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EFFECTS OF WEIGHTED VERSUS STANDARD JUMP ROPE TRAINING ON PHYSICAL FITNESS IN ADOLESCENT FEMALE VOLLEYBALL PLAYERS: A RANDOMIZED CONTROLLED TRIAL

RESEARCH ARTICLE

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ABSTRACT

Purpose: The aim of this study was to compare the effects of 12-week standard versus weighted jump rope training on physical fitness tests including anaerobic power, speed, agility and flexibility in female adolescent volleyball players.

Methods: Twenty-five female volleyball players were recruited to the study. Participants were randomly separated into three study groups; weighted jump rope training (n=8), standard jump rope training (n=9) and control group (n=8). All participants were assessed at baseline and after 12-week training. Physical fitness was measured by using vertical jump test, 30-meter sprint test, hexagonal obstacle test, zigzag test and sit and reach test. Repeated-measures ANOVA was used for statistical analysis.

Results: Comparisons showed that after 12-week training, weighted jump-rope training resulted in higher improvements in anaerobic power (p=0.03) and agility (p=0.003) when compared to control training; and higher improvement in agility when compared to standard jump rope training (p=0.001). In addition, at the end of training, speed and flexibility gains were similar in all groups (p>0.05).

Discussion: Weighted jump rope training resulted in higher improvements of anaerobic power and agility in female adolescent volleyball players. The findings of the study provide basic knowledge for developing training protocols for adolescent volleyball players.

Key Words: Adolescent; athlete health; plyometric exercise; volleyball.

ADÖLESAN KADIN VOLEYBOL OYUNCULARINDA AĞIRLIKLI VE STANDART İP ATLAMA EĞİTİMİNİN FİZİKSEL UYGUNLUK ÜZERİNE ETKİSİ: RASTGELE KONTROLLÜ ÇALIŞMA

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Bu çalışmanın amacı, adolesan kadın voleybol oyuncularında 12 haftalık standart ve ağırlıklı ip atlama eğitiminin anaerobik güç, hız, çeviklik ve esnekliği içeren fiziksel uygunluk testleri üzerine etkisini karşılaştırmaktır.

Yöntemler: Yirmi beş kadın voleybol oyuncusu çalışmaya dahil edildi. Katılımcılar ağırlıklı ip atlama (n=8), standart ip atlama (n=9) ve kontrol grubu (n=8) olmak üzere 3 gruba ayrıldı. Tüm katılımcılar eğitim öncesi ve 12 haftalık eğitimin ardından tekrar değerlendirildi. Fiziksel uygunluk, dikey sıçrama, 30 metre sprint, beşgen engel, zikzak test ve otur-uzan testleri kullanılarak değerlendirildi. İstatistiksel analizde ANOVA kullanıldı.

Sonuçlar: On iki haftalık eğitimin ardından ağırlıklı ip atlama grubunda kontrol grubu ile karşılaştırıldığında anaerobik güç (p=0.03) ve çeviklikte (p=0.003); standart ip atlama grubu ile karşılaştırıldığında ise çeviklikte (p=0.001) daha fazla gelişme kaydedildi. Ayrıca, eğitim sonucunda hız ve esneklik kazanımı tüm gruplarda benzer bulundu (p> 0.05).

Tartışma: Adolesan kadın voleybol oyuncularında ağırlıklı ip atlama eğitimi anaerobik güç ve çeviklikte daha fazla kazanım ile sonuçlanmıştır. Bu çalışmanın bulguları, adolesan voleybol oyuncuları için eğitim protokolleri geliştirilmesinde temel bilgi sunmaktadır.

Anahtar kelimeler: Adolesan; pliometrik egzersiz; sporcu sağlığı; voleybol.

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INTRODUCTION

A high level of physical fitness improves athletic performance and prevents sport-related injuries (1). Young female athletes participating in high-risk sports such as volleyball suffer from musculoskeletal injuries more than male athletes (2-4). From this point of view, developing methods and targeted interventions for performance enhancement has been mainly investigated by the researchers (1, 4-5). In general, it has been recommended that the main goals of training program for volleyball players should include improving performance and long-term activity without injury, increasing power and strength, and improving the ability to change direction and accelerate without the loss of speed and balance (6). Therefore, volleyball training includes various types of exercises and regimens (6-8).

