Journal of Shahrekord University of Medical Sciences
doi:10.15171/jsums.2019.08 2019;21(1):45-50 http://j.skums.ac.ir

Original Article

Comparing the effective interventions on plantar and ankle proprioception in balance control with and without fatigue

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Abstract
Background and aims: The "postural control" is one of the important abilities to maintain body balance especially during upright stances which is a basic requirement in human life. The role of proprioception in the ankle joint function is essential to maintain balance and function correctly during gate and upright stances. Fatigue is one of the essential factors disrupting the proprioception. The purpose of the present study was to compare effective interventions on plantar and ankle proprioception in balance control with and without fatigue.
Methods: Twenty female college students participated in this study. The participants taped the ankle or wore three types of insoles (i.e., normal, 10-degree lateral, and medial wedge) before and after using a fatigue protocol with and without visual information. Their static and dynamic balance was evaluated by the Biodex Balance System (BBS). Data analysis was performed employing the SPSS software. Besides, the significance level was considered at 0.05.
Results: The results indicated that application of wedge insoles was associated with a significant reduction of postural sway during static balance position. In addition, the 10-degree lateral wedge insole had a greater effect for improving the balance of non-visual position after using the fatigue protocol. However, there were no significant differences between taping and insole types regarding improving the dynamic balance.
Conclusion: Generally, it was inferred that wedge insoles could be used to improve the static balance with and without fatigue. However, Kinesio tape had no effect on static balance. Moreover, results regarding the effectiveness of the studied interventions in relation to the dynamic balance improvement were not significant.
Keywords: Balance; Proprioception; Wedge insole; Taping; Fatigue

Received: 24 October 2017, Accepted: 6 March 2018, ePublished: 6 April 2019

Introduction

Postural control, as stated by some researchers, is one of the most important and essential needs in the everyday life of a human, and a complex function that requires inputs of visual, vestibular, and somatosensory systems (1,2). The contribution of each of these sensory systems to the postural control varies depending on the interference that occurs during the environmental conditions (3). In addition, sensory reweighting refers to the set of sensory inputs to control the balance (4). According to sensory reweighting theory, the central nervous system (CNS) can change the dependence on more reliable sources of information to optimize the balance control. Furthermore, proprioception is considered as one of the body information resources for maintaining the balance and the ability to understand or feel the joint spatial position and body movements without vision (4). Since the ankle and foot are the only parts of the body on the ground during the activity, the proprioception accuracy in the ankle joint is necessary to maintain the proper joint function during daily activities and motor skills (5). Due to the role of the ankle and foot as the first responders to maintain the balance against external disorders, fatigue causes the nerve dysfunction in the ankle joint owing to the reduced motor output and decreased proprioceptor sensitivity (6,7). Therefore, active and passive interventions are widely used to improve the proprioception of the ankle and balance control. Some of the inactive interventions include Kinesio tape, insole, and brace (8). Among these approaches, orthotic interventions are found to be effective in improving the balance by stimulating the plantar surface of the foot and changing its angular position (9). The insoles are used for various purposes such as increasing stiffness in the ankle joint, altering the angular position and improving the foot position in addition to therapeutic purposes in the patients (10). Iglesias et al, for instance, stated that semi-rigid and rigid insoles lead to increased postural stability control by this mechanism through which the foot is most likely to be in a natural position (11). Moreover, Kinesio tape is a relatively new and widely used passive intervention to prevent damage, increase neuromuscular function, improve performance during physical activity (12), mechanically support the ankle joint (13), and enhance the ankle joint proprioception (14). Despite the above-mentioned advantages, the results are contradictory respecting the effect of Kinesio tape on the ankle joint proprioception (14-16). Conversely, however, several beneficial effects have been mentioned regarding Kinesio tape intervention as follows: stimulating the mechanoreceptors, increasing the sensory inputs to the CNS, improving the sense of joint condition, elevating blood and lymph circulation due to the application of Kinesio tape (12,13,15,16), changing the foot pressure, strengthening of the foot sensory feedbacks. Moreover, altering the ankle joint alignment and stature (10) as a result of using wedged insoles, according to previous studies, as well as taking into account the fact that maintaining and strengthening the balance is one of the main factors in preventing injury in athletes (17) were also among the advantages of using Kinesio tape intervention. Besides, since the fatigue can impair the transmission of sensory information and the strength of joints or structures of the lower extremities, the current study sought to investigate the impact of using effective interventions on the foot and ankle proprioception in controlling the balance with and without fatigue.

