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ORIGINAL ARTICLE

Effect of ankle taping and bandaging on balance and proprioception among healthy volunteers

Motaz Alawna[1,2] · **Bayram Unver**[3] · **Ertugrul Yuksel**[3]

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Abstract

Background Ankle sprains are one of the most frequent injuries between athletes. After an ankle injury, 72% of patients will experience some degree of functional impairment (proprioception, ankle stability, and balance), which leads to changes in sporting and occupational activities. In the literature, there is no enough information about how bandaging and taping can affect the ankle sprain treatment and rehabilitation process.

Method Seventy-four healthy participants, the age range was 18–30 years old participated in this study. The participants were divided into two groups (taping, and bandaging groups). Proprioception and balance have been measured four times (before using tap, 20 min after using tap, 24 h after using tap, and after removing the tap).

Results In both groups (bandaging group and taping group), proprioception and balance significantly increased immediately after using tape and bandage, after 24 h of using tape and bandage, and after 48 h using tape and bandage when compared to the baseline measurements. There were no significant differences in proprioception and balance between groups.

Conclusion Ankle tape and bandage can significantly improve balance and proprioception in the uninjured ankle during the entire interval of their use.

Keywords Ankle · Ankle injury · Taping · Bandaging · Proprioception · Balance

Introduction

The ankle joint complex is a very complex and highly mobile joint; it is comprised of the lower part of the leg and the foot [1, 2]. The highly complex anatomical components of the ankle joint and the ankle kinetic linkage allow a great mobility degree and great interaction between the lower limb and ground [1, 2]. This interaction is a key requirement for walking and other daily living activities [1, 2]. During daily living activities, especially walking, the ankle joint bear high compressive and shear forces, which make the ankle joint a common site of injuries [1–3].

In both general society and athlete societies, ankle injuries are very common [2, 3]. In the United State, a review of emergency department records has estimated the rate of ankle sprain to be 2.15 per 1000 person-years in the general population [4]. The highest incidence rate was among the individuals, between 18 and 34 years of age (7.2 per 1000 person-years) [4, 5]. It is also believed that most people sustain ankle sprain at least once during their entire life span [6]. Besides, 72% of individuals who experience ankle injury will have a degree of function loss, decreased proprioception, decreased ankle stability, decreased balance, pain, weakness, and giving-way episodes after the injury [7].

However, ankle injuries can cause some limitations during daily living activities, especially locomotion, and limit athletes' ability to play or go back to sports activities [8–11]. The high incidence and the consequences of ankle injuries may lead to huge psychological and financial burdens on both individuals and societies. Thus decreasing the incidence rate of ankle injuries by developing effective

✉ Motaz Alawna
motaz.alawna@aaup.edu; motaz.alawna@gmail.com

1 Department of Physiotherapy and Rehabilitation, Faculty of Allied Medical Sciences, Arab American University, Jenin, Palestine

2 Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Istanbul Gelisim University, Istanbul, Turkey

3 Department of Physiotherapy and Rehabilitation, School of Physical Therapy, Dokuz Eylul University, Izmir, Turkey

prevention methods may contribute to decreasing these consequences [8–11].

Following ankle injuries, physical therapists, athletic trainers, and other rehabilitation professionals emphasize the importance of proprioception reeducation during rehabilitation [12–15], because it is critical components to work on, to achieve the functional success of the treatment and rehabilitation process [12, 13, 16]. Thus external supports are important treatment and prevention components that are commonly used during the different stages of treatment and rehabilitation processes to support, stabilize, and stimulate the proprioceptors [12, 13].

Although bandage and tape are commonly used as external supports to prevent and treat ankle joint injuries. Some previous studies have reported variable and controversial results about the effect of ankle tap and bandage on proprioception and balance. Ankle taping and bandaging helps in controlling the excessive abnormal movements that occur during activities of daily living and sport activities, such as excessive varus stress or excessive ankle plantarflexion. Also, ankle taping and bandaging improves the firing rate of cutaneous mechanoreceptors which helps in better proprioceptive feedback and better balance control and ankle function [17–20]. Elastic bandage is cheap and easy to use, but it is uncomfortable for the patient and may cause some restrictions of the daily activities. Besides the multilayer application of the elastic, bandage needs a good degree of proficiency, thus the improper application of elastic bandage can cause edema. Taping is a little bit more expensive, needing less proficiency to apply, and exerts enough pressure on the cutaneous mechanoreceptors, which stimulate ankle stability. Kinesiotaping has a good effect on proprioception, lighter and more comfortable than taping and bandaging. But it's so much expensive and high proficiency and extra training course to be applied [21–23].

Some authors indicated that the use of tape and bandage can improve proprioception and balance, while others indicated that, bandage and tape have little or no effects [24]. Thus, the effects of ankle joint tape and bandage on proprioception and balance is is till not controversial and not fully clear.

To the authors' knowledge, there are no previous studies about the effect of ankle joint elastic bandaging on balance. Considering the variability in the results of the previous studies, the present study aims to establish whether balance can be improved by ankle taping and bandaging and to compare the effect of ankle taping and bandaging on proprioception and balance. This study hypothesized that the use of ankle joint taping and bandaging would produce significant increases in proprioception, balance among healthy volunteers.

Materials and methods

Participants

Seventy-four healthy subjects participated in this study (37 male and 37 female). The physical characteristics of the participants are shown in Table 1. Healthy subjects were selected because ankle injuries frequently occur during normal locomotion; and most people, not only athletes, experience an ankle injury at least once during their entire life [5, 6]. Participants were excluded if participant reports (a) previous hip/pelvis, knee, ankle, or foot surgery within the past year; (b) lower extremity amputation; (c) injury to the lower extremities within the past year; (d) known balance impairment due to neurological disorder, vestibular disorder, medication use, or other; (f) pregnancy; or (g) concussion within the previous 3 months.

