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DOES BOSU TRAINING AFFECT ON DYNAMIC AND STATIC BALANCE IN ADOLESCENT TAEKWONDO ATHLETES?

ALI VADBA Z ŽOGO BOSU VPLIVA NA DINAMIČNO IN STATIČNO RAVNOTEŽJE PRI MLADOSTNIKIH TAEKWONDOISTIH

ABSTRACT

The purposes of this study were to develop taekwondo-specific core stabilization-balance training and to determine the influence of a core stabilization-exercise protocol, using the BOSU, on dynamic and static balance performance in adolescent TKD athletes. Twenty-four elite taekwondo athletes were randomly divided into two groups: the BOSU-trained group (n = 13) and the control group (n = 11). Subjects in BOSU-trained group had core-stabilization training 3 times a week for 12 weeks in addition to the routine taekwondo training program. The control group had no training protocol in addition to the routine taekwondo training program. Static and dynamic balances of the subjects, both right and left legs were assessed with the Biodex Balance System. ANOVAs showed that the BOSU decreased both the static and the dynamic balance error scores of non-dominant leg from pre to post-training by 0.32±0.17 (28.5%) and 0.75±0.47 (82.5%); respectively ($p<0.05$). Furthermore, the BOSU decreased the dynamic balance error scores of dominant leg from pre to post-training by 40.33% ($p<0.05$). This study demonstrates that the taekwondo-specific BOSU training program is effective in decreasing the balance error scores in dominant and non-dominant leg. It is suggested that the BOSU training can be applied as an effective exercise program for enhancing dynamic and static balance performance.

Keywords: BOSU, balance, core, stabilization, taekwondo

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IZVLEČEK

Namen te raziskave je bil oblikovati trening za stabilizacijo in ravnotežje trupa, specifičen za taekwondo, ter ugotoviti, kako protokol vadbe za stabilizacijo trupa z uporabo žoge BOSU vpliva na dinamično in statično ravnotežje pri mladostnikih, ki trenirajo taekwondo. 24 vrhunskih mladih taekwondoistov smo naključno razdelili v dve skupini: prva je trenirala z žogo BOSU (n = 13), druga pa je bila kontrolna skupina (n = 11). Skupina, ki je vadila z žogo BOSU, je poleg svojega običajnega treninga taekwondoja 12 tednov izvajala vaje za stabilizacijo trupa, in sicer trikrat na teden. Kontrolna skupina ni imela vadbenega protokola, ampak samo običajni trening taekwondoja. Statično in dinamično ravnotežje merjencev, tako na desni kot levi nogi, smo ocenili s sistemom Biodex Balance. ANOVA je pokazala, da je žoga BOSU zmanjšala ocene napake statičnega in tudi dinamičnega ravnotežja pri nedominantni nogi ob merjenju pred treningom in po njem za 0,32 ± 0,17 (28,5 %) oz. 0,75 ± 0,47 (82,5 %) ($p < 0,05$). Poleg tega je vadba z žogo BOSU zmanjšala ocene napake dinamičnega ravnotežja pri dominantni nogi pri merjenju pred treningom in po njem za 40,33 % ($p < 0,05$). Raziskava je pokazala, da program treninga z žogo BOSU, posebej prilagojenega za taekwondu, učinkovito zmanjša ocene napak pri dominantni in nedominantni nogi. Predlaga se izvajanje treninga z žogo BOSU kot učinkovitega vadbenega programa za izboljšanje dinamičnega in statičnega ravnotežja.

Ključne besede: BOSU, ravnotežje, trup, stabilizacija, taekwondo

INTRODUCTION

Taekwondo (TKD), besides being an official Olympic sport, is one of the world's most popular sports among children and adolescents (Fong, Fu & Gabriel, 2012). To perform the tasks required in this sport, physical abilities such as strength, speed, endurance, balance, flexibility, and coordination are essential for the athletic performance (Lystad, Pollard & Graham, 2009). Taekwondo is popular with its kicking techniques, in which unilateral stance stability is crucial and is a determining factor of success in the competitions (Pieter, 2009). For Taekwondo players, the importance of balance at landing during kicks or steps takes a part of fitness factors. Fitness factors such as the ability to turn quickly, quickness, agility, and balance are required in Taekwondo games because attacks and defensive maneuvers are made in response to the movements of opponents, and at least 90% of attacks are made with foot techniques (Yoon, Sung & Park, 2015; Čular, Miletić & Miletić, 2010). Besides, the deficit of postural balance may lead to the system body instability, overload passive musculoskeletal structures and consequently to disorders, pain, and falls. In fact, approximately 3.9% of the neuromuscular and orthopedics disorders come from neuromuscular balance deficits (Kazemi et al. 2009).

