Original article

How balance training on different types of surfaces effect dynamic balance ability and postural sway of gymnast children?

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Abstract. *Study Objectives:* This study aimed to examine the impact of balance training performed on stable and unstable surfaces on the dynamic balance of children. *Methods:* The sample of the study consisted of 40 female gymnasts (7 years old). The sample was randomly divided into two groups and the first group (122.85±1.14 cm in height, 24.05±1.04 kg in weight) performed unstable surface training while the other group (123.92±1.33 cm in height, 24.95±1.36 kg in weight) performed stable surface training. Eight-week balance training programs were administered three days a week for 40 minutes a day. The pre and post-dynamic balances of the participants were measured with the Tecno-body ProKin PK200 model dynamic balance device. ML, PL, AGP, MS, and AP parameters were assessed, and comparisons were made by the paired t test in SPSS 17.00 package program. *Results*: While there was a statistically significant difference in all parameters, except for ML values, in the group who performed the balance training on an unstable surface ($p < 0.05$), no statistically significant difference was found in the other group ($p > 0.05$). *Conclusion*: The results showed that training on unstable surface effect dynamic balance and postural sway in a positive way.

Keywords: Dynamic balance, Training, Postural sway, Gymnast, Children

Introduction

In daily life, we experience walking and posture in many different environments. These environments can be very bright or dark, flat, or unstable surfaces. This change in the visual environment provides inconsistent visual input to the postural control system, which leads to a re-estimation of body direction to prevent postural instability (1,2). In this process, a change in the contribution of sensory systems happens because the central nervous system relies less on the sensory system with the discordant formation and on other sensory systems with reliable formation, afterward, inputs from different planning systems are reassembled for use in motor planning and implementation (2,3). Based on this sensory information, the postural response model quickly and efficiently returns the center of body mass to an unbalanced equilibrium position on the support base (4). The rate at which this equilibrium position is captured and the length of time it can be maintained is directly related to the individual's development level of balance.

Assessment of balance ability is a method to determine the muscular response to efferent or afferent stimulation. The equilibrium is said to be mediated by the same peripheral afferent mechanism mediating joint proprioception but may represent lower limb function compared to assessments at a non-weight bearing position (5). Various studies have been conducted to assess postural control and balance to compensate for compensatory distortions and it is seen that, generally, these studies have documented that children show well-organized muscle responses to impairments between the ages of 7 and 10 years, but the amplitude, latency, and duration of responses are greater than that of adults (6-9).

Balance is divided into dynamic balance and static balance. Dynamic balance can be defined as ensuring balance under the conditions that activate the center of gravity in response to one's body muscle activity (10). It is one of the critical auxiliary motor features that optimize the efficiency of functional skills and constitutes the infrastructure of the movement. Factors affecting balance are composed of internal and external factors and various nerves and biomechanical factors work together to affect balance (11). The factors affecting balance include sensory information from the somato-sensor, visual and vestibular system, motor reactions affecting coordination, mobility, and force. Ensuring balance requires three different sources of sensory information, which are visual, vestibular, and proprioception. As a provider of important sensory information, proprioception may help to accurately perceive the position, posture, and movement of the human body, which is important in sensory information (12). The training of each level of the sensory-motor chain (somatosensory, visual, vestibular) may improve the balance control in complex conditions (13,14). Additionally, training age and the types of training affects the postural control directly.

With the increasing number of sports on unstable surfaces and the number of athletes compete on unstable grounds (15). One of these sports which is very popular around the world is gymnastics and balance plays a crucial role in gymnastics. While keeping the aesthetics of movements, the balance must also be maintained. Therefore, balance training should be an important part of gymnastic training (16). The children that have better-developed motor skills could be much more active than the others with less developed motor skills and basic movement skills develop before the age of 8 years (12,17). Consequently, systematic balance, proprioception, and gross motor training in the period before the age of 8 will contribute to the development of the basic movement.

In this context, our hypothesis proposes that training on unstable surfaces would have a positive effect on dynamic balance and sway. The purpose of this study was to investigate the impact of different types of balance training on postural sway and the dynamic balance of children.

Material and Methods

Participants

The sample of the study consisted of n=40 female gymnasts (7 years old) who have been licensed at least 1 year and still active in gymnastics.

Experimental Design

Groups were randomly divided into 2 groups of n=20. The first group (122.85±1.14 cm in height, 24.05±1.04 kg in weight) performed unstable surface training while the other group (123.92±1.33 cm in height, 24.95±1.36 kg in weight) performed stable surface training.

The training was scheduled every other day after the participants get out of the school and administered for 40 minutes. The training was followed in the gym of Ulugazi Primary School Gymnasium. The pre-and post-tests were performed in the same school and gym. The data set was recorded accordingly. Bose ball, sponge, and unstable balance board were used for unstable surface training and a stable balance board, stable surface, balance beam used for stable surface balance training.

