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ORIGINAL ARTICLE

Ankle taping and bracing does not change static and dynamic balance in volleyball players

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Abstract

The purpose of this study was to compare the effects of nonelastic adhesive tape, dynamic bracing, and no-tape/brace on static and dynamic balance during single-leg stance in women's college volleyball. Seventeen young uninjured players (18.94 ± 2.49 years; 1.71 ± 0.05 m; 65.45 ± 9.49 kg; 9.2 ± 4.1 years played; 4 ± 1 weekly training frequency) were submitted to three conditions presented in randomized order: dynamic bracing; nonelastic adhesive tape and no-tape/brace. In all conditions, the center of gravity displacement (total displacement, TD; anteroposterior displacement, APD and mediolateral displacement, MLD) of the dominant and non-dominant lower limb (DLL and NDLL) was assessed using the static and dynamic platform of the Biodex Balance System. The ANOVA (three-way) test with repeated measures was applied, considering a 5% significance level. The results showed no interaction between any of the independent factors in all displacements ($p > 0.05$). However, there was a significant main level effect for TD ($p = 0.001$, mean difference = 1.1°) and MLD ($p = 0.013$, mean difference = 0.30°), with greater displacement in the dynamic level compared to its static counterpart. There was also a significant main limb effect for APD ($p = 0.003$, mean difference = 0.73°) and MLD ($p \leq 0.001$, mean difference = 0.60°), with a higher degree of instability in MND when compared to MD. In conclusion, the data indicated that the use of nonelastic tape and bracing was not superior to the no-tape/brace condition in controlling center of gravity displacement during single-leg stance.

Keywords Stability · Unilateral balance · Ankle support · Postural control

Introduction

Volleyball, one of the most popular sports worldwide [1], is played by millions of people with different skills and age ranges [2]. Although it is considered a non-contact sport, the maximum dynamic actions in horizontal and vertical directions, rapid response and external stimuli involved induce an inherent risk inherent of musculoskeletal injuries [2–4]. Among the primary distal joints affected, the ankle has a particularly high injury rate (1.4–2.6/1000 game hours), especially in women athletes. Factors such as high load absorption during sports and less stability, mainly in the lateral compartment of the ankle, contribute to the high injury rate [5, 6]. These generally occur at the moment the athlete lands after an attack or block, resulting in contact with an opponent's or teammate's foot [2, 6]. To control this risk, prophylactic strategies have been used in recent years, including peroneal muscle strengthening, sensorimotor training and the use of external ankle supports [7].

A number of literature studies have shown a beneficial effect of braces and nonelastic adhesive tape [8, 9] in reducing the risk of sprain in athletes with previous ankle injury [7]. However, for those with no history of injury, more prophylactic investigations are needed [10]. In general, mechanisms that promote neuromuscular and postural control with the use of these supports are based on kinesthetic and

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mechanical factors, in addition to a possible placebo effect [10]. Nonelastic tape has been shown to be effective not only in restricting maximum inversion range of motion, but also in reducing the response time of peroneal muscles in subjects with previous injuries, possibly by the afferent input to the central nervous system from ankle mechanoreceptors [11, 12]. However, some evidence suggests that the efficacy of the tape declines by 12–50% after 10 min of exercise, not offering support during situations of instability after 30 min of use [13]. Another alternative joint protection method is the use of an ankle brace, which promotes similar mechanical and neuromuscular effects to those of the tape. However, in contrast to the latter, stability with the brace is greater, since joint restriction is not lost, and it is easy to apply and reusable.

