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# THE EFFECTS OF PLYOMETRIC, WEIGHT AND PLYOMETRIC-WEIGHT TRAINING ON ANAEROBIC POWER AND MUSCULAR STRENGTH

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**Abstract**. *The purpose of this study was to compare the effects of 3 different training protocols-plyometric training, weight training, and their combination on the vertical jump performance, anaerobic power and muscular strength. Based on their training, forty-eight male college students were divided into 4 groups: a plyometric training group (n=13), a weight training group (n=11), a plyometric plus weight training group (n=14), and a control group (n=10). The vertical jump, the fifty-yard run and maximal leg strength were measured before and after a six-week training period. Subjects in each of the training groups trained 2 days per week, whereas control subjects did not participate in any training activity. The data was analyzed by a 1-way analysis of variance (repeated-measures design). The results showed that all the training treatments elicited significant (P<0.05) improvement in all of the tested variables. However, the combination training group showed signs of improvement in the vertical jump performance, the 50 yard dash, and leg strength that was significantly greater than the improvement in the other 2 training groups (plyometric training and weight training). This study provides support for the use of a combination of traditional weight training and plyometric drills to improve the vertical jumping ability, explosive performance in general and leg strength.*

**Key words**: *stretch-shortening cycle, power training, explosive performance, plyometric training*

## 1. INTRODUCTION

Success in many sports depends heavily upon the athlete's explosive leg power and muscular strength. In jumping, throwing, track and field events and other activities, the

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athlete must be able to use strength as quickly and forcefully as possible. This display comes in the form of speed-strength or power (Yessis, & Hatfield 1986). Power represents the amount of work a muscle can produce per unit of time. An increase in power gives the athlete the possibility of improved performance in sports in which the improvement of the speed-strength relationship is sought (Paul, et. al., 2003).

Several studies used plyometric training and have shown that it improves power output and increases explosiveness (Adams, et al., 1992; Ioannis, et. al., 2000) by training the muscles to do more work in a shorter amount of time (Holcomba, 1996). This is accomplished by optimizing the stretch-shortening cycle, which occurs when the active muscle switches from rapid eccentric muscle action (deceleration) to rapid concentric muscle action (acceleration), (Wagner, & Kocak, 1997; Potteiger, et. al., 1999). The rapid eccentric movement creates a stretch reflex that produces a more forceful concentric muscle action (Wagner, & Kocak, 1997; Cachnce, 1995) than could otherwise be generated from a resting position (Potteiger, et. al., 1999). The faster the muscle is stretched, the greater the force produced, and the more powerful the muscle movement (Clutch, et. al., 1983; Wagner, & Kocak, 1997). Plyometric exercises that exploit the stretch-shortening cycle have been shown to enhance the performance of the concentric phase of movement (Gehri, et. al., 1998) and increase power output (Adams, et al. 1992; Paul, et. al., 2003).

Jumping is a complex multi-joint action that demands not only force production but also a high power output. Numerous investigators have underlined the significance of maximal rate of force development in the improvement of explosive jumping performance (Behm, & Sale, 1993; Hakkinen, & Komi, 1985). Plyometric training has been advocated for sports that require the athletes to have explosiveness and an increased vertical jumping ability.

Plyometric exercises evoke the elastic properties of the muscle fibers and connective tissue in a way that allows the muscle to store energy during the deceleration phase and release that energy during the acceleration period (Asmussen, 1974; Bosco, et. al., 1982; Kaneko, et. al., 1983; Stone, &. O'Bryant, 1986). Weight training has been able to improve vertical jumping performance in most cases by 2 – 8 cm (or by 5 – 15 %) (Adams, et al. 1992; Anderst, et. al., 1994; Blakey, & Southard, 1987; Blattner, & Noble, 1979; Ioannis, et. al., 2000).

The comparison of plyometric exercises and weight-training protocols has produced controversial results. Plyometric protocols have been shown to be more effective (Verkhoshanski, & Tatyan, 1983), equally effective (Adams, et al. 1992; Anderst, et. al., 1994; Ioannis, et. al., 2000), or less effective (Stone, & O'Bryant, 1986; Verkhoshanski, & Tatyan, 1983) than weight training in improving the vertical jumping ability.