Jump rope training was previously reported to be effective in increasing fitness and muscular function of the involved extremities; and improving cardiovascular functions and physical fitness (7-12). This training requires the coordination of several muscle groups to sustain precisely timed and rhythmic plyometric movements, in order to be able to involve a high-intensity concentric contraction immediately after a rapid and powerful eccentric contraction (13). Since the rope has been considered a safe, inexpensive and portable tool, jump rope training has been preferred for adolescent population (14). Additionally, effects of jump rope training on health-related and sport-related fitness have been extensively studied. Interestingly, studies showed that eccentric training have significant effects on muscular flexibility similar to static stretching programs (15).

Weighted jump rope training has been suggested to be another choice, since using weighted ropes allow combining the loading principle of exercise with standard jump rope training (16). Also, the use of weighted ropes may also have additional advantages that are typically associated with plyometrics, such as improving upper-body strength and coordination for lower-body (7-8, 17-18). A recent systematic review and meta-analysis revealed that plyometric training programs have only small to medium-sized effects to improve measures of physical fitness and athletic performance, whereas complex training programs have predominantly larger effects (19). This might indicate that higher loads are needed during training to induce performance gains and could be considered to justify the comparison between weighted and standard jump rope training. However, at present, definitive conclusions regarding the superiority of weighted or standard jump-rope training in improving physical fitness cannot be drawn.

Thus, investigating the effects of standard versus weighted jump-rope training on physical fitness may enable us to gain comprehensive knowledge about fitness enhancement and may further provide a basis for developing training protocols for adolescent volleyball players. Therefore, the purpose of the current study was to investigate the effects of 12-week standard versus weighted jump rope training program on anaerobic power, speed, agility and flexibility in female adolescent volleyball players. Based on related studies, it may be hypothesized that weighted jump rope training will improve physical fitness more than standard jump rope training in female adolescent volleyball players.

METHODS

Experimental approach to the problem

A parallel group randomized controlled trial design was used to investigate the effects of 12-week standard and weighted jump rope training program on anaerobic power, speed, agility and flexibility in female adolescent volleyball players.

Participants

The current study was carried out at the laboratories and gymnasium of Gazi University, School of Physical Education and Sport. The Institutional Review Board approved the protocol for this study, and all participants were informed about the nature of the study and signed a consent form. Also, parental signed consents were obtained, since the mean age of the participants was 14.6>1.1 years.

A prior sample size analysis suggested that, recruiting a total of 25 subjects would test the hypothesis with 80% power and 95% type 1 error. Twenty-five female adolescent volleyball players at national collegiate level with more than two-years

Table 1. 12-week jump rope training program for weighted and standard jump rope training groups.

	Training No	Training/ Rest Duration (s)	Number of sets		Training No	Training/ Rest Duration (s)	Number of sets		Training No	Training/ Rest Duration (s)	Number of sets		Training No	Training/ Rest Duration (s)	Number of sets
1- week	1	30	1	2- week	4	40	1	3- week	7	50	1	4- week	10	60	1
	2	30	1		5	40	1		8	50	1		11	60	1
	3	30	1		6	40	1		9	50	1		12	60	1
5- week	13	30/30	2	6- week	16	40/40	2	7- week	19	50/50	2	8- week	22	60/60	2
	14	30/30	2		17	40/40	2		20	50/50	2		23	60/60	2
	15	30/30	2		18	40/40	2		21	50/50	2		24	60/60	2
9- week	25	30/30	3	10- week	28	40/40	3	11- week	31	50/50	3	12- week	34	60/60	3
	26	30/30	3		29	40/40	3		32	50/50	3		35	60/60	3
	27	30/30	3		30	40/40	3		33	50/50	3		36	60/60	3

of experience in the field were included to the study (Table 1). All participants were recruited from the same sport club and were following the same routine volleyball training program. Participants were excluded if they had any current pain or discomfort during regular training, which was rated at least 3/10 on numeric rating scale, had a history of sport-related injury during the last 3 months, or had any systemic disorders including inflammatory joint disease.

