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Baseball Throwing Velocity: A Comparison of Medicine Ball Training and Weight Training

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ABSTRACT

This study examined the effect of upper body plyometric training, using medicine balls, and upper body conventional weight training on baseball throwing velocity and strength levels as assessed by a 6-RM bench press. Twenty-four junior development baseball players took part in an 8-week training study in conjunction with their baseball training. They were randomly allocated to one of three groups: a medicine ball training group, a weight training group, and a control group. The first group performed explosive upper body medicine ball throws, the weight training group performed conventional upper body weight training, and the control group only performed their normal baseball training. Pre- and post-training measurements of throwing velocity and 6-RM bench press were recorded. The weight training group produced the greatest increase in throwing velocity and 6-RM strength. The medicine ball group showed no significant increase in throwing velocity but did show a significant increase in strength. For this group of non-strength-trained baseball players, it was more effective to implement a weight training program rather than medicine ball training to increase throwing velocity.

Key Words: resistance training, plyometrics, strength, power, upper body

Introduction

By the nature of the game, baseball is very dependant on the physical qualities of power and speed in base running, batting, and throwing (16, 29, 30). Baseball trainers in the past have used a variety of methods to enhance the dynamic performance of the player. Two common training methods have been conventional weight training (1, 10, 14, 16, 26, 29, 33) and medicine ball training (8, 9, 13, 19, 24, 27, 32).

In an attempt to validate the methods employed in the field, several research studies have examined training methods for enhancing the performance of various aspects of baseball, in particular the effects of various resistance training methods on throwing velocity. Studies that have produced increases in throwing velocity have used training modalities including conventional weight training (28, 31, 40), ball throws with over- and underweight balls (7, 12, 39), and loaded pulley systems (7, 23). Other investigations have shown nonsignificant changes in throwing velocity in water polo (4) and baseball throwing (38) as a result of resistance training.

A training method that is very popular among baseball coaches and trainers is plyometrics (9, 24, 27, 32). This most often involves traditional upper body exercises such as medicine ball throws, and lower body exercises such as depth jumps, hopping, and bounding. Although baseball players train using plyometric techniques, little research has been conducted into the effects of plyometric training on skilled baseball movements.

The research into plyometrics has predominantly been confined to the lower body (5, 37), most often in terms of vertical jump performance. Based on the results of this research, it has been difficult to make recommendations with regard to the effects of plyometric training on skilled sport movements such as baseball throwing. The purpose of this study was to examine the effects of upper body plyometric training, using medicine balls, and upper body conventional weight training on baseball throwing velocity and upper body strength levels.

Methods

Subjects

Twenty-four male junior development squad members of an Australian National League baseball team volunteered for an 8-week training study. Procedures for the study were explained and informed consent was obtained from each subject. All subjects had extensive baseball experience, being at least state representative players in their age category and able to throw a baseball at a velocity of at least 30 m $\cdot$ s^{-1}. None had ever participated in resistance training. They ranged between 16 and 23 years of age, with a mean of 18.6 (±1.9 *SD*). Their mean (±*SD*) height and weight were 1.79 ±

0.06 m and 73.7 ± 8.2 kg, respectively. Two of the 24 subjects were lefthanded throwers.

Testing Procedures
The following two tests were performed to assess throwing velocity and strength levels:

1. Maximum throwing velocity was assessed over a distance of 18.44 m, the distance between the pitcher's mound and home plate. After an adequate general warm-up and stretch, subjects were allowed an unlimited number of warm-up throws. They were then instructed to perform five throws from the pitcher's mound into the strike zone at maximum effort, with 20 to 30 sec rest between repeat throws. Velocity was recorded on a handheld ProSpeed-Professional radar gun (Decatur Electronics) (31) situated 2 m directly behind home plate. The radar gun was calibrated immediately prior to all test sessions according to the user's manual (Decatur Electronics). This procedure involved recording the vibration of a tuning fork calibrated to 27.8 $m \cdot s^{-1}$.