Materials and Methods

The present quasi-experimental and causal-comparative study was performed on 20 female athlete volunteers with the demographic characteristics shown in Table 1. The inclusion criteria were lack of any history of severe injury, surgery, fracture, burn, musculoskeletal problems, back pain or severe trauma in the lower extremity during the last six months (17,18), and dominance of the right foot, as well as having normal navicular height according to the Brody method (19). The dominant foot of the subjects was determined by hitting the ball test (17). Following being informed about the research objectives and method, participants completed the informed written consent. After recording the baseline information, the balance tests were performed using standard and uniform shoes in which the studied insoles had been applied. The insoles used in the study were made of ethylene-vinyl acetate (EVA) of a semi-rigid type. In this study, three models of 10-degree medial, lateral, and normal wedged insoles were used (Figure 1).

Table 1. Demographic Characteristics of the Study Participants (Mean ± SD)

Age (y)	Height (cm)	Weight (kg)	BMI (kg/m^2)
24.31±2.47	162.18±6.34	56.84±6.94	21.44±2.64

Abbreviation: BMI, body mass index.

The participants conducted the balance tests with wedged (10-degree medial and lateral wedged insoles) and non-waged (normal) insoles with ankle taping using the normal insole before and after applying the fatigue protocol. Each participant was allowed 5 minutes to become familiar with the insole after wearing the shoe. Besides, the choice of the tests order was randomly carried out for each participant. The subjects with any insole (waged, normal [non-waged], and ankle tape) repeated the balance tests three times. The mean value of the three tests was also included in data analysis. The current study was conducted using the Kinesio tape (Korea) and the Basketweave taping methods (20) (Figure 2) . The BBS was employed to measure the individual's balance. This device records the mean postural distortion in three overall, anterior-posterior, and lateral-medial directions (2). The information used in this study was related to the overall stability index. After determining the order of the tests, which was carried out completely at random, single-leg stance and fall risk programs were applied to measure the static and dynamic balance, respectively, as follows:

Static balance

The participants were asked to stand on the platform with a dominant leg while the hands were freely next to the body, bending the other leg from the knee, holding it high and trying to keep the balance with the least possible fluctuation within the set time. Each participant repeated the test three times (20 seconds each time), first with open eyes, and then with closed eyes (in order to eliminate vision information). Additionally, a 10-second rest period was considered between the repetitions.

Dynamic balance (fall risk test)

The participants were asked to stand on the platform while

Figure 1. An Example of Lateral Waged Insole.

Figure 2. Ankle Taping by Basketweave Method.

Figure 3. A Participant Undergoing Fall Risk Test.

the hands were freely next to the body, trying to maintain the balance during the test period. The platform was set at 2 and 8. Similar to the static balance, this test was also repeated three times for 20 seconds with a 10-second rest period between the repetitions by wearing all three insoles (Figure 3). The treadmill (H/P/COSMOS-mercury, Germany) was used to apply fatigue according to the standard Bruce protocol (multi-stage protocols), with a change in velocity and gradient resulting in an increase in pressure. Since Bruce protocol is an aerobic method and the information received from the feet and vision receptors are reportedly changed increasingly after the aerobic fatigue protocol, the present study employed the Bruce protocol of aerobic fatigue to exert the fatigue (21). It is worth noting that the heart rate of the participants was controlled simultaneously with the use of the Heart Rate Monitor (Polar A300). Immediately after the fatigue, post-test was performed completely similar to the pre-test, and then the information was recorded.