Procedures

With using computer-generated numbers, participants were randomly assigned to one of the following groups; weighted jump rope training group (n=8), standard jump rope training group (n=9) and control group (n=8). Participants in weighted jump rope training group performed rope jumping with weighted ropes and followed the program for twelve weeks, three times weekly. The rope (Power Rope, V-3067) used in this group was weighted 600 grams and 695 grams, depending on the length of the rope. Participants in standard jump rope training group performed rope jumping with standard ropes and followed the program for twelve weeks, three times weekly. The rope used in this group was a cable rope (Selex, Alexandria, VA), which weighted between 100 grams to 160 grams, depending on the length of the rope. Details of rope training program were presented in Table 1. Participants in the control group were followed by only technical training program for twelve weeks, three times weekly. The control group was only followed by a routine volleyball training program. The routine volleyball training program was a standard training which was designed to develop passing, setting, serving, spiking, and blocking techniques, game tactics and positioning skill for all three groups, for six days a week, including volleyball specific skill and team strategy training, strength, and endurance conditioning.

All participants were tested at baseline and after 12-week training. Before the testing session, all participants were informed and educated regarding to particular requirements of each test procedure and performed a standard warm-up.

Anaerobic power was measured by vertical jump test (20). During testing, the participants were asked to stand side on to a wall and reach up with the hand closest to the wall. Keeping the feet flat on the ground, the point of the fingertips was recorded. This was defined as the standing reach height. The participants then asked to perform countermovement jump as high as possible and to touch the wall at the highest point of the jump. The

Table 2. Characteristics of cohorts.

Variable	Weighted jump rope group (n=8) Mean±SD	Standard jump rope group (n=9) Mean±SD	Control group (n=8) Mean±SD	P
Age (years)	15.0±1.0	14.1±1.3	14.4±1.3	0.30
Height (cm)	166±6	165±5	161±5	0.13
Weight (kg)	59.4±8.3	57.7±9.7	50±7.8	0.76
BMI (kg/m2)	21.4±1.9	21.2±3.1	19.1±2.0	0.15

Note: Data given as mean and standard deviation

difference in distance between the standing reach height and the jump height was the score. The best of three attempts was recorded. Power was calculated with using Lewis formula (21):

Power (Watts) = √4.9 x body mass (kg) x √vertical jump score (m) x 9.81

Speed was measured by 30-meter sprint test (22). The test involves running a single maximum sprint over 30 meters. Participants were asked to take standard stationary position, with one foot in front of the other and to hold the position for 2 seconds prior to start, and no rocking movements were allowed. All participants were encouraged to continue running hard through the finish line. Duration of the test was recorded in seconds.

Agility was measured using hexagonal obstacle test and zigzag test (23-24). During hexagonal obstacle test, an athletic tape was used to mark a hexagon on the floor. Participants were asked to stand with both feet together in the middle of the hexagon facing the front line. With the command, participants were asked to jump ahead across the line, then back over the same line into the middle of the hexagon for three circuits. Duration of the test was recorded in seconds. The zigzag test was performed in a setting including four cones placed on the corners of a rectangle 10 by 16 feet, and with one more cone placed in the centre. Participants were asked to run zigzag in the shortest possible time. Duration of the test was recorded in seconds.

Flexibility was measured by sit and reach test (22, 25). Participants were asked to sit on the floor with legs out straight ahead. The feet were placed with the soles flat against the box, shoulder-width apart. Both knees were kept flat against the floor during test. Then, the participants were asked to reach forward as far as possible and the distance was recorded.

Statistical Analyses

Differences between groups were analysed on per protocol basis. In order to show differences in continuous outcomes, inter-group comparisons were analysed using 3-by-2 ANOVA with factors Group (standard jump rope training group, weighted jump rope training group and control group) and Time (baseline, after 12-week training). The Greenhouse-Geisser correction was used to adjust the degrees of freedom when the sphericity assumption was violated. When a significant interaction term was significant, pairwise analyses were performed. Bonferroni corrections were used for adjustment of significance level. When a significant interaction term was not significant, the main effect for Time and Group were evaluated. The SPSS version 15.0 was used for data management and statistical analyses. The significance level was set at 0.05.

RESULTS

Demographics of the participants in each study group were presented in Table 2. There were no significant differences at baseline characteristics among the groups ($p>0.05$).

