Effects of 12-Week Medicine Ball Training on Muscle Strength and Power in Young Female Handball Players

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Abstract

Ignjatovic, AM, Markovic, ZM, and Radovanovic, DS. Effects of 12-week medicine ball training on muscle strength and power in young female handball players. *J Strength Cond Res* 26(8): 2166–2173, 2012—The purpose of this study was to examine the effects of medicine ball training on the strength and power in young female handball athletes. Twenty-one young female handball players (age, 16.9 ± 1.2 years) were randomly assigned to experimental and control groups. Experimental group ($n = 11$) participated in a 12-week medicine ball training program incorporated into the regular training session, whereas controls ($n = 10$) participated only in the regular training. Performance in the medicine ball throws in standing and sitting positions, 1 repetition maximum (1RM) bench and shoulder press, and power test at 2 different loads (30 and 50% of 1RM) on bench and shoulder press were assessed at pre- and posttraining testing. The athletes participating in the medicine ball training program made significantly greater gains in all medicine ball throw tests compared with the controls ($p < 0.01$). Also, the experimental group made significantly greater gains in bench and shoulder press power than control group ($p < 0.05$). Both training groups (E) and (C) significantly ($p < 0.05$) increased 1RM bench and shoulder strength, with no differences observed between the groups. Additionally, medicine ball throw tests showed stronger correlation with power tests, than with 1RM tests. These data suggest that 12-week medicine ball training, when incorporated into a regular training session, can provide greater sport-specific training improvements in the upper body for young female handball players.

Key Words resistance training, medicine ball throw, peak power, bench press, shoulder press

Introduction

With an ever-increasing participation in youth sports (1,4), there is also an increasing desire of young athletes and their coaches to improve performance. Handball, and many other team sports, requires the exercise of several components of physical fitness. Muscle strength and power, among other fitness components, are demanded in varying degrees for success, constituting an essential part of the overall training program of any young athlete.

An important component of a comprehensive physical training program for young athletes is resistance training. Resistance training (27) is a specialized method of physical conditioning that involves the progressive use of a wide range of resistive loads and a variety of training modalities–from medicine balls to high-intensity weightlifting that enhance or maintain muscular fitness (i.e., muscular strength and muscular power). Leading world fitness and health organizations guidelines (3,7,8,27), review articles (11,18), and meta-analyses (14), all indicate that resistance training, if properly done, can be very beneficial for adolescents.

Difference in strength between boys and girls is mostly because of the hormonal changes that occur at puberty. Before puberty, they show similar values, but after puberty, development of muscle strength accelerates in boys, whereas it reaches a plateau in girls (10). Almost all the differences in strength between the sexes are because of differences in muscle mass (6). At 18 years, girls have 50% of the upper limb muscle of boys and 70% of the lower limb muscle. After the age of 14 years, muscle strength in girls, especially in the upper body will not improve naturally as in boys. To achieve good results and maintain performance, they need to undertake resistance training, especially if they are involved in sports in which the upper-body performance is of great importance as in handball.

The ability to closely mimic powerful actions that are essential for success in handball makes medicine ball exercises a very good resistance training activity for young female handball players. In previous studies, the effects of medicine ball training on youths (13,32) and young athletes (28) were investigated. Although researches investigated the

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effects of different modes of resistance training programs on young individuals, published research investigating the effects of medicine ball exercises on muscular fitness in young female subjects seems to be lacking.

Some studies have investigated the relationship between dynamic performance and muscle strength power (24,34). Gorostiaga et al. (16) examined the correlations between different dynamic performances in elite and amateur handball players. Also, studies using the medicine ball have investigated the relationship between the upper- and lower-body strength and power and total body explosive power performance during medicine ball throws (19,26,31).

Methods

Experimental Approach to the Problem

This study was designed to investigate whether significant increases in upper-body muscle strength and power could be obtained in young female handball players when adding 12-week medicine ball exercise program to a regular training program. The relationship between the applied tests was also investigated.

Subjects were assessed in different medicine ball throw tests (seated and standing shot put and overhead throw with 1- and 3-kg medicine ball), 1 repetition maximum (1RM) bench and shoulder press and with upper-body power test at 2 different loads (30 and 50% of 1RM) in 2 different exercises (bench press and shoulder press in Smith machine), during which measures of barbell velocity and power were obtained via a computer-interfaced Fitrodyne dynamometer (Fitronic, Bratislava, Slovakia) attached to the barbell via a tether.

