



Original Article

Effects of short-term plyometric training on physical fitness parameters in female futsal athletes

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Abstract. [Purpose] To verify the effects of short-term plyometric training (PM) on body composition, flexibility and muscle power output in female Futsal athletes. [Subjects and Methods] Twenty female Futsal athletes (19.5 ± 1.29 years) equally and randomly divided into control and experimental groups were submitted to a sit-and-reach flexibility test, body composition measures and horizontal jump, at baseline and one day after the final training session. Both groups retained their training routines while only the experimental group participated in an additional 25 minutes of PM 2 times a week over 4 weeks. [Results] The experimental group showed higher values of flexibility and muscle power and lower body fat after the intervention in comparison to the baseline and control group. In addition, the effect size within-group after intervention indicated a moderate, large and very large effect for body fat, flexibility and muscle power, respectively. [Conclusion] These results show that plyometric training may be effective in reducing body fat and increasing flexibility and muscle power in female Futsal athletes. Thus, it may suggest that PM can be applied in the field of preventive physical therapy.

Key words: Sport, Body composition, Athletic performance

(This article was submitted Jul. 2, 2016, and was accepted Nov. 18, 2016)

INTRODUCTION

Futsal is an intermittent high-intensity sport characterized by the elevated technical and tactical level of the athletes^{1,2)}. In addition, because Futsal is a high-intensity sport, physical requirements must be considered when implementing training programs for athletes of this modality³⁾. Thus, physical training for these athletes is extremely important to maintain the competitive level in each match throughout the season⁴⁾, and it is necessary to search for and apply more efficient training methods. A widely used but less scientifically explored alternative method for Futsal athletes is plyometric training (PM).

PM develops muscle strength, maximum power, speed and explosive anaerobic power⁵⁾. Furthermore, strength and muscle power gains promoted by PM seem to be similar to those promoted by resistance training⁶⁾. However, without the need for sophisticated and expensive equipment. Making PM an interesting alternative for professional and amateur teams with a low financial investment for those that appropriate training center often is unavailable. Moreover, added to muscle

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power improvements, this method can also be effective to improve body composition and flexibility parameters because of the high energy expenditure and range of motion necessary to perform jumping exercises⁷, which may lead to performance improvements during the game⁸. It is noteworthy that the exercises used during PM are part of most of the movements during sports itself⁹.

In some studies on female Futsal athletes, this method has already demonstrated to improve muscle power output, muscle strength and speed^{8, 10, 11}. However, compared to male athletes, few studies have investigated the effects of PM on the parameters mentioned above. Moreover, to the best of our knowledge, there is only one study that investigated the effects of PM on body composition in female Futsal athletes⁸. It is noteworthy that this parameter has been widely accepted as a predictor of performance¹²⁻¹⁴.

In addition, there are no studies that have investigated the effects of PM on the flexibility levels of Futsal athletes. It should be noted that this parameter has been associated with performance enhancement and injury prevention by regaining joint range of motion¹⁵⁻¹⁷. Therefore, the aim of this study was to verify the effects of PM on power output, body composition and flexibility in female Futsal athletes.

SUBJECTS AND METHODS

Twenty female Futsal university athletes without any muscle, bone and/or joint limitations, no use of any drugs, had practiced Futsal for at least 3 years and had attended at least 80% of the training sessions were included in the analysis. The athletes were randomly and equally divided in two groups, the experimental group (EG=10) and the control group (CG=10). The final sample size (n=20) conferred a statistic power *a priori* of 60% ($1 - \beta = 0.6$; $\alpha=0.05$). General characteristics of the volunteers are presented in Table 2. All procedures were carried out according to resolution 466/2012 of the National Health Council and to the Declaration of Helsinki for experiments to be conducted on humans. This study had approval of the local Ethics Committee for Human Research (protocol: 21306613.1.0000.0023) and obtained a written informed consent from the volunteers.

All volunteers were instructed to maintain their dietary habits during the investigation protocol. Both groups (EG and CG) underwent an evaluation of their body composition (skinfold and waist-to-height ratio), flexibility (sit-and-reach) and muscle power output (horizontal jump test) at baseline and one day after the 4-week intervention period. During these 4 weeks, both groups maintained their tactical and technical training routines with specific activities of the modality. Meanwhile, the EG underwent PM (Table 1) twice a week for approximately 25 minutes per training session. Plyometric exercises were progressive and were adapted from Bompa¹⁸.