The combination of plyometric exercises and weight training increased (Adams, et al. 1992; Baur, et. al., 1990,, Behm, & Sale, 1993; Ioannis, et. al., 2000) or maintained unaffected vertical jumping performance (Stone, & O'Bryant, 1986). Adams et al. (Adams, et al. 1992) suggested that this combination may provide a more powerful training stimulus for the vertical jumping performance than either weight training or plyometric training alone. However, Clutch et al. (1983) did not reach similar conclusions and Ioannis, et. al. (2000) suggested that the combination of plyometric and weight training increased muscular strength.

It seems that researchers have not come to an agreement about the relative effectiveness of plyometric training compared with weight training or the combination of both in the development of the vertical jumping ability. It seems likely that different durations of training periods, different training statuses of the subjects, or different training designs (i.e., training loads or volumes or exercises) might have caused the discrepancy in the results of previous studies. Therefore, the purpose of the present investigation was to determine how selected variables of vertical jumping performance, namely, leg power, jumping height, and leg strength, are affected by a typical 6-week plyometric training program, a typical 6-week weight-training program, and 6-week training program that combines plyometric exercises and weight training.

## 2. METHODS

### Subjects

Forty-eight male college students (19.27 ± 1.36 years of age) volunteered to participate in this study (the subjects' characteristics are given in Table 1). All of the subjects played on different teams in college and none were being trained by means of a plyometric training program. All of the subjects had successfully passed a physical exam and completed a medical history questionnaire in which they were screened for any possible injury or illness. The subjects received all the necessary information about the study's procedures in oral and written form. Each subject completed a medical history form (special care was given to hypertension and orthopedic status screening), a training background questionnaire, and a written informed consent form.

Table 1. Descriptive data of subject's characteristics

| Group* | n | Height (cm) | Weight (kg) | Age (y) |
|---|---|---|---|---|
| Control | 10 | 174.80 ± 6.94 | 70.13 ± 6.60 | 19.30 ± 1.1 |
| P.T. | 13 | 174.79 ± 6.36 | 68.36 ± 7.74 | 19.70 ± 1.5 |
| W.T. | 11 | 178.90 ± 9.80 | 71.59 ± 4.40 | 19.09 ± 1.2 |
| P.W.T. | 14 | 173.64 ± 5.51 | 66.99 ± 9.90 | 18.92 ± 0.9 |

### Data Acquisition

Each subject underwent measurements of his vertical jumping performance, the 50-yard run and maximal leg strength. Pre-testing was conducted in 5 sessions 1 week before initiation of the training period. The first session included an introduction of the testing protocols to the subjects. The second session included the measurement of vertical jumping performance. In the third session, leg strength was determined by the 1RM Squat. During the fourth session, the 50- yard run was measured. There was a 24-hour pause between the testing sessions. Identical measurements were performed in the same order 4 days following the completion of the training period.

### Vertical Jump Height

Vertical jump height was measured by the stand and reach test (Chu, 1996). A vertical jump test was completed from a 2-foot standing position without a step into the jump. The subjects were allowed to use their hands as they desired. Three test jumps were completed, and the highest of these was recorded. This test was selected because it has high validity (0.80) and reliability (0.93) coefficients (Safrit, 1990) and because it allows arm movement and a squat motion before the jump, such as those performed in sports.

### Measurement of the 50 yard dash

The 50-yard dash is one of the short-term tests of muscular power that indirectly reflects the measure of the subject's ability to regenrate ATP during that interval. This test was selected because it has a high correlation coefficient (0.974) with the Margaria-Kalamen Power Test (Fox & Mathews, 1971). This protocol has the subjects start 15 yards from the start line and time is measured from a start distance of 50 yards.

### Measurement of Leg Strength

To assess strength isotonically a one repetition maximum (1RM) test was performed. Leg strength was assessed by the 1RM (1 repetition maximum) squat. In the squat 1RM test, subjects executed the traditional back squat exercise following the NSCA guidelines for the execution of this particular test. However, a manual goniometer was used at the knee to standardize the range of motion. The subjects started the squat exercise at a 30° knee flexion, descended to 90°, and then forcefully returned to the starting position by extending both knees and hips and plantar flexing at the ankles. Testers alerted the subjects when the starting and finishing positions were attained (Brown, et. al., 1986).

### Training Protocols

After the initial measurements, the subjects were divided into 4 groups: the control group ($n = 10$), the plyometric training group ($n = 13$), the conventional weight training group ($n = 11$), and the combination of plyometric plus weight training group ($n = 14$). The control group did not train. The other 3 training groups trained for 6 weeks, 2 days per week. Before the initiation of the training periods, the subjects of all groups were instructed about the proper execution of all the exercises to be used during the training period for all training regimens. The training protocols included only leg exercises. None of the subjects had used plyometric exercises before. The training programs were designed to overload the leg muscles involved in the vertical jumping motion and explosive performance.