Core stabilization-balance training improves the strength and the balance performance through perturbation of the musculoskeletal system that enhances neuromuscular capability, quickness, and reaction (Cox, Lephart & Irrgang, 1993; Laskowski, Newcomer-Aney & Smith, 1997; Wolf, Barnhart, Ellison & Coogler, 1997; Sung et al., 2016; Arslanoglu, Aydogmus, Arslanoglu & Senel, 2010). Regarding the young TKD athletes, it is widely known that balance is one of the most important coordination motor abilities of elite athletes. Postural balance is essential to the practice of TKD techniques since most of the movements are performed on one-leg support (Rabello et al., 2014).

There are many different core stabilization-balance training products available, it is focused on the Both Sides Utilized (BOSU) balance trainer (Bosu Fitness, LLC, SanDiego, CA, USA), which has become increasingly popular over the past several years (Laudner & Koschnitzky, 2010). The BOSU is a device that was designed for balance training. The design of the BOSU provides a solid plastic base integrated with an inflatable rubber bladder that resembles a halved Swiss ball. The BOSU has a solid surface facing down that which provides an unstable surface on stable ground with it's facing down design. Furthermore, it's design aims to improve stability not only while the user maintains an upright position, but also when the user is in a horizontal position (Yaggie & Campbell, 2006).

There is no other study in published literature about the effects of static and dynamic balance improvements after taekwondo-specific BOSU training. The purposes of this study are to develop taekwondo-specific core stabilization-balance training and to determine the influence of a stabilization-exercise protocol, using the BOSU, on dynamic, static and postural balance performance in elite TKD athletes.

METHODS

Participants

Twenty-four professional adolescent taekwondo athletes, aged 15-17 years who had done experienced-taekwondo for at least 3 years were included in this study. Subjects were paired regarding

gender and were randomly assigned to BOSU-trained (n=13) and control (n=11) groups. The mean age was 16.8 years, mean height was 168.78 cm, mean weight was 61.4 kg, mean body mass index (BMI) was 24.2 in the BOSU-trained group while the mean age was 17.11 years, mean height was 168 cm, mean weight was 60.54 kg, mean BMI was 24.2 in the control group. The characteristics are shown in Table 3. All subjects and their parents had read and signed an institutionally approved informed consent form before the evaluations. The study was approved by the Ethics Committee of University, and parents of each subject provided an informed consent in written form before participation.

Study protocol

A routine taekwondo training program included cardio, lower extremity strengthening, stabilization, flexibility, and sport-specific skills at least 2h/d, 6 times a week for all the groups. Subjects

Table 1. 12-wk stabilization training program.

Periodization												
Weeks		**1**			**2**			**3**			**4**	
Sessions	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Number of Action	10	10	10	10	10	10	10	10	10	10	10	10
Set	1	1	1	1	1	1	1	1	1	1	1	1
Rep	2	2	2	2	2	2	2	2	2	2	2	2
Time(s)	2x30"	2x30'	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"
Rest(s)	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"
Training Mode	BBA + JBB	BBA + JBB	BBA + JBB	BBA + JBB	BBA + JBB	BBA + JBB	JBB + SFG	JBB + SFG	JBB + SFG	JBB + SFG	JBB + SFG	JBB + SFG
Weeks		**5**			**6**			**7**			**8**	
Sessions	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Number of Action	10	10	10	10	10	10	10	10	10	10	10	10
Set	1	1	1	1	1	1	1	1	1	1	1	1
Rep	2	2	2	2	2	2	2	2	2	2	2	2
Time(s)	2x30"	2x30'	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"
Rest(s)	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"
Training Mode	SFG + DFG	SFG + DFG	SFG + DFG	SFG + DFG	SFG + DFG	SFG + DFG	BBA + TABB	BBA + TABB	BBA + TABB	BBA + TABB	BBA + TABB	BBA + TABB
Weeks		**9**			**10**			**11**			**12**	
Sessions	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Number of Action	10	10	10	10	10	10	10	10	10	10	10	10
Set	1	1	1	1	1	1	1	1	1	1	1	1
Rep	2	2	2	2	2	2	2	2	2	2	2	2
Time(s)	2x30"	2x30'	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"	2x30"
Rest(s)	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"	2x45"
Training Mode	DFG + TAFG	DFG + TAFG	DFG + TAFG	DFG + TAFG	DFG + TAFG	DFG + TAFG	CKP	CKP	CKP	CKFG	CKFG	CKFG

BBA: Basic Bosu Action; **JBB:** Jumping on Bosu Ball; **SFG:** Static on Bosu Action from Flat Ground; **DFG:** Dinamic on Bosu Action from Flat Ground ; **TABB:** Technical Action on Bosu Ball ; **TAFG:** Technical Action on Bosu from Flat Ground; **CKP:** Co-work with Kick Pad On Bosu Ball; **CKFG:** Technical Action on Bosu from Flat Ground

Table 2. Training program with BOSU.

