EFFECTS OF TRAMPOLINE TRAINING ON JUMP, LEG STRENGTH, STATIC AND DYNAMIC BALANCE OF BOYS

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Abstract

The purpose of this study is to examine the effects of 12-week trampoline training on static-dynamic balance, vertical jump and leg strength parameters in boys who do not exercise regularly. Twenty-eight 9-to10-year old boys were assigned to the trampoline training group (TG, N=15) and control group (CG, N=13) to examine effects of 12-week trampoline training (TT) on leg strength (LS), vertical jump (VJ), static balance (SB) and dynamic balance (DB). TG was given 12-week training, whereas no sport activities were assigned to CG. According to our results, differences between the pre-test and post-test bipedal SB, VJ, DB in TG are statistically significant ($p<0.05$). No significant difference was observed between the pre and post-test results in terms of unipedal SB, LS. Whereas in the CG, there was no significant difference between pre-test and post-test results based on any of the performance parameters ($p>0.05$). 12-week trampoline training increased bipedal SB-DB and VJ parameters; however, it had no effect on unipedal SB and LS parameters in boys. The trampoline training used in our study may form an example for the sports educators for improving strength and balance in children.

Keywords: *trampoline training, postural balance, children, muscle strength, power.*

INTRODUCTION

The ability of balance is one of the coordinative characteristics, like the reaction speed, and rhythm talent, and is an important attribute in learning sportive skills, and shows differences depending on the characteristics of sports branches (Sirmen et al., 2008). For example; while judo trainings have significant effect on understanding somato-sensorial input, dance trainings contribute to a larger extent to the improvement of balance based on visual input (Perrin et al., 2002). Special postural adaptation which is necessary for balance ability can be improved depending specifically on the nature of each sports branch (Paillard, 2006; Bressel et al., 2007; Asseman et al., 2008; Matsuda et al., 2008; Sirmen et al., 2008). The balance ability increases in parallel to the training experiences in sports. For this reason, it has been reported that, when training athletes and preparing training programs, it is important to evaluate the static-dynamic balance profiles of individuals who are engaged in different branches of sports, and who are not engaged in sports activities (Bergmann et al., 2002; Sirmen et al., 2008; Akan et al., 2009).

Learning rate and level of technical skills in sports are closely associated with balance. It is important to keep the whole body in balance and to maintain this balance when learning the movements and changing positions rapidly. Performing complex motor skills, such as those performed by gymnasts or dancers, requires a great sense of balance (Vuillerme et al., 2001). Gymnastics requires a great diversity of movements: transition from dynamic and static elements and vice versa, frequent changes of the body position in space (Paject et al., 2010). Gymnastics offers a great range of locomotive, stability and body control movements which are highly important for the development of children. In certain sports branches like gymnastics that require complex skills, balance is often lost due to the nature of the movements, and this may adversely influence performance (Vuillerme et al., 2001). Trampoline exercises are used during gymnastics trainings, and facilitate learning of the skills.

The modern trampoline was patented by George Nissen in 1936 who championed its use for recreation and competition. During World War II, the trampoline was used to train pilots to improve their spatial orientation and balance, and after the war, it was used in schools and competitively. The recreational use of trampolines and competitive trampolining is widespread and growing rapidly around the world (Esposito & Esposito, 2009). Trampoline is a skill-oriented and difficult to perform for showing beauty sport, the game requires the athlete’s feet together to perform a variety of forward and backward somersault with twist or non-twist movement.

As a result the balance ability and control is essential for the trampolinist. Beside, trampoline in training is always changed posture and center of gravity trajectory by high speed jump and transforming movement and their balance control is contributed by visual, vestibular, proprioception and lower extremity muscles, etc. coordination to complete (Song & Qian, 2011). Moreover, jumping on the trampoline is also enjoyable activity which develops motor coordination, aerobic fitness, strength, balance and a sense of rhythm and timing (Heitkamp et al., 2001; Crowther et al., 2007). However, mini-trampoline exercises consist of a multi component approach which are likely to affect many other physical factors other than strength, such as body stability, muscle coordinative responses, joint movement amplitudes and spatial integration (Aragao et al., 2011).