Participant's age range was 18–30 years old and participants were recruited from the university population. Participants were divided randomly into two groups (taping group $n=37$) and (bandaging group $n=37$). Before startıng the procedures, the standard clinical stability testing of the ankle ligamentous structures (inversion stress test, anterior drawer test, talar tilt test) was performed by an orthopedist to rule out anterior and lateral talocrural joint instability and lower extremity injuries during the previous 12 months. The inversion stress was performed while the participant in the sitting or supine position and the knee in full extension. Then, the orthopedist stabilized the distal leg with one hand while the other hand holds the heel with the ankle in neutral position, and started to stress the calcaneofibular ligament by doing inversion. The anterior drawer test was performed while the participant in supine lying or sitting position with the knee in flexed position to relax the calf muscles and prevent the patient from resisting the examiner. One hand of the examiner stabilizes the distal tibia and fibula while the other hand holds the calcaneus maintaining the ankle in a neutral position or 20° of plantar flexion. A translatory force is applied on the calcaneus pulling it anteriorly while the

Table 1 Physical characteristics of participants in all groups

Items	Taping group Mean ± SD	Bandaging group Mean ± SD	*P*
Age (years)	23.24 ± 2.86	22.96 ± 4.15	> 0.05
BMI	23.53 ± 1.03	24.11 ± 1.13	> 0.05
Male	18	19	> 0.05
Female	37	14	> 0.05
Leg length (cm)	93.45 ± 3.33	92.81 ± 4.52	> 0.05
Smoking	5	7	> 0.05
Non-smoking	32	30	> 0.05

tibia and fibula are pushed posteriorly. The talar tilt test was performed while the participant in sitting or supine lying with the knee in full extension. The examiner stabilized the distal leg with one hand while the other hand holds the heel with the ankle in neutral position. The heel is inverted with respect to the tibia. Pain in the area of the ligament or a sensation of clunk would indicate a positive test.

Each volunteer signed an informed consent form before participation. This study was approved by Dokuz Elylul university ethics committee. This clinical protocol was registered on the ClinicalTrials.gov Registration website, the registration number is NCT04583059.

Procedures

Leg length was measured (right and left leg) while the participant lying supine, from the anterior superior iliac spine to the inferior border of the ipsilateral medial malleoli by using standard measure tape. The dominant leg was determined according to Vauhnik. & ark. modified version method. The inferior limb which used in at least two of the following activities: [(1) kicking a ball, (2) drawing a diamond figure on the ground, and (3) using his leg and step over a spider toy], was considered as the dominant leg [25].

Ankle taping procedures

A hard-preventive zinc oxide tape was used in this study. The taping procedure consists of three separate steps: the first step involved the application of the anchor tape, which was achieved by applying the tape circumferentially just above the malleolar level at the lower end of the shank. The second step involved the application of the stirrup. During this step, the foot was held in neutral, and the tape was applied to pass from the medial side of the ankle, under the foot just over the heel area (posterior one-third of the foot), and up along the lateral side of the ankle. The second step was repeated to apply the second stirrup. Both ends of the stirrups were firmly attached to the anchor tape applied during the first step and this attachment was reinforced with a locking tape during the third and final step by once again applying the tape circumferentially just above the malleolar level at the lower end of the shank. The taping was applied by a physical therapist according to the health association requirements [26]. The tape was removed after 48 h.

Ankle bandaging procedures

A standard 10 cm width Triple Cross Premium bandage was used in this study. It is a crepe bandage which is used as a gentle support and compression bandage to help reduce pain and maintain stability in sprains and strains. It can be used for heavy retention and for the fixation of splints and devices and post-orthopedic and general surgery. The elastic bandage was wrapped around the ankle joint to form an 8-figure shape starting from the forefoot. Then, the bandage was taken diagonally upwards, steeply enough to go well above the heel. Then, the bandage was taken around the lower calf area to form an anchor. Then it's diagonally taken down across the midfoot. Again the bandage was wrapped around the forefoot and going diagonally up to finish off around the lower calf, leaving the heel open [27]. During the bandage application process, the therapist do not stretch the bandage, because the bandage does not need to be stretched during the application, as the bandage becomes naturally tight when its layers are wrapped over each other. The participant was asked to take off the sport shoes over the bandage during the measurement procedures. The bandage was removed after 48 h.

Balance assessment

Star excursion balance test (SEBT) is a widely used field based-test to assess dynamic postural control and has an excellent interrater reliability (ICC = 0.86–0.92) [28]. In this study, the SEBT was used to evaluate balance. Eight strips of athletic tape with a length of 6 feet were used. Then a '+' sign was formed. Then '*x*' sign was formed with the other two strips. The lines were separated from each other by an angle of 45°. The participant was asked to wear sports clothes and take off the shoes, then to step on the center of the grid formed by eight lines using the dominant leg, the plantar aspect of the first metatarsophalangeal joint (ball of the foot) was positioned on the intersecting lines at the center of the grid to maintain consistency in foot placement. The participant starts to reach as possible as far in the eight lines, make a light touch on the line, and return the reaching leg back to the center, while maintaining a single-leg stance with the other leg in the center of the grid, starting from anterior direction and progressing clockwise. The order of the directional reaches was as follows: A (anterior), AM (anteromedial), M (medial), PM (posteromedial), P (posterior), PL (posterolateral), L (lateral), AL (anterolateral). When reaching in the lateral and posterolateral directions, participants must reach behind the stance leg to complete the task [29, 30].

To reduce the learning effect, participants were asked to perform six training attempts. Then the participants were allowed to rest for 5 min, then the participants were asked to performed three trials in each of the eight directions. The participants were allowed to rest for 5 min between each one of these three trials. The examiner measured the reaching distance (the distance between the center of the gird to the maximal reaching point) using a standard tape measure. Then, the average of these three attempts was calculated and normalized to the leg length. These obtained normalized

reaching distances were used in the statistical analysis. If the participant used the stance leg for a high amount of support, was unable to maintain balance on the stance leg, or removing his feet from the center any time while doing the trial, the attempt was canceled and repeated again. In the case of a rejected trial, verbal feedback was given to the participants so they attempt to correct the performance error(s) on the next trial [29].