Basic Bosu Action	**Static on Bosu Action from Flat Ground**	**Technical Action on Bosu Ball**
1 - Plank (feet on ball)	1 - Plank (feet on a ball)	1 - Ap-Chagi (right-left)
2 - V-Side	2 - Squat (stand on a ball)	2 - Palding (right-left)
3 - Squat jump on ball	3 - Raising one leg and keeping (right-left)	3 - Duit-Chagi (by step on to ball)
4 - Crunch (hip on ball)	4- Hip Raise and standing (feet on ball)	*4 - Yop-Chagi* (right-left)
5 - Forward Lunch – Side Lunch	5- Straight leg backward altitude	*5 - Huryochagi- Pandalchagi*
Jumping on/on to Bosu Ball	**Dynamic on Bosu Action from Flat Ground**	**Technical Action on Bosu from Flat Ground**
1 - Double feet jumping on to ball	1 - One leg circle internal-external	1 - Ap-Chagi (right-left)
2 - Bounce on fingertip on ball	2 - Push Up (feet on ball)	2 - Palding (right-left)
3 - Steps (right leg –left leg)	3 - Squat	3 - Duit-Chagi (by step on to ball)
4 - Tuck Jump	4 - Hip Raise - Hip Lower (feet on a ball)	*4 - Yop-Chagi (right-left)*
5 - Forward Lunch – Side Lunch	5 - Tuck position on one straight leg (raising and lower/right-left)	*5 - Huryochagi- Pandalchagi*

in BOSU-trained group had stabilization training 3 times a week for 12 weeks in addition to the routine taekwondo training program. The control group followed only a routine taekwondo training program for the same duration. All athletes completed a pretest and a posttest designed to determine whether individuals experienced a positive response from Taekwondo-specific stabilization-balance training program (BOSU-trained) or not. The balance training on the BOSU began within the 2 days following the pre-test. The stabilization-training protocol was consisted of exercises program from the simplest to most complex sessions. The 12-week BOSU stabilization-training program is detailed in Table 1-2.

Balance measurement

All subjects completed a standardized warm-up program. The leg dominance of subjects were evaluated through the sandbag kick test. For the sandbag kick test, the used leg for kicking the sandbag was identified as the dominant leg. The static and dynamic balance errors of subjects were assessed with the Biodex Balance System (Biodex Medical Systems, Shirley, NY). To begin, participants stood on their dominant and non-dominant leg on the Biodex Balance System's locked platform. Subjects were asked to stand in the most comfortable position on the platform. Horizontal and vertical leg positions were recorded so that they could be in the same leg position each time. The platform was then unlocked to allow motion. Dominant and nan-dominant leg static and dynamic balance tests were repeated 3 times with a 10 seconds rest interval for 20 seconds. Subjects were asked to keep their other legs in the flexion position from 90 degrees during the single leg balance tests. The balance error scores (BES) were evaluated as the average of 3 repetitions.

Data process and analysis

SPSS for Windows (Version 22.0) was used for statistical analyses. All variables were examined to determine their normal distribution. Data are presented as means (M) and standard deviations (SD). One-way analysis of variance (ANOVA) was conducted to compare the two groups at pre and post-training. Whenever a significant interaction effect of group by time was demonstrated, pairwise t-tests were used to investigate whether there was any within-group difference between the two assessments. The level of significance for all statistical analysis was set at $p< 0.05$.

RESULTS

The means and standard deviations of descriptive statistics for the subjects can be found in Table 3.