It is noteworthy that no past studies were found regarding the use of trampoline training as a sports activity for children for improving the leg strength, vertical jump and balance. On the other hand, it was reported that the studies more generally focused on relationship between athletes’ performance and balance and the injuries of athletes and balance (Hrysomallis, 2011). Because of the lack of research in this area, physical educators and coaches do not realize the effects of trampolining on muscular power, endurance, speed, agility, and coordination.

In light of the above, the purpose of the study is to investigate the effects of 12-week trampoline training on static, dynamic balance, vertical jump and leg strength measurements in boys who do not exercise regularly. It was hypothesized that trampoline training will improve static-dynamic balance, vertical jump and leg strenght.

METHODS

Subjects

Total 28 boys between ages 9-11 who do not exercise regularly voluntarily participated in this study. The parents of children were notified by a letter and asked for their child’s participation in the reliability assessment for postural stability using the balance master system and trampoline training. They gave their informed consent to the experimental procedure as required by the Helsinki Declaration. Boys who had no neurological diseases, vestibular visual disorders, lower extremity injuries or orthopaedic problems, and who did not previously join in any sports activities on a regular basis were included in the experimental group. Non-attendance of the subjects in the trainings for more than twice, injury, or unwillingness to continue was determined as conditions to exclude the subjects from the study. In all of the subjects, right legs were dominant. The study was planned during the fall semester of 2010-2011 academic years of elementary schools and was realised in the gymnasium of the Faculty of Physical Training and Sports and Biomechanics Laboratory of Marmara University. The experiment was approved by the ethics commission of the Marmara University in Istanbul.

Procedures

The subjects were taken to the laboratory twice for pre-tests and post-tests. Prior to testing, subjects were familiarized with the balance device and provided practice sessions on the testing procedures to decrease the change of a learning effect occurring during testing. The tests were conducted at the same times of the day (10.00-13.00) when the body had rested, and measures were taken to prevent distraction due to environmental factors (noise, temperature). First of all, the anthropometric measurements of the subjects were taken, and after warm-up exercises performance tests were conducted (Gelen, 2011). The measurements lasted 20 minutes for each child. The tests of whole group were completed within two days. The group was divided into two homogenous sub-groups by looking at the anthropometric characteristics of the subjects. One of the groups was given TT for 12 weeks, whereas no training was given to CG, and they did not participate in any sports activities. 12 weeks later, the initial measurements were repeated, and the data were statistically interpreted.

Mini-trampoline and trampoline training program

The trampoline training was given a 12-week training program by trainers specialised in the trampoline branch, for 2 days a week, 1.5 hours per day (36 hours in total). During the program, after a 15-minute general warm-up exercises (Gelen, 2011), 15-minute special warm-up exercises specific to gymnastic branch; basic body positions, position of body limbs? Posture, special walking exercises were done. Later, the basic movements of jumping, standing, rotating and landing on mini- trampoline and trampoline were taught in accompany of two trainers (Table 1).

For TT, Trampoline (model 8140) and mini-trampoline (model 5010) were used. All the exercise equipment are FIG (Federation International Gymnast)-approved contest equipment and have protection sliding mats that conform to international standards (model 392) (Spieth Gymnastic GmbH Esslingen/Germany).

Testing procedures

Anthropometric measurements were carried out using anthropometric standardisation references manual (Lohman et al., 1988) by health care professional. The subjects were on naked foot and had light clothing. The heights of the subjects were measured by using portable stadiometer (Holtain Ltd,, Pembrokeshire, UK.), foot length, leg heights and foot width were measured by using anthrop meter (Clas Ohlson, Sweden). Weight measurements were made by using electronic platform scales (nearest 0.1 kg) (Seca 770 Wedderburn, GmbH, Germany). Body mass index was calculated according to the formula weight / height^2 (kg/m^2).

Measurement of Leg Strength: For measuring leg strength (LS), Leg dynamometer (back-leg dynamometer Takai, Tokyo, Japan) was used (LS). After a 5-minute warm-up exercise, the subjects stood on a platform with their feet apart at a comfortable distance of shoulder width for balance. Their hands grasped each end of a bar. The subject was asked to flex at their knees to approximately 135 degrees. The back was kept straight and the hips were positioned direcly over the ankle joints. In this way, the activation of back muscles was eliminated. The chest was kept forward and the head was held in an erect position. The subject took in a large breath and slowly exhaled as they attempted to extend their knees smoothly and as forcefully as possible. Three attempts were made and a best score was recorded (Saygın & Öztürk, 2011).

