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Original Article

Effect of an eight-week plyometric training on different surfaces on the jumping performance of male volleyball players

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Abstract:
The aim of this study was to investigate whether the effect of 8 weeks of plyometric training performed on wooden and synthetic surface on volleyball players jump performance. Thirty six male volleyball players whose ages differs between 18-24 were voluntarily participated in this study. All participants were randomly divided 3 groups; wooden surface (n:12), synthetic surface (n:12) and control group (n:12). Wooden and synthetic surface experimental training groups performed 3 days a week for 8 weeks.The training program that include 20 different plyometric exercise drills and these drills performed through that 8 week training period.
All tests were performed by the subjects for three groups before and after 8-week plyometric training. SPSS program was used to evaluate the data. Paired samples t test was used to determine the difference between measurements. One-way ANOVA was performed to determine the difference between groups. Statistically significant difference was found after the 8 weeks plyometric training on the vertical and horizontal jump parameters in favor of the experimental group ($p<0.05$). But, no significant difference was found between wooden and synthetic surface volleyball players jump performance ($p>0.05$). It is observed that wooden and synthetic surface doesn't affect to jump performance of volleyball players. According to these results plyometric training program effective on jump performance of volleyball players despite this training surface doesn't effect on jumping performance. In conclusion plyometric training on wooden or synthetic surfaces haven't significant differences for improving jumping performance in healthy adult male volleyball players.
Key words: volleyball, plyometric training, jump performance, wooden and synthetic surface

Introduction

Volleyball is a popular sport which has thousands of supporters and practitioners at the international area and a competitive sport played on different surfaces such as indoors or outdoors courts. Indoor volleyball is played upon a hard flat surface that is mostly made out of wood or synthetic materials (Gortsila et al., 2013). Jumping ability is very important ability for success in volleyball and it very connected with surface.

Locomotor activities, heart rate, blood lactate levels and perceived exertion differ among surfaces of game court (Brito et al., 2012). Different surfaces must be taken into account at plyometric training (Ramirez-Campillo, et al., 2013). Plyometric training on sand is viable option for sport specialists and athletes of many sports including soccer (Zisis, 2013), karate (Margaritopoulo et al., 2015), volleyball (Cretu and Vladu, 2010), Handball (Chelly et al., 2014), Basketball (Matavulj et al., 2001), Badminton (Middleton, et al., 2013), Tennis (Salonikidis and Zafeiridis, 2008) to enhance performance in athletes,while reducing risk of muscle soreness and damage (Arminder et al., 2014). Besides that plyometric training is performed on a hard training surface with a moderate training volume induces optimal stimulus to increase explosive performance requiring fast SSC actions (e.g., DJ), maximal dynamic strength enhancement and higher training efficiency (Ramirez-Campillo, et al., 2013).

Today's sport conjuncture oriented in success and competitiveness. In order to be successful players should do hard trainings with dedication and as a result they can gain fast, strong durable and excellent technique (Koç and Büyükipekci, 2010). In countries which engage in scientific methods in sports area, training period became the main topic of many multifaceted research, observation and applications. As a result of the evaluation of all these studies, training science was born and it has been the most important decisive criterion in the preparation of athletes to the competitions and training science became an important tool to maximize athletes' performances (Sevim, 2006).

The evaluation of scientific studies and the use of scientific methods is a requirement for high performance in sport and volleyball as well. Nowadays volleyball has become a sport in which physical strenght as well as technical and tactical elements are used at the top level. One of the most important conditional features

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specific to volleyball is the jump force. It effects performance significantly in sport branches which requires jumping. So it has become focus of interest for many researches in recent years (Topuz, 2008). In particular, many of the volleyball coaches are on the believe that vertical jump ability is one of the most important physical properties for volleyball players (Sheppard et al., 2007). One of the main objectives of the volleyball coaches is to improve height of jump by training exercises. Therefore, both scientist and coaches developed models that improves height of jump (Baktaal, 2008). The natural muscle action variations are periodically subjected to impact or strech forces and are in form of stretch and shortening cycle (Komi, 2000; 2008). The method known as plyometric training developed as a special speed-strength training method by Verkhoshansky and originally called "shock" training method in Russia (Verkhoshansky and Siff, 2009). Plyometric training is specific training program to improve the relationship between maximum strength and explosive power which are important component of most athletic performances (Radcliffe and Farentinos, 2015). In this phenomenon, the increase in concentric strength in response to rapid "shock" loading is a result of increased muscle tension elicited by the powerful myostatic strech reflex and the explosive release of elastic energy stored in the connective and elastic tissues of the muscle complex during eccentric muscle contraction (Verkhoshansky and Siff, 2009). Among these models which are developed to improve jump height, plyometric training has a significant place during season (Soundara rajan and Pushparajan, 2010).