In recent years, extrinsic ankle support has been proposed to alter postural control assessment in healthy subjects [14–16], with conflicting results among studies. Although these devices provide somatosensory feedback, which may have a positive influence on maintaining balance [17, 18], other researchers have reported decreased postural control, which may have been caused by inadequate ankle joint mobility with the use of these supports [14]. Bennel and Coldie [14] analyzed the effects of the Swede-O lace-up brace and adhesive tape on uninjured participants and showed that application reduced one-legged static stability. On the other hand, Baier and Hopf [15] assessed athletes with ankle instability and found that rigid and semi-rigid braces significantly improved balance. However, when a healthy control group was tested, they found no differences between supports. Ozer et al. [16] also found that the Aircast ankle brace and nonelastic adhesive tape had no effect on balance in either dominant or non-dominant legs. Although these external supports are widely prescribed, the variety of populations studied and measuring techniques are the primary reasons for these inconsistent findings. Moreover, the studies assessed changes in postural control in healthy subjects of both sexes, but did not investigate a specific modality (e.g., volleyball), which hinders understanding these results in a population. Despite the inconsistent results, uninjured volleyball players are still using ankle external supports as a prophylactic strategy in clinical practice. É importante abordar esta questão porque se o uso de estabilizadores externos não modifica em nada o controle postural, então recomendações pertinentes podem ser delineadas para melhorar a eficácia de estratégias preventivas de lesão.

As such, the purpose of this study was to compare the effects of nonelastic adhesive tape, dynamic bracing, and no-tape/brace on static and dynamic balance during single-leg stance in women's college volleyball. We hypothesized that both tape and bracing would stabilize the ankles when compared to no joint stabilization, thereby improving static and dynamic balance.

Methods

Design

The study consisted of a repeated-measures design, carried out over a period of three alternate days. Each participant was submitted to three different interventions, with a 48-h interval between them. The protocol was approved by the institutional Ethics Committee (CAEE: 11963712.5.0000.5188) and all participants signed an informed consent form, according to Resolution 466/2012 of the National Health Council and Declaration of Helsinki. Prior to participating in the study, the participants were informed about the procedures, enabling them the right to withdraw. If the athlete was a minor, the legal guardian signed the consent form.

Participants

Participants were 22 female players (18.94 ± 2.49 years; 1.71 ± 0.05 m; 65.45 ± 9.49 kg; 9.2 ± 4.1 years played; 4 ± 1 weekly training frequency) from the university volleyball team, who practiced two or three times a week for at least the previous 2 years, and had sustained no musculoskeletal leg injuries for at least 1 year. All participants were tested in the middle of the season. However, during the week of data collection, the athletes did not perform volleyball specific training. All procedures were performed in the afternoon and the athletes were instructed to eat and hydrate normally and avoid heavy foods before the test. Five athletes were excluded, leaving a total of 17 subjects, as shown in Fig. 1.

Sample size was determined using G*Power 3.1.0 software and the procedures followed Beck's recommendations [19]. Based on a previously performed pilot study ($n = 3$), we adopted a power of 0.80, $\alpha = 0.05$, coefficient of correction of 0.5, non-sphericity correction of 1 and an effect size of 0.35. Overall displacement was used in the calculation. For all groups, an "n" of 15 subjects was calculated. The sample size exhibited 80.03% statistical power; however, post hoc analysis showed that 17 participants represent 85.92% of the statistical power.

General procedures

First, the athletes responded to the American Orthopedic Foot and Ankle Society (AOFAS) questionnaire, applied in an interview. This instrument displays an excellent intra-observer (0.96) and inter-observer (0.95) intra-class correlation (ICC) [20], and consists of 9 items, divided into three domains: (a) pain (40 points); (b) function (50 points)