Table 1. *Trampoline training exercises.*

Week	Unit	Basic exercises performed mini-trampoline and trampoline	Load
1	1 2	Running and hopping exercise on the mini trampoline-trampoline	5-8 sets for each exercises
2	3 4	Teaching arms, legs, head and body straight position while jumping mini trampoline-trampoline	
3	5 6	High jump and landing exercises on the mini trampoline-trampoline	
4	7 8	Straight jump and landing exercises on the mini trampoline-trampoline	
5	9 10	Tuck jump and landing exercises on the mini trampoline-trampoline	
6	11 12	Straddle jump on the trampoline before landing mini trampoline	
7	13 14	Pike sitting and straight jumping exercises on the trampoline and different jump before landing mini-trampoline	
8	15 16	Pike jump and landing exercises on the mini trampoline-trampoline	
9	17 18	¼ twist on the trampoline, before landing mini-trampoline	
10	19 20	½ twist on the trampoline, before landing mini-trampoline	
11	21 22	1/1 twist on the trampoline, before landing mini-trampoline	
12	23 24	Forward roll on the mat after jumping on the mini-trampoline-trampoline	

Vertical jump (Newtest, Oulu, Finland) measurement was made by using jumping platform through the squat jump (SJ) method. The subjects were asked to make an experimental jump before the test. In SJ, the knee-hip angles of the subjects were measured by using standard goniometer, and the angle was adjusted as 90 degrees. At the beginning of the test, the subjects were asked to jump as high as they could with their hand on their waist. Vertical jump measurements were taken on squat jump double feet (SJB), squat jump right (SJR) and squat jump left foot (SJL). Every child jumped three times and the highest records were used to analyze jumping performance (Agopyan et al., 2011).

Balance; Static and dynamic balance measurements were made by using Prokin 5.0 (Prokin System 5.0 Pk-Manop-05-en-01 Begomo, Italy). After explaining the tests to the subjects, data were entered (height, weight, age) and the device was calibrated. The feet of the subjects were placed on the balance platform nakedly (in a fashion that the distance between feet was 10 centimeters and the projection of the maximum point of the medial arcs was on the x-axis). The subjects were asked to look at the screen in front of them with 10 cm distance between their feet while their arms were at sides, and to keep them fixed at (0) point. After completion of each test, when the device was being re-calibrated, the subject was asked to sit down and rest. At the time of the measurements, no verbal feedback was given to the subjects other than what was necessary (http://www.tecnobody.it).

Static balance tests were performed for 30 seconds;

a- Bipedal static balance; Eyes open (EO) and eyes closed (EC). The data obtained were evaluated in terms of Eyes open perimeter (EOPE), Eyes Open ellipse area (EOEA), Eyes closed perimeter error (ECPE), Eyes closed ellipse area (ECEA), Romberg test perimeter ratio (RTPR) and Romberg test area ratio (RTAR).

b- Unipedal static balance; static balance was measured respectively on right and left foot, eyes open and the values in terms of Right foot perimeter (RFPE), Right foot ellipse area (RFEA), Left foot perimeter (LFPE) and Left foot ellipse area (LFEA) were taken (Figure 1).

