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Effects of Plyometric Training on Anaerobic Capacity and Motor Skills in Female Futsal Players

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ABSTRACT This study was conducted to define the effects of an 8-week plyometric training program on anaerobic capacity, leg strength, vertical jumping and speed values in female futsal players. The study was conducted on 20 volunteer futsal players playing for the top teams of the 2013-2014 season of the Interuniversity League. 20 players futsal players were randomly assigned to the experimental group (n=10), and control group (n=10). The Wingate anaerobic test was used to measure anaerobic power and capacity, a dynamometer was used to measure leg strength, and the Newtest Powertimer measurement device was used to measure the players' 30-meter sprint and vertical jumping values. The multivariate analysis of variance (MANOVA) method was used for statistical analysis. A statistically significant difference was observed in the following factors among the female futsal players of leg power (F (1.36)= 4.20, p= 0.05), absolute peak power (F (1.36)= 6.61, p= 0.01), absolute mean power (F (1.36)= 4.77, p= 0.04), vertical jump (F (1.36)= 14.73, p= 0.00), and speed (F (1.36)= 14.28, p= 0.00). In conclusion, this 8-week training program increased the abovementioned factors in female futsal players.

INTRODUCTION

Futsal, a variant of football, is a sport played worldwide at amateur, semi-professional and professional levels (Moore et al. 2014). Futsal is an indoor version of soccer that is officially sanctioned by the international governing body of soccer (Fédération Internationale de Football Association, FIFA). Futsal is played between two teams of 5 players, one of which is the goalkeeper, and four are outfield players. Each team may have 7 substitutes (6 outfield players and 1 goalkeeper), and unlimited substitutions may be made during an official competition. This indoor, small-sided version of soccer is played on a 40 m x 20 m (length by width, respectively) indoor court with 3 m x 2 m goals. The match lasts two equal 20-minute periods, but similarly as in basketball, the clock is stopped for certain events (fouls, out of play ball). This timing means that match durations are seventy-five to eighty-five percent longer than the expected 40 minutes (Barbero et al. 2008). Teams are allowed to request a 1-minute timeout during each of the halves, which are separated by a 10-minute break. During official competitions, futsal is played with a smaller and less bouncy ball than a typical soccer ball. Each match is officiated by two referees and a linesman. Male and female futsal championships are contested all over the world. Since 1989, the World Championship has been contested by 16 national teams every 4 years. The emphasis in futsal is placed on improvisation, creativity and technique (Barbero-Alvarez et al. 2009).

A soccer player's performance is determined by many completely interdependent abilities, capacities and qualities (Hoff 2005). Essentially, futsal players consist of endurance, strength, speed, agility, local muscular resistance and muscular potency (Busara et al. 2015). Furthermore, the reduced pitch dimensions and frequent turnovers during futsal matches require fast decision-making and high sprint capabilities under pressure from players during the attacking and defending phases (Vaeyens et al. 2007). In fact, futsal players have higher technical competence than football players. The ball used in futsal bounces thirty percent less, which is markedly less, making it more difficult for players to ensure control and to rapidly move the ball from place to place (Benvenuti et al. 2010). Futsal athletes with high performance and technical capacity levels have an important advantage over their rivals (Karavelioglu 2014). Futsal is a very physically intense sport, and consequently, the physical demands of futsal are important considerations for coaches when applying training programs for competition (Moore et al. 2014).

Plyometric training is one such technique that may enable greater force application in a short amount of time (Cossor et al. 1999). In recent years, plyometric training has been added as a new technique alongside quick strength exercises. Plyometric training develops maximal strength and speed as well as explosive anaerobic power (Gokhan and Aktas 2013). Plyometric refers to exercises that are designed to enhance neuromuscular performance. For the lower body, this process involves applying jumping, hopping and bounding training. Plyometric exercises constitute a natural part of most sport movements as they involve jumping, hopping and skipping (Villarreal et al. 2010). In many studies on female football players, plyometric training has been found to improve performance values such as jumping, anaerobic capacity, muscle strength and speed (Compo et al. 2009; Rubley et al. 2011; Ozbar et al. 2014; Myer 2006; Chimera et al. 2004; Vescovi et al. 2008).

However, notably, an insufficient number of studies have addressed the effects of plyometric training on female futsal players in particular. Investigating the effects of plyometric training on female futsal players was important to determine whether plyometric training can be an effective method in training female futsal players. This study aimed to determine the effects of 30 minutes of plyometric training performed three times/week on the anaerobic capacity, leg strength, vertical jumping and speed values of female futsal players.