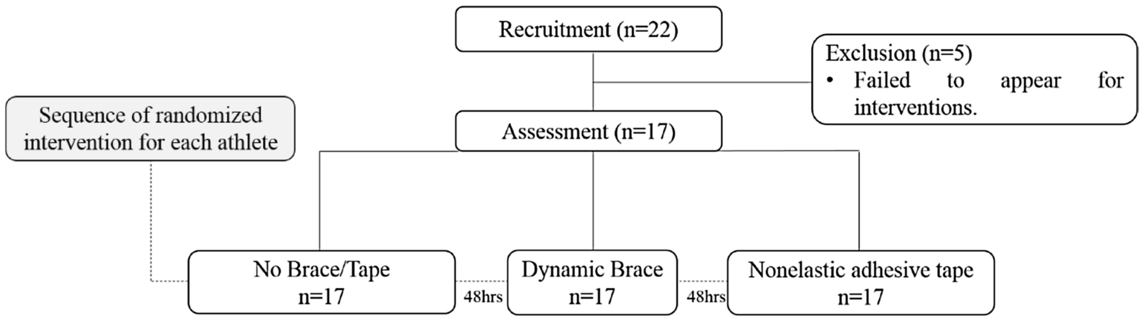

Fig. 1 Flowchart of the sample

and (c) alignment (10 points), where a score of 100 points indicates normal function. Each athlete was then submitted to three conditions presented in randomized order (http://www.randomization.com) with a 48-h washout period, so that possible learning effects were minimized: (1) no-tape/brace, (2) a dynamic brace (Active Ankle Systems—Louisville, KY—USA), and (3) nonelastic adhesive tape (Cremer, Brazil, affiliated with Mueller Underwrap, USA). Ankle stability was assessed in each condition and center of gravity displacement was recorded.

Biodex Balance System (Biodex Medical Systems, NY, USA) was used for assessments [21]. The limb used at the start of the test (DLL or NDLL) was randomized for each athlete, and this order was repeated in all the stability conditions. Next, wearing sneakers, subjects were instructed to adjust the position of their feet on the Biodex Balance System (BBS) platform to achieve the greatest possible stability. Positioning parameters were then recorded for each lower limb (letter closest to the heel, number closest to the Achilles tendon and the closest angle between the second and third toe), which were also repeated in the following analyses. While the stance limb of the athletes was kept at ≅ 10° with the knee in semiflexion (controlled by a universal goniometer), the contralateral limb was maintained at a comfortable angle (≅ 90º of knee flexion). The arms remained crossed over the chest, and subjects were instructed to look at a fixed point in front of them, with no visual feedback from the BBS monitor (Fig. 2). To simulate their practice, athletes were assessed wearing own shoes, since they already use them in practices and competitions. During recording of center of gravity displacement, the athletes were also instructed not to touch the equipment with their hands or contralateral foot (in suspension); if this occurred the procedure was interrupted, excluded and repeated. A maximum number of three repetitions was allowed until the athlete completed the test.

Before the assessments, each athlete was familiarized with the postural instability tests. For each stance condition, static stability was tested on a fixed platform (three 60-s repetitions with 30 s between repetitions). Next, dynamic instability was evaluated (three 60-s repetitions), with an automatic change in stability levels (level 12 = most stable, to level 1 = least stable) every 5 s, a 30-s interval between repetitions and 2 min between stance conditions [21, 22].

For each repetition, BBS produced total (TD), anteroposterior (APD) and mediolateral (MLD) displacement values, in degrees. The mean ± SD of the three repetitions in each lower limb was calculated in the static or dynamic modes, for each stability condition.

Statistical analysis

The statistical procedures were conducted using Statistical Package for the Social Sciences software (SPSS—version 22.0; USA). Data were analyzed in terms of normality and homogeneity of variance, using the Shapiro–Wilk and Levene tests, respectively. Based on the normal distribution found, the ANOVA (three-way) test with repeated measures was carried out, given that the same athletes were assessed on the following: (1) stabilization level (static and dynamic); (2) stability conditions (dynamic brace; nonelastic adhesive tape and no-tape/brace) and (3) stance conditions (DLL and NDLL), for each center of gravity displacement (TD, APD and MLD). Interactions between the independent factors (stabilization level, stability conditions and stance conditions) and/or the main effect between the levels, limbs and/or stability conditions were assessed. When necessary, Tukey's post hoc test was conducted and the results were expressed in mean ± standard deviation (SD), adopting a 5% significance level for all the comparisons. When there were differences on the levels, limbs and/or stability conditions, Cohen's *d* coefficient was used to calculate the magnitude of effect size of the differences. An effect size large, was considered greater than 0.8; moderate, between 0.5 and 0.7; small from 0.4 to 0.2; and has no effect 0.1 or < 0 [23].

