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The Effect of Teaching with Slackline Exercises on Balance Skills Learning of University Students

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Abstract

This study aims to analyze the impact of slackline exercises on the balance skills of university student on their learning. Twenty university student kickboxers voluntarily attended the study (8 women and 12 men). They were randomly divided into two groups (each group four females and six males) as the experimental group (EG) and the control group (CG), each consisting of 10 subjects. CG only followed regular training, while EG applied supervised slackline exercises for two days a week and 10 min sessions in addition to regular training for 4-week. Some tests were done before and after slackline exercises in the evaluation of all participants: counter movement jump, standing long jump, leg strength test, back strength test, static balance test "Stork Stand Balance" (SST) and dynamic balance test. According to the post-test results, the SST values which are the static balance test of EG were significantly higher than the CG. As a result, if slackline exercises, which are organized in addition to the regular training sessions specific to the branch, are applied in more extended periods, it can contribute to the balance skill learning and the balance necessary for performing technical movement.

Keywords: balance teaching, physical education, athlete student, slackline

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Introduction

Combat sports involve dynamic and high-density intermittent activities that require complex skills and tactical perfection. In these sports, successful performance is determined by powerful actions that are performed in unpredictable situations. (Matsushigue et al., 2009; Silva et al., 2011). Kickboxing is a mix of martial arts based on barefoot kicking like karate and punching like boxing. During the fight, the goal is to use power, sports-specific skills, and endurance to prevail physically (Streissguth, 2008).

In recent years, the Ministry of National Education has encouraged students to participate in physical and sports activities in schools. Because mental health is known to be related to physical fitness (Ozkara, et al., 2016). As in all sports branches at universities, students are very interested in combat sports.

A formal fight consists of three rounds of two minutes each and one-minute rest between rounds. As in many martial arts, kickboxing athletes' work done depends on both aerobic and anaerobic power (Buse, 2009). In a fight, kickboxing athletes' average cardiovascular responses, lactate levels, and perceived effort rates gradually increase from round one to the end. As a result, there is a significant decrease in concentric quadriceps strength, hamstring strength, hamstring-quadriceps strength ratio, and kicks and punches towards advancing rounds. (Salci, 2015)

During the fight, kickboxer tries to dominate by using the kicking and punching techniques thanks to his robust conditional features, and by developing the best tactics against the opponent by considering his weaknesses thanks to his superior characteristics. A sweeping technique, one of the critical techniques, is used to disrupt the balance of the opponent by reducing the resistance of the opponent for a good attack. The opponent's balance should be observed well. The opponents try to create a good kick or punch opportunity by unbalancing each other. Accordingly, fighters must have an extensive movement repertoire to take a good balance position after a move that will overbalance them. They should possess an excellent balance capability in both offensive and defensive actions (O'Keefe, 2005).

Postural control or balance can be defined as maintaining a support base with statically minimal motion and the ability to accomplish a task while keeping a dynamically steady position (Winter et al., 1990). Factors concerning balance involve sensory information and coordination from somato-sensorial, visual and vestibular systems, joint motion range and motor reactions that affect strength. (Grigg, 1994; Palmieri et al., 2002). While considerable studies are demonstrating the relationship between balance and postural control and athletes' risk of disability (Hrysomallis, 2007), the relationship with the performance is unclear (Hrysomallis, 2011).

According to the characteristics of sports branches, athletes (such as gymnasts) have superior balance skills in some branches, which has been put forward in the meta-analyses examining previous studies. Also, studies have been conducted examining athletes' balance skills with regards to competition levels and experience levels. In studies examining the relationship between athletes' balance skills and performance in different branches, it has been stated that elite athletes have higher equilibrium skills than the lower elites and achieve better results in branch-specific performance. (Hrysomallis, 2011)

Specialized balance training is effective for the recovery of postural and neuromuscular control of athletes. (Zech, et al., 2010). Slacklining, a kind of fun activity, has recently developed into a vital balance training that enhances balance and power performance. Slackline consists of a mechanism in which a durable band made of polyester material with a width of 2.5-5 cm, and a length of 6-20 m is tightly stretched between two solid poles fixed on the ground. It is then adjusted at a height and tension that will not touch the ground due to the stretch that occurs when the band is climbed on. In slacklining exercises, movements such as standing, walking, jumping, and turning on the band need an excellent postural balance, core body strength, and focus when performing with one foot and both foot. Since it gives a small unstable support base and produces very fast medio-lateral perturbations to the body, slacklining provides very high motion variability. (Pfusterschmied et al., 2013; Donath et al., 2017; Kosmalla et al., 2018; Fernandez et al., 2019). Besides, slackline exercises were further improved, and the opportunity to train with an interactive method projected on the screen with computer software was developed (Kosmalla et al., 2018).