The balance measurements were done four times, (before ankle taping and bandaging, after 20 min while using ankle taping and bandaging, after 24 h while using ankle taping, and immediately after removing the tap and bandage (after 48 h).

Proprioception assessment

We used the measurement procedure described in the study which was done by Iris et al. [26]. The first step: volunteers seated in a high chair, and while their eyes are closed, the examiner guided the voulenteers to step over on different graduated surfaces (10° dorsiflexion, neutral position, 10° plantarflexion, and 20° plantarflexion), respectively, each position will be done for just one time and will be held for 5 s. The examiner told the volunteers that they have to memorize the positions because they have to do it again by themselves. Simultaneously, each joint position was recorded to obtain the target angle using the universal goniometer. This was the angle that the volunteer was instructed to reproduce during the testing part of the study. The second step: the volunteer was then encouraged to walk freely next to the researcher for 10 min, still blindfolded. The third step: then the volunteer sat on a high chair that did not allow his or her feet to touch the floor (to avoid any information from the sole). Finally, the researcher encouraged the subject to reproduce the four memorized positions, starting from and finishing in the neutral position each time. The volunteer maintained each ankle position, announced by the researcher at random, for five seconds. The volunteer's ankle movement was recorded using the universal goniometer, and this reproduced ankle angle was called the estimated angle.

The difference between the learned positions and the positions that were done by the volunteer was calculated and documented. Deviation from the learned angle (degrees) described the direction of error when subjects tried to reproduce the requested position. Deviation was obtained by coding net error, which was based on the correct position occurring when the learned and estimated angle were equal (±5°) [26].

The position (ROM) measurements were done on four occasions, (before ankle external support, after 20 min while using external support, after 24 h while using external support, and immediately after removing the external support (after 48 h).

Statistical analysis

A priori power analysis was applied to calculate the suitable sample size for this study. The G*POWER software (ver. 3.1.9.2, Heinrich-Heine-University, Düsseldorf, Germany) was used to calculate the suitable sample size for the MANOVA test using two groups, a power level of 75%, a significance level of 5%, 12 measurements and medium effect size (dz = 0.8) [31]. Founded on the above-mentioned assumptions, the sample size needed for this study was 72 patients. We added two subjects to compensate for any dropout. Participants' files were coded by a faculty administrator who did not involve in this study. The data analysis trailed the intention-to-treat analysis, and general linear models of multivariate of analysis for repeated measurements (MANOVA) test were used to calculate the treatment–time interaction in every group, whereas independent MANOVA test was used to calculate the treatment–time interactions between groups. The outcome measures were taken at the, (before ankle taping and bandaging, after 20 min while using ankle taping and bandaging, after 24 h while using ankle taping, and immediately after removing the tap and bandage (after 48 h). The mean and standard deviation were calculated for every dependent variable. In this study, the baseline characteristics of participants in the intervention and control groups were compared using Pearson Chi-squared tests for categorical variables, involving gender, previous pain history, and diabetic history. A *t* test was used for the continuous variables of leg length. The significance level was established at $P < 0.05$ SPSS (ver. 25, IBM Inc., Armonk, NY, USA) was utilized for the statistical analysis in this study.

Results

In both groups (bandaging group and taping group), when the normalized reaching distance was compared between the four occasions (before using the external support, after 20 min while using the external support, after 24 h while using the external support, and immediately after removing the external support), there were significant differences between the values of normalized reaching distance at the occasions (after 20 min while using the external support, and after 24 h while using the external support) in comparison to the occasion (before using the external supports) in the eight directions $P < 0.05$ (Figs. 1, 2).

At the occasion (after 20 min while using the external support), we found that the normalized reaching distance was the highest. In this occasion, the best improvement was in the lateral and posterolateral directions, while the least improvement was in the medial direction. these improvements were significant as $P < 0.05$ (Figs. 1, 2). The second highest normalized reaching distance was at the occasion

