Sabuncuoglu Serefeddin Health Science (SSHS)
ISSN: 2667-6338, 2020/Vol.2:2

DO EXTERNAL SUPPORTS CAUSE ANY IATROGENIC EFFECTS ON THE FOOT AND ANKLE?

***[1]Gül Oznur KARABICAK, [2]Nilgün BEK, [3]S. Fatma UYGUR**

[1]Adnan Menderes University, Department of Physiotherapy and Rehabilitation, Aydın, Turkey
[2]Lokman Hekim University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Ankara, Turkey
[3]Cyprus International University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Nicosia, North Cyprus

Research Article
Received: 10/06/2020, Accepted: 30/08/2020
*Corresponding author: guloznur@gmail.com

Abstract

The aim of this study was to investigate the effects of orthosis and taping, which are commonly used by athletes, on balance and proprioception in licensed basketball players with healthy ankles. Twenty basketball players with a mean age of 16±1.5 years participated in this study. Participants were assessed three times: barefoot, with taping, and with orthosis. We used the Modified Star Excursion Balance Test to assess dynamic postural control, the Balance Error Scoring System to assess static postural control, and the Monitored Functional Squat System to assess proprioception. In the Star Excursion Balance Test, anterior reach was better in barefoot condition ($p=0.02$). In the Balance Error Scoring System measurements, orthosis and taping increased error for tandem stance ($p=0.03$) and single leg stance. During proprioception assessments, there was no statistically significant difference between the number of errors recorded among the three conditions in eyes open and eyes closed ($p>0.05$). This study's results show the negative effects of orthosis and taping on balance and dynamic postural stability. It was

found that functional orthosis and taping applications may have some negative effects compared to barefoot in terms of the static and dynamic postural stability parameters related to the ankle. These results suggest the advantage of protection and stability provided by these external supports has a cost for the static and dynamic postural control.

Key words: Ankle, Balance, Taping, Orthosis, Proprioception.

Özet

Bu çalışmanın amacı sporcularda sık kullanılan ortez ve bantlamanın sağlıklı ayak bileğinde denge ve propriosepsiyon üzerine olan etkilerini araştırmaktır. Çalışmamıza yaş ortalaması 16.6±1.5 yıl olan 20 gönüllü basketbol oyuncusu katıldı. Katılımcılar çıplak ayakla, ortez ve bantlama uygulaması ile olmak üzere 3 kez değerlendirildi. Dinamik postural kontrolün değerlendirmesi için "Modifiye Star Excursion Balance Test", statik postural kontrolün değerlendirmesi için "Balance Error Scoring System" ve eklem pozisyon hissinin değerlendirilmesi için "Monitörize Fonksiyonel Squat Sistem" kullanıldı. Modifiye Star Excursion testte anterior yöne uzanımlar çıplak ayakla daha iyiydi ($p=0.02$). Balance Error Scoring System değerlendirmelerinde ortez ve bantlama, tandem duruş ($p=0.03$) ve tek ayakta duruşta ($p=0.03$) oluşan hataları artırdı. Propriyosepsiyon değerlendirmeleri sırasında, gözler açık ve gözler kapalı üç durum arasında kaydedilen hata sayısı istatistiksel olarak anlamlı bir fark göstermedi ($p>0.05$). Bu çalışmanın sonuçları ortez ve bantlamanın denge ve dinamik postural stabilite üzerine olumsuz etkilerini göstermektedir. Ayak bileği ile ilgili statik ve dinamik postural stabilite parametreleri açısından fonksiyonel ortez ve bantlama uygulamasının çıplak ayak ile karşılaştırıldığında bazı olumsuz etkilerinin olabileceği belirlendi. Bu sonuçlar, eksternal desteklerin sağladığı koruma ve stabilite avantajının statik ve dinamik postural kontrol için bir bedeli olduğunu göstermektedir.

Anahtar kelimeler: Ayak bileği, Denge, Bantlama, Ortez, Propriyosepsiyon.

1. Introduction

Injuries in the ankle joint complex of basketball players cause them to take a short break from playing, which may eventually affect their future sport life permanently (Chaiwanichsiri et al., 2005; Doherty et al., 2014). Basketball players experiencing injuries in the ankle are at a higher risk of a recurrent injury (Riva et al., 2016). This disorder also includes the loss of proprioception in acute injuries. Losses in dynamic postural control and proprioception occur due to the structures around the ankle after injury, which are risk factors for new injuries(Cho & Park, 2019; Simpson et al., 2019).

