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Original Article

The effect of a balance and proprioception training program on amateur basketball players' passing skills.

KOSTOPOULOS NIKOLAOS[1], BEKRIS EVANGELOS[1], APOSTOLIDIS NIKOLAOS[1], KAVROULAKIS EMMANOUIL[2], KOSTOPOULOS PANAGIOTIS[2].
[1]*University of Athens. Department of Sports Science*. GREECE
[2]*Democritous University of Thrace. Department of Sports Science*. GREECE

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Abstract.
Balance plays a pivotal role in basketball. Sudden and intense change of direction, commencement and stopping as well as contact among players are combined with the application of technical skills. Passing is a frequent and decisive skill regarding the outcome of the game. The purpose of the present study was to determine the effect of a 12-week balance and proprioception training program on amateur basketball players' passing skills.26 amateur basketball players participated in the study. The experimental group consisted of 13 basketball players 22.69±0.70 years old, while the control group consisted of 13 basketball players 21.61±0.71 years old. Both groups included players of all positions (G, F, C). The equipment used in the program comprised Balance disc, Bosu, Togu and Trampoline. All basketball players underwent a passing assessment test before and after the program. The data were statistically analyzed by one way anova with repeated measures (significance level a=0.05). The results showed that the experimental group remarkably improved their performance by 14.92%, while the control group improved their passing skills by only 1.72% ($p = 0.002 < 0.05$).G, F and C experimental group players showed a statistically significant improvement compared to their control group counterparts by 13.25% ($p = 0.035$), 15.34% ($p = 0.047$) and 17.01% ($p = 0.012$) respectively. The findings of the present study show the improvement in basketball players' passing skills following the implementation of a balance and proprioception routine. This improvement may also be affected by the players' anthropometric characteristics as well as their position.
Key words: Proprioception, Balance, Passing, Basketball.

Introduction.

Balance is considered to be one of the most important coordination skills in sport and even more so in basketball. Studies first observed the importance of good balance skills in minimizing the risk of injury (Mc Leod et al 2009) usually sustained on the limbs (Stergioulas et al 2007), and reported the benefits of proprioception routines in preventing and healing athletes' injuries (Hubscher et al 2010). In basketball, abrupt and intense change of direction, frequent commencement and stopping, and contact among players largely depend on dynamic balance. It is obvious that basketball playing ability is probably related to balance maintenance while moving, passing, shooting, dribbling etc.Moreover, in basketball, good balance enables players to control their bodies, to minimize errors, to protect themselves against falling when they change direction and to move fast within the pitch in order to implement technical skills effectively (Mahmoud 2011).Static and dynamic balance play a pivotal role in achieving high performance in basketball. That is why they constitute an integral part of strength and fitness routines in general (Santana et al 2002, Williardson et al 2007).According to Karlsson et al (1994), the ability to maintain balance depends on proprioception. Therefore, proprioception development is probably decisive in basketball skills such as passing, where there is usually a lack of static and dynamic balance, given the unforeseeable and different circumstances of each game.Some researches studied basketball players' balance levels, while others compared basketball players with other athletes.Hahn et al (1999) realized the positive correlation of balancing on one foot to the years that an athlete has been playing basketball, and these results were not related to gender or age.In an attempt to estimate basketball players' dynamic balance levels in relation to athletes from other sports, Bressel et al (2007) discovered that female basketball players' dynamic balance scores were lower than footballers' and similar to gymnasts'.A recent study investigated the relationship between balancing ability and performance during the game. It concluded that static and dynamic balance tests could not determine Basketball Playing Ability (BPA)

Corresponding Author: BEKRIS EVANGELOS, *Email:* vag_bekris@yahoo.gr

among college basketball players.Passing is one of the most important technical skills in basketball. Nevertheless, there have not been any studies investigating the improvement in passing through a balance and proprioception routine.The aim of this study is to investigate the effect of a 12-week balance and proprioception routine on amateur basketball players' passing skills.

Materials and methods.
Subjects.