The subjects in the plyometric group performed four plyometric drills – the Depth jump, the Split squat jump, the Rim jump, the Box to box depth jump. The depth jump height started at 40 centimeters and progressed to 75 centimeters in the Fourth 3-Session. The subjects in the weight training group started with four sets of ten repetitions at 40 percent of 1RM during the First 3-Session, and progressed to four sets of six at 100 percent of 1RM during the Fourth 3-Session. The plyometric-weight training group performed a combination of the two training programs (plyometric and weight training program) but the volume and intensity of the work was reduced by 25 percent (Adams, et al., 1992). All training sessions were supervised. The training programs are shown in Tables 2, 3, 4.

Table 2. Plyometric training (PT) Program

| Plyometric training | First 3-Session | Second 3-Session | Third 3-Session | Fourth 3-Session |
|---|---|---|---|---|
| Depth jump | † 3*6 (40) 30 | 3*8(50) 30 | 4*7 (60) 30 | 4*8 (75) 30 |
| Split squat jump | 3*6 (-) 30 | 3*8(-) 30 | 4*7 (-) 30 | 4*8 (-) 30 |
| Rim jump | 3*6 (-) 30 | 3*8(-) 30 | 4*7 (-) 30 | 4*8 (-) 30 |
| Box to box depth jump | ★2*6/4 (40) 30 | 3*5/5(50) 30 | 4*5/5 (60) 30 | 4*6/6 (75) 30 |

†Sets*reps at( box height (cm)) rest time between sets
★ Sets*reps/number of boxes at( box height (cm)) rest time between sets

Table 3. Weight training (WT) Program

| Weight training | First 3-Session | Second 3-Session | Third 3-Session | Fourth 3-Session |
|---|---|---|---|---|
| Squat | ‡ 4*10 (40%) 60 | 4*10 (60%) 60 | 4*8 (80%) 50 | 4*6 (100%) 40 |
| Leg press | 4*10 (40%) 60 | 4*10 (60%) 60 | 4*8 (80%) 50 | 4*6 (100%) 40 |
| Leg extension | 4*10 (40%) 60 | 4*10 (60%) 60 | 4*8 (80%) 50 | 4*6 (100%) 40 |
| Leg extension | 4*10 (40%) 60 | 4*10 (60%) 60 | 4*8 (80%) 50 | 4*6 (100%) 40 |

‡ Sets*reps at (percentage of 1RM) rest time between sets

Table 4. Playometric + Weight training (PWT) Program

| Complex training | First 3-Session | Second 3-Session | Third 3-Session | Fourth 3-Session |
|---|---|---|---|---|
| Depth jump | †3*4 (30) 30 | 3*6 (40) 30 | 3*7 (45) 30 | 4*6 (55) 30 |
| Split squat jump | 3*4 (-) 30 | 3*6 (-) 30 | 3*7 (-) 30 | 4*6 (-) 30 |
| Rim jump | 3*4 (-) 30 | 3*6 (-) 30 | 3*7 (-) 30 | 4*6 (-) 30 |
| Box to box depth jump | ★3*4/3 (30)30 | 3*4/4 (40) 30 | 3*5/5 (45) 30 | 3*6/6 (55) 30 |
| Squat | ‡4*8 (30%) 60 | 4*8 (45%) 60 | 4*6 (60%) 50 | 3*6 (75%) 40 |
| Leg press | 4*8 (30%) 60 | 4*8 (45%) 60 | 4*6 (60%) 50 | 3*6 (75%) 40 |
| Leg extension | 4*8 (30%) 60 | 4*8 (45%) 60 | 4*6 (60%) 50 | 3*6 (75%) 40 |
| Leg extension | 4*8 (30%) 60 | 4*8 (45%) 60 | 4*6 (60%) 50 | 3*6 (75%) 40 |

†Sets*reps at ( box height (cm)) rest time between sets
★ Sets*reps/ number of boxes at( box height (cm)) rest time between sets
‡ Sets*reps at (percentage of 1RM) rest time between sets

### Statistical Analyses

Paired t-tests were used to identify any significant differences between the groups at the PRE and POS-tests for the dependent variables. An analysis of variance with repeated measures was used to determine significant differences for vertical jump height, leg strength and the 50-yard dash time within the 4 training groups. When a significant difference among the training programs was detected, a pair-wise comparison of the programs was done using a Bonferroni post hoc test to identify significant differences between the training programs. The alpha level was set at 0.05 in order for the difference to be considered significant. All values are reported as mean ± standard deviation (Table 5).