Anaerobic power

There was statistically significant group-by-time interaction for anaerobic power ($F_{2, 22}=4.93$; $p=0.01$). Pairwise comparisons indicated that weighted jump rope group gained more anaerobic power when compared to control group (mean difference 11.83 Watts; $p=0.03$; Figure 1; Table 3).

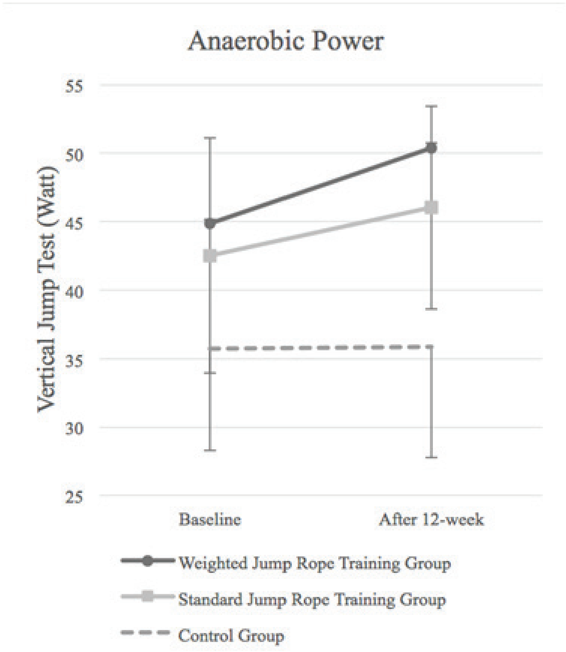

Figure 1. Results of anaerobic power evaluated at baseline and after 12-week training.

Note: Standard deviation for weighted jump rope training group presented only with positive bar, for standard jump rope training group presented with positive and negative bars, and for control group presented only with negative bar.

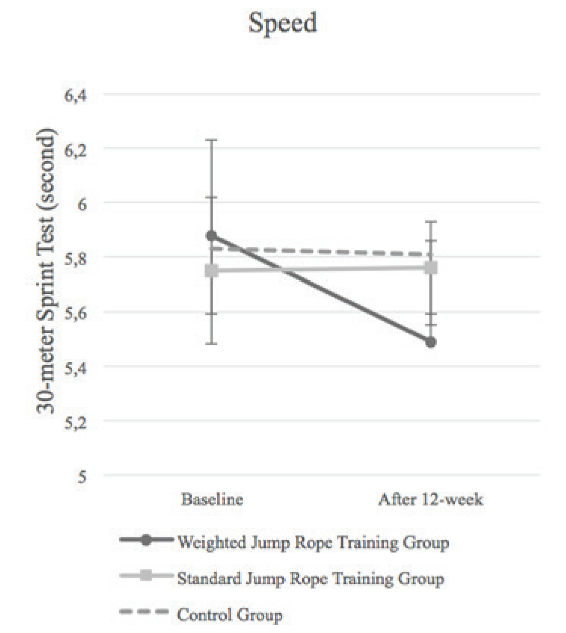

Figure 2. Results of speed evaluated at baseline and after 12-week training.

Note: Standard deviation for weighted jump rope training group presented only with positive bar, for standard jump rope training group presented with positive and negative bars, and for control group presented only with negative bar.

Speed

There was statistically significant main effect of time (F1, 22=15.6; p=0.001) for 30-meter sprint test outcome (5.8 seconds for recordings at baseline versus 5.6 seconds for recordings after 12-week), indicating that all groups gained speed in 30-meter sprint test (Figure 2; Table 3).

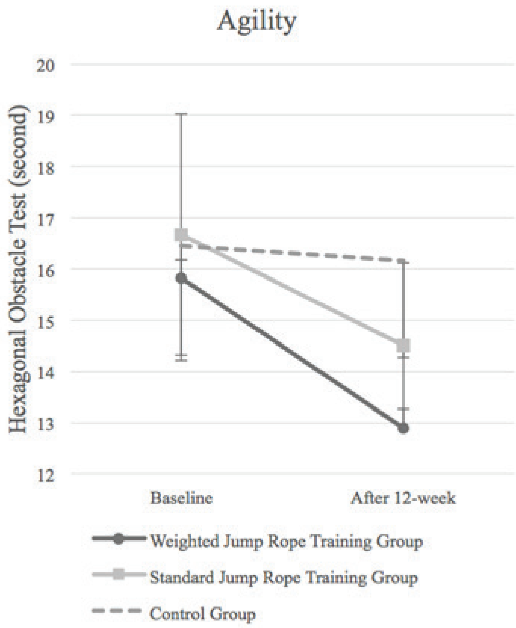

Figure 3. Results of agility evaluated by using hexagonal obstacle test at baseline and after 12-week training.