Trainings done with plyometric exercises usually requires functions such as body weight and gravity. Activities that requires plyometric exercises includes; repetitive aplied jumps (in place and standing), jumps (short and long term), hopping (short and long term) and depth jumps (Foran, 2001).

Plyometric training on different surfaces may be associated with different training-induced effects on some neuromuscular factors related to the efficiency of the stretch-shortening cycle (Impellizzeri et al., 2008). Vertical jump on sand surface is lower than hard surface because of sand surface is more instability and this instability decreases maximum power and take off velocity.Furthermore jump kinematics is different on sand surface than hard surface (Giatsis et al., 2004). Arazi et al. (2014) recommended that training on hard surface for sprint, jump performance and trainin on sand surface for agility and strength performance according to results their study performed 6 week plyometric training on different surface of healthy male subjects (Arazi et al., 2014). Although the majority of studies in volleyball players performance were evaluated on hard surfaces and there are very limited studies the effects of different hard surfaces such as wooden or synthetic material on volleyball performance. Therefore the aim of these study was to investigate the effect of plyometric training performed on two different surfaces that wooden and synthetic surfaces on jumping performance of adult male volleyball players. Although many studies have investigated the athletic performances on different surfaces, there is no knowledge of the effect of long term plyometric training on different indoor surfaces of jumping performance for volleyball players. In this manner it would be important to investigate whether differences between wooden or synthetic surface to plyometric training for jumping heights. Many studies in literature jump heights lower on sand surfaces than hard material surfaces. Therefore, the main aim of this study was to investigate the influence of 8 week plyometric training performed on wooden and synthetic surface on jumping performance.

Method & Material

Healthy and adult 36 male volleyball players who are play in Turkish 3. Divison National Volleyball Leauge voluntarily participated in this study. This study was conducted on 3 different groups including; control group (n:12), wooden surface group (n:12) and synthetic surface group (n:12). First measurements were taken from all volleyball players participated in this study before the start of pre-season training program. Plyometric training was practiced 3 days in a week during 8 weeks period in experimental groups. The plyometric training program included nonconsecutive three days a week for 8 weeks (Table 1). Eight weeks training period with incremental volume was chosen because of long term training is better for muscular adaptation. Each training session lasted about 50-60 min and including 10 min warm-up (jogging, stretching, dinamic and consantric contractions), 35-45 min training (plyometric training on wooden or synthetic training surface), 5 min cooling (jogging, stretching). Subjects performed 1 or 2 sets of 10 repetitions according to training schedule. Inter-set rest intervals are 2 min between sets and exercises (Willardson and Burkett, 2008). After 8 weeks period second measurements were taken. Control group didn't perform any training program.

Table 1. 8-week Plyometric Exercise Training Program

Plyometric Drills	**Training number**						**Sets x Reps**
Jump rope	1st	2nd	3rd	4th	5th	6th	2 x 10
	7th	10th	13th	16th	19th	22th	1 x 10
Repeated countermovement jump	1st	2nd	3rd	4th	5th	6th	2 x 10
	7th	10th	13th	16th	19th	22th	1 x 10
Standing single leg hoping	1st	2nd	3rd	4th	5th	6th	2 x 10
	7th	10th	13th	16th	19th	22th	1 x 10
Tuck jump	1st	2nd	3rd	4th	5th	6th	2 x 10