Height was measured with the volunteer in a standing position and barefoot, with the ankles, calves, buttocks, scapulas and head leaning against the wall. The head was positioned according to Frankfurt's plan, and stature was measured at the moment of inhaling air. Body mass was measured while the participants wore light clothes. Body mass index (BMI) was calculated as $\text{weight (kg)} \cdot \text{height (m}^{-2}\text{)}$.

Relative body fat was estimated by the sum of four skinfolds (subscapular; triceps; suprailiac; abdominal) using a skinfold caliper (Sanny[®]) and applying the equation and protocol proposed by Falkner¹⁹. The skinfolds were collected at each point in rotational sequence, beginning on the right side of the body, and the median value was recorded (Table 2).

Flexibility of the hamstrings and lower back muscles was evaluated by the sit-and-reach test²⁰. Individuals were placed in a seated position with legs straight and slightly parted, feet flat on the wall of the wooden box (Well's Bench), elbows extended and upper limbs flexed in the sagittal plane. From this position, individuals were instructed to stretch forward over the box and attempt to reach with their hands as far as possible on a graduated scale in centimeters at the top of the box. The largest absolute value over three attempts constituted the measurement of flexibility.

Participants began the test with both feet parallel on a marked line and were instructed to perform three maximum jumps to cover the greatest horizontal distance possible. Using a floor mounted tape measure, the distance covered by each jump was determined from the start line to the where the heel closest to the start line landed. We recorded the best jump performance value²¹.

After assessing the normality and homogeneity of the data through the Shapiro-Wilk and Levene's test, respectively, the data were presented as the mean and standard deviation (\pm). In order to compare the characteristics of the groups, Student's t-test for independent samples was applied. Between and within-group comparisons were carried out using split-plot ANOVA (Mixed ANOVA). When any of the dependent variables did not show sphericity in Mauchly's test, the epsilon of Greenhouse-Geisser was used to analyze the *F* statistic. Because there were only two groups, a *post hoc* test was unable to locate the differences; it is necessary to apply a parallel test called pairwise comparisons. Thus, a paired Student's t-test was used to compare the values at baseline and after the intervention period. The effect size within (baseline vs. post) and between groups (EG vs. CG) was calculated using Cohen's *d*²². Pearson's correlation coefficient was applied to test for associations between the variables. For the sample size calculation, was used the statistical power ($1-\beta$) a priori using the comparison analysis applied (ANOVA for repeated measures), an effect size of $f=0.35$ and, significance level set at 5% ($p<0.05$) to all procedures. All procedures were carried out using the Statistical Package for the Social Sciences (SPSS 20.0) and G*Power (version 3.1.9.2).

RESULTS

At baseline, the groups (EG and CG) presented no statistical differences among the variables of characterization, with the exception of body fat, that showed lower values for the EG (Table 2). In contrast, both groups were classified in the same stratum (excellent) for body fat, taking into account sex and age²³. The within-group comparisons indicated a significant reduction in the body fat and an improvement in flexibility and muscle power output for the EG ($p < 0.05$). Furthermore, the between-group comparison indicated that the EG had significantly lower post-intervention values for body fat and significantly higher values for power and flexibility (Table 3).

The within-group comparison of the effect size showed that the CG values did not change significantly in all of the investigated variables; meanwhile, the EG displayed effects of moderate, large and very large standards for body fat, flexibility and muscle power, respectively. In the between-group comparison of the effect size, only the waist-to-height ratio (WHR) had no effect ($d = 0.16$), while there was a large effect for the body fat ($d = -1.11$), and a very large effect for flexibility ($d = 2.09$) and for muscle power ($d = 2.55$) (Table 3).

Pearson's correlation coefficient indicated a positive and significant ($p < 0.05$) association between baseline values of flexibility and post-intervention horizontal jump and flexibility. In addition, the results showed a negative and significant association between baseline flexibility and post-intervention body fat. Furthermore, a negative and significant association was found between baseline body fat and post intervention horizontal jump and flexibility (Table 4).