Subjects

Twenty-one young female athletes (age, 16.9 ± 1.2 years) participated in this study. All subjects have been performing organized handball training for at least for 2 years (average, 2.7 years) and they have regularly trained 3–5 times per week. They had some experience with resistance training but primarily with calisthenics and less with free weights or machines. Moreover, they were not familiar with regular supervised strength training lasting longer, over a period of several weeks.

The participants were matched for maximal strength (1RM) in bench press and then randomly assigned to experimental and control group. There were no statistically significant differences between the groups in strength and power measurement. Also, there were no differences between groups in medicine ball throw tests, except in 3-kg sitting shot put throw, where the control group had slightly better results. The experimental program was performed during the second part of competition season (April–June). Both groups participated in the same regular handball training program with competitive matches on weekends, whereas the experimental group had additional medicine ball training sessions. The experimental group subjects were asked to come 15 minutes before joint training sessions so that they could perform additional medicine ball training and then participate in regular training together with controls. To be included in the analyses, subjects had to attend more than 90% of the training sessions. Written informed consent was obtained from the head coach and parents or guardians of the young female athletes. The study had been approved by the institutional review board.

Testing Protocol

In the week before the start of the experimental program, all subjects were carefully familiarized with testing procedures in 2 separate familiarization sessions. During 1 of these 2 sessions, the load for 1RM was determined for each subject in the bench press and the shoulder press exercises on the Smith machine using the protocol suggested by Kraemer and Fry (21). Afterward, the performance of the subjects was tested in 2 instances: before starting the 12-week training program (pretest) and after finishing the 12-week training period (posttests). Strength and power testing and medicine ball throws were tested on separate days with 2-day rest between them. A warm-up session consisting of at least 10 minutes of low- to moderate-intensity aerobic exercise and dynamic stretching preceded all the tests. Subjects were instructed not to participate in any exhausting exercise for 24 hours before testing, with no food, energy, or caffeine drinks for 2 hours before testing. Subjects were permitted to have noncaffeinated liquids before testing.

Power Testing

A Fitrodyne dynamometer (Fitronic) was used to measure the muscle power output. This device attaches to the conventional resistance training equipment and measures the speed and position of the vertical motion of the load during the lift movement. A high degree of reliability in muscle power measurement was confirmed by Jennings et al. (20). The testing was performed for both bench press and shoulder press with 2 different loads (30 and 50% of 1RM). The testing order was randomized (i.e., the order of loads and the order of bench or shoulder press protocol). The subjects were instructed to lower the barbell at self-selected velocity during the eccentric faze and then to accelerate as fast as possible during the entire range of concentric motion, without releasing the barbell. The subjects were permitted to lift off from the bench after the full extension of the arms because of the movement inertia. During the concentric phase, the measures of peak power were obtained via a computer-interfaced Fitrodyne attached to the barbell via a tether. Any pauses between the eccentric and concentric phases and bouncing the bar from the chest or shoulders were not allowed. The period of rest, which ranged between 1 and 3 minutes for each repetition and load, was determined by the examinees themselves. Two trials for each load in each lift protocol were performed. The best out of 2 attempts for each load was accepted for further analysis.

Medicine Ball Testing

Medicine ball throws were performed using the 21.5-cm-diameter 1- and 3-kg rubber medicine balls (Tigar, Pirot,