Following collecting the research data, descriptive statistics were applied to investigate the demographic characteristics of the subjects. Then, the Shapiro-Wilk test was employed to examine the normal distribution of the data. According to the normal distribution of the data ($P > 0.05$), repeated measures ANOVA was run to determine the difference between the studied factors at a significance level of $P \leq 0.05$. In case of a significant difference, the LSD test was used. All the statistical analyses were performed using the SPSS (Statistical Package for the Social Sciences) software version 22.

Results

The participants of this study included 20 female athletes with a mean age of 24.31±2.47 years, a mean height of 162.18±6.34 cm, a mean weight of 56.6±6.94 kg, and a mean BMI of 21.44±2.64 kg/m^2.

The repeated measures ANOVA was used to evaluate the difference between different modes (i.e., without wedge insole, or with 10-degree lateral wedged insoles, and 10-degrees medial wedged insoles and taping) before and after the fatigue, and with open and closed eyes. The results of the test are provided in Table 2.

As can be seen in Table 2, both 10-degree lateral and medial waged insoles with closed eyes significantly decreased postural fluctuations. However, no significant improvement was observed in the mean scores of the dynamic balance. Similarly, Kinesio tape had no significant effect on the improvement of static and dynamic balance.

Conversely, the LSD test results demonstrated significant differences between different positions while wearing a 10-degree lateral wedged insole compared to the non-waged insole with open eyes and without any fatigue (MD = 0.389, $P = 0.01$) and with closed eyes with fatigue (MD= -0.56, P=0.005). There was also a significant difference between the 10-degree lateral wedged insole and the Kinesio tape (MD = -0.61, $P = 0.004$) with closed eyes after the fatigue.

Discussion

As previously mentioned, this study aimed to compare

Table 2. Repeated measures ANOVA results regarding the differences between the variables

Variable index			Before fatigue (Mean ± SD)	After fatigue (Mean ± SD)	*df*	F	*P* value
Plane insole	Static Balance (Degree)	Open eye	1.86±0.17	1.55±0.16	18	4.102	0.5
		Closed eye	3.61±0.19	3.28±0.2	18	3.38	0.8
	Dynamic Balance (degree)		1.5±0.15	1.33±0.17	18	2.43	0.13
10° Lateral wedged insole	Static Balance (Degree)	Open eye	1.47±0.11	1.74±0.20	18	-1.35	0.19
		Closed eye	3.46±0.19	2.72±0.098	18	4.39	0.001*
	Dynamic balance (degree)		1.44±0.16	1.44±0.17	18	0.000	1
10° Medial wedged insole	Static balance (degree)	Open eye	1.60±0.16	1.68±0.17	18	-0.52	0.6
		Closed eye	3.42±0.22	3.03±0.19	18	2.35	0.03*
	Dynamic balance (degree)		1.44±0.16	1.47±0.17	18	-0.39	0.6
Taping	Static balance (degree)	Open eye	1.73±0.16	1.94±0.14	18	-1.29	0.21
		Closed eye	3.33±0.19	3.24±0.22	18	-0.59	0.55
	Dynamic balance (degree)		1.44±0.17	1.32±0.14	18	1.09	0.28

Note. The asterisk (*) Significant difference at the level of $P < 0.05$.

the effective interventions on the ankle and foot proprioception in the control of balance with and without fatigue. The balance is considered one of the controversial concepts of the motor-sensory system. Meanwhile, the human foot with its low surface area plays an important role in maintaining this balance, so the least changes in the support area can affect the postural control (23). In addition, the foot is the first body part that contacts with the ground in many daily activities, As a result, any external perturbation from the ground enters to the foot and ankle joint. Therefore, the ankle joint is considered to be the first area to recover and maintain the balance (19,24).