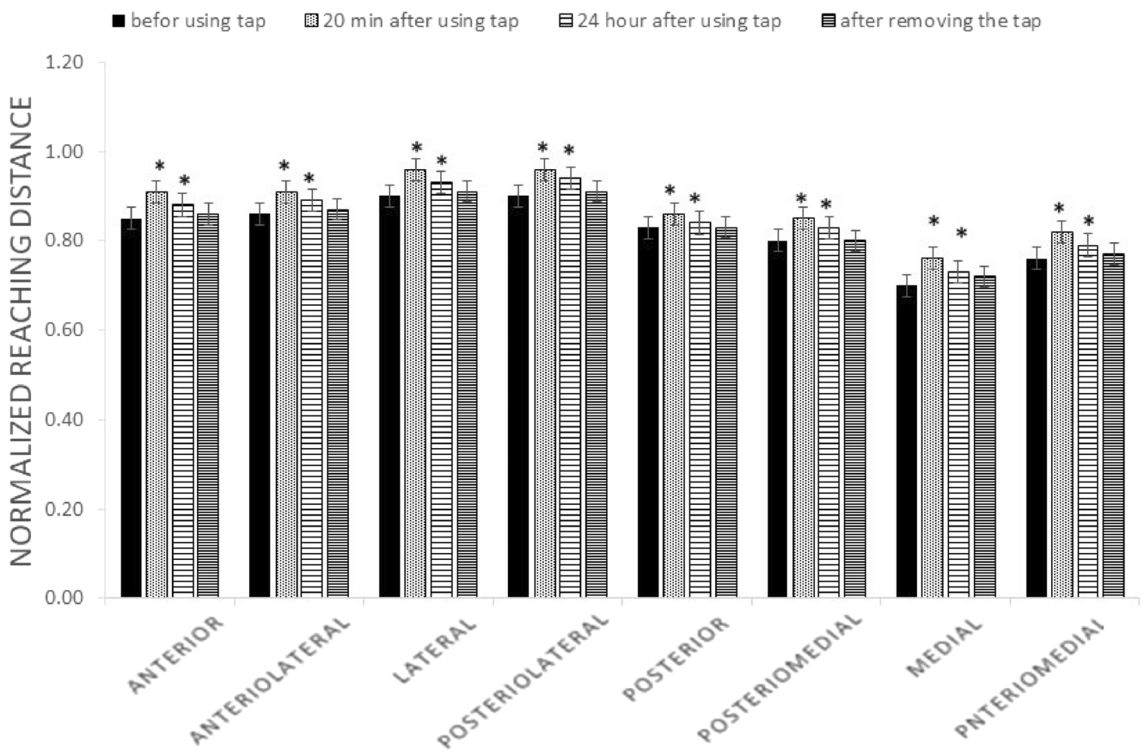

Fig. 1 Repeated measure ANOVA between the baseline measurements and after 20 min, 24 h, and after removing tape for the normalized reaching distance (tape group). Asterisk indicates significance ($P < 0.05$)

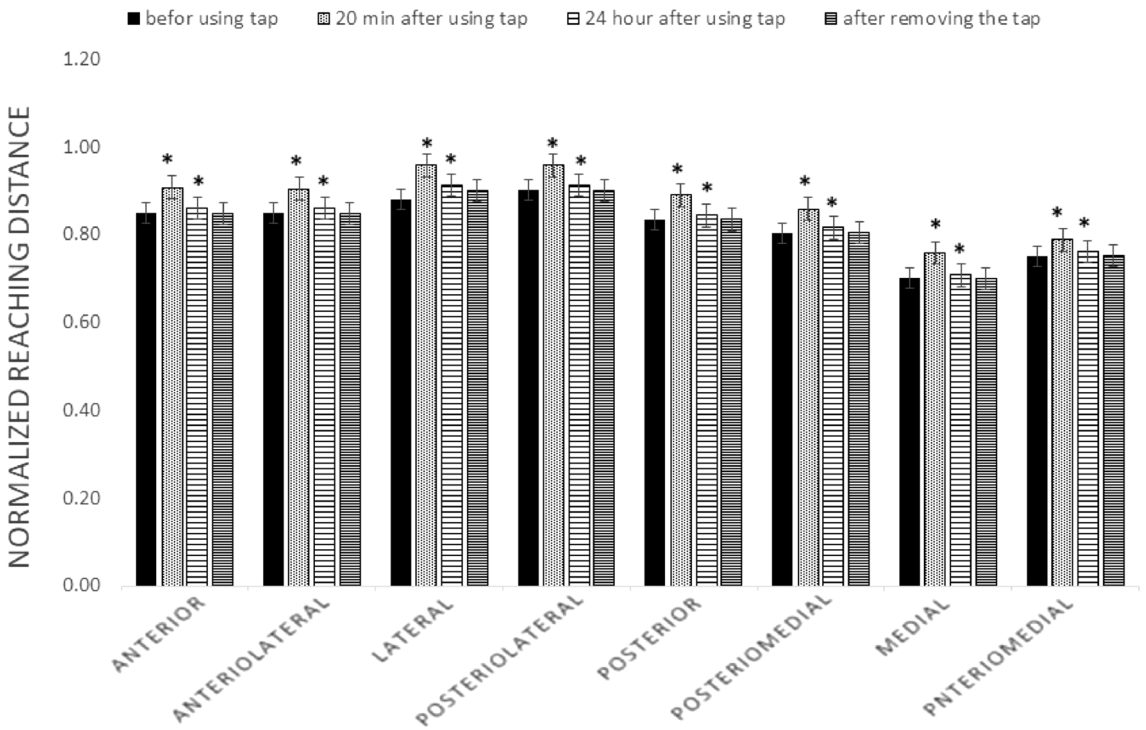

Fig. 2 Repeated measure ANOVA between the baseline measurements and after 20 min, 24 h, and after removing tape for the normalized reaching distance (bandage group). Asterisk indicates significance ($P < 0.05$)

(after 24 h while using the external support), On this occasion, the improvement order was the same as the previous occasions improvement order, this improvement was also significant as $P < 0.05$ (Figs. 1, 2). The least normalized reaching distance was at the occasion (immediately after removing the external support), it was almost the same as before using the external support as $P > 0.05$ (Figs. 1, 2).

In comparing the two groups, the balance improved during the entire interval of tape and bandage use. There were no significant differences between the groups at all occasions (before using the external support, after 20 min while using the external support, after 24 h while using the external support, and immediately after removing the external support) in the eight directions, as the normalized reaching distance values were close to each other for all positions $P > 0.05$ (Fig. 3).

The difference between the learned angle and the estimated angle was calculated. This difference between the two angles (absolute error) was used in the statistical analysis. Table 2 summarizes the results by listing the mean absolute error observed and the standard deviation. Note that all numbers are non-negative since the error was defined as an absolute difference.

In both groups (bandaging group and taping group), when the absolute error was compared between the four occasions, we found that there were significant differences between the values of standard error at the occasions (after 20 min while using the external support, after 24 h while using the external support) in comparison to the occasion before using the external supports in the four ROM angles $P < 0.05$ (Figs. 4, 5).

On the occasion (after 20 min while using the external support), we found that the absolute error was the least. On this occasion, the best improvement was in the neutral position, then 10° dorsiflexion, then 10° Plantarflexion, then 20° plantarflexion, these improvements were significant as $P < 0.05$ (Figs. 4, 5). The second-best improvement was at the occasion (after 24 h while using the external support), on this occasion, the improvement order was the same as the previous occasion improvement order (neutral position, then 10° dorsiflexion, then 10° Plantarflexion, then 20° plantarflexion), these improvements were also significant as $P < 0.05$ (Figs. 4, 5). The highest absolute error was at the occasion (immediately after removing the external support), it was almost the same as before using the external support as $P > 0.05$.