Table 3. Descriptive statistics for BOSU-trained and control groups.

		n	Min.	Max.	Mean	Std. Dev.
	Age (yr)		16	19	16.57	0.85
	Weight (kg)		53.7	70	61.4	7.82
BOSU-trained	Height (cm)	14	146	181	168.8	9.8
	BMI(kg/m2)		19.7	31.0	25.9	3.4
	BFP (%)		10.2	24.1	18.5	4.9
	Age (yr)		16	19	17.11	1.05
	Weight (kg)		51.9	70.3	60.54	6.11
Control	Height (cm)	12	160	177	168	6.32
	BMI (kg/m2)		20.2	28.0	24.2	2.4
	BFP (%)		11.4	20.8	15.3	3.0

BMI: Body Mass Index, BFP: Body Fat Percentage

The results of this study showed that the BOSU decreased both the static and the dynamic balance error scores of non-dominant leg from pre to post-training by 0.32±0.17 (28.5%) and 0.75±0.47 (82.5%) respectively ($p<0.05$). The dynamic balance error scores of non-dominant leg of BOSU-trained group were significantly lower than the control group in post-training ($p<0.05$)

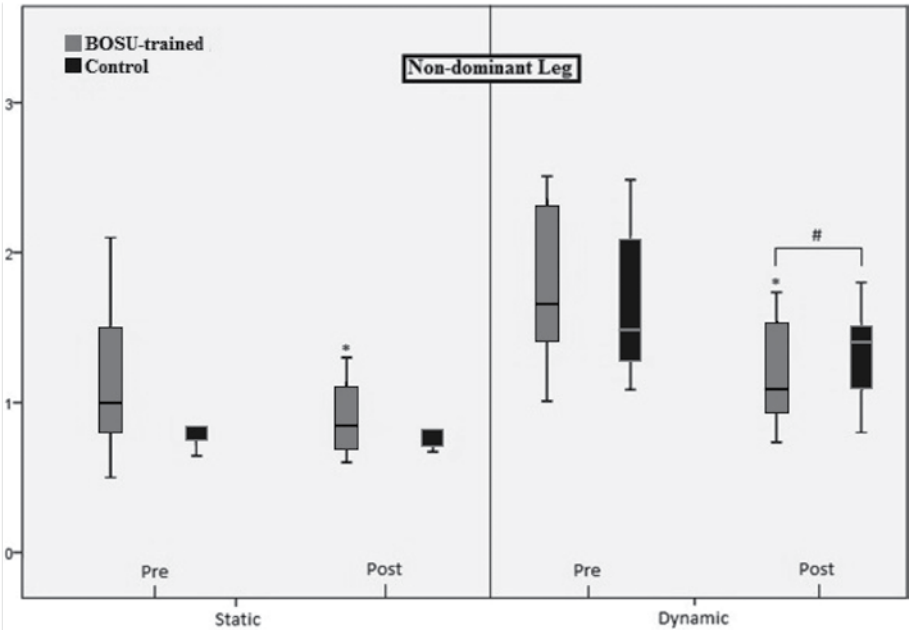

Figure 1. Comparisons of the non-dominant leg balance error scores. *Significant difference compared with Pre ($p<0.05$). #Significantly different between BOSU-trained and control groups ($p<0.05$).

(Figure 1). Besides, the non-dominant static balance error score of BOSU-trained group in the post-training was significantly lower compared to the control group ($p<0.05$) (Figure 1).

There were no significant differences between the pre-training balance error scores of both groups in dominant and non-dominant leg ($p>0.05$) (Figure 1-2). The BOSU decreased the dynamic balance error scores of dominant leg from pre to post-training by 0.48 ± 0,31 (40.33%) ($p<0.05$). The dynamic balance error scores of dominant leg of BOSU-trained group were significantly lower than the control group in post-training ($p<0.05$) (Figure 2).

