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Effects of Weighted Rope Jump Training on Power Performance Tests in Collegians

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ABSTRACT

The purpose of this investigation was to determine the efficacy of weighted jump ropes as an alternative to core plyometric exercises in developing explosive-reactive power and anaerobic capacity. Thirty-six university students served as subjects for the study and were divided into three groups. Group 1 received the weighted rope jumping regime. Group 2 underwent a traditional form of training: maximal vertical jumps. Group 3, the control group, participated only in stretching exercises. Subjects participated in the exercise program three times a week for 10 weeks. The effects of these exercise programs on subjects' performance on the 50-yard dash, the Sargent jump, the Wingate ergometer test, bench press, and leg press were explored. Results indicated that Group 1 made significant improvements between all pre- and posttreatment measures except the 50-yard dash and Wingate peak power test at the 0.01 level of significance. However, the pre- to posttreatment assessments for the other two groups showed no improvement at the 0.01 level of significance. These findings suggest that weighted rope jumping is a viable alternative to high impact plyometric exercises.

Key Words: plyometrics, rope jumping, Wingate test, power

Introduction

Plyometrics were developed by Soviet researchers after they noted the extraordinary relationship between power and athletic performance (28). These researchers felt that strength training was not developing the sufficient explosive power needed in sports. Accordingly, the Soviets developed an exercise training regimen that increases power and quickness for sports that call for bursts of power. Chu (11) refers to plyometrics as the linking of speed and strength for the development of explosive-reactive power.

There are many types of plyometric exercises in use, most of which attempt to overload the neuromuscular system in order to improve its reactive ability. These exercises can be classified into two types of plyometrics. The first group, lead-up plyometrics, consists of skipping, hopping, and jumping jacks. These exercises have been used as a training tool for learning the proper mechanics of the plyometric jump (23). The second group, core or "shock" plyometrics, consists of drills that involve high impact, such as drop jumping, bounding, and obstacle jumps (6, 29). These high-impact exercises are used to produce a powerful and acute overload of the neuromuscular system to more thoroughly develop the reactive components of the motor unit (28). Most of the research regarding plyometric efficacy has been conducted on drop jumping, a form of core plyometrics.

Previous studies have indicated that core plyometrics are effective. Brown et al. (10) pretested vertical jumping ability in 26 freshman and sophomore male basketball players. They then submitted the athletes to 12 weeks of training that involved three weekly sessions of 10 drop jumps. Posttesting revealed an improvement of approximately 21% in vertical jumping ability. Brown et al. concluded that plyometrics (drop jumping) developed coordination of neuromuscular skills and muscular strength.

Miller (18) trained a group of 24 females in a physical education class once a week for 8 weeks by having them perform 10 repetitions of drop jumps from 50 centimeters. After the 8-week period the drop jumpers improved their vertical jumps by more than 5 cm. Ford et al. (13) found plyometrics in combination with weight training to be effective in improving the scores on several fitness tests, such as the 40-yard dash, vertical jump, pull-ups, and sit-ups.

As a result of the preliminary success of core plyometrics in developing explosive-reactive power, Russian researchers (2) have been experimenting with increases in the height of the drop jump in an effort to achieve even more dramatic results. For some individuals, however, there are potential problems with the use of core plyometrics. Smythe (23) states that athletes should not undergo core plyometric training until they can leg press at least two and one-half times their body weight because of the risk of injury caused by impact forces during the exercise. Bobbert et al. (9) found that when dropping from heights of 60 cm, subjects could not generate the forces needed to keep their heels from touching the ground before the rebound action took place. They also reported cartilage and subchondral bone degeneration in animals who were regularly subjected to such impact forces. Although it may be difficult to draw parallels between loading patterns in animals and humans, caution is called for in jump heights of even 60 cm.

One solution to the problem of injury risk would be to use only lead-up plyometrics. Clutch et al. (12) reported that maximal vertical jump drills were just as effective as drop jumping, as long as both programs were combined with weight training. Adams et al. (3) found that maximal vertical jump drills were as effective as drop jumping at improving maximal vertical leaps and 50-yard dash times. Once again, however, both programs were combined with weight training. Lead-up plyometrics offer the advantages of being effective and carrying a minimal risk of injury. However, their efficacy alone, in the absence of weight training, has not been proven.

Another solution to the problem of injury risk would be to use lead-up plyometrics until a sufficient level of strength is developed to withstand core plyometrics (3, 13, 22). Coaches may not have such a luxury, however, given a limited amount of training time before the competitive season begins. They need a drill that will promote maximum benefits in a minimum period of time.

