compared between the two groups before and after treatment and are shown in Table 1.

In the taping group, the OSI in the double leg stance with the eyes open and closed, APSI in the double leg stance with the eyes closed, MLSI in the double leg stance with the eyes closed, OSI in the right leg stance with the eyes open, APSI in the single leg stance on the right leg with the eyes closed, APSI in the single leg stance on the right leg with the eyes open, OSI in the single leg stance on the right leg with the eyes open, MLSI in the single leg stance on the left leg with the eyes open, and OSI in the standing position on the left leg with the eyes closed showed significant decrease ($p<0.05$) (Table 1). In this group, OSI in the double leg stance with the eyes open, APSI in the double leg stance with the eyes open, MLSI in the double leg stance with the eyes open, MLSI in the single leg stance on the right leg with the eyes open and closed, APSI in the single leg stance on the left leg with the eyes open and closed, and MLSI in

Table 1. Means and standard deviations of overall, mediolateral, and anteroposterior stability indices, and p-values for within and between-group comparisons

Outcome measures	Taping group (n=15)		Balance exercises group (n=15)	
	Before	After	Before	After
OSIBEO	1.4±0.34[a]	1.4±0.57	1.4±0.45	1.1±0.34
APBEO	1±0.28	0.1±0.41	1.1±0.44	0.8±0.32
MLBEO	0.6±0.18	0.7±0.42	7.3±0.26	0.7±0.44
OSIBEC	6±1.4	4.8±1.3	5.7±1.69	4.5±1.94
APBEC	4.2±1.27	3.4±0.97	4.1±1.61	3±1.21
MLBEC	3.2±0.75	2.7±0.7	3.5±1.4	2.2±1.3
OSIREO	4.1±1.08	3.7±0.1	4.6±2.52	3.8±2.23
APREO	1.5±0.93	0.8±0.62	1.5±0.65	1.1±0.37
MLREO	3.7±1.5	3.5±1.39	4.3±2.53	3.6±1.83
OSIREC	6.7±1.84	5.9±1.53	6.4±1.59	5.3±1.77
APREC	4.3±1.67	3.4±1.28	3.5±0.84	2.6±0.85
MLREC	4.4±1.88	4.4±1.27	5.3±3.09	4.2±2.17
OSILEO	5.4±2.08	4.2±1.68	6.1±3.61	4.8±2.57
APLEO	1.8±1.3	1.5±1.1	1.6±0.98	1.1±0.82
MLLEO	4.5±2.59	3.5±1.76	5.7±3.59	4.4±2.5
OSILEC	7.6±1.72	6.7±1.56	7.7±2.22	6.4±3.01
APLEC	4.3±0.1	3.7±1.04	3.9±1.01	3.1±1.19
MLLEC	5.7±2.5	4.7±1.83	6.8±4.03	5.7±3.39

[a] Values are means ± SD
[b] Statistical different at p<0.05
OSIBEO, overall stability index, bilateral standing, eyes open; APBEO, anteroposterior stability index, bilateral standing, eyes open; MLBEO, mediolateral stability index, bilateral standing, eyes open; OSIBEC, overall stability index, bilateral standing, eyes closed; APBEC, anteroposterior stability index, bilateral standing, eyes closed; MLBEC, mediolateral stability index, bilateral standing, eyes closed; OSIREO, overall stability index, right unilateral standing, eyes open; APREO, anteroposterior stability index, right unilateral standing, eyes open; MLREO, mediolateral stability index, right unilateral standing, eyes open; OSIREC, overall stability index, right unilateral standing, eyes closed; APREC, anteroposterior stability index, right unilateral standing, eyes closed; MLREC, mediolateral stability index, right unilateral standing, eyes closed; OSILEO, overall stability index, left unilateral standing, eyes open; APLEO, anteroposterior stability index, left unilateral standing, eyes open; MLLEO, mediolateral stability index, left unilateral standing, eyes open; OSILEC, overall stability index, left unilateral standing, eyes closed; APLEC, anteroposterior stability index, left unilateral standing, eyes closed; MLLEC, mediolateral stability index, left unilateral standing, eyes closed.

the standing position on the left leg with the eyes closed showed not significant decreases ($p>0.05$).

In the balance exercise group, OSI in the double leg stance with the eyes open and closed, APSI in the double leg stance with the eyes closed, MLSI in the double leg stance with the eyes closed, APSI in the single leg stance on the right leg with the eyes open, OSI in the single leg stance on the right leg with the eyes closed, APSI in the single leg stance on the right leg with the eyes closed, MLSI in the single leg stance on the right leg with the eyes closed, OSI in the single leg stance on the left leg with the eyes open, APSI in the single leg stance on the left leg with the eyes open, MLSI in the single leg stance on the left leg with the eyes open, OSI in the single leg stance on the left leg with the eyes closed, APSI in the single leg stance on the left leg with the eyes closed, and APSI in the single leg stance on the left leg with the eyes closed were significantly decreased ($p<0.05$). In this group, MLSI in the double leg stance with the eyes open, OSI in the single leg stance on the right leg with the eyes open, and MLSI in the single leg stance on the right leg with the eyes open were not decreased ($p>0.05$) (Table 1).

