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Comparison of three methods of plyometric training on muscles power

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ABSTRACT

The purpose of this study was to compare three methods of plyometric training on muscles power among female students. Thirty three participants (age, 16.8 ± 3.7 yrs; weight, 56.26 ± 6.9; height, 155.96 ± 7.2) selected for this study. The subjects were randomize in three groups included over handle jump (N=11), drop jump (N=11) and high jump groups (N=11). All of the groups performed plyometric training in separate protocols for 18 sessions, 3 times per week and at least 30 minutes activity after warm up. The subjects measured in two sessions before and after training sessions. The result of the study revealed that a significantly improvement in pretest and posttest in three methods of groups. The finding of the study provided evidence that no significant difference between three methods of plyometric (OJ, DJ and HJ groups) on muscles power is detected. Therefore, the plyometric training can use to improvement in muscles power in female students.

Keywords: Plyometric Training, Muscles Power, Female Students

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INTRODUCTION

Given the nature of sport, athletes and sport champions have various needs, priorities, and preferences in terms of physical fitness and mobility status. In other words, all sport courses hold individual requirements in strength, endurance, power, flexibility, and speed, or a combination of them; which vary from one sport to another [19]. Muscle power is an effective parameter to success [24]. Power is defined an ability to do work per unit of time. In physical education, it refers to the maximal force that a muscle generates in the shortest possible time in order to confront the resistance, it is equal to muscular force or explosive power [2]. Increased power enables muscles to do the same work in small time period, or high work volume within the same time. Peak muscle power is determined by the ability to generate maximum strength and speed, and represented as the highest power output during a specific movement [24]. The variable can be improved through several exercises. Among them, plyometric exercises have been applied by athletes, especially runners and jumpers, over the past three decade [10]. Traditional and classical techniques presented running and weight training. Such technical performances were used for a long time; however, no significant effects were observed. Emerging plyometric exercises have led to improvements in power functions, particularly in jumps. [12, 34]. The word "plyometric" consists of two parts:"plio" meaning "more"; and "metric" meaning "measure" [9]. In the mid-1960s, russian scientists conducted fundamental research in this field. Research indicates a huge potential for practical applications of plyometrics [31]. Based on the findings of Miller and Power (1981) for eccentric contractions, scientific principles of drop jump training were developed. In accordance with the theory of primary muscle strain, the jump training is aimed to increase the use of kinetic energy [30].

Plyometric practices involve specific muscles in eccentric-concentric movement cycles. Frequency of eccentric (stretching) and concentric (shortening) actions provides higher power than of simple concentric action [13, 25]. Elastic energy within the muscle can produce more force [31, 38]. Increased power generation plays an important role in improving sprint running times, which require high explosive power. Cavagna et al. (1971) evaluated the amount of force generated during sprint running, from start to end points (9.4 m/s) and found that the peak power outputs were obtained by 5 m/s mean time due to inherited contracted features of muscles and the appearance of elastic energy before concentric movement [8]. Later, several studies have been confirmed the role of elastic energy in human movements [15, 21]. Today, plyometric training is often used by coaches in many exercise programs [29]. As stated, because of the special features of sports such as weight drop and sprint running, the power factor is of great importance. Hence, it is useful to evaluate its components. The components of power are Force (F) and Velocity (V). Due to the presence of Force, many researchers believe that the use of overload can cause more irritation and maximal power output [16, 23]. Alternatively, Larson (2003) showed that there is no significant difference in jump heights between groups with and without overload after performing plyometric exercise [27]. Plyometric exercises which can strength hip extensor muscle, have been often considered to increase muscle power values in runners and jumpers, although the research findings are inconsistent. Some research has reported an improved performance by these exercises [6, 21], while there are conflicting results in this field [4, 11].

When the focus is on feet extensor muscles, those plyometric exercises which are performed based on drop jump from an initial height to on the land r on a hard and flat surface, is usually considered [32]. Meanwhile, some studies have concentrated on the initial jump height. For example, Asmussen and Bonde (1974) and Komi and Bosco (1978) recommend a height ranging from 40 to 62 cm [3, 26]. Also, Bobbert et al. (1987) claim that the height of 20 and 40 cm can generate the maximum power outputs in knee and ankle joints, greater than a 60 height [7]. However, Lees and Fahmi (1994) suggest height values less than previous ones. The height of their interest was 12 cm [28].

According to previous studies, plyometric exercises can cause similar achievements with resistance practices in jumping performance [5]. Furthermore, no significant difference has been evident in findings of various plyometric types [10]. Some recent research concludes that plyometric exercises may improve muscle power and momentum values in subjects [18]. Several studies also indicate that combinations of resistance and plyometric exercises may improve the explosive power and speed values [15, 33]. Robinson et al. (2004) found that aquatic plyometric exercises, like land plyometric exercises, may lead to improvements in selected factors [35]. The same result was provided by John and Bert (2007) [22]. Furthermore, many studies report significant improvements in jump performance jump, explosive power, and lower extremity power output achieved after a plyometric training period [20]. However, after 8 weeks of plyometric training, Miller et al. (2002) observed no significant difference in muscle power and peak torque values [31]. Also, no evidences of improvement as the result of training protocols were provided by Aagard et al. (1993) and Trolle et al. (1993) [1, 37].