A meta-analysis study of slackline workouts shows the significant task-specific exercise effects of slackline practices, which are most closely related to training content such as slackline standing time and dynamic stance balance in balance performance tasks. In these studies, it has been stated that transfer effects on static and dynamic posture balance performance tasks are limited (Donath, et al., 2017).

In the current literature information, it has been found that slackline training has led to improvements in studies specific to slackline. Still, there is no definite conclusion about the effects of this improvement on balance ability. This study aimed to examine the effect of additional slackline training on balance performances applied by university student elite kickboxers for four weeks.

Method

Participants

A total of twenty students, including a university student kickboxer 10 athlete experimental group (EG) and 10 athlete control group (CG), participated in the study. The average of age, height, year of experience, dominant foot and gender distributions are given in Table 1, (respectively: 22.10 ±

2.03 - 21.90 ± 2.38 yrs, 171.90 ± 7.58 - 172.40 ± 9.66 cm, 7.50 ± 5.50 - 6.90 ± 3.00 yrs., right/left: 9/1 - 8/2 and female/male: 4/6 - 4/6). The study was conducted following the Declaration of Helsinki and was authorized by the Muğla Sıtkı Koçman University Ethics Committee. All participants were notified of the potential risks and ailments of the testing procedures and informed in written and gave consent to participate in the study.

Table 1. Participants' demographics and baseline characteristics. (mean±sd)

Demographics	EG (n=10)	CG (n=10)
Age (years)	22.10±2.03	21.90±2.38
Body height (cm)	171.90±7,58	172.40±9.66
Experience (years)	7.50±5.50	6.90±3.00
Dominant foot-hand (right/left)	9/1	8/2
Sex (female/male)	4/6	4/6

EG: experimental group, CG: control group

Experimental design

In this study, a random parallel group design was adopted. Participants were randomly assigned to the experimental (EG) and control (CG) group. While both groups performed their planned kickboxing lesson for four weeks, the EG group additionally practiced "slackline" exercises for two days and 10 minutes a week (see slackline education protocol). They applied static and dynamic balance tests before (pre-test) and after (post-test), leg strength, back strength, Counter Movement Jump and Standing Long Jump tests (see testing procedures).

Slackline training protocol

Both groups applied the planned kickboxing training five days a week. The experimental group also (EG) performed slackline exercises for 10 minutes, two consecutive days a week, for four weeks. While the EG was training slackline, the control group (CG) continued their kickboxing training during this period. Slackline training was designed as a part of routine kickboxing training and implemented to the experimental group. In a suitable part of the kickboxing training hall in school, slackline, a 5 cm wide and 10 m long polyester material woven tape, which is mounted on two walls with a distance of 10 m, at the height of 50 cm from the ground, is stretched by attaching to solid hooks. The slackline was adjusted to the tightness of at least 25 cm high above the ground when stepped on. The floor is covered with soft floor cushions to be safe against the risk of falling.

Education program applied to the experimental group

After the subjects were offered the required prior knowledge about the slackline, they were divided into pairs and started the exercises with an instructor.

Week 1: Slackline exercises; standing on the band, stepping forward, and backward exercises were done as paired and fully assisted.

Week 2: Stepping forward and backward and semi-assisted walking exercises were done on the band as paired and semi-assisted.

Week 3: Walking, turning, kneeling, standing up, raising feet, punching and kneeling hitting exercises were done as paired and assisted.

Week 4: Unassisted walking and kicking on the band, kneeling exercises, and exercises to resist the small blows that would disturb the balance on the band were done.