METHODOLOGY

Participants

Individual consent forms were collected from the players to conduct the training program. Twenty female futsal players playing for the teams that were ranked 1st, 2nd and 3rd in the 2013-2014 Interuniversity League voluntarily participated in the study. Using a random assignment method, 10 players (aged 20.40 ± 1.02 years old) were classified into the control group, and the other 10 (aged 20.80 ± 1.17 years old) were classified into the experimental group. The training program was performed thrice a week for 8 weeks.

Both groups continued their regular futsal trainings, and the experimental group additionally performed 30 minutes of plyometric training three days a week. Measurements were not performed during the players' menstruation cycles to eliminate negative performance effects.

Measures

Wingate Test: The participating athletes' anaerobic power was measured via the Wingate anaerobic power test (Monark 894 E Peak Bike, Sweden). Before the test, the athletes cycled at 60-70 RPM for 5 minutes to warm up. The seat and handlebars were adjusted according to the height of each participant. The load to be applied was set at 7.5 percent of the body weight of each athlete. When ready, the participants cycled at maximal speed for 30 seconds. All of the test values were uploaded to a computer via an RS 232 connection and were automatically recorded.

Leg Strength: The subjects' isometric leg strength was measured using a digital back dynamometer (TKK 5402, Takei Scientific Instruments, Japan). Each subject stood on the dynamometer foot stand and gripped the handle in both hands. A pulling force was then applied to the handle by straightening the knees and lifting the dynamometer chain. The leg strength was recorded on the dial of the dynamometer as the best value of two trials, in kg.

30-meter Sprint: The 30-meter speed test was performed in a hallway with 0.01 precision photocells (Newtest Powertimer 300-series, Finland) placed at the starting and ending points at a 30-meter distance. The sprint was performed twice, and the better time was recorded in seconds.

Jumping Measurements: The vertical jumping test was performed on a force platform (Newtest Powertimer 300-series, Finland). Participants were asked to jump upward while maintaining their hands on their waists, their feet open to shoulder width, and their trunk straight, with their knees in a half-flexed position. The test was performed twice, and the better result was recorded in centimeters.

Procedure

All of the participants were first tested using the Wingate, leg strength, 30-meter sprint, and jumping tests as baseline performance measures. For the statistical analysis, SPSS 20.0 was utilized.

Training Protocol: After the pre-test results of all of the participants were recorded, the participants were provided information on the plyometric training to be performed by the experimental group according to the Baldon's plyometric training program (Baldon et al. 2014). All of the athletes continued their routine futsal trainings in the sports hall for 8 weeks, and the experimental group additionally performed 30-minute plyometric training three days a week, after their regular training (Table 1).

At the end of the 8 weeks of training, all the participants in both groups were again tested with the Wingate, leg strength, 30-meter sprint, and jumping tests to compare the results to the baseline performance measures.

RESULTS

Before conducting statistical analysis, assumptions of the multivariate analysis of variance (MANOVA) test were assessed. Firstly, covariance homogeneity was checked with Box's M test, which showed that homogeneity of the covariance matrices was not violated ($p>0.05$). The normality assumption was assessed for both the univariate and multivariate tests. The univariate tests included Levene's test (Table 2) as well as histogram and p-p plot assessments, whereas Mardial's test was the multivariate test. The results indicated no violation of the normality assumption ($p>0.05$). On the multi-collinearity assumption, the tolerance and variance inflation factor (VIF) values were assessed, and no high correlations were detected. Lastly, the interquartile range was used to check for outliers that could affect the statistical analysis results. The range