	7th	10th	13th	16th	19th	22th	1 x 10
Double-leg hop forward	1st	2nd	3rd	4th	5th	6th	2 x 10
	7th	10th	13th	16th	19th	22th	1 x 10
Double-leg side-to-side jump (30cm)	7th	8th	9th	10th	11th	12th	2 x 10
	13th	16th	19th	22th			1 x 10
Single-leg side-to-side jump (30cm)	7th	8th	9th	10th	11th	12th	2 x 10
	13th	16th	19th	22th			1 x 10
Kangaroo jump forward	7th	8th	9th	10th	11th	12th	2 x 10
	13th	16th	19th	22th			1 x 10
Double-leg hurdle jump forward	7th	8th	9th	10th	11th	12th	2 x 10
	13th	16th	19th	22th			1 x 10
Single-leg lateral bench jump (30cm)	7th	8th	9th	10th	11th	12th	2 x 10
	13th	16th	19th	22th			1 x 10
Single-leg stair jump (Right leg)	1st	14th	15th	16th	17th	18th	2 x 10
	19th	22th					1 x 10
Single-leg stair jump (Left leg)	1st	14th	15th	16th	17th	18th	2 x 10
	19th	22th					1 x 10
Double-leg stair jump	1st	14th	15th	16th	17th	18th	2 x 10
	19th	22th					1 x 10
Double-leg box jump (40cm)	1st	14th	15th	16th	17th	18th	2 x 10
	19th	22th					1 x 10
Double-leg depth jump (40cm)	1st	14th	15th	16th	17th	18th	2 x 10
	19th	22th					1 x 10
Right-leg box jumps (30cm)	19th	20th	21th	22th	23th	24th	2 x 10
Left-leg box jumps (30cm)	19th	20th	21th	22th	23th	24th	2 x 10
Double-leg box jumps (30cm)	19th	20th	21th	22th	23th	24th	2 x 10
Box jump 2 different heights (30&40cm)	19th	20th	21th	22th	23th	24th	2 x 10
Incremental box jumps (30-40-50-60-70cm)	19th	20th	21th	22th	23th	24th	2 x 10

Plyometric training program participants were informed about the aim of the study thereby, participants motivational level was raised. Light jogging and stretching type exercises were performed by plyometric training participants so that tests can be conducted in an efficient manner. Athletes height was measured by wall scale which has 0.1 cm degree of precision. Furthermore, body weights of the athletes was measured in "kg" by "Tanita" brand weight-scale. Athletes with shorts and T-shirts and without shoes stood on the anatomical position on scale. Hypodermic fat measurement was taken "Holtain" brand skinfold calliper which has ± 0,2 mm degree of precision. Measurements were taken on the right side of the body while athletes were standing on an upright position. Skin and hypodermic fat tissue of the athletes was pulled forward by thumb and forefinger then numbers on skinfold calliper was read by the researcher in 2-3 minutes. In order to determine the body fat percentage of the athletes, the following formula was used which is proposed by Green (Green, 1970).

*%Fat=(Triceps+biceps+subscapula+abdominal+suprailiak+quadriceps femoris)*0.097+3.64*

Five different vertical jump measurements were taken from athletes including; half squat, full squat, right foot and left foot vertical jump by taking one step forward. Athletes' vertical jump heights were measured by means of reach method (Vertec), in this method marking the highest point that athletes could reach by jumping and via the highest point that athletes could reach by extending their arms up on a standing position (Leard et al., 2007; Buckthorpe et al., 2012). Afterwards, the difference between measurements was recorded in centimetres. Horizontal jump measurements were taken from athletes by apparatus prepared on the gym surface. 5 different jump types including; right foot, left foot, double foot, right foot by taking one step, left foot by taking one step was practiced by athletes with two times trial. Athletes jumped forward with all their capacity and measurements for vertical jump were taken from the point of contact with the ground at the level of the athletes heel. This test was repeated twice and best result was recorded in cm.

Statistical Analysis

Data were evaluated by SPSS 15.0 software package program. Measurement results were presented as means and standard deviations. Shapiro Wilk Test was used to see whether data display a normal distribution and data was found to exhibit a normal distribution. In determining the difference between the measurements (pre and post test) Paired Samples T test was conducted and one-way ANOVA was used to compare the groups. Tukey and Tamhare tests, one of the multiple comparison tests, were used to see which groups are different from each other p value of < 0.05 was considered significant.