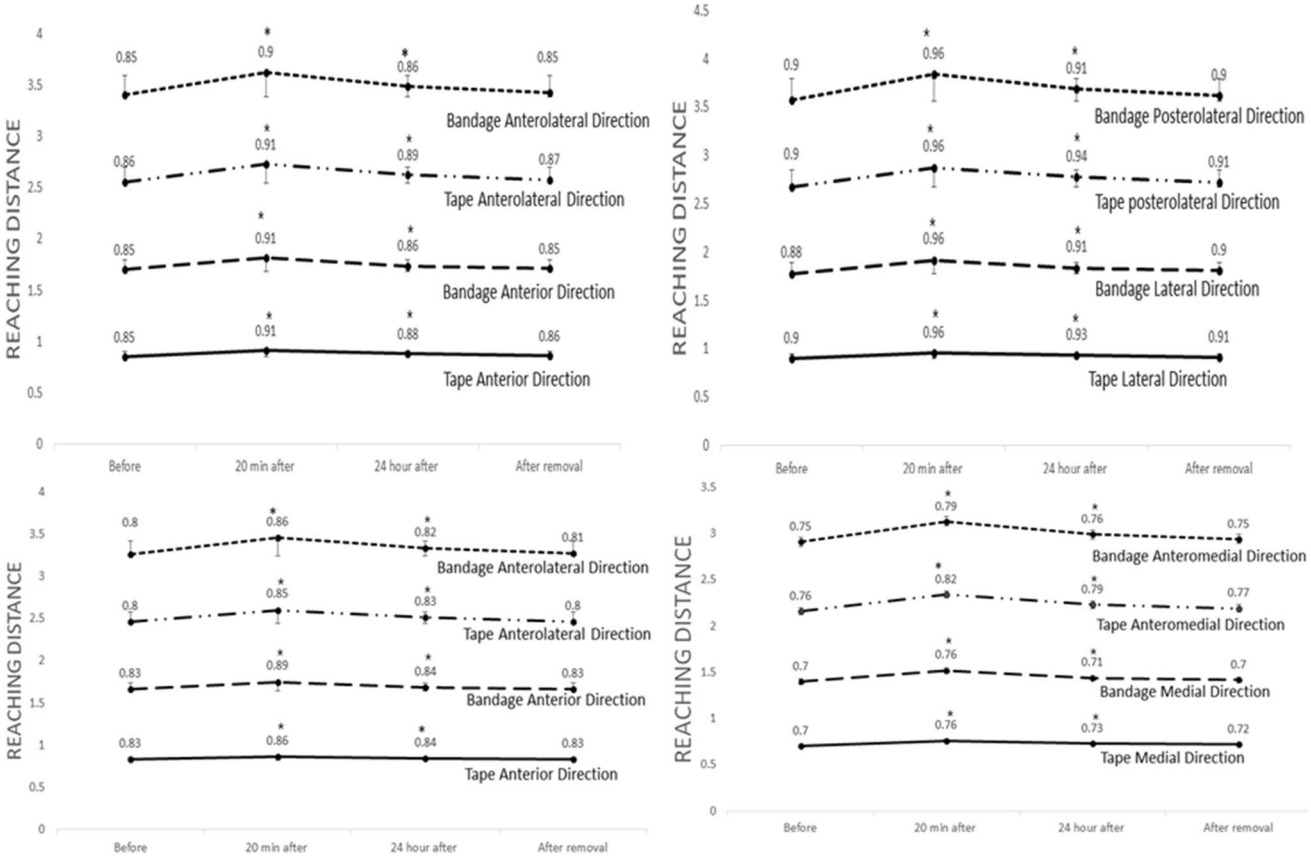

Fig. 3 Repeated measure ANOVA between the baseline measurements and after 20 min, 24 h, and after removing tape for the normalized reaching distance. Asterisk indicates significance ($P < 0.05$)

Table 2 Error (degrees) taping group and bandaging group: mean degrees (standard deviation)

	Taping group $n=35$				Bandaging group $n=35$				Difference between groups			
	Before using tap	20 min after using tap	24 h after using tap	After removing the tap	Before using bandage	20 min after using bandage	24 h after using bandage	After removing the bandage	Before using tap	20 min after using tap	24 h after using tap	After removing the tap
10° dorsiflexion	4.73 (1.68)	0.68 (0.75)	4.14 (0.67)	5.01 (1.01)	5.14 (0.67)	0.76 (0.64)	1.65 (0.75)	5.14 (0.67)	− 0.41 $P=0.11$	− 0.08 $P=0.24$	2.49 $P=0.03$	− 0.13 $P=0.04$
Neutral position	4.38 (0.89)	0.08 (0.28)	3.46 (0.51)	4.2 (0.88)	4.46 (0.51)	0.27 (0.61)	0.89 (0.57)	4.27 (0.65)	− 0.08 $P=0.23$	− 0.19 $P=0.31$	2.57 $P=0.03$	− 0.07 $P=0.04$
10° plantarflexion	6.03 (0.96)	1.03 (0.83)	4.41 (1.04)	5.31 (1.28)	5.41 (1.04)	1.19 (0.97)	2.05 (1.15)	5.41 (1.04)	0.62 $P=0.34$	− 0.16 $P=0.23$	2.36 $P=0.02$	− 0.1 $P=0.03$
20° plantarflexion	8.59 (1.48)	3.19 (1.08)	6.65 (1.18)	7.5 (2.16)	8.54 (1.26)	3.24 (1.75)	4.03 (2.06)	7.62 (1.21)	0.05 $P=0.14$	− 0.05 $P=0.17$	2.62 $P=0.03$	− 0.12 $P=0.03$

Error is the absolute difference between the estimated and the target angle

In comparing the two groups, the proprioception had improved during the entire interval of tape and bandage use. There was a significant difference between the two groups at the occasion (after 24 h while using the external support) in the four ROM angels, as the absolute error was higher in the taping group $P<0.05$. There were no significant differences between the groups at the other occasions (before using the external support, after 20 min while using the external support, and immediately after removing the external support), as the standard error values were close to each other for all positions $P>0.05$ (Fig. 6).