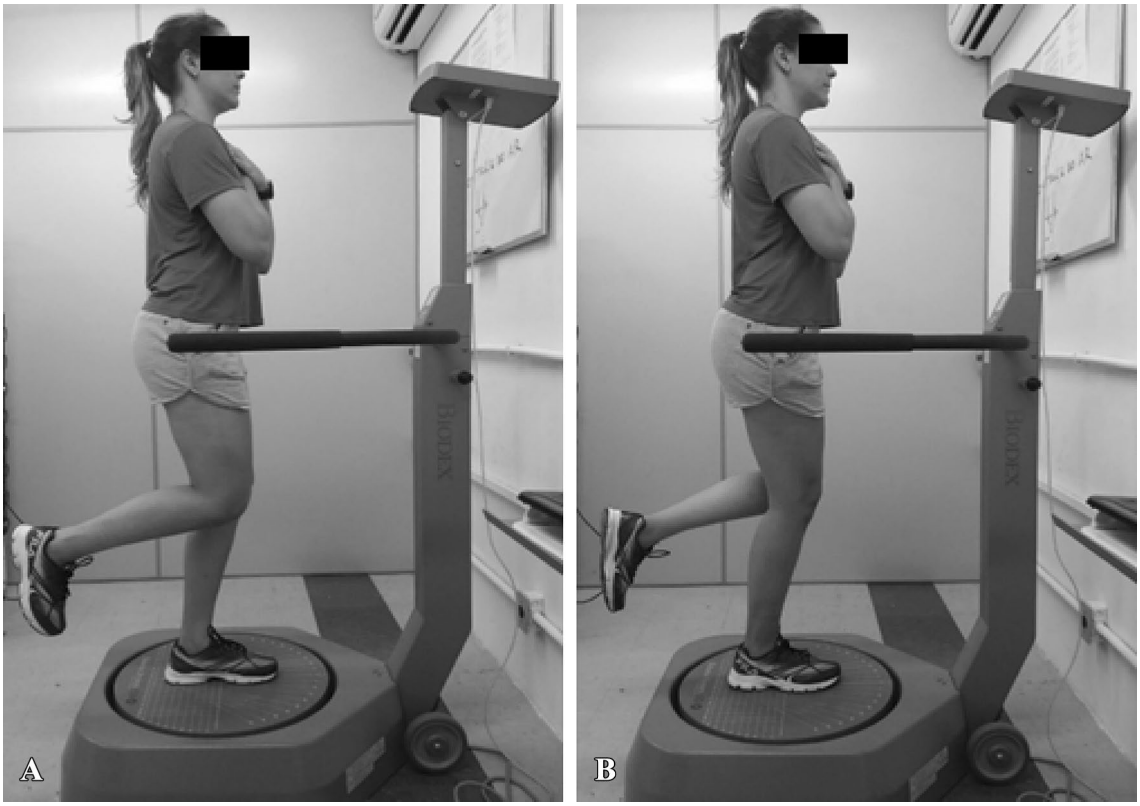

Fig. 2 Assessment of center of gravity displacement in single-leg stance (*A* = dominant lower limb and *B* = non-dominant lower limb) without ankle stabilization

Table 1 Average score on the ankle and hind foot assessment scale of the American Orthopedic Foot and Ankle Society (AOFAS)

No. of athletes	Domains			
	Pain	Function	Alignment	Total score
17	38.24	49.82	7.06	95.12

Results

The volleyball players selected involved 5 game positions, with predominance for outside hitters (41.2%) and setters (23.5%) and the vast majority showed right lower limb dominance (88.2%). With respect to the clinical criterion of the AOFAS for the ankle and hind foot, the athletes obtained an average score of 95.12 points (Table 1), indicating normal functionality.

Total displacement

There was a statistically significant difference between the levels ($p = 0.001$; $F_{1,16} = 16.605$; $d = 4.67$), with higher TD in dynamic than static level (mean difference = 1.1°). However, no interactions and/or differences were identified between the lower limbs and stability conditions ($p \geq 0.05$; Table 2).

AP displacement

There was a statistically significant difference between the lower limbs ($p = 0.003$; $F_{1,16} = 11.822$; $d = 4.05$), with a higher degree of instability in the NDLL compared to the DLL (mean difference = 0.73°). No interactions and/or differences were found between the levels and stability conditions ($p \geq 0.05$; Table 2).