Table 1: Plyometric training program used in the 8-week training group

Exercise	*Duration or repetitions*
Phase 1- Technique (wks 1-2)	
1. Wall jumps	20 s
2. Athletic position (5 s)	5 reps
3. Squat jumps (60 degrees of knee flexion)	15 s
4. Lunge jumps	15 s
5. Horizontal jump + athletic position (5s)	8 reps
6. 180-degree jumps	20 s
7. Forward–backward jumps over the line	20 s
8. Jump over barriers (10 cm)	8 reps
9. Lateral–medial jumps over the line	20 s
10. Lateral jump over the line + vertical jump	8 reps
11. Drop landing + athletic position (5 s)	8 reps
Phase II—Fundamental (wks 3-5)	
1. Athletic position in single-leg standing (5 s)	10 reps
2. Wall jumps	30 s
3. Squat jumps (60 degrees of knee flexion)	2x15 s
4. Triple horizontal jump + vertical jump	6 reps
5. 180-degree jumps	15 s
6. Lunge jumps	15 s
7. Jump over barrier + jump to platform	6 reps
8. Lateral-medial jumps over barrier (10 cm)	2x15 s
9. Forward-backward jumps over barrier (10 cm)	2x15 s
10. Anterior drop jump + maximum vertical jump	6 reps
11. Lateral drop jump + maximum vertical jump	6 reps
12. Vertical hop + athletic position in single-leg standing	6 reps
Phase III—Performance (wks 6-8)	
1. Athletic position in single-leg standing (5 s)	10 reps
2. Tuck jumps	15 s
3. 180-degree horizontal jumps	20 s
4. Lunge jumps with trunk rotation	20 s
5. Maximum horizontal jump + maximum vertical jump	6 reps
6. Forward–backward hops over the line	15 s
7. Lateral–medial hops over the line	15 s
8. Horizontal hop + athletic position in single-leg standing (5 s)	4 reps
9. Lateral drop landing + maximum vertical jump +maximum horizontal jump	6 reps
10. Horizontal hop over barriers (3) + hop to platform	4 reps
11. Lateral (2) and medial (2) hop over barriers (2) + hop to platform	8 reps
12. Single-leg drop landing + maximum vertical hop 4 rep	4 reps

reps: repetitions

findings indicated that there were no strong outliers.

Table 2: Levene's test of equality of error variances

	F	*df1*	*df2*	*Sig.*
Leg Power	.47	3	36	.70
Absolute Peak Power	.27	3	36	.85
Relative Peak Power	.02	3	36	.99
Absolute Mean Power	.33	3	36	.80
Relative Mean Power	2.70	3	36	.06
Vertical Jump	1.04	3	36	.39
Speed	2.01	3	36	.13

Wilks' Lambda test for MANOVA analysis revealed that there was a significant main effect between pre and posttest and group variables on selected dependent variables (Wilks' λ= 0.87. F (3.36)= 3.74, p <0.05, partial eta squared= 0.47). Given the significance of overall test, the univariate main effects were examined (Table 3).

With respect to the group findings, significant main effects were obtained for leg power (F (1.36)= 4.20, p= 0.05, partial eta squared= 0.10), absolute peak power (F (1.36)= 6.61, p= 0.01, partial eta squared= 0.16), absolute mean power (F (1.36)= 4.77, p= 0.04, partial eta squared= 0.12), vertical jump (F (1.36)= 14.73, p= 0.00, partial eta squared= 0.29), and speed (F (1.36)= 14.28, p= 0.00, partial eta squared= 0.28, p<0.05) (Table 4). Overall, the study results revealed an interaction among the group, pre-test and post-test variables and selected result variables. Specifically, the 8-week plyometric training program had effects on anaerobic capacity and selected motor skills.

DISCUSSION

This study assessed the effects of a 30-minute plyometric training performed three times a week for 8 weeks in addition to routine training on the anaerobic capacity, leg strength, vertical jumping and speed values in female futsal players, who have not been previously assessed in a sufficient number of studies.

In their study on male football players, Vaczi et al. (2013) reported improved anaerobic capacity after six weeks of plyometric training. Siegler

Table 3: MANOVA test of variables

	Effect	*Value*	*F*	*Hypothesis df*	*Error df*	*Sig.*	*Partial Eta squared*
Intercept	Pillai's Trace	0.99	3445.41^{b}	7	30.00	0.00	0.99
	Wilks' Lambda	0	3445.41^{b}	7	30.00	0.00	0.99
	Hotelling's Trace	803.93	3445.41^{b}	7	30.00	0.00	0.99
	Roy's Largest Root	803.93	3445.41^{b}	7	30.00	0.00	0.99
Pre_Posttest	Pillai's Trace	0.74	11.86^{b}	7	30.00	0.00	0.74
	Wilks' Lambda	0.27	11.86^{b}	7	30.00	0.00	0.74
	Hotelling's Trace	2.77	11.86^{b}	7	30.00	0.00	0.74
	Roy's Largest Root	2.77	11.86^{b}	7	30.00	0.00	0.74
Group	Pillai's Trace	0.59	6.26^{b}	7	30.00	0.00	0.59
	Wilks' Lambda	0.41	6.26^{b}	7	30.00	0.00	0.59
	Hotelling's Trace	1.46	6.26^{b}	7	30.00	0.00	0.59
	Roy's Largest Rot	1.46	6.26^{b}	7	30.00	0.00	0.59
Pre_Posttest	Pillai's Trace	0.47	3.74^{b}	7	30.00	0.01	0.47
**Group*	Wilks' Lambda	0.53	3.74^{b}	7	30.00	0.01	0.47
	Hotelling's Trace	0.87	3.74^{b}	7	30.00	0.01	0.47
	Roy's Largest Root	0.87	3.74^{b}	7	30.00	0.01	0.47