Ligamentous ankle injuries are the most common sports injuries in athletes and constitute 10%-30% of all sports injuries (Andreoli et al., 2018; Carter et al., 2011). Taping and orthosis applications are recommended and applied in the literature as effective physical tools to prevent the occurrence of new injuries both during the post-injury rehabilitation period and during the period of return-to-sport (Olmsted et al., 2004; Derya Ozer et al., 2009). There are studies suggesting that the application of taping and orthosis restricts joint movement and improves proprioception in the ankle and subtalar joints, and affect peroneal muscle activity (Bicici et al., 2012; Gehrke et al., 2018; Olmsted et al., 2004; Quackenbush et al., 2008; Wilkerson et al., 2005). While taping is opted for because it increases the sense of joint position, the literature states that it also loses its effectiveness due to fatigue (Fleet et al., 2009). The use of orthoses is among the support tools recommended in the literature for the purpose of preventing recurrent injuries by supporting ankle stability (Callaghan, 1997; de Camargo Neves Sacco et al., 2006; Doherty et al., 2014; Olmsted et al., 2004; Riva et al., 2016; Stoffel et al., 2010).

Possible effects of taping and orthosis applications on the ankle after injury have been reported in various studies in the literature (Bicici et al., 2012; de Camargo Neves Sacco et al., 2006; Olmsted et al., 2004). To determine the effects of these external supports on the ankle and foot movements and on proprioception, to understand whether they affect balance positively/negatively, and to reveal their effects on performance after acute or chronic injuries, contaminating factors that may occur in terms of these parameters should be eliminated in the study. Such results can be achieved through studies involving healthy feet and ankles. However, when the literature is analyzed from this point of view, there is no study on the effects of these supports on the healthy ankle.

We planned this study to investigate the effects of orthosis and taping applications on static and dynamic postural control and joint position sense compared to barefoot in healthy basketball

players. The hypothesis of the study is that taping and orthosis will positively affect the static and dynamic parameters of postural control and decrease proprioceptive errors.

2. Material and Methods

2.1. Participants

This study was completed with 20 licensed, healthy, young basketball players (mean age 16.6 ± 1.5 years). Players who did not experience any injury involving the lower extremity in the previous 3 months, who did not have a vestibular problem, and who played basketball professionally were included. Athletes with ligamentous injury or chronic instability in the foot-ankle region, individuals older than 18 years old, and those who participated in less than 2 basketball exercises per week were excluded. The participants were provided with a written and verbal explanation regarding the study procedures, and informed consent was obtained from each subject prior to testing. This study was approved by the Institutional Review Board of Hacettepe University (Number: E.69971; Date 11.11.2019).

Before the baseline measurements, all participants' age, sports age, injury history, dominant lower extremity data, and leg lengths (from the Spina iliaca anterior superior to medial malleolus in the supine position) were recorded. To determine the lower extremity dominance of the individuals, the foot with which they hit the ball was inquired and the answer was recorded as the dominant foot (van Melick et al., 2017). All the measurements administered were performed three times: with barefoot, with the stabilizing orthosis, and with the taping application. Tools specific to evaluate static and dynamic postural control and joint position sense were used. The measurements were repeated after 7 days. Data were recorded only for the dominant lower extremity. The acute effects of these three conditions on the evaluated parameters were examined by performing measurements immediately after application for all cases. The order of applications for evaluations was randomized and all evaluations were performed only with barefoot, with tape application, and with orthoses, all without shoes. Before measurements, the participants were asked to perform the tests 1-3 times in order for them to get familiar with the measurement tools. The measurements were administered in the order specified below.

2.2. Protocol

2.2.1. Taping Applications

Nonelastic taping was used to investigate the effect of stabilizing taping (7 cm Mueller M Wrap ProTape). Gibney closed basket weave taping method was applied, which stabilizes the ankle mediolaterally and envelops the ankle to control the pronation and supination movements of the subtalar joint. Taping was terminated with locking tapes in both supination and pronation directions. Taping was terminated proximally at the muscle tendon junction of the gastrocnemius-soleus muscle complex and at the distal midtarsal region (Figure 1)(Spanos et al., 2008).

Figure 1. Non-elastic ankle taping

2.2.2. *Functional Orthosis Application*

To test the effects of orthoses on the ankle and foot, a Don Joy Universal Ankle Stirrup® (DJO Inc.), a functional off-the-shelf orthosis, was used. This orthosis envelops the ankle not restricting dorsiflexion and plantar flexion movements, provides some mediolateral stabilization preventing pronation and supination movement of the subtalar joint, and encapsulates the midtarsal region with a neoprene piece. The orthosis used for acute injuries and prophylactic purposes consists of two thermoplastic rigid lateral skeletons combined with neoprene material (Figure 2).