A net was placed between home plate and the tester holding the radar gun. The gun was held at chest height and aimed at the base of the pitcher's mound. This was to ensure that the throwing velocity measured was that of the baseball passing over the plate rather than that of the thrower's hand. Throws that did not pass through the strike zone were disregarded. The mean of the five throws was recorded in meters per second. Reliability was determined by correlating the pre- and posttraining results of the control group and using a paired t test to determine any differences between the test data. The correlation was $r = 0.953$ ($p < 0.000$), with no significant difference between pre- and posttraining results (two tailed $t_7 = 0.73$, $p = 0.487$). Therefore this technique was deemed reliable for measuring throwing velocity.

2. Strength performance on a six-repetition maximum (6-RM) free weight bench press was determined using a standard Olympic bar, free weights, and a bench. After an adequate general warm-up and stretch, subjects were given two warm-up sets at comfortable submaximal loads. Loads thereafter were progressively increased, with 3 min rest between sets, until each subject's maximum weight for six repetitions was obtained. The final and heaviest weight was recorded in kilograms as his 6-RM. The test-retest correlation for the control group was 0.982 ($p < 0.000$).

Experimental Design
The experiment was designed as a conventional training study involving two experimental groups and a control group. All subjects were tested according to the procedures outlined above. They then completed 8 weeks of a training intervention and were retested at the end of the training period.

The subjects were randomly allocated to the three groups before beginning the training program: The medicine ball training group performed upper body plyometric medicine ball throws in conjunction with their normal baseball training. The weight training group performed conventional upper body weight training exercises in conjunction with their normal baseball training. The control group performed only their normal baseball training.

The groups were statistically compared using a one-way analysis of variance of pretest throwing velocity to ensure that the random allocation process was effective. No significant differences, $F(2, 21) = 1.120$, $p = 0.345$, were observed between groups.

Training Procedures
The medicine ball group participated in a supervised medicine ball throwing program twice a week over the 8-week training period. Exercises consisted of an explosive two-hand chest pass and a two-hand overhead throw. All throws were performed with a countermovement to ensure that they involved a stretch-shorten cycle similar to the baseball throwing action. To reduce any contribution to the throw of a forward step and to emphasize the upper body musculature, the feet were held in place during both exercises. Exercises were performed with maximum effort for each throw. The exercises are commonly done by baseball players and involve the muscles used in the action of throwing (16, 17).

All subjects completed the same warm-up consisting of 5 min of light jogging followed by pectoralis major and tricep static stretches and several submaximal warm-up throws. The subjects were then instructed to perform three sets of 8 medicine ball throws at maximum effort for each exercise for the first 4 weeks. Thereafter they were to perform three sets of 10 throws at maximum effort for the last 4 weeks of the training study.

Both chest pass and overhead throw exercises were completed, giving a total of six sets per session. The subjects rested for 3 min between sets. The medicine balls weighed 3 kg each and the subjects were consistently encouraged to throw at maximum effort. They also participated in normal baseball training twice a week with the other two groups.

The weight training group participated in a supervised weight training program twice a week over the same 8-week period. Exercises consisted of the barbell bench press and the barbell pullover. These exercises are also commonly performed by baseball players and involve the muscles used in throwing (16, 17). All subjects completed the same warm-up as described for the medicine ball training group; however, the warm-up throws were replaced by one set of barbell bench presses and one set of barbell pullovers using a light load.

The subjects completed three sets of 8- to 10-RM for each exercise for the first 4 weeks. Thereafter they performed three sets of 6- to 8-RM for the last 4 weeks of the 8-week training study. Similar to the medicine ball training group, the subjects rested for 3 min between sets. They were consistently encouraged to increase the weight when possible. They also participated in normal baseball training twice a week with the other two groups.

The control group did not participate in any form of resistance training over the 8-week training period, but they did participate with the other two groups in normal baseball training sessions on the same days. The medicine ball and weight training groups performed their resistance training prior to baseball training on the same days.