In both groups, we found that proprioception has been reduced in the occasion immediately after removing the tape and bandage in comparison with the occasion before using the tape and bandage.

Discussion

This study aimed to investigate the effect of ankle tape and bandage on proprioception and balance. Our results indicate that ankle tape and bandage had a positive effect on balance and proprioception. These results support our hypothesis that the use of ankle joint taping and bandaging can produce significant increases in proprioception, balance among healthy volunteers. This will help to decrease the incidence of ankle injuries. Healthy subjects were selected because ankle injuries frequently occur during normal locomotion; and most people, not only athletes, experience an ankle injury at least once during their entire life [5, 6]. Thus there is a big need to investigate the effect of ankle taping and bandaging on proprioception and balance among healthy volunteers to figure if it is possible to use it as prevention to reduce the incidence of ankle injuries.

The best improvement of balance was at the occasion after 20 min while using tape and bandage, this result indicates that the effect of ankle tape and bandage was the best after 20 min of its use. Our results were the same as the results obtained by Broglio et al. [32], as they found that, elastic taping may reduce pain, increases circulation of the blood, lymph, and tissue fluids, improves reflexive inhibition of the Golgi tendon organ, alleviates excessive tension of the muscles and supports the stability of the ankle joints that lead to improvement of gait and balance ability as they tested the effect of bilateral prophylactic brace, ankle taping, laced brace devices on balance using the Balance Error Scoring System [32]. Also we were in some agreement with Cortesi et al. [33], who reported little bit similar results, as they found that, ankle taping may be useful in immediately stabilizing body posture in subjects with multiple sclerosis as they tested the effect of Kinesio Taping on body stability using the computerized

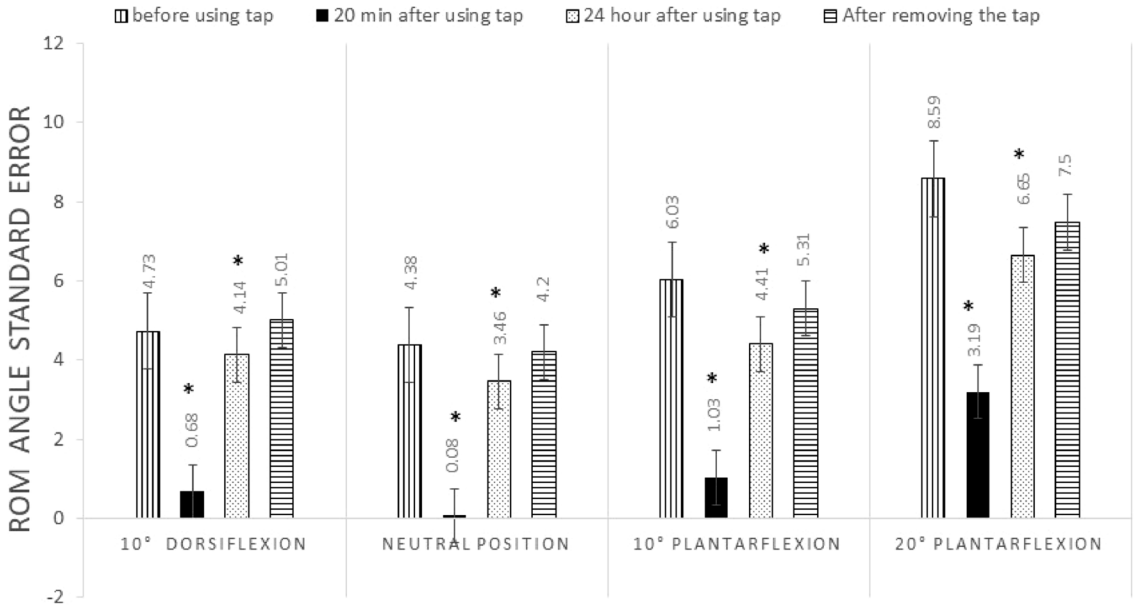

Fig. 4 Repeated measure ANOVA between the baseline measurements and after 20 min, 24 h, and after removing tape for the ankle ROM angle standards error (tape group). Asterisk indicates significant ($P < 0.05$)