The purpose of this study was to explore the efficacy of weighted rope jumping as an alternative to traditional core plyometrics. This technique involved the limited risks of injury associated with lead-up plyometrics, yet had the potential to facilitate rapid improvements in explosive-reactive power. Rope jumping has long been classified as a lead-up exercise to plyometrics (23). Studies (20, 24, 27) have illustrated the potential of rope jumping to utilize two anaerobic energy systems: ATP-CP and anaerobic glycolysis. It can also be used to develop coordination of neuromuscular skills, muscular strength, and cardiovascular endurance (19, 24). The use of weighted ropes may carry additional advantages that are typically associated with core plyometrics. Their use can add approximately 10 to 40 kg of centrifugal force to the exercise, depending on the weight of the rope and the speed at which it is turned (25). This should further enhance the muscle prestretch in the eccentric phase (16, 25).

Although it has not been demonstrated empirically, there is some anecdotal support for the use of weighted ropes from coaches like Albro (4), who put 31 basketball players on a 6-week weighted rope training program. Posttesting demonstrated significant improvement in the vertical jump and 40-yard dash. Wolters (30) reported that weighted rope jumping helped her volleyball team attain greater levels of endurance, strength, and speed.

In summary, the primary purpose of this study was to determine the efficacy of a progressive training program involving weighted ropes as an alternative to core plyometric exercises. The benefits of weighted rope jumping were compared to those associated with maximum vertical jumping drills. Maximum vertical jumping was chosen as a control method because it had already been used as a control comparison for core plyometrics (drop jumping) (3, 8, 12). Maximum vertical jumping offered limited risk to subjects and required no minimum strength level.

Method

Subjects

This research was approved by the Office of University Research before data collection began, and all subjects signed an informed consent document. The subjects were untrained college-age students taken from a physical education activity class at the University of Mississippi. The initial pool included 19 males and 17 females, with a mean age of 20 years. Table 1 describes the subjects' characteristics. Subjects were randomly assigned to one of three groups: the rope jumping group (Group 1) (n=10), the vertical jump group (Group 2) (n=

Table 1
Subject Characteristics

Characteristic		Group 1 (n=10)	Group 2 (n=12)	Group 3 (n=10)	Total (n=32)
Male/Female		10	12	10	32
		6/4	7/5	5/5	18/14
Age	*M*	20.2	20.3	20.2	20.25
	SD	1.8	1.6	1.8	1.70
Weight (kg)	*M*	67.56	72.61	66.21	69.03
	SD	12.39	12.68	15.48	13.40
Reach Ht* (cm)	*M*	223.27	223.52	220.37	222.45
	SD	16.31	13.26	12.27	13.62

*There was a measurement of height to the fingertips while both arms were extended upward (taken from the Sargent jump).

12), and the control group (Group 3) (n=10). The other 4 subjects, 2 from the control group and 2 from the rope jumping group, failed to complete the study because of personal or health problems.

Subject division and treatment administration were as follows:

- Group 1: R O_1 X_1 O_2
- Group 2: R O_1 X_2 O_2
- Group 3: R O_1 X_3 O_2

R represents the random assignment, O_1 is the pretreatment observations and O_2 is posttreatment observations. X_1 is the rope jumping treatment, X_2 is the maximal vertical jumping treatment, and X_3 is the control treatment. Group 1 participated in a progressive program of weighted rope jumping. Group 2 participated in a progressive program of maximal vertical jumps. Group 3 received no treatment and was used to control for factors such as activity levels, maturation, and history. Subjects were not permitted to participate in any other training program during the course of the study.

Power Measures

Pre- and posttreatment measures were taken for each subject on five performance tests: a maximal vertical leap (Sargent jump), a Wingate anaerobic cycle test, a 50-yard dash (45.72 m), a 1-RM leg press, and a 1-RM bench press. No encouragement or feedback was given during testing; however, prior to each test the subjects were told of the importance of these tests to the study (5).

The Sargent jump is a standard power test in which the ability to manipulate body mass is critical for achieving peak power (7, 14, 26). The subjects had a base height determined by standing upright against a wall with feet flat on the floor. There was a measurement of height to fingertips with both arms extended upward. The subject was then asked to jump straight up as high as possible without using a run or step. A natural countermovement was permissible. The subjects were given one practice jump followed by three trials. The best of the three heights was recorded. The formula,

$$\text{Peak power (W)} = 61.9 \times \text{jump height (cm)} + 36.0 \times \text{body mass (kg)} - 1822$$

devised by Harman et al. (14), was used to translate all vertical heights into estimations of power output which are reported in the results. Harman et al. found that the widely used Lewis formula underestimates peak power and minimizes individual differences.