Testing procedures

Leg Strength Test (LST). The chain length on the dynamometer was adjusted so that the players squatted over the dynamometer with their knees flexed at approximately 30˚.

Back Strength Test (BST). Their legs were straight and their back was flexed to allow the bar to be at the level of the patella. A back dynamometer (Takei, Tokyo, Japan) was used in the two tests. The tests were repeated twice, and the best score was retained (in kg) (Ten Hoor et al., 2016; Nikolaidis et al., 2014; Skinner, 2005).

Counter Movement Jump (CMJ). The participant jumped vertically as high as possible using both arms and legs to assist in projecting the body upwards. The jumping height was determined by subtracting stand reach height from jumping reach height. The test was repeated twice, and the best score was retained (in cm) (Castro-Pinero, et al., 2009).

Standing Long Jump (SLJ). The participant stood behind the starting line, with feet together, and pushed off vigorously and jumped forward as far as possible. The distance is measured from the take-off line to the point where the back of the heel nearest to the take-off line lands on the mat or non slippery floor. The test was repeated twice, and the best score was retained (in cm) (Castro-Pinero et al., 2009).

Static Balance Test "Stork Stand Balance" (SST). Static balance was assessed using the Stork stand balance (SST) protocol. To perform the Stork stand test, participants stood with their opposite foot against the inside of the supporting knee, and both hands on his hips. On the command, the subject raised the heel of their foot from the floor and attempted to maintain their balance as long as possible. The trial ended if the subject moved his hands from his hips, the ball of the dominant foot moved from its original position, or if the heel touched the floor. This test was carried out on the dominant and non-dominant leg acting as the standing leg. The test was timed (in seconds) using a stopwatch. The total time was recorded in seconds. The score was the best of 3 attempts. (Chaouachi et al., 2014; Hammami et al., 2016; Makhlouf et al., 2018)

Dynamic Balance Test (DBT). Dynamic balance ability was measured by [Prokin Tecno Body, PKW 200 PL, Italy]. TechnoBody PK200WL (Prokin Tecno Body, PKW 200 PL, Italy) computerized balance device was used for dynamic balance assessment (http://www.tecnobody.it). The subject's barefoot was placed on the balance platform in a standardized position (the maximum point of the medial longitudinal arch was projected on the x-axis and the distance between feet was 8 cm). The test compromises trying to move in a reference circle seen on the computer screen which provides continuous visual feedback to understand the difference between what he/she was feeling on a kinaesthetic level and what is actually happening at motor level (Fousekis et al., 2012).

Dynamic balance on the right foot (RF), on the left foot (LF) and on bipedal stance (BS) were tested with open eyes separately for 30-s and medium mode was used. Test was conducted twice for each participant. The rest duration for each measurement was 60 second. Test results included 5 parameters that Perimeter Length (PL) was used to evaluate the dynamic balance skills of the athletes. (PL:The total degrees came about during the test time). All measurements were performed in lab by the same expert.

Statistical Analyses

Data are presented as mean and standard deviation. The normality test (Kolmogorov-Smirnov) was applied to the data of all variables as a result of the tests (pre-post test) applied by both groups (experimental-control group). In-group and inter-groups comparison tests (paired-sample t-test) of some motoric tests and balance tests applied to the experimental and control groups before and after 4-weeks were completed. The significance level was set at $p < .05$. SPSS (version 22.0) was used in all analyzes. Finally, effect size (Cohen’s d) was also assessed (small < .50; moderate .50- .79; large ≥ .80). (Cohen, 1988).

Results

As a result of the tests, a significant difference was observed between the EG and CG post-test values in the balance values of the right foot and left foot in the stork balance test (SBT), which is the static balance test ($p < .05$).

SST post-test averages of EG were higher than CG post-test values for right foot (RF) and left foot (LF) (respectively: SST-RFpost EG = 13.10 ± 3.14; CG = 10.00 ± 2.58. SST-LFpost EG=13.70± 3.71; CG= 10.50 ± 2.92), ($p< .05$). The effect size for both was found to be large (RF-d = 1.08, LF- d = .96).