With a review on the literature, it is clear that more research about plyometric exercises have been conducted on drop jump, while the impact of high jump has been less studied. Given the lack of research about the impact of plyometric training (over hurdle jump, high jump, drop jump) on lower extremity muscle power, the paper is aimed to investigate the impact of plyometric training (over hurdle jump, high jump, drop jump) on lower extremity muscle power. Furthermore, since previous research has mostly used the vertical jump measurements, the current study seeks to examine the factors using standing long jump.

MATERIALS AND METHODS

Regarding the comparative effect of 6-week plyometric training on muscle power and the use of randomized sampling, this is an experimental paper. Research plan consists of three casual-comparative groups, with two pre- and post-test stages. The statistical population includes 118 female high school students in Aliabad Katoul town (Iran), from which 33 healthy students were randomly selected and invited to participate in the study. The sampling technique was targeted and available. Before starting the program, the students were fully acknowledged with the research objectives, and then registered to attend tests. After signing the consent form, they completed personal and medical information, and research training details. Table 1 shows the subjects' profiles.

Table 1. Descriptive Characteristics of Subjects

Subject Status	N	Age (Year)	Height (Cm)	Wight (Kg)
Over hurdle jump	11	16.9±2.6	156.2±7.4	56.5±8.1
High Jump	11	17.1±3.1	156.0±6.5	56.8±5.7
Drop Jump	11	16.5±2.4	155.7±7.7	55.5±6.9

The subjects were randomly divided into three training groups of over hurdle jump, high jump, and drop jump (each with 11 people). For all three groups, height and weight measurements were recorded. Before implementing the protocol, all subjects were exposed to a separate pre-test session. The pre-test included 5 times standing long jump with 60 seconds rest between each effort. The best record obtained from 5 jumping was applied for the statistical analysis [36]. Then, for 6 weeks, with 3 sessions per week on Saturdays, Mondays and Wednesdays, each groups practiced the protocol for 30 minutes, after 15-minute warming and running time. When 18 sessions were completed, the post-test was conducted.

For all groups, the training program was as the following:
- To repeat four of 5 continuous jumps with 30 sec. rest between each period for over hurdle jump group.
- To repeat four of 5 continuous jumps with 30 sec. rest between each period for high jump group.
- To repeat four of 5 continuous jumps with 30 sec. rest between each period for drop jump group [34].

Note that the difference of long jump steps was 40 cm[7]. The subjects were allowed to use winging hand and knee flexion movements to jump out. Descriptive and inferential statistical methods were used to analyze research data. To ensure normality, Kolmogorov–Smirnov test as applied. Furthermore, Levine test was used to meet the condition of variance homogeneity for all three groups. The research used the independent t-statistical approach to confirm that there is no significant difference in the pre-test session ($P \leq 0/05$). The dependent t-statistical approach was also applied to examine the hypothesis ($P \leq 0/05$). Subsequently, the ANOVA test was used to estimate and compare the effect and the average values of three independent groups. Statistical measurements were calculated by computer-aided software programs of SPSS 15 and Excel 2007.

RESULTS

Results of Kolmogorov–Smirnov test showed a normal distribution for all variables measured in two groups. Moreover, Levine test ensured that the condition of variance homogeneity for the pre-test was met in all three groups. Pre-test values obtained for research variable were compared in three groups, and no significant differences were observed for base values in three groups of over hurdle, high and drop jumps.

Table 2. T-Statistics for Initial Tests and Final Tests in Three Groups

Variable	Test Status	Mean & SD		Mean Difference	t	Sig
		Pre-Test	Post-Test			
standing long jump	Over hurdle	148.09±11.67	154.73±8.33	6.64	-5.87	0.0001
	High	150.18±12.75	157.27±10.40	7.09	-4.42	0.001
	Drop	149.45±8.88	154.73±7.93	5.28	-4.74	0.001

Correlation is significant at the 0.05 level.