Table 5. Means ± SEs between pre-training and post-training for all the dependent variables for the 4 groups

| Group | | Vertical jump height (cm) | Squat (Kg) | 50 yard dash (second) |
|---|---|---|---|---|
| Plyometric tra. (n=13) | Pre | 43.57 ± 7.65 | 84.60 ± 14.06 | 6.740 ± 0.63 |
| | Post | 52.30 ± 5.61†‡§ | 110.70 ± 14.40†£‡§ | 6.440 ± 0.45 ‡§ |
| Weight tra. (n=11) | Pre | 43.22 ± 6.30 | 81.80 ± 9.02 | 6.740 ± 0.37 |
| | Post | 50.36 ± 3.44†¶§ | 145.90 ± 22.10†£§ | 6.442 ± 0.40†¶§ |
| Complex tra. (n=14) | Pre | 43.92 ± 8.15 | 90.30 ± 12.40 | 6.710 ± 0.51 |
| | Post | 58.39 ± 3.29†‡¶§ | 139.60 ± 30.90†‡§ | 5.625 ± 0.41†‡¶§ |
| Control (n=10) | Pre | 43.00 ± 7.07 | 81.00 ± 18.00 | 6.750 ± 0.54 |
| | Post | 45.80 ± 9.53 | 78.00 ± 13.50 | 6.638 ± 0.56 |

†Significant difference between pre-training and post-training ($P < 0.05$).
§Significant difference compared with the control group ($P < 0.05$).
‡Significant difference between the PT and PWT groups ($P < 0.05$).
¶Significant difference between the WT and PWT groups ($P < 0.05$).
£Significant difference between the PT and WT groups ($P < 0.05$)

## 3. RESULTS

Means and SEs for vertical jump height, the 50-yard dash and leg strength (in squat tests) are listed in Table 5. ANOVA procedures demonstrated a significant value ($P < 0.05$) for all the tests and the results of the experimental groups were better than those of the control group and the Bonferroni post hoc test was used for a pair-wise comparison of the programs (Table 5).

PWT (complex training) training was significantly better ($P = 0.001$) than either PT or WT, but there were no differences between PT and WT ($P = 0.842$ [vj]; 0.756 [50-yard]) in increasing hip and thigh power production and speed as measured by the vertical jump and the 50-yard dash tests.

PWT (complex training) training was significantly better ($P = 0.001$) than PT, WT was significantly better ($P = 0.002$) than PT, but there were no differences between PWT and WT ($P = 0.895$) in increasing leg strength production as measured by the 1RM Squat.

Paired t-tests showed that the experimental groups showed significant increase in the vertical jump height (PT = 8.73 cm, $P = 0.001$; WT = 7.14 cm, $P = 0.002$ and PWT = 14.47 cm, $P = 0.001$), leg strength (PT = 26.1 kg, Wt = 64.1 kg, PWT = 49 kg; $P = 0.0001$), and time for running the 50 yards had decreased (PT = 0.3 sec, $P = 0.063$; WT = 0.298 sec, $P = 0.001$; PWT = 1.085sec, $P = 0.004$) in post-training in relation to pre-training.

## 4. DISCUSSION

The purpose of this study was to determine if plyometric training alone or in combination with weight training can enhance vertical jumping performance, leg strength and speed. The results indicate that short term plyometric training is capable of improving the vertical jumping ability, muscular strength and anaerobic power but its combination with weight training is even more beneficial.

The results of this investigation are in accordance with previous studies (Asmussen, 1974; Adams, et al. 1992; Behm, & Sale, 1993; Cavagna, 1977; Cavagna, 1968), showing that a combined program of weightlifting and plyometrics can significantly increase the vertical jump ability.

Despite its wide-spread use in athletics and the specific guidelines given regarding its use, more studies are needed to evaluate its effectiveness, especially compared with other conventional training methods such as weight training or its combination with them. The combination of different training methods will promote all the qualities of muscle power and strength.

Several previous investigations have failed to find that plyometric training is significantly more effective than other training methods in improving the vertical jumping ability (Clutch, et. al., 1983; Ford, 1983; Holcomba, 1996; Lyttle, 1996; NSCA, 1993). Furthermore, previous research that used a combination of plyometric and weight training found either an increased (Adams, et al. 1992; Baur, et. al., 1990; Blakey, & Southard, 1979; Ioannis, et. al., 2000) or unaffected vertical jumping performance (Ford, et. al., 1983). Other investigators (Clutch, et. al., 1983, Lyttle, 1996) found that the combination of plyometric and weight training is equally effective as either plyometric or weight training. The results of the present study indicate otherwise. This combination training provided the most powerful stimulus for improving the vertical jumping ability.