Figure 2. Don Joy Universal Ankle Stirrup® functional orthosis

2.2.3. Static Postural Control

The Balance Error Scoring System (BESS) was used to determine the effects of the three test conditions on static balance parameters. The test evaluates postural control at different posture positions, and its reliability was established by Riemann et al.(Riemann et al., 1999) The BESS test includes two different posture positions on the dominant foot on hard and soft surfaces. These positions are single leg stance and tandem stance. The test was performed on soft and hard surfaces. Individuals were asked to position their hands on the iliac crest and were told that that the test would begin when they closed their eyes. We asked them to remain silent and still as much as possible. If they lost their balance, we asked them to return to the test position as soon as possible. In cases specified in Table 1, individuals received 1 error score. Higher scores indicate decreased postural control. The players waited for 20 seconds with eyes closed and hands on the iliac crest in each position, and the scoring was made based on errors recorded. If the player was not able to maintain his balance for at least 5 seconds during the test, the test was assumed incomplete at that position. The score of this individual was recorded as 1 point higher than the athlete who got the highest score. Each point was scored as an error.

Table 1. Errors scored in the Balance Error Scoring System

Removing hands off the iliac crest
Opening eyes
Jumping, swinging, falling
Remaining more than 5 seconds off the test position
Flexion/abduction of the hip more than 30 degrees
Raising the heel or forefoot

2.2.4. Dynamic Postural Control

Dynamic postural control is one of the important mechanisms in providing ankle and foot-based balance strategies. The modified version of the Star Excursion Balance Test was used to measure the effects of different test conditions on dynamic postural control. The modified Star Excursion Balance test (mSEBT) is a clinical test used in the evaluation of dynamic postural control with high test-retest values (ICC varies between 0.82 and 0.87)(Brumitt, 2008; Bulow et al., 2019; Gribble et al., 2012; Gribble & Hertel, 2003; Hyong & Kim, 2014). The test area starts at a central point, extending in 3 different directions (anterior, posteromedial, posterolateral) equally spaced, each 120 cm long, and lines were made visible using tapes fixed on the floor (Figure 3).

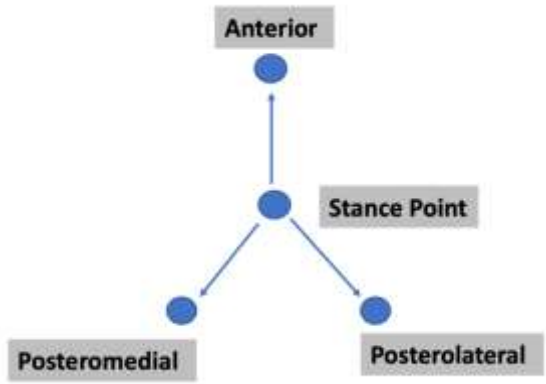

Figure 3. Modified Star Excursion Balance Test set-up

Individuals were asked to reach out in three directions (anterior, posteromedial, posterolateral) for 1-3 times for trial. After the trial, all individuals exercised on a bicycle ergometer to warm up for 5 minutes, and before the test, they were prepared for measurements by performing a slightly intensive stretching exercises on the knee extensor and flexor and hip adductor muscles. During the test, the individuals were asked to stretch in three directions with their non-dominant foot without support while the dominant leg was fixed on the ground. The average of three stretches in each direction was recorded in cm. The test was performed twice for each direction with 30 seconds of rest between directions. The values recorded were divided by the leg length recorded in cm and multiplied by 100 in order to eliminate the length of the leg

affecting the test result. Thus, the ratio of leg length to extension distance was recorded as a percentage(Chang et al., 2020).

2.2.5. Joint Position Sense

The Monitored Functional Squat System® was used to measure the ankle joint sense of the athletes. This method allows the measurement of neurophysiological parameters of the lower extremity such as endurance coordination, proprioception, and reaction time (Maffiuletti et al., 2005; Derya Ozer et al., 2009). In the Functional Squat System, where individuals are positioned on their back, they are asked to find and select the position of the red "+" sign that appears on the screen with their lower extremities only with the dominant foot and maintain that position (Figure 4). Before the test, the maximum range of motion was calculated by bringing the knees to full extension while the soles of the feet were in contact with the device. The visual feedback was given to the participants in the first two tests, they were asked to complete the test only with proprioceptive information without feedback in the last two tests. The test phase without visual feedback was defined as eyes closed, and the test phase with visual feedback was defined as eyes open. The proprioceptive test is a good indicator of the proprioceptive capacity of the joint at the chosen angle. The aim was to keep the lower limb at desired angles with motor learning with and without visual stimuli at different ankle and knee angles(Derya Ozer et al., 2009).

Figure 4. Lower extremity positions of individuals during the joint position sense measurement

2.3. Statistical analysis

The data were analyzed using SPSS 15.0 for Windows statistical software program. The Kruskal Wallis test was used for comparison of the three groups. Statistical significance level was set at $p<0.05$.