Results

Table 2. Intra-group and inter-group pre-test and post-test values on physical characteristics measurements

Variables	Control Group (n=12)		Wooden Group (n=12)		Synthetic Group (n=12)		ANOVA	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test	p^1	p^2
	$\bar{X} \pm SS$	$\bar{X} \pm SS$	$\bar{X} \pm SS$	$\bar{X} \pm SS$	$\bar{X} \pm SS$	$\bar{X} \pm SS$		
Height (cm)	185.3±3.8	185.3±3.8	183.5±7.3	183.5±7.3	185.4±3.7	185.4±3.7	0.602	0.690
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B.weight (kg)	79.7±3.1	79.1 ±3.2	73.7±6.7	73.2±5.9	83.1 ± 14.8	81.3 ±12.5	0.068	0.054
	0.046*		0.223		**0.042***			
B.M.I (kg/m²)	23.2 ± 0.5^a	23.0 ± 0.6^a	21.9 ± 1.0^b	21.6 ± 0.7^b	24.1 ± 3.6^a	23.6 ± 3.0^a	0.054	**0.034***
	0.048*		0.086		**0.027***			
B.F.P (%)	10.1 ± 1.0	9.8 ± 1.1	10.5 ± 1.7	9.8 ± 1.7	10.7 ± 3.5	10.2 ± 3.1	0.811	0.909
	0.001*		**0.003****		**0.008****			

*p<0,05 **p<0,01,

[a,b,c] The difference between groups in the same line with different lettters is significant (p<0.05).

p^1 : Comparison of the pre-training values **p^2:** Comparison of the post-training values

A significant difference was found (p<0.05) in intra-group comparisons of the control group's body weight, body mass index and body fat percentage values; experimental P group's percentage of body fat values and experimental S group's body weight, body mass index and body fat percentage values. A significant difference was not found in experimental P groups body weight and body mass index values. Moreover, there was no significant difference between the pre-test comparisons. In the post-test comparisons between the groups non significant difference was detected in height, weight and body fat percentage values. However, there was a significant difference in post-test body mass index values (p<0.05).

Table 3. Intra-group and inter-group pre-test and post-test values on horizontal jump

Variables	Control (n=12)		Wooden Surface (n=12)		Synthetic Surface (n=12)		ANOVA	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test	p^1	p^2
	$\bar{X} \pm SS$	$\bar{X} \pm SS$	$\bar{X} \pm SS$	$\bar{X} \pm SS$	$\bar{X} \pm SS$	$\bar{X} \pm SS$		
Right Foot	208.3 ± 6.6^a	211.3 ± 6.1^a	183.5 ± 20.1^b	213.2 ± 9.5^a	212.9 ± 12.2^a	223.4 ± 13.1^b	**0.000****	**0.012***
	0.001**		**0.000****		**0.000****			
Left Foot	215.2 ± 6.8^a	217.17 ± 7.5	186.08 ± 21.2^b	216.92 ± 14.3	216.1 ± 11.7^a	226.9 ± 13.8	**0.000****	0.090
	0.001**		**0.000****		**0.000****			
Double Foot	227.3 ± 8.2	229.8 ± 8.3	218.0 ± 20.1	241.1 ± 16.5	230.8 ± 15.1	241.6 ± 15.7	0.120	0.081
	0.000**		**0.004****		**0.000****			
Right Foot by Taking a Step	214.5 ± 5.0	215.3 ± 5.2^a	212.4 ± 27.2	233.9 ± 17.1^b	225.1 ± 12.5	235.8 ± 14.3^b	0.180	**0.001****
	0.380		**0.002****		**0.000****			
Left Foot by Taking a Step	221.0 ± 8.3^a	223.2 ± 8.1^a	203.9 ± 21.8^b	239.4 ± 22.7^b	228.3 ± 13.3^c	239.8 ± 16.2^b	**0.002****	**0.032***
	0.000**		**0.000****		**0.001****			

*p<0,05 **p<0,01,

[a,b,c] The difference between groups in the same line with different lettters is significant (p<0.05).

p^1 : Comparison of the pre-training values **p^2:** Comparison of the post-training values

In intra-group comparisons of the control group's right foot, left foot, double foot and left foot by taking one step jump; experimental P group right foot, left foot, double foot, right foot by taking one step jump, left foot by taking one step jump and experimental S groups right foot, left foot, double foot, right foot by taking one step jump and left foot by taking one step jump values displayed significant difference (p<0.05). However, experimental P group's right foot taking one step jump values did not differ significantly.

A significant difference was found in the pre–test comparisons between groups on right foot, left foot and jump by taking a step with left foot values (p<0.05). However, double foot and jump by taking a step with right foot values did not differed significantly between pre–test groups. On the post–test comparisons between groups a significant difference was found on right foot, taking a step with right foot and taking a step with left foot values (p<0.05). On the other hand, right foot and jump with double foot values did not differed significantly.