Table 1. Description of the plyometric training exercises performed

Planning (training session)	Description	Number of series and repetitions (reps)
Week 1 (≈ 25 minutes)	Alternate leg bounding; unilateral squat jump; power skipping	4 × (15 reps) in each exercise
Week 2 (≈ 20 minutes)	Power skipping; squat jump; alternate leg bounding	3 × (8–15 reps) in each exercise
Week 3 (≈ 15 minutes)	Squat jump; repeated long jumps; unilateral squat jump; static tuck jumps	3 × (8–15 reps) in each exercise
Week 4 (≈ 15 minutes)	Progressive power skipping; rhythm skips; jump rope (30 seconds); unilateral squat jump; diagonal obstacle jump; repeated tuck jumps	2–3 series: circuit with 90 seconds interval

Table 2. Sample characteristics

	Control (n=10)	Plyometric training (n=10)
Age (years)	19.5 ± 1.4	19.4 ± 1.3
Height (cm)	165.1 ± 5.8	161.1 ± 9.6
Body mass (kg)	62.5 ± 8.8	59.8 ± 8.7
BMI (kg·m ⁻²)	23.5 ± 2.7	22.1 ± 0.9
Body fat (%)	16.5 ± 1.8	15.1 ± 3.2 *
WHR	0.44 ± 0.0	0.44 ± 0.1

Data expressed as mean and (±) SD

BMI: body mass index; WHR: waist-to-height ratio; *Statistical difference ($p < 0.05$)

Table 3. Within- and between-group comparisons of waist-to-height ratio, body fat, sit-and-reach and horizontal jump

		Control	Plyometric training
Waist-to-height ratio	Baseline	0.44 ± 0.03	0.44 ± 0.10
	Post-training	0.44 ± 0.01	0.45 ± 0.10
	Effect size	0.1	0.1
Body fat (%)	Baseline	16.5 ± 1.8	15.1 ± 3.2
	Post-training	16.5 ± 1.8	13.9 ± 2.9 *
	Effect size	-0.02	-0.39
Flexibility (cm)	Baseline	24.9 ± 3.7	31.6 ± 5.1
	Post-training	25.0 ± 3.7	35.6 ± 4.6 *†
	Effect size	0.01	1.99
Horizontal jump (cm)	Baseline	133.1 ± 22.4	151.1 ± 8.8
	Post-training	132.9 ± 23.0	170.4 ± 10.5 *†
	Effect size	0.02	0.81

Within-group comparisons' effect size estimated by Cohen's d. Data expressed in mean and standard deviation.

*Within-group statistical difference ($p < 0.05$); †Between-group statistical difference for the same moment ($p < 0.05$).

DISCUSSION

The aim of this study was to investigate the effects of four-week-long PM on physical fitness parameters. The main finding was that, in addition to muscle power, PM was also effective to promote an increase in flexibility levels and reduce body fat in young female Futsal players.

The high-intensity stretch-shortening cycles performed during PM may cause several peripheral adaptations, such as muscle hypertrophy. Malisoux et al.⁷⁾ submitted eight trained men to eight weeks of PM and reported a significant increase ($p < 0.01$) in the cross-sectional area of muscle fibers type I and IIa of the *vastuslateralis*. An increase in muscle mass may lead to a higher resting metabolic rate and promote higher energy expenditure at rest, which may lead to other changes in body composition over the medium and long term, such as a decrease in body fat²⁴⁾. Similarly, it was observed in the present results ($p < 0.05$), which showed a moderate and large effect in the comparisons within-groups (baseline vs. post) according to the Cohen's standard²²⁾. It is important to emphasize that an improvement in body composition parameters can be fundamental for the performance of athletes during the match, especially Futsal, since this sport involves rapid movements and jumps and the direction changes continuously; any excess body weight or fat may influence the athletes' general performance²⁵⁾.

With regard to WHR, the results demonstrate that it remained unchanged after PM in both groups, which may be because young athletes, such as those used in this study, have absolute mean values of this index below the average and median compared to reference values for this age²⁶⁾. Thus, are not very susceptible to a reduction along with other body composition parameters.

Flexibility improvement for Futsal athletes after PM is an important finding because the deficit of this physical fitness component has been postulated as being responsible for muscle and joint injuries in the lower limbs in athletes and recreational players²⁷⁾. Thus, alternative training methods that may reduce the risk of injury may be of interest to teams, coaches and athletes²⁸⁾. O'Sullivan et al.²⁹⁾, reported evidence that a training method focused on eccentric contractions can raise flexibility levels in the lower limbs and suggests that the most likely mechanism involved may be the increase of sarcomeres, a phenomenon already observed in animal models³⁰⁾. Therefore, the flexibility gains in this study may be explained on account of PM having a large eccentric component in its repeated high-intensity stretch-shortening cycles⁷⁾, promoting similar adaptations to those suggested above.