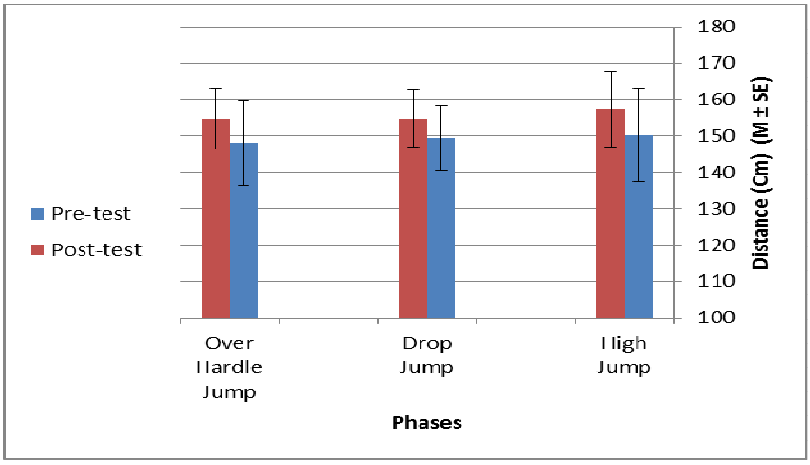

Figure 1. Changes in Mean ± SD Values for Groups under study.

Table 2 represents long jump data (mean and standard deviation) before and after exercises implemented by three groups of over hurdle, high and drop. Comparing intra-group data using a paired t-test indicates that all three types of plyometric exercises have significant effect on lower extremity muscle power, and increase the long jump values in the subjects ($P \leq 05/0$) (Fig.1). A one-way analysis of variance (ANOVA) test was used to determine inter-group

differences. F-test result shows no significant difference between the effect of various exercises on lower extremity muscle power (P=0.23, F5, 60=1.43).

DISCUSSION AND CONCLUSION

As already stated, since plyometric exercise involves specific muscles in stretch- shortening movement cycles, it provides more power benefits than of simple shortening action [13, 25]. Eventually, elastic energy within the muscle can produce higher force outputs [31, 38]. Original findings of the current research revealed a significant difference between the pre-test and post-test sessions in the over hurdle jump groups. Hence, one can conclude that a 6-week program of over hurdle jump exercises has a significant impact on lower extremity muscle power. This is confirmed by the findings of Sylvia et al. (2009). After the 36 sessions of plyometric exercises in the form of over hurdle jump for 10 female soccer players (with average age=22.8 + 2.1), they found a significant improvement in counter movement and drop jump. Also, Robinson at al. (2004) conducted a comparative study on plyometric exercises in the dry land as over hurdle jump and within the water. Evaluating 32 female athletes during 8 weeks, they concluded that both such types could significantly improve the subjects' peak power; although the improvement was higher in the aquatic group. Furthermore, the amount of muscle soreness and stiffness showed a statistically significant decrease compared with the dry land group. However, Blattner and Nobel (1979) reported inconsistent results. After the 8 week program of plyometric exercises in the form of Scout jump, no significant improvement in the subjects' muscle power was observed, inconsistent findings can be justified by differences of jump types and protocol implementation time. For high jump group, research result showed a significant difference between the pre-test and post-test groups. It can be, therefore, concluded that a 6-week program of high jump exercises has a significant impact on lower extremity muscle power. By implementing a plyometric training program as high jump and scout jump exercises for 21 male athletes, John and Burt (2007) evaluated their vertical jump performance. Their findings indicated that both exercises caused a significant improvement in jump performance, and that no significant difference was observed between two groups. In their 10-week study, Jones et al. (2001) obtained the same result and concluded that high jumping exercises, such as counter movement could cause significant improvements in long jump and drop performances. While Finniet et al (2001) believe that explosive concentric practices can lead to significant improvement in human functions. Due to shortage of similar studies, however, the present authors could not found inconsistent results. For drop jump group, the research showed a significant difference between the pre-test and post-test groups; hence, the conclusion was that a 6-week program of drop jump exercises has a significant impact on lower extremity muscle power. In this line, Daniel and Brent (2007) investigated the effect of drop jump on lower extremity muscle power in 28 male basketball athletes. The indicator of interest was measured by long jump and vertical jump. Their findings showed that the 4-week drop jump training had a significant effect on lower extremity muscle power. Consistent with previous findings, Hoffman et al. (2005) evaluated the athletic performance of 16 college football players after 5 weeks of plyometric training and observed a significant improvement in the subjects' explosive power. Blattner and Nobel (1979), Miller and Power (1981), Bobbert (1990), Less and Fahmi (1994), and Raj and Harish (2005) also reported the same conclusion as previous studies. In contrast, Makaruk et al. (2010) implemented a 6-week plyometric training program for 44 men, and observed no significant improvement in long jump. However, Improvements in counter movement and drop was evident. Plyometric exercises which can strength hip extensor muscle, have been often considered to increase muscle power values in runners and jumpers, although the research findings are inconsistent. Some research has reported an improved performance by these exercises [6, 21], while there are conflicting results in this field [4, 11]. Overall, based on results of this study and previous research, it can be said that different types of plyometric exercises (over hurdle, high, drop jumps) may cause positive effects on lower extremity muscle power, and that there is no significant difference between methods applied. However, in regard to high jump and its impact, a very little research is available and to provide a distinctive insight requires further research to be conducted. Regarding the research result and the importance of power athletes, such as running and jumping types, it is recommended the coaches encourage their athletes to plyometric training and use its different exercise in order to reach better results.

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