3. Results and Discussion

Twenty licensed basketball players with an average age of 16.6±1.5 years with healthy ankles were evaluated in the study to investigate the effects of ankle and subtalar joint stabilizing orthosis on the frontal plane and taping application on static and dynamic postural control and joint position sense. The demographic characteristics of the participants are presented in Table 2.

Table 2. Participant characteristics (n=20)

Parameter /characteristics	
Age (year)	16.6(1.5)
Height (cm), mean (SD)	190.4(8.0)
Weight (kg), mean (SD)	79.2(9.1)
BMI (kg/cm^2), mean (SD)	21.8(1.8)
Leg length (cm), mean (SD)	100.8 (6.2)
Sports age (year), mean (SD)	5.7 (2.1)
History of ankle injury, n (%)	15 (75)
Dominant leg right/ left, n (%) / n (%)	5 (25) / 15 (75)

The BESS results, in which static postural control was evaluated, showed that the values obtained with barefoot, taping, and orthosis showed differences in the evaluation performed on single foot on hard surface ($p = 0.03$). These results showed that the amount of error in balance measurement with barefoot was significantly less than the other two conditions, and the error in the taped foot was less than that with orthosis, but there was no statistically difference between the two conditions ($p>0.05$) (Table 3).

According to the BESS test results, there was difference between groups in the evaluation performed on one foot on soft surface ($p = 0.02$). It was found that this difference was due to the fact that the error recorded with the orthosis on the soft surface was significantly higher than the error with barefoot, but there was no difference between the taping application

and the data obtained with the orthosis and barefoot (p>0.05) (Table 3). The data obtained in tandem stance on hard surface showed that there was difference between the errors made in three different conditions (p=0.03). It was observed that this difference was related to the fact that the amount of errors recorded with orthosis was significantly larger than the error made with barefoot, and that there was no difference between taping application and orthosis and barefoot data (p>0.05) (Table 3). However, there was no difference in the comparison of the errors made in tandem stance on soft surface (p> 0.05) (Table 3).

Table 3. Static postural control measurement BESS results

	Barefoot (Mean±SD)	**Orthosis** (Mean±SD)	**Tape** (Mean±SD)	**p**
Single firm (count)	7.75±5.8	11.4±4.6	11.2±5.3	**0.03***
Singe soft (count)	11.9±4.2	15±5.7	13.4±6.4	**0.02***
Tandem stance firm (count)	3.0±2.5	4.9±2.4	4.4±3.5	**0.03***
Tandem stance soft (count)	6 ± 2.3	7.4 ± 4.8	7.2 ± 4.6	0.43

*p< 0.05

Looking at the results of modified Star Excursion Balance test (mSEBT) used in the evaluation of dynamic postural control, it was found that there was a statistical difference between the three conditions (p<0.05) in terms of stretching in the anterior direction, which was due to the greater amount of extension recorded with barefoot. It was found that there were no differences in the posterolateral and posteromedial directions in the three conditions tested (p>0.05) (Table 4).

When the results of the measurements of the joint position sense performed with eyes open and eyes closed were analyzed, no difference was found between the amounts of errors recorded with eyes open and eyes closed in all three conditions (p> 0.05).

Table 4. Modified Star Excursion Balance Test values of the participants.

Directions	**Barefoot (X±SD)**	**Orthosis (X±SD)**	**Tape (X±SD)**	**p**
Anterior	71.6±6.7	68.5±6.6	67.9±6.1	**0.02***
Posteromedial	79.6±8.5	78.4±9.5	79.0±8.9	0.38
Posterolateral	74.4±12.0	75.3±9.1	77.4±10.3	0.52

*p< 0.05

In our study, we aimed to investigate the effects of non-elastic taping techniques, which are widely used as a stabilizer in return-to-sport after sports ankle ligament injuries and for common prophylactic purposes in athletes, and stabilizer functional orthoses on static and dynamic postural control and joint position sense in young healthy basketball players. Conservative treatment options for external support, such as taping and orthosis, are often used to support injuries in athletes or to support injured athletes in the return-to-sport process (Koyama et al., 2013; Olmsted et al., 2004; Quackenbush et al., 2008; Spanos et al., 2008; Wade, 2008). Taping applications restrict excessive joint movement in the sprained ankle, providing mechanical support to the weakened muscle tissue and joint capsule after the sprain (Quackenbush et al., 2008). However, the issue of increased proprioceptive input from taping in the literature is still controversial (Callaghan, 1997; Spanos et al., 2008). The closed basketweave taping method chosen for the study, which was developed by Gibney, is used to prevent excessive inversion movement after sports injuries and to prevent new injuries during rehabilitation after returning to sports (Bicici et al., 2012; Quackenbush et al., 2008; Shoara et al., 2012; Spanos et al., 2008; Wade, 2008).