The study was carried out on 26 amateur basketball players. The experimental group consisted of 13 players aged 22.69±0.70 years old, while the control group was made up of 13 players aged 21.61±0.71 years old (Table 1). Both groups included players of all positions, Guard (G), Forward (F), Center (C).

Table 1: Anthropometric characteristics of the experimental and control groups (mean and standard error of the mean regarding age, weight, height).

Groups	Position	Age	Height (cm)	Weight (kg)
Experimental Group (n=13)	G n=5 F n=5 C n=3	22,69±0,70	188,38± 3,34	95,61±2,92
Control Group (n=13)	G n=4 F n=5 C n=4	21,61±0,71	190,38±2,73	94±3,08

Devices used: Balance disc, Bosu (Both Sides Up balance trainer), Togu (Dynair Senso Ball Cushion), Trampoline.

Passing assessment test.
All subjects (basketball players) underwent the A.A.H.P.E. R.D. (1984) passing assessment test of the American Institution for Health, Physical Education, Psychology and Dance before and after the training intervention program.

Test Description.
Purpose: Measurement of the subject's ability to pass and receive the ball while moving.
Materials: a normal basketball ball, a stopwatch, a smooth wall and adhesive tape to set the targets and the distances between them.
Dimensions – Distances: the targets were squares with sides of 61 cm. They were drawn at different altitudes from the ground. More specifically, the bases of the first (A), third (C) and fifth (E) squares were 162cm above the ground, while those of the second (B), fourth (D) and sixth (F) were 91 cm above the ground. All squares were 61 cm apart. A line behind which the subjects were moving was drawn 244 cm away from the wall.
Execution: According to the procedure, each subject executed 3 attempts, lasting 30 seconds each. The first one was a trial attempt, while the other two were recorded for the survey. From the word 'Go', the subject started his attempt from the left, passing the ball with both hands at chest level to target A. He then received the ball and moved on to pass it to target B, and the procedure continued until he reached target F to which he passed the ball twice. He then moved backwards to target A through targets E, D, C and B. On reaching target A, he had to dribble the ball twice before continuing.
Penalties: If the subject stepped on the 244 cm line, that particular passing did not receive any points. If he passed the ball to targets B, C, D, E twice instead of once, then the second passing did not receive any points. If he did not use both hands to pass the ball, then that passing did not receive any points.
Scoring: Every passing that hit the target or the line that surrounded it received two points. Every passing that hit the space between the targets received one point.The points accumulated during the 30-second time frame were the score for that particular attempt. The final score was the sum of the accumulated points on both attempts.

Statistical analysis – Results.
To process data, the SPSS 15 statistical program was used, and there was variance analysis by one way anova with repeated measures. The significance level was a = 0.05. The comparisons were made between the experimental and the control groups, and between players from both teams who played in the same position (C, G, F).

Table 2: Passing test scores before and after the training intervention.
Mean and Std. Deviation.

	GROUP	Mean	Std. Deviation	N
PRE TRAINING SCORE	CONTROL GROUP	129,8462	9,33494	13
	EXPERIMENTAL GROUP	134,0769	9,07801	13
POST TRAINING SCORE	CONTROL GROUP	132,0769	9,02276	13
	EXPERIMENTAL GROUP	154,0769	10,46790	13

The statistical analysis showed that there was statistically significant difference between the two groups (p-value = 0.002 < 0.05) (figure 1).