As a result of dynamic balance tests for both groups, the difference between the mean pre-test and post-test values of double feet, right, and left foot PL was not significant. Although not significant, an improvement was observed in the dynamic balance skill of both groups, and a setback was seen in dynamic balance skill in the right foot. There was no significant difference between the dynamic balance post-test values between the groups ($p <0.05$) (Table 2 and 3).

Table 2 Comparison of balance skills and motor skills pre-test and post-test results within groups

Variables	Tests	EG (n=10)				CG (n=10)			
		Mean±Sd	t	p	ES	Mean±Sd	t	p	ES
Body mass (kg)	Pre	65.71 ± 11.58	.19	.85	.08 small	65.20 ± 11.05	-.14	.89	.06 small
	Post	64.73 ± 11.95				65.90 ± 11.34			
Leg strength (kg.m)	Pre	96.30 ± 29.32	-.15	.88	.07 small	90.45 ± 35.86	-.03	.97	.02 small
	Post	98.40 ± 34.06				91.00 ± 38.99			
Back strength (kg.m)	Pre	109.30 ± 38.73	-.09	.93	.04 small	94.30 ± 31.98	-.03	.98	.01 small
	Post	110.75 ± 33.64				94.70 ± 31.07			
Vertical jump (cm)	Pre	39.60 ± 10.35	-0.08	.94	.04 small	36.90 ± 10.34	-.71	.49	.32 small
	Post	40.00 ± 11.54				39.90 ± 8.45			
Standing long jump (cm)	Pre	211.60 ± 35.35	-.034	.74	.15 small	196.90 ± 36.11	-.31	.76	.14 small
	Post	216.80 ± 33.46				202.00 ± 36.72			
Stork Balance Test Right foot (sec)	Pre	10.50 ± 3.21	-1.83	.08	.82 large	8.60 ± 2.59	-1.21	.24	.54 mid
	Post	13.10 ± 3.14				10.00 ± 2.58			
Stork Balance Test Left Foot (sec)	Pre	11.90 ± 4.18	-1.02	.32	.46 small	9.10 ± 2.23	-1.21	.24	.54 mid
	Post	13.70 ± 3.71				10.50 ± 2.92			
Bipedal Balance Test (PL)	Pre	470.12±77.83	.67	.51	.30 small	450.20±106.33	.23	.82	.10 small
	Post	446.59±78.78				439.40±106.15			
Right Foot Balance Test (PL)	Pre	487.89±157.95	-.26	.80	.12 small	435.32±167.23	-.51	.62	.23 small
	Post	504.93±137.32				473.76±172.60			
Left Foot Balance Test (PL)	Pre	467.80±107.04	.53	.42	.37 small	504.71±191.97	.79	.44	.35 small
	Post	425.62±121.30				446.81±128.91			

EG: experimental group, CG: control group, ES: effect size-Cohen’s d, PL: Perimeter Length, *p< .05

Table 3 Comparison of balance skills and motor skills pre-test and post-test results between groups

Dependent Variables	Tests	Between Groups		
		t	p	ES
Body mass (kg)	Pre	.10	.92	.05 small
	Post	-.23	.83	.10 small
Leg strength (kg.m)	Pre	.40	.69	.07 small
	Post	.46	.66	.23 small
Back strength (kg.m)	Pre	.94	.36	.42 small
	Post	1.11	.28	.50 mid
Vertical jump (cm)	Pre	.58	.57	.26 small
	Post	.02	.98	.01 small
Standing long jump (cm)	Pre	.92	.37	.41 small
	Post	.94	.36	.42 small
Stork Balance Test Right foot (sec)	Pre	1.46	.16	.65 mid
	Post	2.41*	.027	1.08 large
Stork Balance Test Left Foot (sec)	Pre	1.87	.08	.83 large
	Post	2.14*	.046	.96 large
Bipedal Balance Test (PL)	Pre	.48	.64	.21 small
	Post	.17	.87	.08 small
Right Foot Balance Test (PL)	Pre	.72	.48	.32 small
	Post	.45	.66	.20 small
Left Foot Balance Test (PL)	Pre	-.53	.60	.24 small
	Post	-.38	.71	.17 small

EG: experimental group, CG: control group, ES: effect size-Cohen’s d, PL: Perimeter Length, *p< .05.