Orthotics are recommended in basketball players in the literature to prevent ankle injuries or to support injured ankle (Olmsted et al., 2004). In studies performed by professional athletes, it was observed that there was no protective efficacy in healthy feet, while it improved balance in athletes with instability (Baier & Hopf, 1998; Bennell & Goldie, 1994; Hadadi et al., 2009). Orthosis is preferred because it is easy-to-use and more cost-effective than taping (Olmsted et al., 2004). With the use of orthosis, the inversion range of motion decreases, the joint velocity decreases, and muscle activation and excitability increase, all of which explain the mechanism of reducing injury risk in basketball players (Taylor et al., 2015).

These two approaches are frequently used by the professional basketball players who participated in the present study. In addition, professional athletes are exposed to more violent forces during the game due to their high aerobic performance and strength, and competition, which also increases the risk of injury. Especially in competitive and/or team sports, including basketball, volleyball, handball, and football, players' jumping, and landing activities include moments when the sense of joint proprioception gains immense importance as much as the ankle's static and dynamic postural control. There are studies showing that acute or chronic injuries have biomechanically negative effects on these activities, which are important in sport performance and success (McGuine et al., 2000; McKay et al., 2001). However, the extent to which

the ankle and subtalar joint postural control and proprioceptive sense required by these types of activities, which may determine the fate of the game, were affected by the external supports used for therapeutic purposes, has not been subject to much research. These conservative approaches are often preferred for the purpose of preventing injuries, preventing chronicization of the damage, supporting post-injury treatment processes, and protecting the joint, and knowing how these approaches iatrogenically affect static and dynamic balance parameters and the sense of joint movement is important to shed light on how often these approaches should be used, and for how long, and in what conditions.

In this study, young healthy basketball players with no history of acute ankle and subtalar joint injury and who were not diagnosed with mechanical and physiological chronic instability were included, and consequently, possible contaminating effects of previous injuries on the parameters to be examined were eliminated. Moreover, given the frequent use of these two applications in this study group, a comparison of the use and non-use of these supports on sporting performance is also important for understanding their effects.

In order to investigate these effects, the BESS, which is a valid method used in the evaluation of static postural control in the literature, was chosen (Broglio et al., 2009; Lee & Lee, 2017). It was shown that the BESS can reflect postural deficits better than dynamic tests in in-training athletes because it contains static postures (Halabchi et al., 2019). In our study, according to the results of the BESS data recorded on single stance and tandem stance, compared to the measurements performed on barefoot, orthosis use and taping application were shown to iatrogenically affect the static postural control in terms of ankle and subtalar joints. This result suggests that the advantage of protection and stability provided by these external supports has a cost for the static postural control that the athlete can provide with the ankle.

The Star Excursion Balance Test (SEBT) and its time-saving modified version Modified Star Excursion Balance Test (mSEBT) are cost-effective, simple, and reliable methods that are frequently used in evaluating the foot-ankle-based dynamic parameters of balance, and they are accepted as a good alternative to complex devices in determining dynamic postural stability (Onofrei et al., 2019; van Lieshout et al., 2016). In terms of mSEBT results, the results obtained in our study revealed that, while the athletes were on the dominant lower extremities, there was no difference between the legs extending to the posterolateral and posteromedial direction, and there was a difference in favor of the barefoot condition in the anterior direction. This result can be interpreted as that the basic indication for the taping and functional orthosis used provides

mediolateral stabilization, but also restricts the forward movement of the tibia. In other words, they restrict the amount of dorsiflexion movement of the leg while the foot is still.

In our study, the sense of joint position, which is accepted as an important parameter of proprioception provided by mechanoreceptors in athlete's ankle, subtalar joint, and surrounding soft tissues, was tested using the Monitored Functional Squat System following the evaluation protocol recommended in the literature, which is used in the evaluation of performance athletes and it is often used in studies on the evaluation of post-injury treatment effects (Bicici et al., 2012; D. Ozer et al., 2011; Derya Ozer et al., 2009). The results of the measurements of the joint position sense with eyes open and eyes closed showed there was no statistically significant difference between the amount of errors recorded among the three conditions in eyes open and eyes closed, which contradicts with the results reported in the literature that full contact external supports providing stabilization such as taping applications are advantageous in terms of joint proprioception. These results can also be attributed to the assessment of the immediate effects of such applications as orthosis and taping, since proprioception is among the deep cortical senses and is unlikely to change with rapid adaptation. In addition, the test protocol used in the evaluation of joint position sense in the ankle varies mostly in terms of dorsiflexion movement, and, also the mediolateral movement is not so dominant. However, the external supports used are more effective on the control of movements in this direction than barefoot.