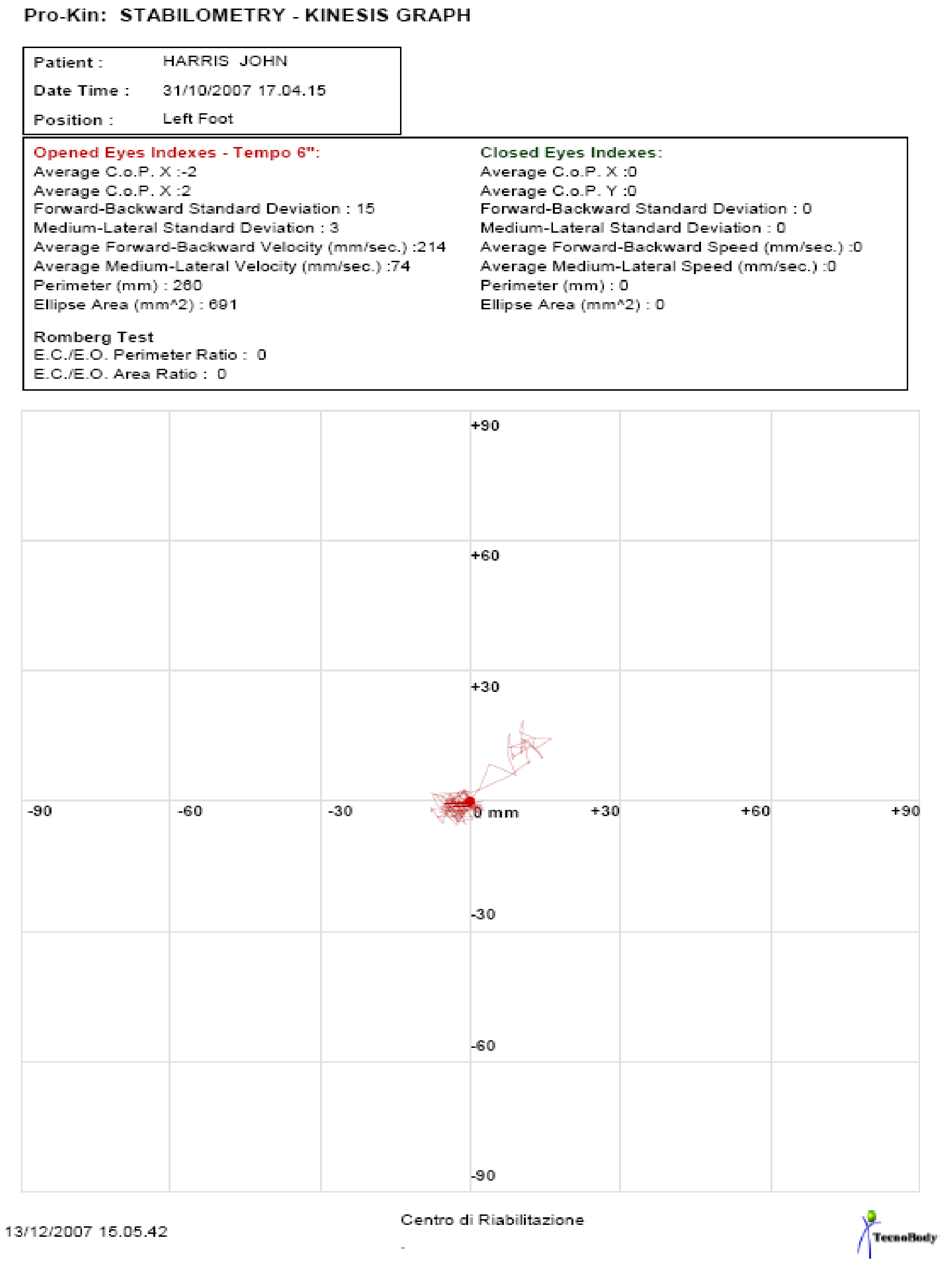

Figure 1. *Static balance tests.*

Dynamic (Equilibrium/ Disequilibrium test); In this test, the subject sees some galleries that come against. The subject's scope is to enter into those galleries and to maintain the tilting board as firm as possible. In this test it's important only one axis, so you have to harden the force absorbers of the other axis. It was performed for 60 seconds and medio-lateral direction. In dynamic equilibrium-disequilibrium test; Front/Right Standard Deviation (DBFRSD), Backward/Left Standard Deviation (DBVLSD) and Distance Medium Error (DBDME) parameters were evaluated (Figure 2).