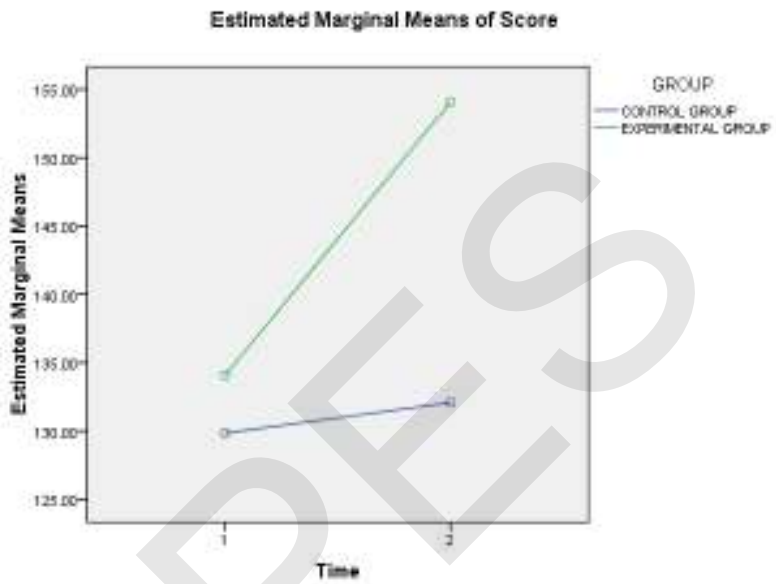

Figure 1: The experimental group shows statistically significant increase (p = 0.002).

According to the results, the experimental group improved by 14.92%, while the control group improved by only 1.72%.Moreover, there were statistically significant differences between players who played in the same positions in both groups respectively.
More specifically: G position players in the experimental group improved by 13.25%, while those in the control group improved by only 2.14% (p = 0.035 < 0.05). F position players in the experimental group improved by 15.34%, while those in the control group improved by only 0.88% (p = 0.047 < 0.05). C position players in the experimental group improved by 17.01%, while those in the control group improved by only 2.43% (p = 0.012 < 0.05). (Table 3).

Table 3: Means / position in the experimental and control groups.

		POSITION G	POSITION F	POSITION C
PRE TRAINING SCORE	CONTROL GROUP	128,5±6,45	136±9,02	123,5±8,88
	EXPERIMENTAL GROUP	132,8±7,39	138,2±9,01	129,33±11,93
POST TRAINING SCORE	CONTROL GROUP	131,25±6,75	137,2±8,87	126,5±9,43
	EXPERIMENTAL GROUP	150,4±9,31	159,4±10,06	151,33±12,85

Discussion.

According to this survey's results, the experimental group improved by 14.92%, while the control group by only 1.72% (p = 0.002). It is, therefore, clear that a proprioception and balance routine can improve amateur basketball players' passing skills.The present survey also agrees with that of Zech et al (2010), according to which, balance enhances neuromuscular control, while Bressel et al (2007) shows that dynamic

balance is connected with performance in sports, although without connecting the former with technical skills.In an attempt to prove the correlation between balance and Basketball Playing Ability, Hobbs et al (2008) compared the dynamic and static balance of: 1) collegiate basketball players versus novice basketball players, 2) collegiate basketball starters versus non-starters, and3) collegiate basketball players with the most playing time versus those with the least playing time. To that end, he used 3 different balance tests. He did not find any statistically significant differences between male college basketball players and novice basketball players, between male college basketball starters and male college basketball non-starters, as well as between male college basketball players with most time played and male college basketball players with least time played.
Consequently, he concluded that those balance tests could not be utilized to determine college basketball players' BPA, and suggested the development of more specialized tests for basketball players.Mahmoud (2011) pointed to the importance of balance in implementing technical skills, such as passing, dribbling and shooting while changing direction, stopping, jumping and pretending. The same researcher mentioned that effective execution of the above skills on a small balance base was an indication of a high fitness level and creativity on the player's part.