As a result, it was found that functional orthosis and taping application may have some negative effects compared to barefoot in terms of the static and dynamic postural stability parameters related to the ankle. This result emphasizes that, in athletes, the parameters revealed to be restricted by the external supports used here should be used with caution when sporting performance is needed for success. At this point, the secondary injury to be prevented with orthosis and the possible gains to be achieved during the protection phase of the treatment, and the limitations to be experienced with the use of orthoses should be evaluated comparatively, and decisions should be made in line with the priorities. Although our study results show similar results between orthosis and taping, when the arithmetic mean values are examined, it is seen that better results are obtained from orthosis despite the increase in the error parameters in balance parameters compared to the data recorded with barefoot.

Our study contributes to the literature by revealing that the advantages such as stability, protection, and prevention provided by external supports may have a downside, such as some iatrogenic limitations during sports performance. However, in our study, despite the fact that

professional athletes were chosen as subjects, field tests for sportive performance were not used in the evaluation and follow-up tests after a certain period of use of taping techniques and orthosis application were not performed, which weakened the results of the study.

4. Conclusion

This study outlines functional orthosis and taping application may have some negative effects compared to barefoot in terms of the static and dynamic postural stability parameters related to the ankle. It should be kept in mind that orthoses should be applied in individuals whose indications are established.

Conflicts of interest

The authors declare that there are no potential conflicts of interest relevant to this article.

References

Andreoli, C. V., Chiaramonti, B. C., Buriel, E., Pochini, A. D. C., Ejnisman, B., & Cohen, M. (2018). Epidemiology of sports injuries in basketball: Integrative systematic review. In *BMJ Open Sport and Exercise Medicine*, 4(1). https://doi.org/10.1136/bmjsem-2018-000468

Baier, M., & Hopf, T. (1998). Ankle orthoses effect on single-limb standing balance in athletes with functional ankle instability. *Archives of Physical Medicine and Rehabilitation*, *79*(8), 939-944. https://doi.org/10.1016/S0003-9993(98)90091-0

Bennell, K. L., & Goldie, P. A. (1994). The differential effects of external ankle support on postural control. *Journal of Orthopaedic and Sports Physical Therapy, 20*(6), 287-295. https://doi.org/10.2519/jospt.1994.20.6.287

Bicici, S., Karatas, N., & Baltaci, G. (2012). Effect of athletic taping and kinesiotaping® on measurements of functional performance in basketball players with chronic inversion ankle sprains. *International Journal of Sports Physical Therapy, 7*(2), 154-166. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3325641/#__ffn_sectitle

Broglio, S. P., Monk, A., Sopiarz, K., & Cooper, E. R. (2009). The influence of ankle support on postural control. *Journal of Science and Medicine in Sport*, *12*(3), 388-392. https://doi.org/10.1016/j.jsams.2007.12.010

Brumitt, J. (2008). Assessing athletic balance with the star excursion balance test. *NSCA'S Performance Training Journal*, *7*(3), 3-4.

Bulow, A., Anderson, J. E., Leiter, J. R., MacDonald, P. B., & Peeler, J. (2019). The modıfied star excursıon balance and y-balance test results dıffer when assessıng physıcally actıve healthy adolescent females. *International Journal of Sports Physical Therapy*, *14*(2), 192. https://doi.org/10.26603/ijspt20190192

Callaghan, M. J. (1997). Role of ankle taping and bracing in the athlete. In *British Journal of Sports Medicine, 31*(2), 102-108. https://doi.org/10.1136/bjsm.31.2.102

Carter, E. A., Westerman, B. J., & Hunting, K. L. (2011). Risk of injury in basketball, football, and soccer players, ages 15 years and older, 2003-2007. *Journal of Athletic Training, 2003-2007* https://doi.org/10.4085/1062-6050-46.5.484

Chang, W. D., Chou, L. W., Chang, N. J., & Chen, S. (2020). Comparison of Functional Movement Screen, Star Excursion Balance Test, and Physical Fitness in Junior Athletes with Different Sports Injury Risk. *BioMed Research International*. https://doi.org/10.1155/2020/8690540

Cho, B. K., & Park, J. K. (2019). Correlation Between Joint-Position Sense, Peroneal Strength, Postural Control, and Functional Performance Ability in Patients With Chronic Lateral Ankle Instability. *Foot and Ankle International 40*(8), 961-968. https://doi.org/10.1177/1071100719846114

Chaiwanichsiri, D., Lorprayoon, E., & Noomanoch, L. (2005). Star excursion balance training: effects on ankle functional stability after ankle sprain. *Journal-Medical Association of Thailand*, *88*, S90.