TABLE 1. Detailed description of the medicine ball training program.*

Weeks	1–4		5–8		9–12	
Training days	Monday/Tuesday	Wednesday/Thursday	Monday/Tuesday	Wednesday/Thursday	Monday/Tuesday	Wednesday/Thursday
Duration (min)	15		20		25	
Sets/repetitions (*n*)	3/10		3/12		3/15	
Rest (s)	10/30		10/30		10/30	
Exercises (*n*)	10		12		14	
Exercises (load)	SSP (1 kg)	SSP (1 kg)	SSP RH (1 kg)	SSP (1 kg)	SSP (1 kg)	SSP (1 kg)
	SSP RH (1 kg)	JSP (1 kg)	SSP LH (1 kg)	SSP (3 kg)	SSP (3 kg)	SSP (3 kg)
	SSP LH (1 kg)	SOT (1 kg)	SSP (3 kg)	JSP (1 kg)	SSP RH (3 kg)	JSP (1 kg)
	JSP (1 kg)	StSP (1 kg)	JSP RH (1 kg)	JSP (3 kg)	SSP LH (3 kg)	JSP (3 kg)
	JSP RH (1 kg)	StSP RH (1 kg)	JSP LH (1 kg)	StSP RH (1 kg)	JSP (3 kg)	StSP RH (3 kg)
	JSP LH (1 kg)	StSp LH (1 kg)	JSP (3 kg)	StSP LH (1 kg)	JSP RH (3 kg)	StSP LH (3 kg)
	SOT (1 kg)	StO (1 kg)	StO (1 kg)	StSP (3 kg)	JSP LH (3 kg)	StSP (3 kg)
	StO (1 kg)	LOT (1 kg)	StO (3 kg)	StO (3 kg)	SOT (1 kg)	StO (3 kg)
	LOT (1 kg)	LBT (1 kg)	SOT (1 kg)	LOT (1 kg)	SOT (3 kg)	LOT (1 kg)
	ST (1 kg)	ST (1 kg)	SOT (3 kg)	LBT (1 kg)	StO (3 kg)	LOT (3 kg)
			ST (1 kg)	ST (1 kg)	LOT (1 kg)	LBT (1 kg)
			ST (3 kg)	ST (3 kg)	LOT (3 kg)	LBT (3 kg)
					ST (1 kg)	ST (1 kg)
					ST (3 kg)	ST (3 kg)

*SSP = standing shot put throw with both hands; SSP RH = standing shot put throw with right hand; SSP LH = standing shot put throw with left hand; JSP = jumping shot put throw; JSP RH = jumping shot put throw with right hand; JSP LH = jumping shot put throw with left hand; StSP = sitting shot put throw with both hands; StSP RH = sitting shot put throw with right hand; StSP LH = sitting shot put throw with left hand; SOT = standing overhead throw; JOT = jumping overhead throw; StO = sitting overhead throw; LOT = lying on the stomach overhead throw; LBT = lying on the back throw; ST = side throw.

Serbia). All subjects were introduced to the testing on familiarization session. A brief description of the proper form was given to each player based on the suggested angle of release to achieve a maximum distance (15). The medicine ball was slightly covered with the gym chalk powder (magnesium carbonate) to serve as a drying agent for hands by absorbing sweat and ensuring reliable and stronger grip to prevent slipping of the ball from the subject's hands. It also left the mark on the floor where the ball landed and ensured precise measurement of the throwing distance. The score was measured from the front of the line to the place where the ball landed. The following 4 tests were performed with 1- and 3-kg medicine balls: standing shot put throw–standing behind the baseline of an indoor handball court, the subject grasped the medicine ball with both hands, and on the given sign forcefully pushed the ball from the chest; sitting shot put throw–the subject was in the sitting position and on the given sign forcefully pushed the ball from the chest; standing overhead throw (SO)–the subject was standing behind the line facing forward, holding the medicine ball, and tossed the ball as far as possible from an overhead position; sitting overhead throw–the subject was in the sitting position and tossed the ball as far as possible from an overhead position. Each test was performed in 3 instances, separated by approximately 2 minutes of recovery between different tests. The score for each test was recorded to the nearest 5 cm, and the best score was taken for further analysis.

Training Program

The medicine ball training was held before the regular training sessions. The subjects participated in 2 medicine ball training sessions every week during the period of 12 weeks (total of 24 training sessions). The training sessions were performed on weekdays and never on weekends. If the game was to be played on Sunday, the first training session was held on Tuesday, and if the game was to be played on Saturday, the training session was held on Thursday. Before the medicine ball training, a 5-minute dynamic warm-up was performed. During the medicine ball training program, our subjects performed a variety of medicine ball exercises (shot put, overhead throw, and side throw) from 4 different positions: standing, sitting, lying, and jumping. A detailed description of the medicine ball training program is given in Table 1. All exercises were done in pairs. All subjects performed the same number of exercises for the same number of sets and repetitions throughout the study period. In addition, the subject did not report the use of any medicaments or nutritional supplements that could affect the tests.

Statistical Analyses

All data are presented as mean ± *SD*, and all statistical analyses were performed using the SPSS (version 16.0; SPSS Inc., Chicago, IL, USA) software. Changes in muscle power were analyzed separately using 2 × 2 (treatment × time) repeated measure analysis of variance (ANOVA). If a significant interaction or a major effect occurred, then follow-up analyses included the *t*-tests. The Pearson correlation coefficients (*r*) were used to determine the relationships among different medicine ball throw tests and strength and power test. The results from the final testing of entire group (experimental and control; $n = 21$) were used for correlation. The level of statistical significance for all analyses was set at $p \leq 0.05$. Test-retest reliability was determined using an intraclass correlation coefficient (ICC).