Note: Standard deviation for weighted jump rope training group presented only with positive bar, for standard jump rope training group presented with positive and negative bars, and for control group presented only with negative bar.

Agility

There was statistically significant group-by-time interaction for hexagonal obstacle test outcome (F2, 22=7.69; p<0.001). Although there was a trend toward increased agility for weighted jump rope group when compared to control group (mean difference 1.95 seconds; p=0.08), pairwise comparisons have failed to indicate any significant difference between groups (p>0.05; Figure 3; Table 3).

There was statistically significant group-by-time interaction for zigzag test outcome (F2, 22=4.93; p=0.01). Pairwise comparisons indicated that weighted jump rope group gained more agility when compared to standard jump rope group (mean difference 0.67 seconds; p=0.003) and control group (mean difference 0.80 seconds; p=0.001; Figure 4; Table 3).

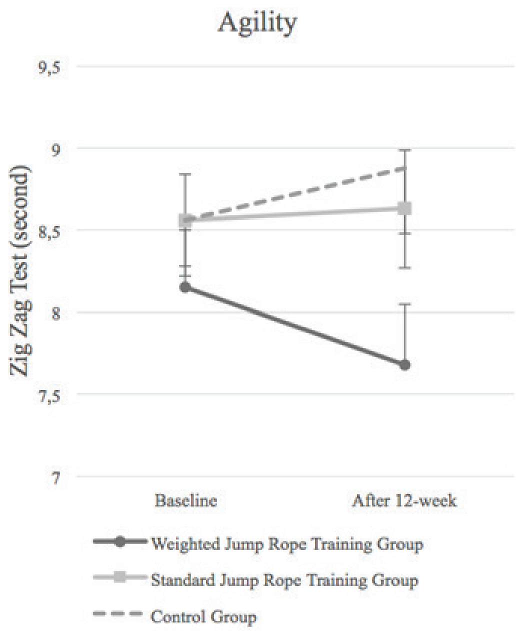

Figure 4. Results of agility evaluated by using zigzag test at baseline and after 12-week training.

Note: Standard deviation for weighted jump rope training group presented only with positive bar, for standard jump rope training group presented with positive and negative bars, and for control group presented only with negative bar.

Flexibility

There was statistically significant main effect of time ($F_{1, 22}$=59.05; p<0.001) for sit and reach test outcome (24.9 cm for recordings at baseline versus 28.5 cm for recordings after 12-week), indicating that, all groups gained flexibility according to sit and reach test results (Figure 5; Table 3).

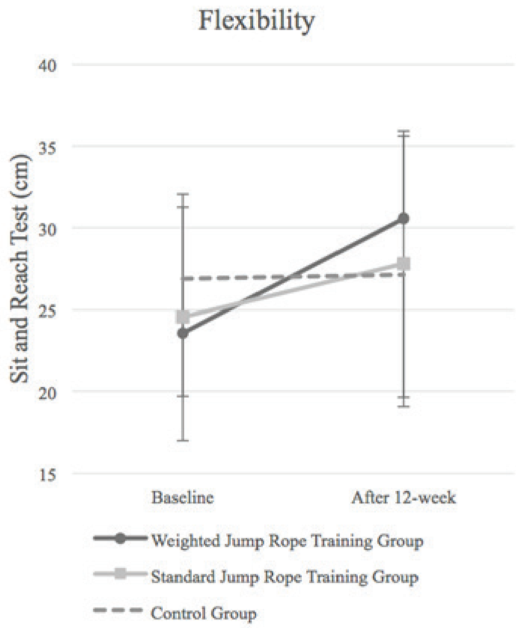

Figure 5. Results of flexibility evaluated at baseline and after 12-week training.

Note: Standard deviation for weighted jump rope training group presented only with positive bar, for standard jump rope training group presented with positive and negative bars, and for control group presented only with negative bar.

Table 3. Results of 12-week jump rope training program.