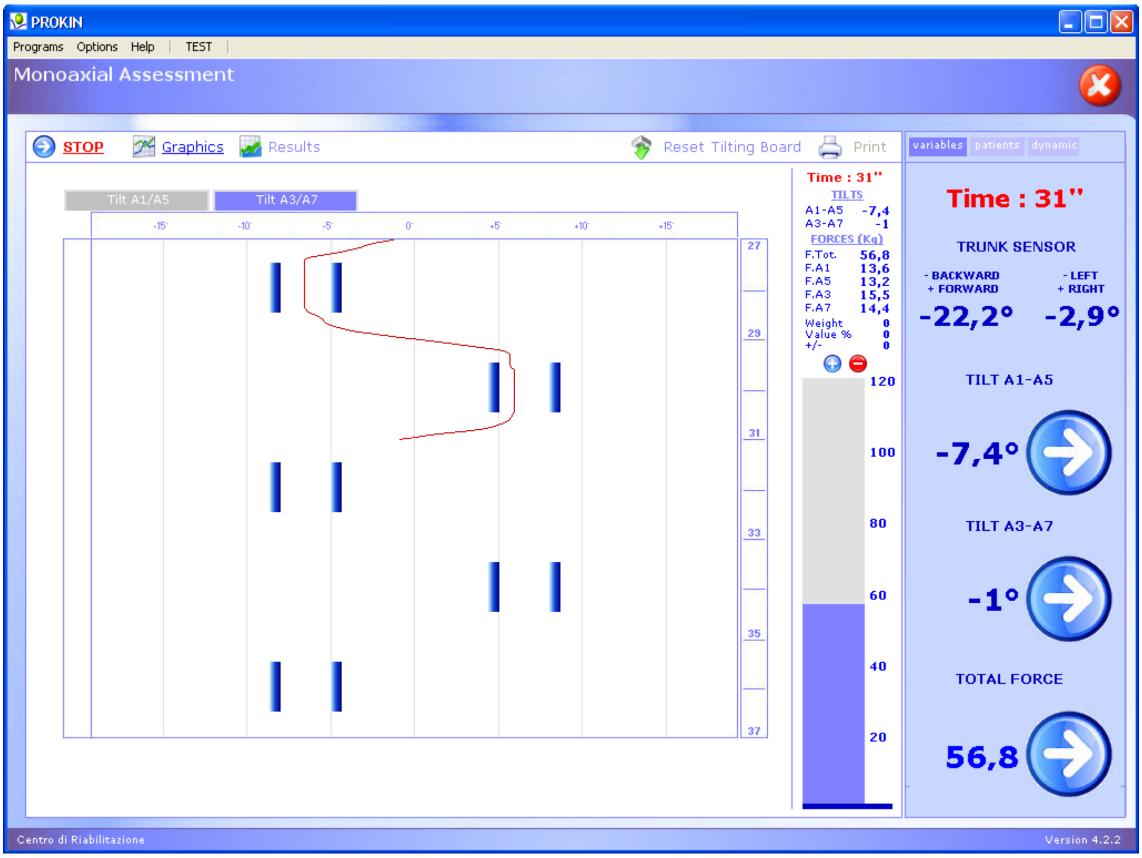

Figure 2. *Dynamic balance tests.*

Statistical analysis

The mean and standard deviation of test results were calculated for pre- and post-tests sessions. The pre- and post-tests data were compared according to the Wilcoxon Signed Rank test within each group for each of the variables. The level of statistical significant was set p≤0,05. The data analysis was performed with SPSS for Windows 14.0 (SPSS Inc, Ghicago, II,USA).

RESULTS

The demographic characteristics of our experimental group have been shown in Table 2. Age, height, weight, leg height are similar in terms of BMI and CMI statistically.

Table 2. *Demographic characteristics of the groups.*

Variables	Trampoline education group n=15	Control group n=13
Age (year)	9.27±0.94	8.97±0.46
Height (cm)	137.91±7.72	133.94±5.4
Weight (kg)	37.49±10.45	35.26±10.81
Leg Height (cm)	64.58±5.85	62.23±3.27
BMI(kg/m^2)	19.49±4.33	19.42±4.94
Foot Length(cm)	21.92±1.69	21.13±1.57
Foot Width(cm)	7.82±.607	7.53±.48
CMI	53.21±2.81	53.53±1.27

BMI: body mass index
CMI: cormic index

Table 3 shows the pre-test post-test balance values of the experimental and control groups. Static Balance EOEA of children who received TG is not statistically significant. However, EOPE (Z= -2.386; p=0.17) ECEA (Z= -2,101; p=0,036) and RTPR (Z= -1,990; p=0,047) values have been found to be statistically significant. In CG, SB pre-test, post-test values are not statistically significant (p>0.05).