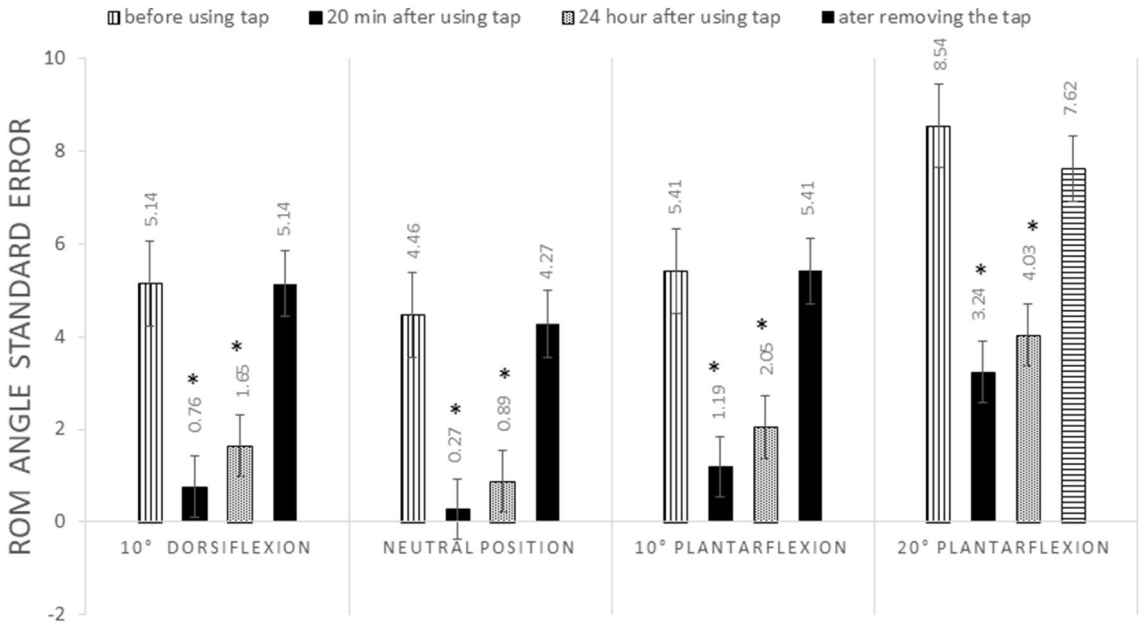

Fig. 5 Repeated measure ANOVA between the baseline measurements and after 20 min, 24 h, and after removing tape for the ankle ROM angle standards error (bandage group). Asterisk indicates significant ($P < 0.05$)

dynamic posturography [33]. Also Simon et al. [34] found that athletes balance reactions related to adhesive taping or bracing are limited [34]. But our results conflicted with Barkoukis et al. (2002), who found that no significant differences in performance of a balance task after the application of ankle taping and another three different ankle stabilizers as they examined the effect of ankle taping and bracing on the performance of a task with demands on the frontal plane [35].

Our results indicate also that, on the occasion after 20 min while using the external support, the normalized reaching distance was the highest. On this occasion, the

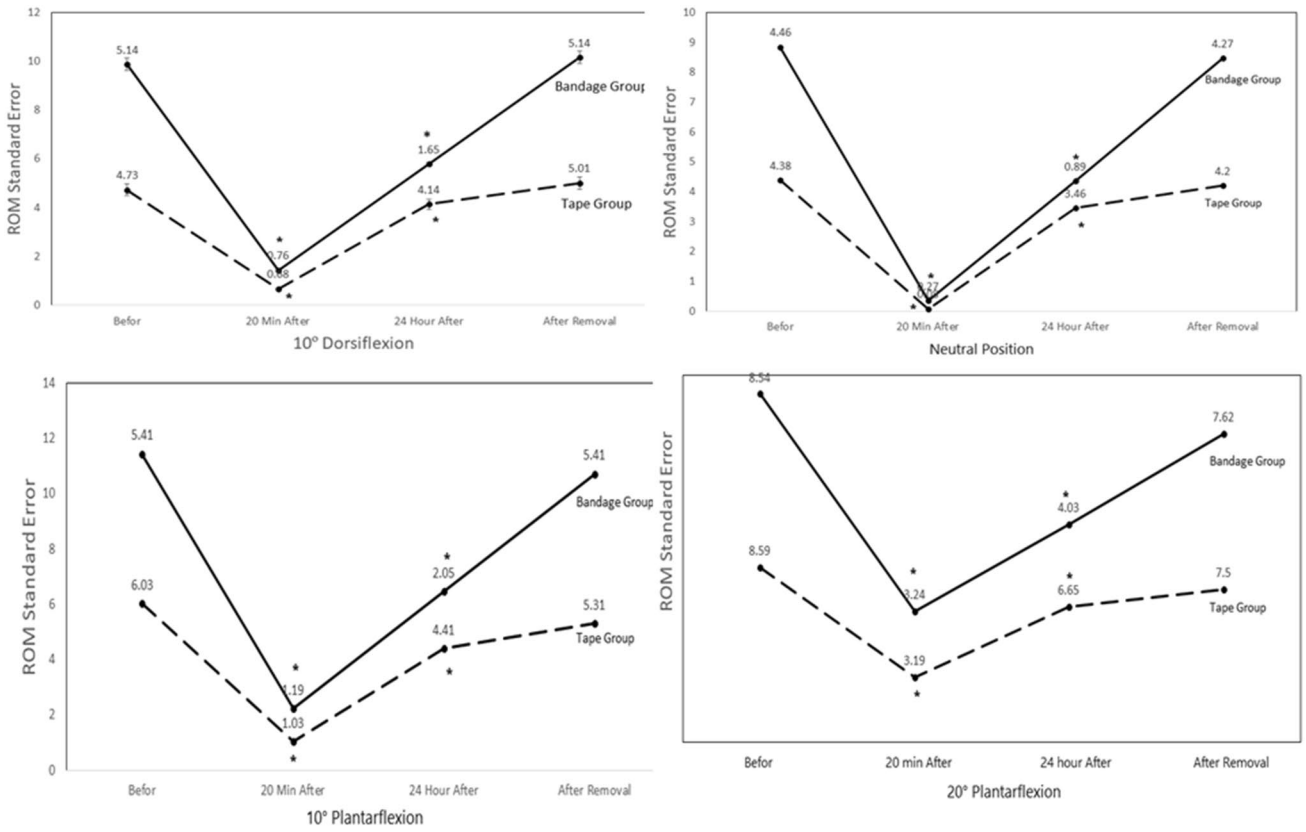

Fig. 6 Repeated measure ANOVA between the baseline measurements and after 20 min, 24 h, and after removing tape for the ankle ROM angle standards error. Asterisk indicates significant ($P < 0.05$)

best improvement was in the lateral and posterolateral directions. This may be related to, when the participant attempt to reach these two directions, the leg movement counterbalanced by posture movement to the opposite side so that the participants were able to reach the longer distance. The least reaching distance was in the medial direction because the stance leg limits the reaching of the swing leg to the medial side and the movement of posture to the lateral side is limited, so they cannot counterbalance the swing leg movement. The order of balance improvement in all occasions (before using the external support, after 20 min while using the external support, after 24 h while using the external support, and immediately after removing the external support), from the highest to the lowest was, L, PL, A, AL, P, PM, AM, M.