Table 4. Intra-group and inter-group, pre-test and post-test vertical jump values

Variables	Control (n=12)		Wooden Surface (n=12)		Synthetic Surface (n=12)		ANOVA	
	Pre-Test	Post-Test	Pre-Test	Post-Test	Pre-Test	Post-Test	p^1	p^2
	$\bar{X} \pm SS$	$\bar{X} \pm SS$	$\bar{X} \pm SS$	$\bar{X} \pm SS$	$\bar{X} \pm SS$	$\bar{X} \pm SS$		
Half Squat	53.0 ± 3.1	54.6 ± 3.1^a	54.7 ± 4.6	60.8 ± [illegible]^b	52.6 ± 4.1	56.8 ± 4.3^a	0.412	**0.008****
	0.000**		**0.000****		**0.000****			
Full Squat	51.2 ± 2.7	52.5 ± 2.6^a	52.9 ± 5.5	57.9 ± 5.5^b	52.6 ± 3.5	56.2 ± 4.7^b	0.575	**0.017***
	0.000**		**0.000****		**0.000****			
By Taking a Step	56.0 ± 3.6	57.9 ± 3.3^a	59.2 ± 5.8	65.9 ± 6.7^b	56.7 ± 3.7	60.9 ± 4.7^c	0.193	**0.002****
	0.000**		**0.000****		**0.000****			
Right Foot	42.0 ± 2.1^a	42.8 ± 2.1^a	38.7 ± 7.3^b	44.6 ± 7.1^a	44.9 ± 5.4^a	48.3 ± 5.5^b	**0.029***	**0.049***
	0.000**		**0.000****		**0.000****			
Left Foot	44.6 ± 2.2	45.8 ± 2.5^a	44.2 ± 5.7	51.1 ± 6.1^b	47.8 ± 5.4	51.1 ± 5.2^b	0.137	**0.016***
	0.003**		**0.000****		**0.000****			

$^*p<0,05$ $^{**}p<0,01$,

^{a,b,c} The difference between groups in the same line with different lettters is significant ($p<0.05$).

p^1 : Comparison of the pre-training values **p^2:** Comparison of the post-training values

In intra group comparisons; half squat, full squat, jump by taking a step, jump with right foot and jump with left foot values differed significantly (p<0.05) between control group, experimental S group and experimental P group. In the pre-test comparison between groups half squat, full squat, jump by taking a step and jump with left foot values did not differ significantly (p<0.05). But a significant difference was found on jump with right foot value (p<0.05). Finally, on the post–test comparisons between groups a significant difference was found on half squat, full squat, jump by taking a step, jump with right foot and jump with left foot values (p<0.05).

Discussion & Conclusion

To achieve a successful performance in all sports, athletes should have sufficient motoric and physical strength pertinent with their branches. Volleyball ranks among the first sport branches that requires jump ability. Therefore, one of the most essential features in volleyball is the jump force. Plyometric training is the most important form of training that develops jump force specific to volleyball (Ziyagil et al., 1994). Plyometric training on sand surface is effective for improving muscular performance (Mirzaei et al., 2014).

Plyometric training is mostly defined with names like “elastic strength training” , “reactive training” and “eccentric training” . It is also divided into subscales such as “jump depth” and “blow method”. Plyometric training allows muscle to reach maximal force in the shortest possible time (Muratlı et al., 2007). Plyometric trainig was reported to increase the activity of force-nerve reaction. Furthermore, plyometric trainig is stated to develop vertical jump skills (Bedi et al., 1987). Speed and strength type of exercises increases power and reactive explosive strength and this type of activities is known as plyometric training (Chu, 1992).

Plyometric training is used in conjunction with the strength training. Plyometrics training is improved as a result of back contraction and extension of muscles. This elastic back case produce more power in some activities such as jumping, hopping and skipping (Bompa, 1994; Yüksel, 2001).

Plyometric training must be considered as a part of the entire program and shouldn’t be practiced alone. In plyometric training, purpose is more elastic strength related. High amounth of strength could be applied in a short time period via eccentric contractions after the concentric contractions. With an high speed contraction of neuromuscular system, resistance could be overcome and elastic force occurs. This form of training is a positive and negative type of strength practice which aims to use kinetic energy and strength quickly and improves explosive jump strength (Foran, 2001; Muratlı, 2007).