To ensure that the randomization process had been done correctly, the pretesting data were compared between the two groups, and no significant differences were found between the recorded variables. So the groups were matched properly ($p>0.5$). There was no significant difference between the two groups regarding any study variables ($p>0.5$) (Table 1).

DISCUSSION

The findings of this study support the positive effects of balance exercise on postural stability, and the results can also partially support the positive effects of taping on postural stability. However, contrary to the second assumption of this study, there was no significant difference between the two methods. The results of this study showed that balance exercise has effects on a greater number of balance indices comparing to taping.

Both exercise and taping improved the APSI and MLSI in the double leg stance with the eyes closed, APSI in the standing on the right leg with the eyes open, OSI and API in the single leg stance on the left leg with the eyes open, MLSI in the single leg stance on the left leg with the eyes open, and OSI in the single leg stance on the left leg with the eyes closed.

Neither taping nor exercise had significant effects on MLSI in the double leg stance and single leg stance on the right leg with the eyes open. Unlike taping, the balance exercise had positive effects on the OSI and APSI in the double leg stance with the eyes open, MLSI in the single leg stance on the right leg with the eyes closed, APSI in the single leg stance on the left leg with the eyes open, and APSI and MLSI in the single leg stance on the left leg with the eyes closed. The only index that had more changes with taping than exercise was the OSI in the single leg stance on the right leg.

The overall results indicate several important points. No change in postural control in the frontal plane or MLSI was found after taping. Among the 18 variables recorded in this group, eight indices showed no change after taping, and four of these eight indices (50% of the indices had no significant changes) represented the MLSI. In other words, from six variables recorded for the MLSI, four had not changed after taping. In spite of the significant effects of balance exercise on balance indices, three indices showed no significant change. Two of them were related to postural control in the frontal plane or MLSI. It should be noted that in the taping group, four other stability indices showed no change after treatment, three of which were sagittal plane indices (APSI) and one of which was the OSI. In the taping group, 18 stability indices were measured, and only 8 of them showed positive changes after taping; however, in the exercise group, 15 out of 18 indices were changed, which represnts a considerable difference between the two groups. To be able to explain the cause of these findings, we should look at overall postural stability.

Postural stability is the ability to keep the center of mass (COM) in a limited spatial zone, which is called the limit of stability. The limit of stability is the spatial zone within which a person can maintain their balance without changing the base of support. These limitations are not constant but are related to peripheral situations, biomechanics, and personal activities. Stability is related to a balance between forces that are working for and against it[7]. The postural control system needs to integrate sensory information in order to estimate the spatial position of the body to generate proper force and control the body position, so postural control requires the complex interaction of the neural and musculoskeletal systems[28]. The musculoskeletal parts of this system are joint range of motion, spinal column flexibility, muscle properties, and biomechanical relations of body parts. The neural parts of postural control consist of neuromuscular synergies for motor trajectories and sensory systems like the visual, vestibular, and somatosensory integration and sensory strategies, which regulate the sensory input, internal representation, which is needed for sensory to motor mapping, and higher level of brain activities for adaptive aspects and anticipatory mechanisms. Adaptive postural control is defined as changes in sensory and motor output in response to changes in the environment and tasks. Anticipatory aspects of postural control are based on previous experiences and learning[7, 29].

Postural adjustments might be voluntary, involuntary, or semi voluntary. There is a limited zone for COP swing without falling or changing the limits. This area is 12 degrees in the sagittal plane (8 degrees forward and 4 degrees backward) and 16 degrees in the frontal plane (8 degrees to each side) in adults. There are three main involuntary postural strategies: stepping strategy, hip strategy, and ankle strategy. Anticipatory adjustments of posture are controlled by a feed-forward mechanism. These mechanisms are like involuntary mechanisms, but their response happens before real instability. Voluntary postural adjustment is initiated by a person voluntarily and is controlled and performed by personal experiences and learning in a state of awarness[7, 28].