After 24 h while using the external support, balance improved less than after 20 min. This is maybe because after playing sport or after the daily living activity, the tape and bandage loose tightness and their effectiveness reduced. There was no significant difference between the two occasions (before using the external support and immediately after removing the external support). The result shows us that tape and bandage significantly improved ankle balance in the uninjured ankle during the entire interval of their use. To the author's knowledge, there were no previous studies that compare the effect of ankle tape and bandage on balance. In this study, we found that balance improved during the entire interval of tape and bandage use.

Also, this study suggests that tape and bandage significantly improved ankle joint proprioception in the uninjured ankle during the entire interval of their use. The best improvement of joint proprioception occured at the occasion (after 20 min while using tape and bandage), these results are the same as the results indicated Simoneau et al. (1997), as they concluded that increased cutaneous sensory feedback provided by strips of athletic tape applied across the ankle joint of healthy individuals, can help in improving ankle joint position perception in non-weight bearing, especially for a midrange plantar-flexed ankle position [36]. Also the result found by Miralles et al. was in agreement with our results as they found that ankle taping improved proprioception in healthy volunteers [26]. After 20 min while using tape and bandage, the improvement of proprioception was better than improvement of proprioception after 24 h while using tape and bandage, this may be because, with time and movement, tap and bandage lose their tightness, and the body gets used to tape and bandage.

The results of our study follow the result that indicated by Barrett et al. who found that wearing an elasticated bandage around the knee improves joint position sense where this is deficient [37]. Khabie et al. found that the application of an elastic bandage can improve joint position sense. They explained this as cues from cutaneous or other extra-articular receptors may play a role in elbow joint proprioception [38]. Hassan et al. found that application of elastic bandage around the knee joint among subjects with knee osteoarthritis, can reduce knee pain and improve static postural sway and proprioception [39].

However, some previous studies found that ankle taping did not affect proprioception. Raymond et al. reported that, using an ankle brace or ankle tape had no effect on proprioceptive acuity among participants with recurrent ankle sprain or who have functional ankle instability [40]. Halseth et al. found that tape did not appear to enhance proprioception at the ankle in the motions of plantar flexion and 20º of plantar flexion with inversion [24].

To the authors' knowledge, there were no previous studies that compared the effect of ankle tape and bandage on proprioception. In this study, we found that the proprioception improved during the entire interval of tape and bandage use. The bandage group had less absolute error than the taping group at the occasion (after 24 h while using the external support) for all positions. This means that the proprioception improved better in the bandaging group than in the taping group at this occasion. This lead us to say that, with time the bandage has a better effect on proprioception than tape. As we noticed during this study, that bandage keeps the pressure at a longer time than tape, while tape loses its tightness more than bandage after 24 h.

All groups showed greater degrees of error in plantarflexion than in the other positions. This result is in line with the results that indicated by Miralles et al. [26]. Besides, in line with the results found by Sekizawa et al. as they investigated the effect of shoe sole thickness on joint position sense, they found that the error in reproducing the ankle position was greater in plantarflexion than in the other movements [41]. Plantarflexion movment is more prone to functional decline. This may explain the increased absolute error during plantar flexion than dorsiflexion. Thus it important to consider that clinicians have reinforce this direction of movement when restoring proprioception after an ankle injury [42].

The present study found that taping and bandaging improved proprioception in healthy volunteers. The improvement was statistically significant in dorsiflexion. Miralles et al. [26], and Sekizawa et al. also reported statistical differences only in dorsiflexion (2001) [41]. Therefore, it seems that dorsiflexion was more sensitive to proprioceptive changes and, therefore, may be easier to rehabilitate with the use of external supports. When the position was not correctly reproduced, the direction of Error could be either above or below the requested position, so the position could be overestimated or underestimated. Tending towards overestimation of the required position was observed in both groups for all positions except for the neutral position. When trying to reproduce the ankle positions, our volunteers easily reproduced the neutral position but overestimated the others.

This study showed that ankle joint taping and bandaging improved balance and proprioception, thus, ankle tape and bandage can be used clinically during the ankle joint rehabilitation and prevention processes to increase balance and proprioception and prevent ankle injuries. Also as ankle, tape and bandage are cheap and can be applied by the patient himself it can be effectively used clinically during the ankle joint rehabilitation process. Also, the results of this study provide some helpful clinical information for clinicians who mostly work with healthy individuals, about the benefits of ankle taping and bandaging during the ankle injury rehabilitation process. Because age is linked to decreased balance, the sample of the present study was limited to a young healthy group between 18 and 30 years old. Therefore, our study established basics for future works to investigate the effect of ankle tap and bandage on injured subjects functional ankle instability.

The limitations of this study were that taping and bandaging may decrease their tight after some time because of walking and washing. Also, all included participants were young healthy volunteers, so we recommend future studies to investigate the effect of taping and bandaging among various age groups and among patients with ankle instability. Future studies should investigate differences in the short-term and long-term effects of taping on between genders, and to take into consideration if there are any differences in proprioception between the dominant and the non-dominant legs.

Conclusion

The current study indicated that ankle taping and bandaging can significantly improve balance and proprioception in the uninjured ankle during the entire interval of their use. Thus, both ankle taping and bandaging should be prolonged to produce an improvement in ankle joint proprioception, and balance and help to prevent ankle injuries among healthy volunteers.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This study was approved by Dokuz Eylul university ethics committee. The reference number: 2015/23-25. The authors declare that this study was performed in line with the principles of the declarations of Helsinki.

Informed consent Each volunteer signed an informed consent form before participation.

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