The results of this study showed that using 10-degree medial and lateral wedged insoles had a positive effect on the improvement of the static balance when removing vision information. However, Kinesio tape indicated no positive impact on the improvement of static and dynamic balance. Some of the reasons that can explain the obtained results are as follows:

Apparently, through balancing the subtalar joint and the ankle, the insole was able to prevent abnormal compensated movements in the joint and reduced postural fluctuations in a static state. According to some studies, standing on the wedge can also be associated with increased stiffness in the ankle joint (25,26). Lee et al showed that when individuals were placed on the 10-degree medial and lateral wedged insoles and the lateral perturbation occurred at the shoulder level, co-contraction of muscles in the trunk and thigh segments and the reciprocal activation in the shank muscles on the side of the perturbation were observed in both the anticipatory and compensatory postural adjustments. Therefore, the researchers claimed that the conditions of standing on the waged insole coped with less activity of the triceps surae muscles against disturbances and reduction in postural fluctuations (27). These findings indicate the importance of increasing the stiffness in the ankle joint as a result of using the wage (25). This mechanism is similar to the result of the present study. In addition, the waged insoles (lateral and medial) are found to increase the support area, as the wide base of support increasingly improves the balance (27). Moreover, standing on the insole is said to affect the angular position of the ankle and hip joints in the frontal plane. A change in the angular position of the hip joint in the frontal plane is also one of the reasons for observing a decrease in postural fluctuations (18). It is believed that the medial wage, on the one hand, causes angular changes in the hip and subtalar joints in the frontal plane. Additionally, the medial wage modifies the Achilles tendon direction, which can lead to further changes in the frontal plane. On the other hand, the lateral wage causes the angular changes in the ankle, knee, and hip in the sagittal plane as a result of which movement of the subtalar and the hip joints in the frontal plane is limited (26). Increasing somatosensory through promoting the contact surface of the sole can help improve the postural control as well. According to the results of previous studies, although using the ice on the sole caused a poor balance (28) and the stimulation of the foot skin receptors was increased by tissue insole, the balance control was improved (29). These results indicate that the somatosensory improves the postural control through the tactile stimulation of the foot. According to the sensory reweighting theory, when a sensory pathway is damaged or destroyed, the CNS gives more weight to the remaining inputs in order to adapt to this position and relies on these signals to generate a motor response (4,8). Through removing the vision feedback when testing with closed eyes, the individual's reliance on proprioception information is increased to maintain the balance. In the present study, the waged insole was found to have the greatest impact on the static balance. Furthermore, using the waged insole, as stated by some studies, can have biomechanical effects to improve the foot posture and proprioception information, cause lower extremity motor and neuromuscular functions, and alter angle of the subtalar joint, wrist, knee, hip, pelvis, and trunk in their motor planes (17,26). The present results regarding the effect of waged insoles on improving the balance are in conformity with the findings of Ganesa et al (18) and Eslami et al (26). Among the factors affecting the balance, fatigue as one of the major risk factors for lower extremity damage leads to a decrease in the ability to respond quickly to proprioception responses (17) and increases the postural perturbation and alterations.

As mentioned before, the Kinesio tape has also been widely used by the athletes to prevent damage, increase neuromuscular activity, and improve performance during the physical activity (13), mechanical support of the ankle joint (14), and ankle joint proprioception (15). However, very limited evidence is available to support the benefits attributed to the Kinesio tape. Similarly, contradictory results have been reported for the use of Kinesio tape in sports (14,15,30-32). The results of the current study indicated that Kinesio tape was ineffective in improving the static and dynamic balance. These results are inconsistent with the results of the studies by Fayson et al (31), Nakajima et al (30), and Seo et al (15). One of the reasons for obtaining such results in the present research may be the absence of damage to the participants because they had a good proprioception function. Besides, even the sensory information received from their feet and sole may have been changed due to taping, which in turn disrupts the ability of proprioception. In general, taping around the ankle joint is found to improve sensory input by increasing the proprioception performance of people with poor proprioception. However, it may cause receiving excessive input and proprioception disorder in those who initially have appropriate performance (14). Meanwhile, when a person is standing without moving, it is likely that Kinesio tape not to be enough to change the afferent feedback received from the feet. The results are consistent with the findings of Nunes et al (33) and Long et al (14).