Plyometric exercises provides the usage of elastic properties of muscle fibers and connective tissues. Energy is stored in the phase of slowing down and tension of muscles and energy is released in the acceleration and contraction phase. Agonist muscles are stretched out and this initiates stretch reflex on muscle fibers during high jumping. Stretch reflex transmits inactive muscles with an increased stimulation thereby, further contraction occurs in a higher and faster manner. Tensile rate is of great significance in plyometric trainings. Combined practices which combines quick eccentric movements with concentric contractions such as sprint, leap, depth jump enables athletes to reach high eccentric and concentric movements. The importance of tension ratio have been indicated with different vertical jump tests such as; static squat jump, jump without taking a step. This type of muscle exercises forms the basis of plyometric training (Muratlı, 2007; Çavdar, 2006).

In this study conducted on volleyball players, significant differences were found on the vertical leap values between the experimental group and the control group. In literature, studies carried out with plyometric training program have similar significant differences between experimental and control groups (Kaldırımcı et al., 2004; Khlifa et al., 2010; Avery et al., 2007; Maffiuletti et al., 2002; Cicioğlu et al., 1996; Ioannis et al., 2000; Ateş et al., 2007).

In a study conducted on trained male athletes, vertical jump performance of athletes has been reported to increase significantly before repetitive maximum squat measurements and after the application of depth jumps (Masamoto et al., 2003).

In a study conducted by Adams et al. (1992) on volleyball players practicing vertical jump, the group performing both plyometric and squat exercises significantly differed from the groups of only squat or only plyometric training performers. The difference between the pre-test and post-test results of only squat or only plyometric performing groups, is found to be 3.30 cm and 3.81 cm respectively. The difference between the pre-test and post-test results of the group performing both plyometric and squat exercises is found to be 10.67 cm (Adams et al., 1992).

On the study conducted by Diallo at all. investigating the effect of plyometric training on jump performance, found significant increases in experimental groups' vertical jump, vertical jump on the move, repetitive skipping and long jump values (Diallo et al., 2001).

In this study, as in other studies in literature, a significant increase on the vertical jump values was observed after plyometric training. The high differences between pre and post test measurement values may be due to the fact that, the first measurements were taken before the start of pre season training. Depending on the results of this study, it can be concluded that, improvements on leg strength and explosive power lead to an increment on vertical jump abilitiy.

In the present study, the comparison of experimental and control groups revealed a statistically significant difference on the horizontal jump values which is a parallel finding with other similar studies in literature (Avery et al., 2007; Cicioğlu et al., 1996; Diallo et al., 2001; Sporis et al., 2010).

Akalın et al. (2008) investigated that 10 weeks plyometric training program on volleyball players and found a significant difference between pre-test horizontal jump values (225,9cm±2,07) and post-test horizontal jump values (237,8cm±4,6) (Akalın et al., 2008). Furthermore, Ateş and Ateşoğlu (2007) applied 10 weeks plyometric training program on athletes and found a significant difference between pre-test (213,92±15,19) and post-test (226,67±15,89) results (Ateş and Ateşoğlu, 2007).

In this study, 8-week plyometric training allowed improvements on anaerobic power and explosive strength capacity thereby, significant increments was observed in horizontal jump parameters of experimental group. Jastrzebski et al. (2014) tested 10-15m running performance for soccer players on rubber and grass and synthetic surface and claimed that runing times significantly shorter on rubber surface than natural grass for soccer players and in authors opinion this results could be caused by the lower amount of total friction between surface and footwear (Jastrzebski et al., 2014). Besides that ground reaction force is less than hard surface (Bishop, 2003).

Previously (Katkat et al., 2009) indicated that wooden and synthetic surfaces were more compliant and less fatiguing surfaces on the other hand asphalt and synthetic grass were hard and most fatiguing surfaces for male elit basketball players (Katkat et al., 2009). These findings suggest that short-term plyometric training on sand/non-rigid surface induces similar improvements in strength, endurance, balance and agility as on firm surface but induces significantly less muscle soreness. Hence, plyometric training on sand is viable option for coaches to enhance performance in athletes,while reducing risk of muscle soreness and damage (Amrinder et al., 2014).

As a conclusion, plyometric training was found to increase the jump capacity of volleyball players. The comparison of wooden and synthetic surface groups did not revealed a statistically significant difference which shows that wooden and synthetic surfaces has not a positive effect on athletes jump performance and only plyometric training makes a positive difference.

This study will contribute to literature and will shed light on sport training studies to be conducted and will contribute coaches while preparing training programs. It is suggested to carry out this study more repetitively and on more subjects.

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