		Weighted jump rope group (n = 8) Mean±SD	Standard jump rope group (n = 9) Mean±SD	Control group (n = 8) Mean±SD	Interaction term; P
Anaerobic Power (Watt)	Baseline	44.8±9.3	42.5±8.5	35.7±7.4	0.01
	After 12-week	50.4±12.4	46.02±7.4	35.8±8.08	
Speed (sec)	Baseline	5.8±0.3	5.7±0.2	5.8±0.2	>0.05
	After 12-week	5.4±0.3	5.7±0.1	5.8±0.2	
Agility (sec) Hexagonal obstacle test	Baseline	15.8±1.1	16.6±2.3	16.4±2.2	<0.001
	After 12-week	12.8±1.07	14.5±1.6	16.1±1.8	
Agility (sec) Zigzag test	Baseline	8.1±0.3	8.5±0.2	8.5±0.3	0.01
	After 12-week	7.6±0.6	8.6±0.3	8.8±0.4	
Flexibility (cm)	Baseline	23.5±7.6	24.5±7.5	26.8±7.2	>0.05
	After 12-week	30.5±5	27.7±8.1	27.1±8.03	

DISCUSSION

This study has investigated the effects of a 12-week standard versus weighted jump rope training program over control group on performance tests including anaerobic power, speed, agility and flexibility in female adolescent volleyball players. Twelve-week weighted jump rope training resulted in more improvements in anaerobic power and agility when compared to control training, as well as larger improvements in agility when compared to standard jump rope training. Therefore, this training was found effective in gaining speed and flexibility independent from training intervention. The findings of this study supported the idea that weighted jump rope training elicits additional gain in anaerobic power and in agility in female adolescent volleyball players.

Volleyball is a complex sport with both anaerobic and aerobic components and requires sport-specific skills. Smith et al (26) suggested that technical performance may be limited by physical fitness, and performance characteristics such as speed and vertical jump. In order to enhance performance characteristics, plyometric training has been recommended to be integrated in the training program for athletes, because of the effect of long-term training on muscle-activation strategies and performance (27). Similarly, weighted jump rope training was accepted as a low-level plyometric training aspiring to improve strength and power (18). The findings of the current study correspond with the proposition that jump rope training induces various physical fitness components by developing the explosive reaction power (28). In this study, speed and flexibility increased in all groups after 12 weeks, suggesting that the control training program consisting of technical training was effective in improving skills specific to the sport demands. Similar to previous findings in the literature (15), flexibility increased with jump training regardless of weight, suggesting that integrating rope jump training into the training program yielded benefits from different aspects of physical fitness such as flexibility. However, the findings of this study showed additional jump rope training to skill training for volleyball players can be suggested to have potential advantages for gaining power and agility. Lee (16) has suggested that improved skilled movements with jump rope training may also improve endurance and provide synergy between explosive power, agility and reaction time which is accepted as a key performance skill for volleyball players. Since the power has been reported to be one of the most significant predictors of the agility (29), by increasing anaerobic power, weighted jump rope training may result in further enhancement in agility tests over standard jump rope training and technical training only.

Masterson and Brown (18) investigated the effect of weighted jump rope training as an alternative to core plyometric exercises in developing explosive-reactive power and anaerobic capacity. The findings of their study have supported the idea that 10-week weighted jump rope training is a viable alternative to traditional plyometric exercises. The findings of this study showed that 12-week weighted jump rope training was more effective to build 5% more agility when compared to standard jump rope training. From a biomechanical perspective weighted rope provides more mechanical load and demands more muscular work when compared to standard rope. Therefore, the observed differences in physical fitness parameters among study groups may arise from different physiological responses.

There are some limitations of this study. First, the sample size of this study is relatively small. This is because all participants were recruited from the same sport club, in order to monitor the accompanying effect of regular technical training. However, differences in the score of anaerobic power tested with vertical jump test have reached the suggested minimal detectable change level (30). Also, there was no passive control group participated to monitor changes due to maturation.

In conclusion, the findings of this study showed the effects of 12-week standard versus weighted jump rope training program over control group on anaerobic power, speed, agility and flexibility in female adolescent volleyball players. Given the improvements in anaerobic power and agility, weighted jump rope training can be included in training programs of adolescent volleyball players.

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