None of the studied interventions were effective on the dynamic balance of the participants before and after the fatigue. Of the three strategies to restore the balance, postural control in posterior-anterior direction was often controlled by the ankle strategy while controlling and maintaining the balance of the frontal or lateral plane was mostly done by the thigh and trunk. Besides, abductor and adductor of the hip muscles were detected to have the greatest role in controlling the postural fluctuations in the lateral direction (34). Although the stability of the frontal plane was mainly due to the pelvis and trunk, it was observed that the muscles in the ankle joint also played a part in establishing the lateral stability. In other words, a muscle was not only active in a direction of perturbations but also it showed its maximum activity in one direction while operating differently in various directions during the perturbations (6,35). As previously described, the ankle joint taping was revealed to have less effect on the improvement of the dynamic balance probably due to the involvement of proximal joints in maintaining the dynamic balance. Moreover, the ineffectiveness of the insoles waged on the dynamic balance may be due to the role of other joints including the knee, hip, and even shoulder in maintaining the dynamic balance. The activity of muscles and their activation time were also important in maintaining the balance. The waged insole seems to have been able to help the balance in static conditions improve under less perturbation. However, since the strategies involved in the balance were different under more challenges, none of the applied methods could be effective in improving the dynamic balance.

Conclusion

According to the results of this study, using Kinesio tape in healthy individuals did not affect the dynamic and static balance improvement before and after the fatigue in lower extremity muscles. Meanwhile, application of waged insoles was associated with decreased postural fluctuations in the static state before and after the fatigue. In other words, the waged insole could reduce the complications of fatigue leading to a defect in individuals' balance when standing. Given the ease of insole application, the clinical significance of this finding is that the waged insole can be recommended to sports health centers or physiotherapists. That is, the waged insoles can be applied to improve the balance for individuals with imbalance problems and special considerations in rehabilitation stages in the static conditions. The results regarding the improvement of dynamic balance require further investigation.

Conflict of onterests

None.

Ethical considerations

The study was approved by the Ethics Committee of Hamadan University under the code of ethics IR.UMSHA.REC.1396.652.

Financial Support

Bu-Ali Sina University supported the study.

Acknowledgments

The present article is derived from an MD thesis in Sports Pathology and Corrective Exercises under the ethics code of 1220811, approved on October 27, 2015, at Bu-Ali Sina University of Hamedan, Iran. The authors would like to thank the participants and all those who cooperated in the implementation of this research.