Table 4: Main effects of group tests on selected variables

	Effect	*Value*	*F*	*Hypothesis df*	*Error df*	*Sig.*	*Partial Eta squared*
Group	Leg Power	896.81	1	896.81	4.20	0.05	0.10
	Absolute Peak Power	28614.48	1	28614.48	6.61	0.01	0.16
	Relative Peak Power	1.58	1	1.58	1.85	0.18	0.05
	Absolute Mean Power	11122.23	1	11122.23	4.77	0.04	0.12
	Relative Mean Power	0.42	1	0.42	0.97	0.33	0.03
	Vertical Jump	130.68	1	130.68	14.73	0.00	0.29
	Speed	0.86	1	0.86	14.28	0.00	0.28

et al. (2003) concluded that plyometric training increased football-oriented strength and resistance to exhaustion in female football players. In their study on preadolescent soccer athletes, Michailidis et al. (2013) found that plyometric training had no effect on anaerobic strength. A review of various studies shows that plyometric training has different effects on the anaerobic capacities of female and male football players. Considering that the effects of plyometric training have been evaluated at the end of 6-, 8-, 10-, and 14-week programs, this difference may be attributable to the scope of the training. In the present study, in contrast, the researchers observed statistically significant improvements in Wingate anaerobic peak strength and capacity values at the end of the 8-week plyometric training program. However, this difference disappeared when the results were normalized to body weight.

Actions such as power, running, direction changes, jumps, and short-distance sprinting belong to the lower extremities (Ozbar et al. 2014). Plyometric training is quite effective for lower extremity improvement (Chelly et al. 2010). A change of nine percent indicates that significant adaptation in leg power has occurred, showing the benefits of maximal-intensity plyometric training (Vaczi et al. 2013). Plyometric training decreases injury risk and improves leg strength among female players (Chimera et al. 2004; Myer et al. 2006), and a 4-week plyometric training program in female futsal players improved leg strength (Rezaimanesh et al. 2011). The results of the present study indicate a statistically significant improvement in the leg strength of female futsal players at the end of an 8-week plyometric training program.

Many studies have reported speed performance improvement after plyometric training (Ozbar et al. 2014; Chelly et al. 2014; Villareal et al. 2008; Rimmer and Sleivert 2000). A recent meta-analysis showed that plyometric training is an effective training method for improving sprint performance (Villareal et al. 2012). Ozbar et al. reported improved 20-meter sprint performances by female football players after an 8-week plyometric training program. Chaouachi et al. (2014) concluded that plyometric training improved the 20-meter sprint performances of players by twenty percent more than traditional methods. The results of the present study showed an improved 30-meter sprint performance in female futsal players at the end of the 8-week plyometric training program.

Siegler et al. (2003) tested what was described as a high intensity plyometric program using high school female soccer players and found significantly increased vertical jump performance. In a study on female football players, Rubley et al. (2011) recorded an increase in the vertical jumping values of female footballers. Rezaimanesh et al. (2011) conducted a study on futsal players and found no effect of a 4-week plyometric training program on the players' vertical jumping values. These results indicate the importance of the scope of plyometric training. However, the present study detected positive effects on the vertical jumping values of female futsal players after an 8-week plyometric training program.

CONCLUSION

Plyometrics can be used by female futsal players as an effective training method. A 30-minute plyometric training session performed three times a week for 8 weeks in addition to routine futsal training improved the leg strength, vertical jumping and speed performance of female futsal players.

RECOMMENDATIONS

Determining the effects of different training methods on the performance of female futsal players is quite important for the sports community, and increasing the number of future scientific studies on female futsal players will have a significant impact on sports science.

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