In agreement with the above researcher, the present study pointed to the importance of a specific proprioception and balance training protocol which focused on improving static and dynamic balance, and proprioception. The exercises were progressively difficult and connected with passing. All those exercises that challenge the athlete's balance ability and change the balance position on stable and unstable surfaces improve gravity center awareness and contribute to increased ankle strength in the closed kinetic chain (Bekris et al 2012). Such a training protocol can increase muscle spindle sensitivity, and consequently, the proprioception stimuli to the spinal cord (Lephart 1993). The effort to adopt a functional posture (passing exercise simulation) during static balance exercises probably caused different strain on the musculoskeletal structures around the ankle joints, the knee and the thigh (Prentice 2004).Furthermore, the dynamic balance exercises which involved movement to the front, the back and the side probably developed decisive and more specialized muscular function. According to the present study's results, it is evident that the improvement was different according to the players' position. C position players improved the most, which means that anthropometric characteristics (such as height) affect the results of a proprioception and balance routine. Several studies have investigated anthropometric characteristic influence on basketball players' technical skills, but none related it to balance (Hoffman,et al 1996, Ko et al 2005, Sallet et al 2005, Tsunawake et al 2003, Apostolidis, et al 2004, Bayios et al 2006). C position players' bigger improvement is probably attributable to the frequency of passing with hands at chest level that they had to do during the intervention program compared to the low frequency with which they perform this exercise during actual practice or games. According to the present study findings, the improvement in passing through a proprioception and balance routine is statistically significant for all basketball players and is probably affected by the players' anthropometric characteristics, their position and the time each one participated in the game.

Conclusion.

To conclude, according to the present study, a proprioception and balance routine improves basketball players' passing skills. This improvement may also be affected by other factors, such as the players' positions and anthropometric characteristics .It is suggested specific and complementary proprioception and balance routines be used in contemporary basketball practice. Finally, further investigation of the effect of a balance and proprioception routine on all basketball technical skills is recommended.

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APPENDIX
INTERVENTION TRAINING PROGRAM

1st and 2nd week training units (6 intervention trainings / routines)				
Stable surface exercises	**Set**	**Actual time**	**Recovery**	**Total**
Balance on right leg – hands on the waist	3	30´´	60´´	90´´
Balance on left leg – hands on the waist	3	30´´	60´´	90´´
Balance disc exercises	**Set**	**Actual time**	**Recovery**	**Total**
Balance on both legs	3	30´´	60´´	90´´
Balance on right leg – hands on the waist	3	30´´	60´´	90´´
Balance on left leg – hands on the waist	3	30´´	60´´	90’’
Bosu ball exercises	**Set**	**Actual time**	**Recovery**	**Total**
Standing on left leg and slow abduction of right leg	3	30’’	60’’	90´´
Standing on right leg and slow abduction of left leg	3	30’’	60’’	90´´
Total				**630’’= 10,5 m**

3rd and 4th week training units (6 intervention trainings)				
Stable surface	**Set**	**Actual time**	**Recovery**	**Total**
Balance on right leg – hands on waist – torso bending forward - stabilization	3	30´´	60´´	90´´
Balance on left leg– hands on waist – torso bending forward - stabilization	3	30´´	60´´	90´´
Balance disc exercises	**Set**	**Actual time**	**Recovery**	**Total**
Passing to wall (hands at chest level)	3	20 rep	60’’	60 rep
Squat with proposal of hands	3	20 rep	60’’	60 rep
Standing on both legs, dorsiflexion and pelmatic flexion (right – left)	3	30´´	60´´	90’’
Bosu ball exercises	**Set**	**Actual time**	**Recovery**	**Total**
In pairs, basketball players are on the Bosu, 4 meters apart and pass the ball to each other with hands at chest level	3	30´´	60´´	90’’
Side step on the Bosu, passing to a wall (hands at chest level), step down the Bosu	3	20 rep	60’’	60 rep
Total				**360’’ +180 rep**

5th and 6th week training units (6 intervention trainings)				
Bosu ball exercises	**Set**	**Actual time**	**Recovery**	**Total**
Short jump forward with both legs on the Bosu, with hand proposal (bending & stretching of the elbow)	3	20 rep	60´´	60 rep
In pairs: short jumps on 2 Bosu balls simultaneously; One passing the ball, the other receiving it	3	20 rep	60´´	60 rep
Togu exercises	**Set**	**Actual time**	**Recovery**	**Total**
Slight jog – stop - jump	3	20 rep	60´´	60 rep
Dribbling while running and stopping. Jumping while passing to a wall	3	20 rep	60´´	60 rep
Trampoline exercises	**Set**	**Actual time**	**Recovery**	**Total**
Ball passed by another player, and received while player is moving on the trampoline	3	20 rep	60´´	60 rep
Passes between 2 players, both on a trampoline	3	20 rep	30´´	60 rep