References

1. Chiba R, Takakusaki K, Ota J, Yozu A, Haga N. Human upright posture control models based on multisensory inputs; in fast and slow dynamics. Neurosci Res. 2016;104:96-104. doi: 10.1016/j.neures.2015.12.002.
2. Akbari A, Sarmadi A, Zafardanesh P. The effect of ankle taping and balance exercises on postural stability indices in healthy women. J Phys Ther Sci. 2014;26(5):763-9. doi: 10.1589/jpts.26.763.
3. Ueta Y, Matsugi A, Oku K, Okuno K, Tamaru Y, Nomura S, et al. Gaze stabilization exercises derive sensory reweighting of vestibular for postural control. J Phys Ther Sci. 2017;29(9):1494-6. doi: 10.1589/jpts.29.1494.
4. Asslander L, Peterka RJ. Sensory reweighting dynamics in human postural control. J Neurophysiol. 2014;111(9):1852-64. doi: 10.1152/jn.00669.2013.
5. Lephart SM, Pincivero DM, Giraldo JL, Fu FH. The role of proprioception in the management and rehabilitation of athletic injuries. Am J Sports Med. 1997;25(1):130-7. doi: 10.1177/036354659702500126.
6. Grey T, Redguard D, Wengle R, Wegscheider P. Effect of plantar flexor muscle fatigue on postural control. WURJ: Health and Natural Sciences. 2014;4(1):1. doi: 10.5206/wurjhns.2013-14.1.
7. Vie B, Nester CJ, Porte LM, Behr M, Weber JP, Jammes Y. Pilot study demonstrating that sole mechanosensitivity can be affected by insole use. Gait Posture. 2015;41(1):263-8. doi: 10.1016/j.gaitpost.2014.10.012.
8. Han J, Anson J, Waddington G, Adams R, Liu Y. The Role of Ankle Proprioception for Balance Control in relation to Sports Performance and Injury. Biomed Res Int. 2015;2015:842804. doi: 10.1155/2015/842804.
9. Palluel E, Olivier I, Nougier V. The lasting effects of spike insoles on postural control in the elderly. Behav Neurosci. 2009;123(5):1141-7. doi: 10.1037/a0017115.
10. Shelburne KB, Torry MR, Steadman JR, Pandy MG. Effects of foot orthoses and valgus bracing on the knee adduction moment and medial joint load during gait. Clin Biomech (Bristol, Avon). 2008;23(6):814-21. doi: 10.1016/j.clinbiomech.2008.02.005.
11. Losa Iglesias ME, Becerro de Bengoa Vallejo R, Palacios Pena D. Impact of soft and hard insole density on postural stability in older adults. Geriatr Nurs. 2012;33(4):264-71. doi: 10.1016/j.gerinurse.2012.01.007.
12. Lins CA, Neto FL, Amorim AB, Macedo Lde B, Brasileiro JS. Kinesio Taping((R)) does not alter neuromuscular performance of femoral quadriceps or lower limb function in healthy subjects: randomized, blind, controlled, clinical trial. Man Ther. 2013;18(1):41-5. doi: 10.1016/j.math.2012.06.009.
13. Ozer D, Senbursa G, Baltaci G, Hayran M. The effect on neuromuscular stability, performance, multi-joint coordination and proprioception of barefoot, taping or preventative bracing. Foot (Edinb). 2009;19(4):205-10. doi: 10.1016/j.