For further assessment, we need to know more about involuntary postural responses and their sensory and motor parts. The ankle strategy is usually used for controlling postural sway by the ankle and foot. The head, trunk, hip, and legs move as a whole on an ankle pivot point (anteroposteriorly and laterally). The ankle strategy is used when sways are small in range, slow in speed and near the midline[30]. It is usually used when a person is standing on a large stable surface. The contraction pattern of the muscles is from distal to proximal. The hip strategy is used to control the posture via the hip and trunk. In this strategy, the head and hips moves in different directions. This strategy is used when the sway is large and fast (1 Hz) and near the midway point of the limit of stability area or when a person stands on a narrow unstable surface. In this strategy, the muscle contraction pattern is from proximal to distal[28]. For sway frequencies between 0.3 to 1 Hz, a combination of ankle and hip strategies is used[30]. When the sway is too large and the COP falls outside the limit of stability zone, the step strategy is used because a new stability zone is needed[30]. Studies have shown that humans can switch between postural strategies very quickly. When a person stands on a narrow surface, they shift from the ankle strategy to a hip strategy (in 5 to 15 trials), and when they return to a normal support surface, they shift to an ankle strategy (in 6 trials)[31]. Sensory inputs are important for postural control. Sensory components of postural control include visual, vestibular, and somatosensory inputs[32].

The data from each are combined with other sensory information to produce a proper motor response. Deficits in the visual, vestibular, or somatosensory system can cause postural control deficit[6]. In spite of the importance of visual inputs for postural control, they are not necessary[33]. Vestibular inputs play a role in signaling perturbations in the transitional phase of postural stability[32]. When the vestibular system is intact, the visual inputs are not essential, but in bilateral vestibular dysfunctions, visual inputs are needed for postural control[33].

It is believed that the somatosensory role is not bold when the visual and vestibular systems are intact[1]. Postural control needs forces to control the body position in space. In order to know the proper timing of force generation, the CNS should have a detailed picture of the body in the space and its movement[1]. Each of the sensory systems prepares special information about body position and movement, so each sensory system acts as a reference for postural control[1]. What kind of information sent to the postural control system by each of these sensory systems? Is one of them more important than the others? Does the CNS always use all these three sensory inputs? If not, how does the CNS decide to use one of them? Visual inputs are important for postural control but are not essential. Somatosensory inputs are not available to determine the perpendicular position of the body when the supporting system is not stable. The vestibular system by itself cannot produce a real picture of spatial orientation of the body. How does the postural control system organize this information? Postural control demands are different in a static position compared with in the presence of a perturbation or movement, which are dynamic positions. All three sensations participate in postural control when a person is in a simple standing position. Postural responses to horizontal fluctuations in standing position are dependent on the somatosensory system in adults. The important matter is the CNS functional flexibility to use sensory information while the task and environment factors change. Previous research supports the theory of hierarchy weighting of sensory information based on their relative accuracy in signaling the spatial position and movement of the body. When a specific sensation cannot give accurate information about the body position and movement in a special situation, the weight of this sense reduces and other accurate senses are given more weight. In normal situations, the CNS gives more weight to the somatosensory system versus the visual and vestibular systems[1]. The other parameter that plays a role in choosing the sensory information source is the balance strategy that is used. While the CNS is using the ankle strategy, the somatosensory source is the main sensory information, and when using the hip strategy, the vestibular information is needed[1].

With the knowledge mentioned above, we can interpret the results of this study. Firstly, taping has its greatest impact on the area to which it is applied. In addition, it affects the tissues that are compressed or stretched by the tape, so the taping method in this study would affect ankle somatosensory information of the ankle joint. In this study, the tape covered posterior calf and medial and lateral ankle ligament, so it should have had an equal effect on lateral and anteroposterior stability indices. But the results do not support this theory. It seems that sensors of length and tension in muscles of the calf (muscle spindles and Golgi tendon organs) are the elements responsible for the greater influence of tape on the anteroposterior stability indices. Karig stated that the stretch and compression applied to tissue by taping stimulate the skin mechanoreceptors and send information about movement and position that improves proprioception. Lehpart and Raiman proposed that the information from skin mechanoreceptor has an effect like joint receptors on proprioception[32]. So the information sent to the CNS increases, and this leads to more accurate control of joint movement[6]. Regarding these theories, tape can improve postural control by sending the skin sensory inputs to the CNS. Carleson and Anderson measured the reaction time of the peroneal muscle to evaluate the effect of taping on ankle stability. Their electromyography data showed that taping can reduce the reaction time. They proposed that it could be the result of increased sensory inputs to the CNS after application of tape[33]. Based on the results of the present study, balance exercises have advantage over taping. Balance exercises can improve balance strategies other than the ankle strategy and can also strengthen and facilitate the involved postural reflexes, so they can improve postural stability. Somatosensory inputs from taping can only improve the ankle strategy, while balance exercise in addition to ankle strategy facilitates the hip strategy, which is vestibular dependent. On the other hand, balance exercise requires motor control responses from the brain stem, so these exercises improve motor control at all CNS levels which is an important matter in balance and proprioception rehabilitation. Proper motor control requires spinal reflexes, postural reflexes, and involuntary balance responses in the brain stem and voluntary responses from the cortical level of the brain[27]. We did not have a control group, and this was a limitation of this study.

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