Sacco, I. D. C. N., Takahasi, H. Y., Suda, E. Y., Battistella, L. R., Kavamoto, C. A., Lopes, J. A. F., & Vasconcelos, J. C. P. D. (2006). Ground reaction force in basketball cutting maneuvers with and without ankle bracing and taping. *Sao Paulo Medical Journal*, *124*(5), 245-252. https://doi.org/10.1590/S1516-31802006000500002

Doherty, C., Delahunt, E., Caulfield, B., Hertel, J., Ryan, J., & Bleakley, C. (2014). The incidence and prevalence of ankle sprain injury: A systematic review and meta-analysis of prospective epidemiological studies. In *Sports Medicine, 44*(1), 123-140. https://doi.org/10.1007/s40279-013-0102-5

Halabchi, F., Abbasian, L., Mirshahi, M., Mazaheri, R., Pourgharib Shahi, M. H., & Mansournia, M. A. (2020). Comparison of Static and Dynamic Balance in Male Football and Basketball Players. Foot & Ankle Specialist, 13(3), 228-235. doi: 10.1177/1938640019850618

Fleet, K., Galen, S., & Moore, C. (2009). Duration of strength retention of ankle taping during activities of daily living. *Injury, 40*(3), 333-336.

https://doi.org/10.1016/j.injury.2008.07.020

Gehrke, L. C., Londero, L. X., Loureiro-Chaves, R. F., Souza, H. H., de Freitas, G. P., & Pacheco, A. M. (2018). Effects of athletic taping on performance of basketball athletes with chronic ankle instability. *Revista Brasileira de Medicina Do Esporte, 24*(6), 477-482. https://doi.org/10.1590/1517-869220182406173311

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

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

Gunaydin, G., Hazar Kanik, Z., Karabicak, G. O., Sozlu, U., Pala, O. O., Alkan, Z. B., Basar, S., & Citaker, S. (2016). Cross-cultural adaptation, reliability and validity of the Turkish version of the Japanese Orthopaedic Association Back Pain Evaluation Questionnaire. *Journal of Orthopaedic Science*, *21*(3). https://doi.org/10.1016/j.jos.2016.01.006

Hadadi, M., Mosavi, M., Marofi, N., Bahramizadeh, M., & Rahgozar, M. (2009). Differential effects of semi-rigid and soft orthoses on postural control between affected and unaffected leg in patients with functional ankle instability in compared with healthy subjects. *Koomesh, 10*(3), 155-160. http://koomeshjournal.semums.ac.ir/browse.php?a_code=A-10-4-359&slc_lang=en&sid=1&printcase=1&hbnr=1&hmb=1

Hyong, I. H., & Kim, J. H. (2014). Test of intrarater and interrater reliability for the star excursion balance test. *Journal of Physical Therapy Science, 26*(8), 1139-1141. https://doi.org/10.1589/jpts.26.1139

Koyama, K., Kato, T., & Yamauchi, J. (2013). The effect of ankle taping on the ground reaction force in vertical jump performance. *Journal of Strength and Conditioning Research*, *27*(11), 3183–3189. https://doi.org/10.1519/JSC.0000000000000260

Lee, S. M., & Lee, J. H. (2017). The immediate effects of ankle balance taping with kinesiology tape on ankle active range of motion and performance in the Balance Error Scoring System. *Physical Therapy in Sport, 25*, 99-105. https://doi.org/10.1016/j.ptsp.2016.08.013

Maffiuletti, N. A., Bizzini, M., Schatt, S., & Munzinger, U. (2005). A multi-joint lower-limb tracking-trajectory test for the assessment of motor coordination. *Neuroscience Letters, 384*(1-2),

106-111. https://doi.org/10.1016/j.neulet.2005.04.064

McGuine, T. A., Greene, J. J., Best, T., & Leverson, G. (2000). Balance as a predictor of ankle injuries in high school basketball players. *Clinical Journal of Sport Medicine, 10*(4), 239-244. https://doi.org/10.1097/00042752-200010000-00003

McKay, G. D., Goldie, P. a, Payne, W. R., & Oakes, B. W. (2001). Ankle injuries in basketball: injury rate and risk factors. *British Journal of Sports Medicine*, *35*(2), 103–108. https://doi.org/10.1136/bjsm.35.2.103

Olmsted, L. C., Vela, L. I., Denegar, C. R., & Hertel, J. (2004). Prophylactic Ankle Taping and Bracing: A Numbers-Needed-to-Treat and Cost-Benefit Analysis. *Journal of Athletic Training, 39*(1), 95-100. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC385268/#__ffn_sectitle

Onofrei, R. R., Amaricai, E., Petroman, R., & Suciu, O. (2019). Reproducibility of the modified star excursion balance test composıte and specific reach direction scores. *PeerJ,* 7: e6999 https://doi.org/10.7717/peerj.6999

Ozer, D., Duzgun, I., Baltaci, G., Karacan, S., & Colakoglu, F. (2011). The effects of rope or weighted rope jump training on strength, coordination and proprioception in adolescent female volleyball players. *Journal of Sports Medicine and Physical Fitness, 51*(2), 211.