General and special warm-ups, including walking, jumping, and running were performed at the beginning of each training session (15 minutes). At the end of the training, a 10-minute cooling down and lower extremity stretching were done and the training

Table 1. Training sample for stable surface group

Monday	Wednesday	Friday
Warm-up (Walking, running, gymnastic specific jumping trainings, stretching) 15 min		
Changing direction while standing on one leg (1 set both for right and left) (15 sec work-30 sec rest)		
Collecting objects from the floor while standing on one leg (right and left feet (1 set both for right and left) (15 sec work-30 sec rest)		
One leg standing stark (1 set for both right and left feet) (15 sec work-30 sec rest)		
One leg standing stark while hands ahead (1 set for both right and left feet) (15 sec work-30 sec rest)		
One leg standing stark while hands up(1 set for both right and left feet) (15 sec work-30 sec rest)		
Cool down 10 min		
The duration of the training session is 40 minutes.		

Table 2. Training sample for unstable surface group

Monday	Wednesday	Friday
Warm-up (Walking, running, gymnastic specific jumping trainings, stretching) 15 min		
Double foot balance on Bosu ball (15 sec work – 30 sec rest x 2 sets)		
Double foot balance on Bosu ball while eyes-closed (15 sec work – 30 sec rest x 2 sets)		
One leg standing stark on Bosu ball (1 set for both right and left feet) (15 sec work-30 sec rest)		
One leg standing stark on Bosu ball while eyes-closed (1 set for both right and left feet) (15 sec work-30 sec rest)		
Forward jumps onto Bosu balls (15 sec work – 30 sec rest x 2 sets)		
Cool down 10 min		
The duration of the training session is 40 minutes.		

was terminated. The duration of each training session was 40 minutes. The training was carried out with certified coaches who are experts in the field. During the first 2-week phase, participants were first adapted to the study by providing basic balance training designed specifically for the groups. The level of training of the groups was updated according to the surface characteristics in the 3rd and 4th weeks. The intensity for each of the groups was increased in the 5th and 6th weeks. Then, training intensities of the groups were increased to the planned level at the 7th weeks to 8th weeks. Bose ball, balance board, sponge, and trampoline were used in unstable surface training.

Test Protocol

Before the study, ethical approval was obtained from Kocaeli University Ethics Committee in accordance with the Helsinki Declaration regarding the content of our study. The approval number is stated as KOÜ KAEK 2015/223. It was explained to the participants before the test protocol that the testing procedure would be terminated in case of holding on to anywhere, stepping down the platform, touching the ground, and looking somewhere other than the monitor. The position of the participants on the platform was explained using auxiliary signs on the device. The pre- and post-tests were applied to each participant 30 seconds in the form of 2 trials - 1 test. The participants were given a 1-minute rest period between each trial.

Tecno-body ProKin PK200 model dynamic balance device was used as the data collection tool in the study. The device has a slope position of 12° from the center to each direction on its horizontal axis. This device is capable of measuring three different difficulty levels (Easy-Medium-Hard). The measurements of the study were done based on 1 trial right to each participant in the "easy" level with a double foot method. Besides, the device was calibrated after each measurement. The examined parameters are as follows:

PL: Perimeter Length

AGP: Area Gap Percentage

MS: Medium Speed (°/sec.)

AP: Medium equilibrium center = Anterior-posterior

ML: Medium equilibrium center = Medial-lateral

The heights of the participants were measured with the help of a tape measure. They were weighted with the EKS brand manual weighing device and the values were recorded.

Statistical Analysis

The data obtained from the pre- and post-tests were analyzed in IBM Statistics SPSS 17.0 for Windows package program. The Paired Samples T-Test was used for the differential analysis of the groups. All tests were performed at 95% confidence interval and p<0,05 significance level.

Results

The mean height of unstable surface group was 122,85 ±1,14 cm and the average weight of unstable surface group was 24,05±1,04 kg. The average height of stable surface group was 123,70±1,33 cm and the average weight of stable surface group was 24,95±1,36 kg. There was no statistically difference found between the height and the weight of the groups (Table 3).

The statistically significant difference was found in the PL, AGP, MS, and AP values between pre-test and post-test results for unstable surface training

Table 3. Demographic information of study group

N=40	Unstable surface(n=20)	Stable Surface(n=20)	p
Height (cm)	122,85±1,14	123,70±1,33	0,272
Weight (kg)	24,05±1,04	24,95±1,36	0,568

Table 4. Results of the Unstable Surface Training Group

		N	X̄	SD	t	p
PL	Pre-test	20	349,18	26,62	4,819	**0,001***
	Post-test	20	206,34	16,23		
AGP	Pre-test	20	,099	,022	5,473	**0,001***
	Post-test	20	-,023	,008		
MS	Pre-test	20	11,64	,887	4,820	**0,001***
	Post-test	20	6,87	,541		
AP	Pre-test	20	-,559	,300	-2,286	**0,034***
	Post-test	20	,230	,238		
ML	Pre-test	20	-,164	,362	-,261	0,797
	Post-test	20	-,063	,150		

*p<0,05

group (p <0.05). Although there is a difference in the mean value, no significant difference is found in ML (p> 0.05) (Table 4).