Plyometric training alone, as has been shown by this study and others carried out by authors such as Blattner and Noble (1979) and Bosco (1982), can also have a significant effect in increasing hip and thigh power that is measured by the vertical jump. Bosco believes that this results from enhancing motor unit recruitment and improving the muscles' ability to store kinetic energy within the elastic components of the muscle (Bosco, et. al., 1982). This may enhance hip and thigh power by increasing the explosive capabilities of the athlete. The transfer of this explosiveness to activities other than the vertical jump needs further investigation.

As could be expected, the results of this study illustrated that Plyometric+Weight Training program has a significant effect on Plyometric training and Weight training programs for increasing hip and thigh power as measured by the 50-yard dash test. O'Shea (1985) believes that the dynamic nature of this training is highly conducive to enhancing neuromuscular efficiency (e.g., facilitating the stretch reflex). This in turn allows for excellent transfer of power to other biomechanically similar movements that require a powerful thrust from the hips and thighs, such as running. Training programs that have utilized plyometric exercises have been shown to positively affect performance in power-related movements such as jumping (Blattner & Noble, 1979; Clutch, et. al., 1983; Holcomba, 1996, Lachance, 1995) and speed (Adams, 1984; Ford, et. al., 1983; Rimmer & Sletvert, 2000).

Finally, this study illustrates that a combined PT and WT program significantly increases hip and thigh power production, as measured by the vertical jump, than either the WT or PT program. This result is in accordance with previous studies (Adams, et al. 1992; Baur, et. al., 1990; Blakey, & Southard, 1979; Ioannis, et. al., 2000). Improved muscle performance due to a plyometric training program may also be due in part to increased motor unit functioning. Previous studies have indicated that neuromuscular adaptations such as an increased inhibition of antagonist muscles as well as better activation and co-contraction of synergistic muscles may account for the improvements in power output (Komi, 1984; Lyttle, 1996.).

During a plyometric movement, the muscles undergo a very rapid switch from the eccentric phase to the concentric phase. This stretch-shortening cycle decreases the time of the amortization phase that in turn allows for greater than normal power production (Holcomba, 1996; Potteiger, et. al., 1999.). The muscles store elastic energy and stretch reflex responses are essentially exploited in this manner, permitting more work to be done by the muscle during the concentric phase of movement (Harman, et. al., 1991; Holcomba, 1996).

In this study, maximal strength as measured by the 1RM squat was improved more by weight training than by plyometric training, and there was no significant difference between weight training and plyometric - weight training. This finding probably is related to the nature of muscular strength, that strength is increased in low movement of the phase of eccentric contraction more than during the fast movement of this phase; therefore, a weight training program increases strength more than plyometric training. Weight and plyometric training programs involve eccentric and concentric contractions, but in weight training programs the velocity of the contraction is slower than in plyometric training. Previous studies have documented that strength was increased more during the low velocity movement of the phase of eccentric contraction than during the high velocity of this phase; therefore, a weight training program may stimulate greater strength adaptations.

In contrast to previous studies, the results of the present study indicate that all treatments produce improvement in vertical jumping, explosive performance and muscular strength. However, the combination training treatment evoked the most significant changes in these variables. The discrepancy between these results and the results of previous investigations might be attributed to several reasons. First, the training experience level of the study subjects might offer one explanation. Subjects in the present study were novices in plyometric training in contrast to the subjects in previous investigations. However, they were strength trained enough to be able to sustain plyometric training loads. One needs to be weight trained to enjoy positive adaptations to plyometric training. The second explanation is the nature of the training protocols used in the present study and previous investigations.

This study clearly illustrates the close working relationship between neuromuscular efficiency (e.g., multiple fiber recruitment and facilitating the stretching reflex) and dynamic strength performance. With reasonable confidence, it can be said that WT programs are conducive to the development of hip and thigh strength, while the simultaneous application of plyometrics permits effective use of this strength to produce explosiveness in sports or events demanding speed and quickness. In other words, the role of plyometrics is to facilitate the neuromuscular system into making a more rapid transition from eccentric to concentric contractions, whereby maximal ballistic force is generated (Adams, K., et al. 1992). This lends support to the theories of Gambetta (1986); O'Shea (1985); Yessis and Hatfield (1982), who believe that plyometric training is the link between speed and strength.