In addition to balance skills, when skills such as leg and back strength of slackline exercises, Counter movement jump, and long jump are examined, there was no significant difference between the pre-test and post-test averages of the groups and within-groups ($p < .05$). However, we see an improvement in these skills, as the post-test averages are higher than the pre-test.

Discussion, Conclusion and Recommendations

While four-week slackline exercises applied in addition to classical training did not significantly affect the dynamic balance skill advancement of EG in the balance skill training of university athletes, it significantly enhanced their static balance skills. With the effect of classical and additional training, both groups advanced their leg and back strength, counter movement jump and long jump skills, double-foot, and left foot dynamic balance skills, although not significantly.

By using devices such as bosu ball, trampoline, duradisc, and balance board, balance skills have been trained and improved (Kidgell, 2007). The application of slackline exercises, which are regarded as a new exercise technique to enhance balance skills, is increasing day by day.

In the meta-analysis study, Donath et al. (2017) examined the research on the effect of slackline exercises on balance performance and he reported that slackline exercises mainly produced significant task-specific training effects in balance performance tasks, mostly related to training content such as slackline standing time and dynamic standing balance and that their transfer to static and dynamic standing balance performance tasks was limited. They suggested that slackline training should be included in combined training programs and not used as a single balance training form.

The studies concerning the effect of slackline exercises on balance, focus on three essential points. These are the effects of dynamic balance, static balance, and balance development associated with task-specific slackline exercises.

Giboin et al. (2015) reported a significant improvement in standing and dynamic balance performance on slackline only compared to static balance performance. It can be stated that these results are compatible with the "task-specific principle" of neuromuscular adaptations highlighted after balance training. The results of this research emphasize that slackline type exercises can be limited to transferring and generalization to other balance tasks. In a similar study, Naumann et al. (2015) stated that while game-based balance training showed significant improvements in task-specific balance skills, this balance skill did not have a significant effect on transferring to other balance tasks and reducing postural oscillation.

Related studies show unclear results concerning the transfer of the development in task-specific balance skills to other balance skills. It is emphasized that the effect of trained balance skill on task-specific balanced development can be explained by the "postural synergy" paradigm. This concept is described by the functional connection of the muscles associated with the task-specific neuromuscular requirements resulting from the repetition of movements for rapid postural responses (Kümmel et al., 2016; Donath et al., 2017).

In addition to studies showing improvements in the development of static one-leg balance as a result of slackline exercises (Santos et al., 2014; Thomas & Kalicinski, 2016), studies are also emphasizing that there is no significant effect (Granacher et al., 2010; Donath et al., 2013; Donath et al., 2016).

There are a limited number of studies on athletic groups. Santos et al. (2016) stated that six weeks of slackline exercises of young female basketball players had significant effects on the improvement of postural control (CoP) parameters and counter movement jump performances. Fernández-Rio et al. (2019) reported that young male football players underwent significant improvement in postural control (CoP) parameters and acceleration, agility, squat jump, and counter movement jump performances after six weeks of slackline exercises.

When the studies on athletes are considered, we observe that slackline training is performed in addition to the classical training sessions specific to the branch. Likewise, our study was conducted with an additional training model. Still, improvement in motor skills other than balance did not reveal any significant diversity in previous studies conducted in groups of athletes in the literature. Also, there was no significant difference in dynamic balance parameters. Although not significant, when the pre-test and post-test values are examined, there is an improvement in both balance and CMJ, SLJ, LS, and BS values. Except for the static balance test SBT-RF and LF, we cannot assume that this improvement is due to the slackline exercises. In previous studies, slackline exercises were followed for six weeks and 5-9 minutes three times a week. The duration and intensity of slackline training in our study seem to be less.

Consequently, if slackline exercises are performed in addition to the main training plans in various sports, they will have a positive effect on the ' balance performance of athletes. Slackline exercises combined with branch-specific movements can provide benefits such as comfortable application of branch-specific technical movements and protection from injury, with the effect of developing postural control after motor learning and neuromuscular adaptation. Trainers and athletes can adapt slackline exercises in addition to their training programs to contribute to their training.

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