ML displacement

There was a statistically significant difference between levels ($p = 0.013$; $F_{1,16} = 7.763$; $d = 2.20$) and between lower limbs ($p \leq 0.001$; $F_{1,16} = 21.267$; $d = 4.13$). There was greater center of gravity displacement at the dynamic level, when compared to its static counterpart (mean difference = 0.30°) and a higher degree of instability in NDLL than in DLL stance (mean difference = 0.60°). However, no interactions were observed between the independent factors, or differences between stability conditions ($p \geq 0.05$; Table 2).

Discussion

Our results did not confirm the initial hypothesis and indicated that the use of ankle supports in uninjured athletes did not change center of gravity displacement for either dominant or non-dominant lower limbs. These important findings reinforce the results of previous studies that also reported no alterations with the use of ankle supports in healthy subjects [14, 15].

In recent years, scientific evidence has recommended the use of external ankle support in rehabilitation and after returning to play following an injury [6]. It is well-known that ankle sprain causes structural damage to the peripheral tissues, such as nerves, muscles and tendons, resulting in a decrease in ankle joint stability and increased risk of reinjury [24]. As such, it is important that these individuals use tape or a brace, given that previous studies demonstrated positive effects with external ankle support, including a decrease in ankle range of motion, improved peroneal reaction time, and additional somatosensory feedback [10, 16, 23]. In the present study, we recruited only volleyball players with no previous ankle injuries that obtained AOFAS scores near 100. Moreover, even with the use of ankle external supports, the instability index remained around 3° in total displacement for both limbs, similar to the no-tape/brace condition. By contrast, previous studies demonstrated that individuals with ankle injury obtained total scores of around 65 points, with greater changes in items related to pain and function [26]. Other authors also found that subjects with joint instability exhibited a high instability index when assessed by BBS (from 2.3° to 10.9°), which may be a risk factor for injury [27]. These results reinforce the healthy condition of our sample, given that all the individuals performed the tests without difficulty, obtaining low instability indices.

In the current investigation, we used the BBS, which showed satisfactory balance test reliability in previous studies [26, 27]. Center of gravity displacement was assessed based on the capacity to maintain static and dynamic postural stability on a stable and unstable surface. Although we did not put the athlete in situations of sudden ankle movements with extreme range of motion, the BBS can provide quantitative measures of postural balance and indirect information on the neuromuscular proprioceptive system [20, 21]. Moreover, considering the study population, it is more important to maintain postural balance under unstable conditions, given that external and gravitational forces are acting jointly.

To compare the effect of ankle taping and bracing on postural balance, Gear et al. [22] analyzed ankle dynamic

Table 2 Total, anteroposterior and mediolateral center of gravity displacement between the lower limbs and stability conditions, considering a comparison between static and dynamic levels

Limb	Stability conditions	Center of gravity displacement/levels								
		TD			APD			MLD		
		Static	Dynamic	95% CI[a]	Static	Dynamic	95% CI[a]	Static	Dynamic	95% CI[a]
DLL	No brace/tape	2.18 ± 1.48	3.05 ± 1.03	0.73 to 1.53	1.74 ± 1.50	2.25 ± 0.77	0.51 to 1.23	0.99 ± 0.65	1.55 ± 0.61	0.26 to 0.93
	Brace	2.00 ± 0.83	3.37 ± 2.08	0.36 to 2.37	1.73 ± 0.97	2.24 ± 0.64	− 0.29 to 1.07	0.87 ± 0.39	1.95 ± 2.32	− 0.13 to 2.29
	Tape	2.02 ± 1.08	3.15 ± 1.04	− 0.09 to 1.82	1.61 ± 1.08	2.49 ± 0.92	− 0.36 to 1.36	0.93 ± 0.61	1.53 ± 0.77	0.25 to 0.85
NDLL	No brace/tape	2.25 ± 1.35	3.38 ± 1.01	− 0.16 to 1.79	1.58 ± 1.24	2.68 ± 0.92	− 0.21 to 1.71	1.42 ± 1.12	1.64 ± 0.67	− 0.11 to 1.08
	Brace	2.08 ± 1.01	3.15 ± 0.87	0.33 to 1.80	1.52 ± 0.75	2.16 ± 0.44	0.27 to 1.02	1.19 ± 0.80	1.88 ± 0.97	− 0.09 to 1.46
	Tape	2.57 ± 1.68	3.38 ± 1.08	0.33 to 1.92	1.64 ± 1.67	2.39 ± 1.15	0.35 to 1.84	1.51 ± 1.06	1.99 ± 0.57	− 0.46 to 0.90