Regarding to PM, studies have focused on analyzing the effects on the injury prevention of first time non-contact anterior cruciate ligament (ACL) injury. The result indicates that PM can enhance neuromuscular control in all three planes, which will reduce stress on the ACL transferring to the muscles, tendons and bones, allowing a greater dispersion of force resulting in lower torque applied directly to the knee³¹⁻³⁴⁾.

The primary focus of PM is commonly associated with muscle power improvement, which may be occasioned for several of factors. The increase in muscle power can be explained in part by the fact that PM increases the muscular tension reducing the energy dissipated by the tendon, by an improvement in tensile strength³⁵⁾. Moreover, a simple increase in motor skills to perform horizontal jumps may be one a factor improving jump performance because this movement-jump is classified as a slow shortening-stretching cycle with high range of motion³⁶⁾ and has been suggested as being the most responsive to PM³⁷⁾.

In addition, the reduction in body fat and increase inflexibility levels could also be responsible for higher muscle efficiency and range of motion, respectively. Increasing the ability of athletes to have a higher power output and achieve better results in the horizontal jump test. The association results may reinforce this because the increase in muscle power after intervention was negatively associated with body fat reduction and positively associated with increased flexibility. Furthermore, PM has shown improvements in muscle power of the lower limbs for athletes in several sports³⁸⁾, including Futsal. Almeida and Rogatto¹¹⁾ demonstrated a 10% increase of muscle power in female Futsal athletes, similarly to the present study, which demonstrated an increase of 12%.

Studies suggest that an increase in muscle strength and flexibility may significantly reduce the likelihood of injury³⁹⁻⁴⁵⁾. Furthermore, the excess weight has been considered a risk factor for lower limb injuries in sports^{27, 46, 47)}. Thus, the results of

Table 4. Matrix correlation between baseline and post intervention values of body fat, horizontal jump (power) and flexibility of the experimental group

		Baseline		Post intervention		
		Power	Flexibility	Body fat	Power	Flexibility
Baseline	Body fat	-0.3	-0.6 *	0.9 *	-0.7 *	-0.8 *
	Power	-	0.2	-0.2	0.7 *	0.2
	Flexibility	-	-	-0.7 *	0.6 *	0.9 *
Post intervention	Body fat	-	-	-	-0.7 *	-0.8 *
	Power	-	-	-	-	0.7 *

Data expressed as Pearson's coefficient r (p value).

*Significant correlation ($p \leq 0.05$).

this research may suggest that PM can be applied in the field of preventive physical therapy.

Further, the results may still be relevant for teams and coaches who seek simple, low-cost and efficient methods to optimize the physical training of their athletes and may even be an alternative to resistance training, which can be costly for professional and amateur teams with a low financial budget and who have no access to sophisticated equipment. In this regard, MacDonald et al.⁶⁾ submitted 30 trained men to six weeks of PM or two different methods of resistance training, and, although improvement was reported in all groups for anthropometric measurements (thigh and calf circumference, body fat) and strength (Romanian deadlift; standing calf-press) in the within-group comparison, there were no differences between the groups, suggesting similar adaptations of plyometric and resistance training.

The fact that we have not investigated the mechanisms that may be involved in the improvement of the investigated variables (muscle power, body composition and flexibility) and that there was no nutritional control, can be considered limitations of this research. Nevertheless, all volunteers were instructed to retain their food intake patterns throughout the study. Furthermore, the fact of body fat have shown significant difference between groups at baseline, can also be configured as a limitation. However, it is noteworthy that both groups were classified in the same stratum (excellent) for body fat, considering the gender and age²³⁾. Moreover, relative small sample size may also characterize a limitation. Thus, we suggest that the findings of this study should be interpreted with some caution.

Therefore, in addition to muscle power and strength improvements that PM may promote, this simple and low-cost method can also be effective in improving other parameters of physical fitness and can be an alternative for athletes and coaches during physical preparation. In summary, these results concluded that PM seems to be effective to reduce body fat and raise flexibility and muscle power levels in female Futsal athletes.

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