Ozer, Derya, Senbursa, G., Baltaci, G., & Hayran, M. (2009). The effect on neuromuscular stability, performance, multi-joint coordination and proprioception of barefoot, taping or preventative bracing. *Foot*, *19*, 205–210. https://doi.org/10.1016/j.foot.2009.08.002

Quackenbush, K. E., Barker, P. R. J., Stone Fury, S. M., & Behm, D. G. (2008). The effects of two adhesive ankle-taping methods on strength, power, and range of motion in female athletes. *North American Journal of Sports Physical Therapy : NAJSPT, 3(1):25-32*.

Riemann, B. L., Guskiewicz, K. M., & Shields, E. W. (1999). Relationship between clinical and forceplate measures of postural stability. *Journal of Sport Rehabilitation, 8(2):71-82*. https://doi.org/10.1123/jsr.8.2.71

Riva, D., Bianchi, R., Rocca, F., & Mamo, C. (2016). Proprioceptive Training and Injury Prevention in a Professional Men's Basketball Team: A Six-Year Prospective Study. *Journal of Strength and Conditioning Research, 30(2):461-475*. https://doi.org/10.1519/JSC.0000000000001097

Shoara, E., Rahimi, A., Razeghi, M., & Ebrahimi, S. (2012). The effects of ankle taping on the kinematics findings of the ankle and knee joints during walking on level ground. *Gait & Posture, (36):S51*. https://doi.org/10.1016/j.gaitpost.2011.10.266

Simpson, J. D., Rendos, N. K., Stewart, E. M., Turner, A. J., Wilson, S. J., Macias, D. M., Chander, H., & Knight, A. C. (2019). Bilateral spatiotemporal postural control impairments are present in participants with chronic ankle instability. *Physical Therapy in Sport,39:1-7*. https://doi.org/10.1016/j.ptsp.2019.06.002

Spanos, S., Brunswic, M., & Billis, E. (2008). The effect of taping on the proprioception of the ankle in a non-weight bearing position, amongst injured athletes. The *Foot, 18(1):25-33*. https://doi.org/10.1016/j.foot.2007.07.003

Stoffel, K. K., Nicholls, R. L., Winata, A. R., Dempsey, A. R., Boyle, J. J. W., & Lloyd, D. G. (2010). Effect of ankle taping on knee and ankle joint biomechanics in sporting tasks. *Medicine and Science in Sports and Exercise, 42*(11), 2089-2097. https://doi.org/10.1249/MSS.0b013e3181de2e4f

Taylor, J. B., Ford, K. R., Nguyen, A. D., Terry, L. N., & Hegedus, E. J. (2015). Prevention of Lower Extremity Injuries in Basketball: A Systematic Review and Meta-Analysis. *Sports Health, 7*(5), 392-398. https://doi.org/10.1177/1941738115593441

van Lieshout, R., Reijneveld, E. A. E., van den Berg, S. M., Haerkens, G. M., Koenders, N. H., de Leeuw, A. J., van Oorsouw, R. G., Paap, D., Scheffer, E., Weterings, S., & Stukstette, M. J. (2016). Reproducibility of the modified star excursion balance test composite and specific reach direction scores. International journal of sports physical therapy, 11(3), 356. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4886804/#__ffn_sectitle

van Melick, N., Meddeler, B. M., Hoogeboom, T. J., Nijhuis-van der Sanden, M. W. G., & van Cingel, R. E. H. (2017). How to determine leg dominance: The agreement between self-reported and observed performance in healthy adults. *PLoS ONE, 12*(12), e0189876. https://doi.org/10.1371/journal.pone.0189876

Wade, B. J. (2008). The effects of ankle prophylactic devices on force absorption during a drop jump. PhD Thesis. California University of Pennsylvania, p.62, California,USA.

Wilkerson, G. B., Kovaleski, J. E., Meyer, M., & Stawiz, C. (2005). Effects of the subtalar sling ankle taping technique on combined talocrural-subtalar joint motions. *Foot & Ankle International / American Orthopaedic Foot and Ankle Society [and] Swiss Foot and Ankle Society*, *26*(3), 239–246. https://doi.org/10.1177/107110070502600310