Values expressed as mean ± SD (degrees)

ANOVA (three-way) test with repeated measures

TD total displacement, *APD* anteroposterior displacement, *MLD* mediolateral displacement, *DLL* dominant lower limb, *NDLL* non-dominant lower limb, *RT* rigid tape, *ORT* orthesis, *WS* without stabilization

[a]95% Confidence interval (CI) for the differences between degrees of center of gravity displacement

stability using the BBS in healthy participants and found no difference in center of gravity displacement between barefoot, taping or bracing conditions. However, when they assessed the participants' perceptions, significant differences were observed between ankle taping and the other two conditions. Results from this investigation highlight a possible placebo effect of ankle tape, which was also observed in other studies [28, 29]. Although we did not analyze the athletes' subjective perceptions, evidence shows that the compressive affect around the ankle produces sensory feedback that could instill in participants the belief that the supports would protect them from unstable situations. In addition, factors such as the knowledge of receiving a topical intervention and participants' expectations concerning the supports may improve the athletes' perceptions [32]. Thus, the placebo effect should be considered and analyzed in future studies.

We also analyzed the main effect of levels, limbs and stability conditions in each displacement. In general, analysis of statistical differences and absolute data, regardless of instability condition, revealed greater center of gravity displacement in the dynamic than static level, showing great magnitude of effect for the differences found. These findings were expected, since unstable situations display greater joint range of motion due to the postural adjustments needed to maintain postural control [33]. Moreover, the NDLL was also less stable when compared to the DLL. Previous studies have shown that the non-dominant lower limb is considered less skilled and more trainable, when compared to the dominant leg [34]. Moreover, this difference may be related to functional lateral dominance between the right and left brain hemispheres. The right hemisphere is more involved in spatial perception and somatosensorial processing, while the left controls continuity and rhythm [35]. In single-leg stance and floor oscillation at the dynamic level, peripheral and central interconnection is essential to anticipate postural disturbance. Thus, the left hemisphere may play an important role [36]. These findings underscore the importance of identifying lower limb asymmetry, to intervene early in these differences in an attempt to prevent injury.

Our study exhibits some limitations. Generalizability of our results includes only uninjured female athletes. We did not investigate the maximal stress of inversion, and the test did not reflect a real game situation, since it was executed in a few minutes. During training phases and/or competition, the athletes use ankle supports for several minutes/hours, which could affect the results. Moreover, the fact that we did not include professional athletes may have affected the results. In addition, it is important to underscore that the players did not perform the test when they were fatigued, that is, after being submitted to stress on the musculoskeletal system. Muscle fatigue is a known risk factor for injury [37]. Finally, we did not record the athletes' subjective perceptions, which could be important in controlling the placebo effect of ankle supports.

Conclusion

In uninjured volleyball players, the use of nonelastic tape and bracing was not superior to the no-tape/brace condition in terms of controlling center of gravity displacement during single-leg stance. Although ankle supports can be used in sport activities, the results of the present study reinforce current scientific evidence, not indicating the use of these supports for athletes with no prior ankle injuries. Furthermore, these findings may lead to the search for other effective preventive strategies, with the aim of decreasing the incidence of injury in this population.

Practical applications

Ankle supports in practitioners with no prior injury might not be the best strategy to control center of gravity, especially in instability situations. Thus, implementation of a preventive training (i.e., strengthening and sensory-motor training) may be the best strategy to reduce injury incidence.

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Compliance with ethical standards

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

Ethical approval All procedures involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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