Table 3. *Static balance values of the experimental and control groups.*

	Trampoline education group n=15 Mean±SD			Control group n=13 Mean±SD		
	Pre- test	Post- test	p	Pre- test	Post- test	p
EOEA (mm^2)	619.87±391.84	591.53±211.14	0.78	1449.46±882.550	885.46±634.130	0.065
EOP (mm)	619±69.67	689.33±123.97	0.017*	840.85±362.572	761.38±279.565	0.575
ECEA (mm^2)	921.87±349.653	686.07±245.296	0.036*	1758.92±2065.938	941.08±457.644	0.213
ECP (mm)	806.73±178.301	651.73± 317.2	0.13	1044.46±647.159	790.23±199.55	0.228
RTPR	130.27±25.902	120.60±31.672	0.26	115.54±35.500	109.62±26.738	0.585
RTAR	122.13±58.034	172.60±70.151	0.047*	140.08±86.634	105.92±76.814	0.307

p<0.05* and p<0.01** respectively significant differences between the groups.

In table 4, right and left leg static balance values have been shown. In both groups, the difference between the RFPE, RFEA, LFPE, LFEA static balance pre-test post-test values are not statistically significant (p>0,05).

Table 4. *Right and left leg static balance values of experimental and control groups.*

	Trampoline education group n=15 Mean±SD			Control group n=13 Mean±SD		
	Pre- test	Post- test	p	Pre- test	Post- test	p
RFP (mm)	2004.07±804.97	1798±336.15	0.65	1839.38±394.54	1809±401.51	0.91
RFEA (mm^2)	1801.27±1538.10	1643.87±563.97	0.36	1880±1005.12	2031.46±1085.63	0.70
LFP (mm)	1863.73±515.20	1833.20±316.31	0.91	2013.77±404.83	1729.38±451.07	0.17
LFEA (mm^2)	1633±651.27	1616.8±604.85	1	2242.69±584.42	1921.31±790.64	0.15

p<0.05* and p<0.01** respectively significant differences between the groups.

In table 5, dynamic balance values of TG and CG have been provided. While no statistically significant difference was found between pre-test post-test dynamic balance DBFRSD, DBVLSD of the TG group, DBDME (Z= -1.852; p=0.045) values were found statistically significant. There was no statistically significant difference between CG’s DB pre-test post-test values (p>0.05).

Table 5. *Dynamic balance values of experimental and control groups.*

	Trampoline education group n=15 Mean±SD			Control group n=13 Mean±SD		
	Pre- test	Post- test	p	Pre- test	Post- test	p
DBFRSD	1.72± 0.89	1.08± 0.59	0.043*	1.68± 0.97	1.51± .076	0.172
DBVLSD	1.69± 0.65	1.22± 0.52	0.026*	1.75± 0.74	1.56± 0.51	0.208
DBDME	0.68± 0.67	0.25± 0.21	0.016*	0.69± 0.63	0.40± 0.34	0.157

p<0.05* and p<0.01** respectively significant differences between the groups.

In table 6, LS and VJ values of the TG and CG are provided. There was no statistically significant difference between LS pre-test, post-test values of TG and CG groups. However, TG group's SJB (Z= 2.665; p=0.008), SJR (Z= 2.417; p=0.016) and SJL (Z= 2.77; p=0.006) pre-test post-test values were found statistically significant. The difference between pre-test post-values of the Control Group in respect of SJB, SJR, SJL is not statistically significant (p>0.05).

Table 6. *Leg strength and jump values of experimental and control groups.*

	Trampoline education group n=15 Mean±SD		p	Control group n=13 Mean±SD		p
	Pre- test	Post- test		Pre- test	Post- test	
LS (kğ)	62.23±10.81	65.46±12.85	0.43	58.69±10.90	61.19±10.78	0.377
SJB (cm)	20.13±4.38	23±5.68	0.009*	20.54±2.66	20.55±5.3	1
SJR (cm)	9.2± 2.11	10.93± 3.41	0.016*	11.08±3.47	10.46±2.57	0.498
SJL (cm)	9.73±2.28	11.20±3.14	0.042*	10.08±2.87	10.62±2.69	0.490

p<0.05* and p<0.01** respectively significant differences between the groups.