A 50-yard (45.72 m) dash was used to indicate sustained power (17). The subjects were given three trials with a 15-yard (13.72 m) running start. Times were taken with a handheld stopwatch and measured to the nearest 0.01 second. Subjects ran individually and were allowed full recovery between trials. Each subject's best result constituted the score for this test. Tests for running speed cannot measure anaerobic power because of the lack of a true vertical component, and absolute dash times do not take into consideration the contribution of mass to performance. Therefore, to make the relationship between speed and anaerobic power more acceptable, the subject's weight was divided by the running speed in order to show the contribution of mass to power. The result of this calculation was a measure of relative horizontal power (1).

The Wingate anaerobic test was used as a test of power against time (5). It was administered as described by Stone and O'Bryant (26). The seat height of the Monark ergometer was adjusted so that the subject's extended leg retained a slight bend in the knee joint. The subject was weighed and asked to warm up for approximately 3 minutes with a light load. After the warm-up the subject was instructed to pedal against a resistance of 0.075 kiloponds per kilogram of weight. The subject started with no load but was quickly switched to the predetermined test load and was instructed to pedal as fast as possible for 30 seconds. Anaerobic capacity was calculated in Watts using the following formula:

$$\text{AnC (W)} = (\text{kgm} - 30\text{s})/3$$

Peak power was calculated in Watts using the following formula:

$$\text{Peak-AnP (W)} = 2 \times (\text{kgms} - 5\text{s})$$

One-repetition-maximum testing is a common method for assessing dynamic muscular strength (26). This was used with the leg press to assess hip and leg strength, and with the bench press to assess upper body strength. Testing was done on the Universal Centurion Model 9017. For the leg press, the seat was adjusted so that all subjects started at approximately the same knee (88–90°) and hip (65–69°) angles as measured by a flexometer. The subjects were then given five repetitions of warm-up on a light weight, followed by 1 minute of rest. They were then asked to do three repetitions of 70% of their perceived maximal. This was followed by a 1-min rest. The subject was then asked to make a 1-RM attempt followed by 30-s rest until he or she failed to make the next lift. The final successfully executed lift was recorded as the subject's 1-RM leg press. The bench press 1-RM was scored in the same fashion. To avoid any confounding effects of circadian rhythm in the power testing, the pre- and posttreatment tests were conducted at the same time of day (15).

Treatment

Three times a week for 10 weeks all subjects participated together in the warm-up stretching routine, which lasted approximately 10 minutes. The subjects were then divided into their respective groups for 15 to 20 minutes. Finally, the three groups convened and performed cool-down stretches for approximately 5 minutes. The subjects were then dismissed.

Subjects in Group 1 progressed from three sets of rope jumping for 15 seconds with a .170-kg (6-oz) rope to six sets of rope jumping for 30 seconds with a 1.36-kg (2-lb) rope. The first few training sessions with the .170-kg ropes served as a familiarization period. The jumpers were instructed to refrain from touching their heels to the floor while jumping and to jump as high as possible without losing balance or rhythm. After each set the subjects were given a 3-min active rest period which was limited to walking and stretching.

Subjects in Group 2 were instructed to perform their jumps from a stationary position without a run or step. Natural countermovements such as arm swings were permitted. Subjects were asked to pause between jumps to prevent the effects of stored elastic energy or bounding effects that would approximate core plyometrics (12). Because those in the rope jumping groups were exercising in 15-s intervals, subjects in the vertical jumping group were initially timed for 15-s intervals to determine the number of jumps to set as a goal. All of the subjects jumped four or five jumps, therefore five jumps was set as the initial target.

Similar procedures were used to determine the appropriate number of vertical jumps to set as a match for each increase in interval duration. Thus, as the rope jumpers gradually increased to 30-s intervals, the vertical jumpers gradually increased to 20 leaps. These procedures were used to control for training volume between groups. The subjects in Group 2 progressed from three sets of five maximal leaps to six sets of 20 maximal leaps per set. After each set the subjects were allowed a 3-min active rest period of walking or stretching.

Subjects in the control group were instructed to come to class each day for the entire 10-week period and to participate in the warm-up and cool-down exercises. They were allowed to read, study, or visit with one another in a separate room, but they were not allowed to participate in any exercise training activity.