Table 2. Mean values (*SD*) of 1RM bench and shoulder press in experimental (EG) and control group (CG) pre- and posttraining.*

Group/ variable (unit)		1RM bench (kg)	1RM shoulder (kg)
EG	Pre	37.7 (7.2)	33.0 (3.1)
	Post	40.1* (6.8)	34.6* (2.9)
CG	Pre	38.4 (5.3)	32.3 (2.5)
	Post	39.8† (4.7)	33.5† (2.4)

*1RM = 1 repetition maximum.
†A significant difference ($p < 0.05$) compared with the corresponding pretraining value.

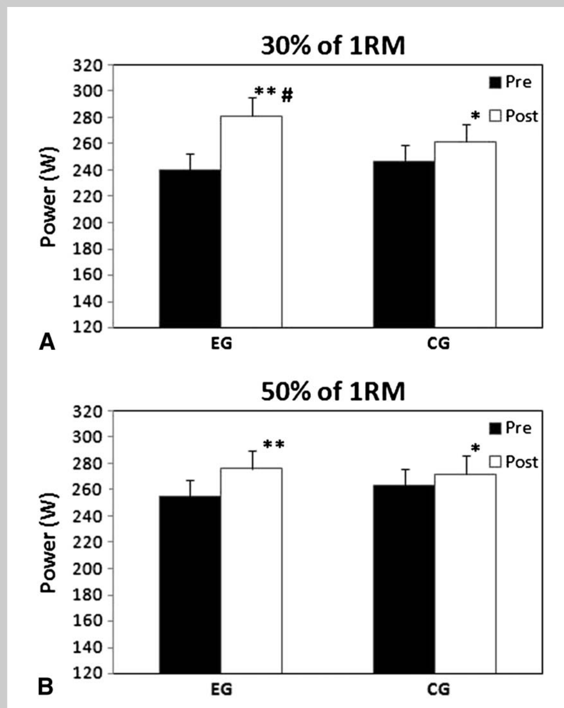

Figure 1. Bench press peak power in experimental (EG) and control group (CG) pre- and posttraining at 30% (A) and at 50% (B) of 1RM. All values are expressed as mean ± *SD*. Significant difference between pre- and postmeasurement, $^{*}p < 0.05$ and $^{**}p < 0.01$. Significant difference between groups, $\#p < 0.05$.

Results

Muscle Strength: Bench and Shoulder Press

Independent sample *t*-tests revealed no statistically significant differences between the groups for 1RM bench and shoulder press before the training. Pre- and posttreatment means and *SD* for 1RM bench and shoulder press for both groups are presented in Table 2. Both groups made significant increases ($p < 0.05$) in predicted 1RM bench and shoulder press after 12 weeks of training; however, there were no significant interaction effects between the groups (Figures 1 and 2). The test-retest reliability coefficient (ICC) for 1RM tests was $r = 0.94$–0.98.

Muscular Power: Bench Press and Shoulder Press

The repeated measures ANOVA revealed a statistically significant difference between groups pre- to posttraining ($F[1,19] = 5.21$, $p < 0.05$) in bench press at 30% of 1RM. The experimental group experienced 15% increase ($p < 0.01$) in power pre- to posttesting, whereas controls had a slight increase of 6% ($p < 0.05$) in the same period. In bench press at 50% of 1RM, ANOVA revealed no statistically significant difference between groups pre- to posttraining ($F[1,19] = 3.63$, $p = 0.07$) The experimental group experienced 10% increase ($p < 0.01$) in power pre- to posttesting, whereas controls had a slight increase of 3% ($p < 0.05$) in the same period.

In shoulder press at 30% of 1RM, ANOVA revealed a statistically significant difference between groups pre- to posttraining ($F[1,19] = 6.67$, $p < 0.05$). The experimental group experienced 14% increase ($p < 0.01$) in power pre- to posttesting, whereas controls had no statistically significant increase of power in the same period. In shoulder press at 50% of 1RM, ANOVA revealed a statistically significant difference between groups pre- to posttraining ($F[1,19] = 8.27$, $p < 0.05$). The experimental group experienced 7% increase ($p < 0.05$) in power pre- to posttesting, whereas controls had no significant changes in the same period.

The test-retest reliability coefficient (ICC) for power tests was $r = 0.87$–0.96.