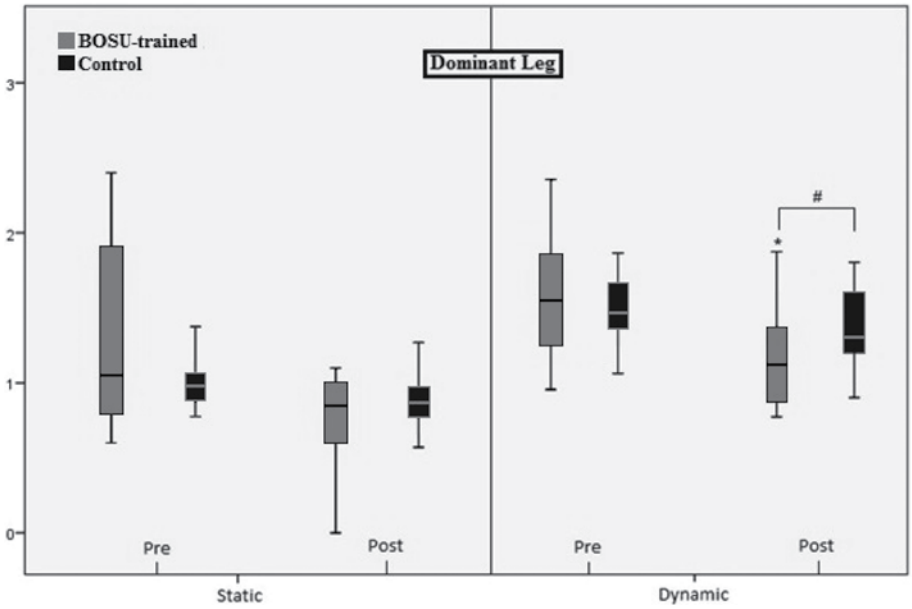

Figure 2. Comparisons of the dominant leg balance error scores. *Significant difference compared with Pre ($p<0.05$). #Significantly different between BOSU-trained and control groups ($p<0.05$).

DISCUSSION & CONCLUSIONS

The main purpose of this study was to develop a 12-week Taekwondo-specific multi-directional stabilization-balance (BOSU) training to examine whether this training affected the static and dynamic balance performance of the adolescent taekwondo athletes or not. It has been indicated in previous studies that taekwondo training improves the balance performance (Fong, Fu & Gabriel, 2012; Fong, Tsang & Gabriel, 2012; Pons Van Dijk et al., 2013), but it is not known what effect stabilization-balance training has on dynamic and static balance performance of taekwondo athletes in addition to taekwondo training. Balance training is a frequently used method for rehabilitation-purpose after sports injuries (Caraffa et al., 1996). However, in sports such as Taekwondo where top-level balance ability is required, stabilization-balance training is not only important for the rehabilitation-purpose but it is also important for the performance development.

Yoon et al. (2015) carried out a study on thirteen taekwondo athletes, indicating that a general core stabilization training of eight-weeks resulted in an increase in the muscular strength and

balance of the athletes. Besides, in a study conducted by Marshall and Murphy (2005), core stabilization-balance trainings have been shown to improve postural balance and stability by activating abdominal muscles. These studies specified support the results of the research we have done.

The data obtained from the study showed that BOSU training improved all aspects of balance. After BOSU training, the static balance error score of the non-dominant foot improved by 28.5%, while the improvement in the dynamic balance error score was 82.5%. In the dominant foot, only 40.33% change in the dynamic balance error score was observed. The development of balance in the non-dominant foot was both static and dynamic oriented, whereas only a dynamic oriented development was seen in the dominant foot. An increase in the static balance performance of the dominant foot has been observed, although it was not statistically significant. It is noteworthy that the development on non-dominant foot is greater than the dominant one. The reason for the greater non-dominant foot development after training is thought to be due to the use of the non-dominant foot as the supporting foot while taekwondo athletes practicing their techniques mostly with the dominant foot. It is recommended to apply this developed BOSU training to all age categories of taekwondo athletes in a sports branch where the balance ability such as Taekwondo is at the forefront.

The result obtained from this study differs when compared to similar studies (Lin, Liu, Hsieh & Lee, 2009; Van Der Harst, Gokeler & Hof, 2007; Verhagen et al., 2005). Verhagen et al. (2005) specified that there was no significant difference found in the dominant and non-dominant balance scores after volleyball and balance exercise applied to thirty university students. In another study, when the balance scores of the dominant and non-dominant feet of soccer players were compared, it was found that the non-dominant foot score was better although there was no statistical difference (Gstöttner et al., 2009). Contrary to these studies, Daneshjoo et al. (2012) reported that as a result of the stabilization training they performed as an eight-week warm-up protocol, the dominant foot balance scores were better than non-dominants. Besides, when the previous studies were examined, neither static nor dynamic oriented performance comparison was found in balance performance after the applied stabilization training (Myer, Ford, Brent & Hewett, 2006; Sever et al., 2016; Fong, Fu & Gabriel, 2012).

Since this study was conducted with limited resources, it did not reveal whether there was any change in the postural analysis of taekwondo athletes after the BOSU training. Another limitation of the study can be said the number of subjects were 24 and the test was only applied to the adolescent taekwondo athletes. This training program, which will be performed to the athletes on a higher number of subjects and from different branches, will provide more general and clear results for all athletes.

As a result, it has been seen that the BOSU training program which includes taekwondo-specific techniques we developed previously have improved both static and dynamic balance performance. It is also an object of curiosity which rehabilitation-purposed consequences could be generated by this training program for the future studies regarding the injured taekwondo athletes.

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