The basketball player jumps with the feet astride and passes the ball alternately to two other players who are 4 meters away	3	20 rep	60´´	60 rep
Total				**540 rep**

7th and 8th week training units (6 intervention trainings)				
Bosu ball exercises	**Set**	**Actual time**	**Recovery**	**Total**
Skipping on the Bosu and passing to a wall	3	20 rep	60´´	60 rep
Balance on left leg– leg lift backwards and forwards while player holds ball and moves hands like when passing with hands at chest level	3	30´´	60´´	90´´
Balance on left leg on the Bosu – jump- landing with both feet on the Bosu	3	20 rep	60´´	60 rep
Togu exercises	**Set**	**Actual time**	**Recovery**	**Total**
Moving to the side and jumping with both legs where one leg steps on togu (2 togu used)	3	20 rep	60´´	60 rep
Moving to the side and jumping with both legs on togu (2 togu used) - passing	3	20 rep	60´´	60 rep
Trampoline	**Set**	**Actual time**	**Recovery**	**Total**
Continuous ball receptions by player to whom 4 other players pass it (fast paced)	3	30´´	60´´	90´´
Jump from Bosu on the trampoline and fast reception of ball passed by fellow player	3	20 rep	60´´	60 rep
Total				**180’’+310 rep**

9th and 10th week training units (6 intervention trainings)				
Bosu exercises	**Set**	**Actual time**	**Recovery**	**Total**
Squats on Bosu	3	30 rep	60´´	90 rep
Squats on Bosu and passing to a fellow player	3	30 rep	60´´	90 rep
Passing to a moving fellow player, while changing position on Bosu	3	30 rep	60´´	90 rep
Balance disc exercises	**Set**	**Actual time**	**Recovery**	**Total**
Ball thrown at the side – reception and passing while maintaining balance	3	20 rep	60´´	60 rep
Standing on one leg - passing	3	20 rep	60´´	60 rep
Togu exercises	**Set**	**Actual time**	**Recovery**	**Total**
Continuous short jumps on 3 togu – stopping – dribbling once – passing to fellow player.	3	60´´	60´´	180´´
Trampoline Exercises	**Set**	**Actual time**	**Recovery**	**Total**
Skipping and continuous passing	3	30 rep	60´´	90 rep
Jump on the trampoline and passing	3	30 rep	60´´	90 rep
Jump to the side on one leg and passing	3	20 rep	60´´	60 rep
Total				**590 rep +3´**

11th and 12th week training units (6 intervention trainings)				
Bosu exercises	**Set**	**Actual time**	**Recovery**	**Total**
Squat on Bosu and passing to fellow player on Bosu	3	30 rep	60´´	90 rep
Squat and passing to fast moving fellow player	3	30´´	60´´	90 ´´
Balance disc exercises	**Set**	**Actual time**	**Recovery**	**Total**
In pairs, passing while standing with legs astride	3	30´´	60	90´´
Standing on one leg – passing – standing on other leg -passing	3	20 rep	60	60 rep
Togu and Bosu exercises	**Set**	**Actual time**	**Recovery**	**Total**
Continuous Bosu – Togu short jumps –stopping – passing to a wall	3	20 rep	60´´	60 rep
Trampoline exercises	**Set**	**Actual time**	**Recovery**	**Total**
The player on the trampoline continuously passes the ball to two fellow players under it	3	30 rep	60´´	90 rep
Jumping on the trampoline and passing to a wall	3	30 rep	60´´	90 rep
Moving to the side and passing to a moving fellow player	3	20 rep	60´´	60 rep
Total				**450 rep +3´**