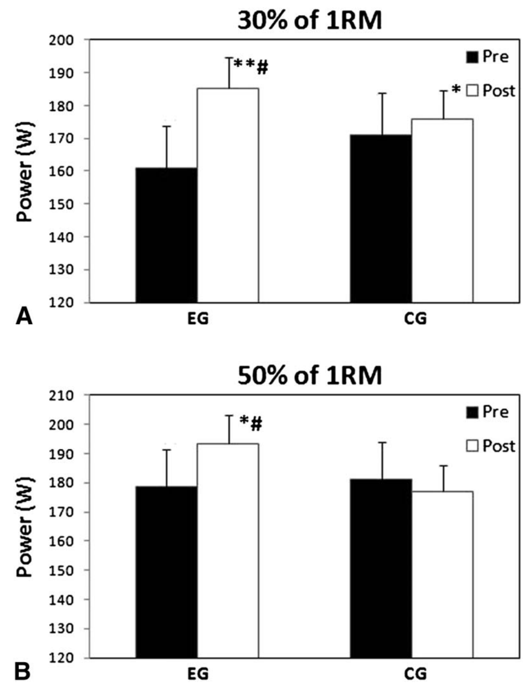

Figure 2. Shoulder press peak power in experimental (EG) and control group (CG) pre- and posttraining at 30% (A) and at 50% (B) of 1 repetition maximum. All values are expressed as mean ± *SD*. Significant difference between pre- and postmeasurement *$p < 0.05$ and **$p < 0.01$. Significant difference between groups #$p < 0.05$.

Medicine Ball Throw

Table 3 shows the means and percent change of medicine ball throw distance for 2 groups at pre- and postmeasurement. There was a significant interaction effect between the groups ($p < 0.01$) in all medicine ball throw tests. The test-retest reliability coefficient (ICC) for different medicine ball throw tests was $r = 0.80$–0.98.

Correlation Between Different Tests

Table 4 shows the Pearson correlation coefficient between different medicine ball throw tests. There was a significant positive correlation between all tests ($p < 0.05$). The highest correlation was observed between different loads within the same test (1 and 3 kg) and between different positions (standing and sitting) in the same test. There was no significant correlation between any of the medicine throw

Table 3. Mean values of different medicine ball throws in experimental (EG) and control group (CG) pre- and posttraining.*

Group	Exercise (load)	SSP (3 kg)	StSP (3 kg)	SO (3 kg)	StO (3 kg)	SSP (1 kg)	StSP (1 kg)	SO (1 kg)	StO (1 kg)
EG	Pre	651	362	589	385	1241	758	989	790
	Post	797	458	698	484	1417	940	1187	945
	Increase (%)	22.4	26.6	18.6	25.7	14.2	24.0	20.1	19.6
CG	Pre	648	403	607	398	1257	725	1013	804
	Post	665	408	594	401	1341	768	1074	871
	Increase (%)	2.6	1.2	−2.1	0.8	6.7	5.9	6.0	8.3

*SSP = standing shot put throw; StSP = sitting shot put throw; SO = standing overhead throw; StO = sitting overhead throw.

Table 4. Relationship among medicine ball throws tests.*

Exercise (load)	SSP (3 kg)	StSP (3 kg)	SO (3 kg)	StO (3 kg)	SSP (1 kg)	StSP (1 kg)	SO (1 kg)	StO (1 kg)
SSP (3 kg)	1							
StSP (3 kg)	0.834†	1						
SO (3 kg)	0.617‡	0.620‡	1					
StO (3 kg)	0.710†	0.826†	0.849†	1				
SSP (1 kg)	0.868†	0.794†	0.765†	0.797†	1			
StSP (1 kg)	0.773†	0.864†	0.688†	0.811†	0.839†	1		
SO (1 kg)	0.715†	0.739†	0.851†	0.897†	0.768†	0.720†	1	
StO (1 kg)	0.595‡	0.646‡	0.865†	0.901†	0.729†	0.702†	0.899†	1

*SSP = standing shot put throw; StSP = sitting shot put throw; SO = standing overhead throw; StO = sitting overhead throw.
†A significant positive correlation between tests ($p < 0.01$).
‡A significant positive correlation between tests ($p < 0.05$).

tests and 1RM strength tests. The correlation between the medicine ball throw tests and power tests was for the most part moderate (range, $r = 0.212–0.606$).