Statistical data were analyzed with a series of 3 × 2 multivariate analyses of variance (MANOVAs) for repeated measures (SPSS/PC+V2.0). The design was a mixed parametric design with group as the between-subject variable and time as the within-subject variable. Tukey's post-hoc procedure was used to follow up the significant interaction among the cell means. Several dependent measures were analyzed and required a series of MANOVAs. Because multiple MANOVAs were performed, we chose a more conservative alpha level ($p<0.01$) for interpretation in order to limit inflation and the possibility of Type I error (21).

Results

Sargent Jump

The main effect for group was not significant, but the main effect for time, $F(1, 29) = 33.79$, $p<0.001$, and the interaction between group and time, $F(2, 29) = 21.94$, $p<0.001$, were significant. Results indicated that the Sargent jump significantly improved from the pre- to posttreatment measurement for Group 1. There was no significant difference in pre- versus posttreatment results for Groups 2 or 3. Results appear in Table 2.

50-Yard Dash

The main effect for group was not significant for the 50-yard dash. The main effect for time, $F(1, 29) = 3.81$, $p<0.061$, and the interaction between group and time, $F(2, 29) = 2.01$, $p<0.152$, also were not significant. These cell means and standard deviations appear in Table 3.

Table 2
Means and Standard Deviations From Sargent Jump

Group		Time	
		Pretreatment	Posttreatment
Group 1	*M*	3969.18	4594.19*
	SD	1149.73	1035.40
Group 2	*M*	3961.68	4082.65
	SD	927.77	983.92
Group 3	*M*	3654.86	3627.30
	SD	1240.75	1285.09

Note. Values expressed in peak power (W) = 61.9 × jump height (cm) + 36.0 × body mass (kg) −1822.
*$p<0.01$.

Table 3
Means and Standard Deviations From 50-yd Dash

Group		Time	
		Pretreatment	Posttreatment
Group 1	*M*	11.84	12.26
	SD	2.8	2.7
Group 2	*M*	12.13	12.10
	SD	3.1	2.8
Group 3	*M*	10.54	10.70
	SD	3.4	3.3

Note. Values reported as (P) = relative horizontal power ($kg \cdot s^{-1}$).

Wingate Ergometer

The main effect for group was not significant on either of the two Wingate tests. The main effect for time, $F(1, 29) = 11.61$, $p<0.002$, and the interaction between group and time, $F(2, 29) = 7.12$, $p<0.003$, were significant on the Wingate anaerobic capacity test (AnC). The performance of Group 1 significantly improved between pre- and posttreatment measurements, but the performance of Groups 2 and 3 did not. Results appear in Table 4. The main effect for time, $F(1, 29) = 3.98$, $p<0.055$, and the interaction between group and time, $F(2, 29) = 3.52$, $p<0.043$, were not significant on the Wingate peak power test (AnP). Cell means and standard deviations appear in Table 5.

Leg Press

The main effect for group was not significant; however, the main effect for time, $F(1, 29) = 32.70$, $p<0.001$, and the interaction between group and time, $F(2, 29) = 15.33$, $p<0.001$, were significant. The pre- to posttreatment measurements for Group 1 significantly improved. However, the pre- to posttreatment assessments for the other two groups showed no improvement at the 0.01 level of significance. These cell means and standard deviations appear in Table 6.

Bench Press

The main effect for group was not significant, but the main effect for time, $F(1, 29) = 15.97$, $p<0.001$, and the interaction between group and time, $F(2, 29) = 14.38$, $p<0.001$, were significant. The performance of Group 1 significantly improved between pre- and posttreatment measurements, but the performance of Groups 2 and 3 did not improve significantly. These cell means and standard deviations appear in Table 7.

Discussion

Results indicate a predominance of significant improvements between pre- and posttreatment measures for Group 1. In contrast, there were no significant improvements in any of the pre- to posttreatments tests for Groups 2 or 3. These findings indicate that weighted rope jump training is more effective in improving explosive-reactive power,

Table 4
Means and Standard Deviations From Wingate (AnC)

Group		Time: Pretreatment	Time: Posttreatment
Group 1	*M*	535.50	652.10*
	SD	166.99	172.05
Group 2	*M*	562.10	573.70
	SD	154.31	150.02
Group 3	*M*	459.31	466.20
	SD	170.99	154.37

Note. Values are expressed in terms of AnC (W) = (kgm −30s)/3.
*$p<0.01$.

Table 5
Means and Standard Deviations From Wingate (AnP)

Group		Time: Pretreatment	Time: Posttreatment
Group 1	*M*	750.54	889.24
	SD	339.65	232.90
Group 2	*M*	764.36	788.34
	SD	241.10	215.80
Group 3	*M*	625.23	607.90
	SD	236.16	184.95

Note. Values are expressed in terms of AnP (W) = 2 × (kgm −5 s).