There were no significant differences in PL, AGP, MS, AP, and ML values between pre-test and post-test results for stable surface training group (p> 0.05) (Table 5).

Discussion and Conclusion

The purpose of this study was to investigate the impact of different types of balance training on postural sway and the dynamic balance of children. Unstable surfaces training group showed a statistically significant difference in the PL, AGP, MS, and AP values (p <0.05). Although there was a difference in the mean value, there is no significant difference in medial-lateral sway (p> 0.05). Childhood is a stage of growth characterized by various biological features. The development in motoric abilities may help children for their physical adaptation to variable situations and increase in performance, consequently, interventions that provide these changes become critical. Distortion of the balance re-creates a flexible signal through the receptors. These receptors are responsible for detecting sudden and unexpected postural changes due to changes in muscle activation and gamma-motor neurons innervate the muscle spindle and adjust the sensitivity of the muscle spindle. Thus, it provides the most appropriate response during muscle contraction (alpha-gamma co-activation) to provide balance as fast as possible (18).

Table 5. Results of the Stable Surface Training Group

		N	X̄	SD	t	p
PL	Pre-test	20	377,32	32,37	,371	0,715
	Post-test	20	365,72	32,15		
AGP	Pre-test	20	,138	,027	1,441	0,166
	Post-test	20	,101	,029		
MS	Pre-test	20	12,57	1,07	,372	0,714
	Post-test	20	12,19	1,07		
AP	Pre-test	20	,086	,400	-,549	0,589
	Post-test	20	,294	,154		
ML	Pre-test	20	,503	,368	-,277	0,785
	Post-test	20	,622	,210		

*p<0,05

The improvement in anterior-posterior could be related to the response or activity of gastrocnemius that block moving the center of mass away and keeping it close to the center of pressure, reducing sway on posture. Due to these improvements, perimeter length did decrease directly, because the sway on the body reduced and the center of mass didn't change. Therefore, the distance traveled on the device was minimized and the amount of angular displacement on the surface was lowered. As opposed to these findings, the stable surface training group didn't show a statistically significant difference in any parameters. Since the balance and body sway were not controlled according to the movement of the surface during the training on unstable surfaces, we found that the control of the body sway and body weight center did not improve significantly in the evaluation on the unstable surface. These results support our hypothesis.

It was previously shown that unstable balance training and gymnastic training have positive effects on dynamic balance and the balance characteristics of the athletes in branches where dynamic balance is prominent are more developed than those in other branches (19-23). In another study, it is indicated that trampoline training was effective in increasing the dynamic balance level (24). By adapting to the unbalanced trampoline surface to achieve stability, changes in complex sensory motor stimulation can be expected and therefore improve balance performance. When previous studies on balance training and muscle activity on unstable surfaces are considered, it is found out that unstable surfaces have positive effects on improving dynamic balance and postural reflex activity (25,26).

Some scientists reported that the subjects who did stable surface training had less development than the ones who did unstable surface training (27). When we evaluate our results together with the results in the literature, we see that one of the criteria for dynamic balance development is to activate visual and sensory motor units by training on unstable surfaces and to adapt the body sway and body stability to these surfaces. Of course static balance training is a method to improve balance, but it is not as effective in improving dynamic balance as dynamic balance training. Literature review revealed that unstable objects, such as biodex balance device, balance disc with soft and hard surfaces, balance board, and swiss ball were used in balance training and balance tests, and some types of balance training were performed on these objects in the upright position, standing on knees and sitting on them (28-31). Additionally, the balance platforms within the Prokin PK series were also used in the studies on dynamic balance tests (32-34).

Recent studies have shown that only children under the age of 12 use different sensory information to maintain a silent posture, and do not compensate for changes in sensory signal quality and size as adults do. Based on these recent results and assuming that the complex relationship between sensory information and motor action is assumed in the development of postural control, balance, and especially postural control, it is assumed that the use of sensory information can be altered in physically practicing postural control and sway (35-37).

The results show that training on unstable surfaces improve dynamic balance ability and reduce postural sway statistically. Improving the balance at younger ages could help the performance in many sport branches. In addition to this, experts can plan similar studies with different sex and age groups. The monthly duration of the training program can be extended to investigate the different motoric effects of trainings. Similar to this study, it can be analyzed the effect of static balance training on dynamic balance by organizing a new experimental group and new training program. Balance trainings can be diversified by using different tools.

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Conflict of interest statement

The authors declare that they have no conflict of interest.

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