Another interesting note is that, despite the fact that the subjects in the combination group performed plyometric and weight training on the same day, their performance was not impaired. This result is in accordance with Ioannis (Ioannis, et. al., 2000) who demonstrated that subject performance was not impaired in this procedure. NSCA and others (Chu, 1996; NSCA, 1993) do not recommend performing heavy strength and plyometric training on the same day, with the exception of track and field athletes, who might benefit from a combination of plyometric and weight training program, "complex training." In the present study, there was enough rest between the sessions to allow recovery of the neuromuscular and metabolic systems of the subjects. Plyometric training was performed first to ensure that the subjects would perform the plyometric drills with the proper technique and full explosiveness.

## 5. Practical Applications

The results of this study provide insight into several aspects for the improvement of athletes' explosiveness and muscular strength. However, strength and conditioning professionals must notice that in this study the combination of plyometric and weight training was significantly more beneficial in increasing vertical jump height, explosive performance and muscular strength. Out of necessity, athletic strength and speed training must focus on optimizing the power flow of linear and rotational energy transfer that occurs during the transition from eccentric to concentric muscle contractions. To train and enhance this transitional phase requires a complex athletic weight-training and plyometric program as used in this study. Therefore, strength professionals must be able to incorporate both elements in their training regimens. Such a program challenges an athlete to develop and apply strength through a wide range of multiple joint movements at progressively higher velocities. It trains the athlete to think in terms of applied strength, speed and technique. A high magnitude of explosive strength is the result.

The results of this study claim that training must incorporate special exercises that focus on power development once the strength levels have been improved. Second, intensity and training volume followed the progressive overload principle in the present study. Weight intensity and the volume of training were built up, gradually allowing the subjects to adjust effectively, especially the subjects who followed the plyometric training protocols. Variation of intensity within each week of training seems to have helped subjects who participated in all the training groups. Third, despite the fact that execution of plyometric training and weight training is not generally recommended on the same day, the present study indicates that this might not be true if adequate recovery is allowed in between. Fourth, it seems that 6 weeks is an adequate period for the improvement of vertical jumping and muscular strength if the training protocols maintain the appropriate intensity and volume. Fifth, in this study, 2 days of training per week has proven to be an effective training frequency for improving the vertical jump performance and muscular strength. However, this cannot be accomplished during the in-season period. Such training protocols should be incorporated in the pre-season or post-season training periods. Sixth, the results of this study concern individuals relatively inexperienced in plyometric training. It is possible that advanced athletes in power sports would not exhibit the same magnitude of improvement with the training protocols used here. It is possible that more advanced athletes need a different manipulation of training intensity and volume and selection of exercises.

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# EFEKTI PLIOMETRIJE, SNAGE I PLIOMETRIJSKO-SNAŽNOG TRENINGA NA ANAEROBNU MOĆ I MIŠIĆNU SNAGU

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*Cilj ove studije je uporedjivanje tri različita trenažna protokola (pliometrijski trening, trening sa opterećenjem i njihova kombinacija) na vertikalan skok, anaerobnu moć i mišićnu snagu. 48 studenata su podeljeni na četiri grupe: pliometrijski trening (n = 13), trening sa opterećenjem (n = 11), pliometrija plus trening sa opterećenjem (n = 14) i kontrolna (n = 10). Skok uvis, trčanje na 50 jardi i maksimalna snaga nogu su mereni pre i posle 6 nedelja treniranja. Ispitanici u svakoj trenažnoj grupi su trenirali dva puta nedeljno, a ispitanici kontrolne grupe nisu trenirali bilo koju aktivnost. Podaci su analizirani sa jednosmernom analizom varijanse (ponovljeni merni dizajn). Rezultati pokazuju da su svi tretmani delovali statistički značajno (P < 0,05) na sve testirane varijable. Ipak, grupa sa kombinovanim treningom (pliometrijski i snažni trening) pokazuje poboljšanje u skoku uvis, trčanju na 50 jardi i snazi nogu u odnosu na druge dve grupe. Ova studija podržava korišćenje kombinacije tradicionalnog treninga sa opterećenjem i pliometrijskih vežbi za poboljšanje sposobnosti skakanja uvis, eksplozivnosti i snage nogu.*

Ključne reči: *ciklus kratkotrajnog strecinga, eksplozivnost, trening snage, pliometrijski trening*