Table 6
Means and Standard Deviations From Leg Press

Group		Time: Pretreatment	Time: Posttreatment
Group 1	*M*	136.7	158.7*
	SD	31.7	31.7
Group 2	*M*	139.1	145.1
	SD	25.7	24.8
Group 3	*M*	133.3	133.3
	SD	42.1	42.3

Note. Values are expressed in kilograms.
*$p<0.01$.

Table 7
Means and Standard Deviations From Bench Press

Group		Time: Pretreatment	Time: Posttreatment
Group 1	*M*	65.5	74.4*
	SD	35.9	37.4*
Group 2	*M*	59.5	59.3
	SD	31.7	33.5
Group 3	*M*	55.3	55.8
	SD	35.0	36.5

Note. Values are expressed in kilograms.
*$p<0.01$.

anaerobic capacity, and arm and leg strength than maximal vertical jumps. Although some improvement was noted in the posttreatment measures for Group 2, these differences did not reach statistical significance.

Recall that Clutch et al. (12) and Adams et al. (3) found no differences in efficacy between maximum vertical jumps and a core plyometric exercise (drop jumping). Both programs were advantageous in increasing power performance as long as weight training was included. The present study failed to demonstrate significant benefits from maximal vertical jumping in the absence of weight training. This supports the suggestion by Clutch et al. (12) that weight training must be included with jumping drills in order to achieve improvements. On the other hand, weighted rope jumping proved to be beneficial as a single treatment. The addition of weights to the rope may serve the same purpose as does weight lifting. Use of a weighted rope might be analogous to jumping and weight lifting simultaneously.

Clutch et al. (12) commented that their drop jumping routines may have resulted in additional benefit if their training programs had been extended, and stated that further research on the necessary duration of plyometric programs was warranted. The subjects in the present study did not require an extensive duration of treatment in order to show improvement. No more than 10 weeks were needed to elicit increases in power performance.

Similarly, Adams (2) suggested that his subjects failed to show improvements because they did not have sufficient base strength to benefit from drop jumping. Subjects in the present study, untrained college-age men and women, were able to begin at a level that was safe and gradually progressed by increasing the weight of the ropes and the number of rope repetitions (sets). The progressive nature of this technique allowed them to develop explosive-reactive power and anaerobic capacity with minimal injury risk.

We chose a conservative level (0.01) for significance because multiple analyses were performed and we wished to control alpha inflation. However, we were interested in whether the choice of a more common alpha level (0.05) would have resulted in different conclusions regarding group comparisons. That is, would the change in other treatment groups between pre- and posttraining be significant, as it was for the rope-jumping group? Only two analyses resulted in significance levels greater than .01 and less than .05. One of these analyses, the effects of training upon leg press, did in fact indicate that the vertical jump group (Group 2) improved from Time 1 to Time 2 when a more liberal alpha rate was employed. The other analysis involved a significant interaction that was determined through follow-up analyses to be due to changes in Group 1 only. These results suggest that the predominance of improvement between pre- and posttraining in Group 1 over the other groups was not an artifact of the use of a conservative alpha level.[1]

In this study we used untrained college-age men and women. It is recommended that further research be done to determine the effect of weighted rope jumping on trained athletes. It is also suggested that research be done to determine the difference between weighted and nonweighted rope training, as the effect of regular rope training on power performance cannot be answered from this study.

Practical Applications

The findings of this study on untrained college men and women confirm the potential of weighted rope jumping as an alternative to traditional core plyometrics. The use of weighted ropes enhances a traditionally effective exercise. Jumping rope has been used to develop coordination of neuromuscular skills, muscular strength, and cardiovascular endurance (19). Jumping a weighted rope, which might be equated with jumping and weight lifting done in synchrony, facilitates improvements in explosive-reactive power, anaerobic capacity, and upper and lower body strength.

A weighted rope offers a multipurpose exercise with several distinct advantages: (a) it can easily be integrated into any training program; (b) it poses minimal risks of injury; (c) it does not require a lot of time during daily workouts; (d) it does not require a minimal level of strength in order to achieve benefits; and (e) it can easily be varied by manipulating factors such as the weight of the rope, its turning speed, the height of the jump, the speed of the jump, the number of sets, and/or the rest between sets to achieve diverse benefits. The use of weighted ropes could be one of the most versatile training methods available and should be considered as a significant part of a training program.

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[1]Specific statistical analyses and results are available from the first author.

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