DISCUSSION

The main finding of this study was that there was a significant increase in bipedal SB, DB and VJ values after 12-week TT on 9-year-old boys who do not exercise regularly, and there was no statistically significant difference in terms of their LS and unipedal SB values. In the CG, there was no improvement between the pre-test post-test performance values. These results have shown that inclusion of TT in the training and exercise programs for children has effect on improvement of particularly dynamic balance.

There are limited number of studies made for the purpose of evaluating the sportive postural balance in children (Polishchuc et al., 2007; Kochanowicz et al., 2010; Granacher et al., 2011). In a special branch like trampoline, other than the studies conducted by Aragao (2011) on the elderly, Kidgell (2007) on athletes with functional ankle instability, Song Ya-Wei (2011) on youth trampolinist and the studies conducted by Heitkamp and Andrea on adolescents, the only literature found was in relation to trampoline injuries. As to our knowledge, this study is the first study in which the effect of TT in 9-year-old boys on SB-DB, VJ and LS are studied. For this reason, we will discuss our results with the other balance training studies.

According to our results, there was improvement in bipedal SB and DB parameters after TT. It is noteworthy that most of the balance studies in literature were not made with children. Mitsiou et al. (2011) found out improvement in static balance after giving trampoline training to children with development coordination disorder. Granacher et al. (2011) conducted 4-week balance trainings for 6-7-year-old children in order to evaluate the effect of balance trainings in children on leg strength and balance parameters, however, found no statistically significant improvements. Aragao et al. (2011) found out that 14-week mini-trampoline exercises prevented sudden front falls in the elderly and improved dynamic balance. Heitkamp et al. (2001) investigated the impact of 6-week balance training program in healthy active adults on variables of static balance and observed that balance training significantly improved unipedal stance. Granacher et al., (2010) found out that 4-week balance training in healthy active youngsters increased SJ and postural control. The results of these studies are in support of our findings.

In our studies, no improvement was observed in unipedal SB parameters. Heitkamp et al. (2001) expressed in this study that mini trampoline exercises improved not only balance but also the coordination between two legs. During exercise trampolinists' muscle relaxation and contraction of the mutual transformation are clearer, and the central control of the muscle of higher muscle co-ordination work more co-ordinately. Standing feet trampolining account balance when proprioceptive control of the dominat role (Song & Qian 2011). It can be thought that, in the trampoline training, the coordination between two legs might have improved with the double feet jumping, and thus, there was no improvement in right and left unipedal SB parameters.

Andrea and Jackie (1997) found out in their study that mini trampoline exercises increased vertical jump. Taube et al. (2007) found out that 6-week balance training in elite athletes' increased jumping height. Kean et al., 2006 and Simek et al., 2007 has been found that their research the addition of a balance training component to the recreationally activities students has resulted in improvement in vertical jump. The findings of these studies are also in parallel to our findings (Andrea & Jackie 1997; Sean et al., 2006; Simek et al., 2007; Taube et al., 2007). Our TT program also included running, bouncing on the trampoline, jumping and landing phase. It can be assumed that the improvement in the jumping abilities in the TT might be due to the mini-trampoline and trampoline making it easier to jump as well as their help in improving the appropriate jumping technique.

Trampoline is characterized by dynamic movement pattern. Trampoline exercises are directed at lower extremities and require particularly kinaesthetic, visual, vestibular perception, balance and movement control. In trampoline exercises, it is important to control the body position in the air at the time of jumps, and to use proper balanced landing and jumping techniques. Also rebounding on a trampoline requires the body to be repetitively in motion, trampolinists' eyes must continually adjust to the different fields of vision. As a result adjusting and reorientation, coordination is greatly improved. It can be thought that the children who receive TT improve bipedal SB-DB because of doing their trainings on the trampoline on bare foot, and on double feet, in order to improve balance and control. Perrin (2002) and Song (2011) expressed in their studies that bare foot trainings of judoists, dancers and trampolinists improved orthostatic balance control by reason of foot position.

As a conclusion, 12-week trampoline training increased bipedal static balance, dynamic balance and vertical jump values in boys who do not exercise regularly. Trampoline training is an effective intervention to improve multifunctional motor features in 9 year-old-boys. Base on this evidence we recommended to use of trampoline training for postural control and explosive power improvement in children to sports trainer and physical education teacher.

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