foot.2009.08.002.
14. Long Z, Wang R, Han J, Waddington G, Adams R, Anson J. Optimizing ankle performance when taped: Effects of kinesiology and athletic taping on proprioception in full weight-bearing stance. J Sci Med Sport. 2017;20(3):236-40. doi: 10.1016/j.jsams.2016.08.024.
15. Seo HD, Kim MY, Choi JE, Lim GH, Jung SI, Park SH, et al. Effects of Kinesio taping on joint position sense of the ankle. J Phys Ther Sci. 2016;28(4):1158-60. doi: 10.1589/jpts.28.1158.
16. Rojhani-Shirazi Z, Amirian S, Meftahi N. Effects of Ankle Kinesio Taping on Postural Control in Stroke Patients. J Stroke Cerebrovasc Dis. 2015;24(11):2565-71. doi: 10.1016/j.jstrokecerebrovasdis.2015.07.008.
17. Yalfani A, Raeisi Z. The effect of different landing states on electromyographic activity of selected muscles Lower limb before and after fatigue in female athletes. Sports Medicine. 2016;8(2):174-59.
18. Ganesan M, Lee YJ, Aruin AS. The effect of lateral or medial wedges on control of postural sway in standing. Gait Posture. 2014;39(3):899-903. doi: 10.1016/j.gaitpost.2013.11.019.
19. Yalfani A, Amini Semiromi E, Raeisi Z. The Effect of Musculoskeletal Abnormalities of Pes Planus, Pes Cavus and Hallux Valgus on Postural Sways during Quiet Stance. Sports Medicine. 2015;7(1):143-62.
20. Quackenbush KE, Barker PR, Stone Fury SM, Behm DG. The effects of two adhesive ankle-taping methods on strength, power, and range of motion in female athletes. N Am J Sports Phys Ther. 2008;3(1):25-32.
21. Derave W, Tombeux N, Cottyn J, Pannier JL, De Clercq D. Treadmill exercise negatively affects visual contribution to static postural stability. Int J Sports Med. 2002;23(1):44-9. doi: 10.1055/s-2002-19374.
22. Orth D, Davids K, Wheat J, Seifert L, Liukkonen J, Jaakkola T, et al. The role of textured material in supporting perceptual-motor functions. PLoS One. 2013;8(4):e60349. doi: 10.1371/journal.pone.0060349.
23. Cote KP, Brunet ME, Gansneder BM, Shultz SJ. Effects of Pronated and Supinated Foot Postures on Static and Dynamic Postural Stability. J Athl Train. 2005;40(1):41-6.
24. Davis IS. How do we accurately measure foot motion? J Orthop Sports Phys Ther. 2004;34(9):502-3. doi: 10.2519/jospt.2004.0109.
25. Lee YJ, Liang JN, Chen B, Ganesan M, Aruin AS. Standing on wedges modifies side-specific postural control in the presence of lateral external perturbations. J Electromyogr Kinesiol. 2017;36:16-24. doi: 10.1016/j.jelekin.2017.06.005.
26. Eslami M, Tanaka C, Hinse S, Farahpour N, Allard P. Effect of foot wedge positions on lower-limb joints, pelvis and trunk angle variability during single-limb stance. Foot. 2006;16(4):208-13. doi: 10.1016/j.foot.2006.07.007.
27. Lee HB, Jang EB, Kim JS, Hong JH, Yu JH, Lee DY. A study of Postural Sway according to the Wedge Direction during one Leg Standing. Indian J Sci Technol. 2016;9(25):1-9. doi: 10.17485/ijst/2016/v9i25/97237.
28. Shin JY, Ryu YU, Yi CW. Effects of insoles contact on static balance. J Phys Ther Sci. 2016;28(4):1241-4. doi: 10.1589/jpts.28.1241.
29. Paton J, Glasser S, Collings R, Marsden J. Getting the right balance: insole design alters the static balance of people with diabetes and neuropathy. J Foot Ankle Res. 2016;9:40. doi: 10.1186/s13047-016-0172-3.
30. Nakajima MA, Baldridge C. The effect of kinesio(R) tape on vertical jump and dynamic postural control. Int J Sports Phys Ther. 2013;8(4):393-406.
31. Fayson SD, Needle AR, Kaminski TW. The effects of ankle Kinesio taping on ankle stiffness and dynamic balance. Res Sports Med. 2013;21(3):204-16.doi:10.1080/15438627.2013.792083.
32. Lee JH. 2-dimensional analysis of low limb taping methods on ambulation for stroke patients. J Phys Ther Sci. 2017;29(6):1098-101. doi: 10.1589/jpts.29.1098.
33. Nunes GS, de Noronha M, Cunha HS, Ruschel C, Borges NG, Jr. Effect of kinesio taping on jumping and balance in athletes: a crossover randomized controlled trial. J Strength Cond Res. 2013;27(11):3183-9. doi: 10.1519/JSC.0b013e31828a2c17.
34. Ross SE, Guskiewicz KM. Examination of static and dynamic postural stability in individuals with functionally stable and unstable ankles. Clin J Sport Med. 2004;14(6):332-8.
35. Hootman JM, Dick R, Agel J. Epidemiology of collegiate injuries for 15 sports: summary and recommendations for injury prevention initiatives. J Athl Train. 2007;42(2):311-9.