Discussion

In this study, the experimental group showed a statistically significant increase in all medicine ball throw distances after 12 weeks' experimental training program. The percent change was similar for both weights of the medicine ball (1 and 3 kg). Magnitude of the increase for 3-kg medicine ball throws ranged between 18 and 26% and for 1-kg ball between 14 and 23%. In the related studies with young male subjects that lasted only 6 weeks, Faigenbaum and Mediate (13) found an increase in the medicine ball throw of 19%. After the study of identical duration (12), with a combined resistance training program involving the medicine ball throws, the authors found an increase of 14%, and in a 12-week study (32), the authors found an increase of 10% in the medicine ball throws. The increases observed in our study were in line with expected increases.

In short-term (8–20 weeks) resistance training programs, the expected progress in strength in children and adolescents is around 30% (27). The Falk and Tenenbaum meta-analysis (14) found that gains in muscle strength were approximately 13–30% greater than that which would be expected to result from growth and maturation. The increases in medicine ball throw distance in our study are in line with expected progress, and the results of peak power at 30% of 1RM bench and shoulder press (15 and 14%, respectively) However, the increases for experimental group for 1RM in bench and shoulder press (6.4 and 4.8% respectively) and peak power at 50% of 1RM (10 and 7%, respectively) are less than expected. It seems that training adaptations in young female athletes, like in adults, are specific to the movement pattern, velocity of movement, and contraction force, so the largest increases are seen in the tests most specific to the training program. These specific adaptations have been observed in female subjects aged 7–19 years (30) and in young female subjects (9,23). Different studies that examined improvements in 1RM during bench or shoulder press in female subjects have suggested that greatest improvement are observed after training the tested activity with high intensity (2,22,23). The majority of studies (2,9,22,23) have found an improvement in 1RM in bench press after various resistance training program. Some researchers (2,6,22) have found smaller increases in upper body than in lower body, whereas the study (29) investigating girls aged between 14 and 17 years found after 15 months of resistance training an improved 1RM in squat, but failed to show an improvement in 1RM in bench press. To increase upper-body muscle strength in young girls, resistance programs should include upper-body exercises with high intensity, especially in athletes, because they have already achieved some level of physiological adaptation.

One of the findings from our study was that there was a very strong correlation between different medicine ball throws, and moderate to strong correlation ($r = 0.212–0.606$) between medicine ball throws and peak power during bench and shoulder throws at 30 and 50% of 1RM. However, no statistically significant correlation between medicine ball throws and 1RM was found.

Previous studies examining the relationship between throwing performance and upper-body strength and power using handball players as subjects have produced equivocal findings, with some studies reporting a relationship (5,17,25) and others (15,33) failing to observe a positive association. Gorostiaga et al. (16) reported that the ball velocity of world-class handball players in a 3-step running throw depends more on upper and lower extremity power output capabilities than in amateur handball players. They observed a positive relationship ($r = 0.57–0.72$) between bar velocity during a bench press test using 30, 60, and 70% of 1RM and standing ball–throwing velocity only for elite players, whereas amateur players showed positive correlation in only 30% of 1RM. Similar results were found in another study (25), where significant correlation was found only for the lighter weights of 26 and 36 kg ($r = 0.56–0.63$), and not for 46 kg.

Also, Ikeda et al. (19) found that side medicine ball throw may be more useful for examining trunk rotation strength in male subjects than in female subjects. Using the same testing equipment as in our study, they found a significant correlation between side medicine ball throw distance and 1RM and 1RM peak power during bench press. They also found a significant correlation between fast side medicine ball throw and 1RM peak power but not between fast side medicine ball throw and 1RM bench press. The stronger correlation in their study can be explained by the fact that their female subjects were older (19.1 vs. 16.9 years) with longer training experience (4.1 vs. 2.7 years of training experience) and consequently stronger and more powerful in bench press (53 vs. 37.7% 1RM; 623 vs. 252 W) than the subjects in our study.

Practical Applications

The findings of the study suggests that a 12-week resistance training program with medicine balls can significantly improve throwing distances in all applied medicine ball throw tests for young female handball athletes. Moreover, applied medicine ball training improved peak power during bench and shoulder press at 30 and 50% of 1RM. However, this training program resulted in a small increase of 1RM tests. Additionally, the medicine ball throw test showed stronger correlation with power tests than with 1RM tests. Medicine ball training in young female athletes demonstrated specificity and showed greatest increases at tests performed with similar load and velocity of movement as that experienced or used during the training.

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