Each group was retested 48 hrs after the 8-week training period on all variables and using the same tests and procedures as the pretesting.

Statistical Analysis

The results for throwing velocity and 6-RM strength were compared using multivariate analysis of covariance with the independent variables being (a) training group and (b) testing occasion. The covariates were pretraining throwing velocity and pretraining 6-RM strength. Scheffé post hoc comparisons were performed to determine which of the groups were significantly different. Within each group, paired samples two-tailed t tests were used to assess changes in throwing velocity and 6-RM strength between the pre- and posttraining testing occasions. The percentage change in throwing velocity was compared to percentage change in 6-RM strength using Pearson's correlation. Statistical significance was accepted at an alpha level of 0.05.

Results

The pre- and posttraining velocity data and percentage changes appear in Table 1. Overall, there was no significant repeated measures or training group interaction effect for velocity, $F(2, 21) = 3.28$, $p = 0.057$. Further analysis revealed that the only group with a significant change in velocity pre- to posttraining was the weight training group (two tailed $t_7 = 2.56$, $p = 0.038$). The weight training group increased their throwing velocity from 31.7 to 33.0 $m \cdot s^{-1}$, which was a mean increase of 1.3 $m \cdot s^{-1}$, or 4.1%. Percentage changes in throwing velocity pre- to posttraining did not differ significantly between any of the groups.

Table 1
Throwing Velocity Pre- and Posttraining

Group	n	Pretraining ($m \cdot s^{-1}$) M	Pretraining SD	Posttraining ($m \cdot s^{-1}$) M	Posttraining SD	Change
C	8	32.5	1.6	32.3	2.3	–0.7
MB	8	31.0	1.9	31.5	1.5	1.6
WT	8	31.7	2.5	33.0	2.2	4.1*

*Significant change, pre- to posttraining at $p \le 0.05$.

Table 2
6-RM Strength Pre- and Posttraining

Group	n	Pretraining (kg) M	Pretraining SD	Posttraining (kg) M	Posttraining SD	Change
C	8	59.6	12.3	61.6	12.9	3.4
MB	8	51.2	6.0	55.8	5.1	8.9*
WT	8	48.7	5.4	59.8	5.0	22.8*+

*Significant change, pre- to posttraining at $p \le 0.05$; +significant difference in percentage change between WT and other two groups at $p \le 0.05$.

The pre- and posttraining 6-RM data and percentage changes appear in Table 2. Overall, there was a significant repeated measures effect as well as an interaction of training group, $F(2, 21) = 12.4$, $p = 0.000$. Both experimental groups significantly increased their strength from training. The weight trained group produced the greatest significant increase of 11.1 kg (22.8%) (two tailed $t_7 = 6.57$, $p < 0.000$). The medicine ball group also increased their strength significantly by 4.5 kg (8.9%) (two tailed $t_7 = 3.53$, $p = 0.01$). However, the control group did not produce any significant change in 6-RM strength. Post hoc analysis of the percentage changes concluded that the weight training group increased significantly more than the medicine ball training group. Although the medicine ball group produced a significant increase in 6-RM strength, this increase was not significantly greater than that of the control group.

The covariates of pretraining throwing velocity and 6-RM strength had no significant effect on the changes in velocity or 6-RM strength pre- to posttraining. No significant relationship was found between change in throwing velocity and change in 6-RM strength ($r = 0.147$, $p = 0.25$).

Discussion

It would appear that the use of medicine ball training to improve throwing velocity in baseball players is based on the rationale that it is more specific to the throwing action in terms of velocity of movement, the load being accelerated, and the execution of a coordinated full-body action. Certainly on these grounds we would expect it to be more effective than traditional weight training.

However, from the results of this study, the group that trained using conventional free weight methods improved both throwing speed and strength to a greater degree than the group that trained with medicine balls. In fact the medicine ball training did not increase throwing velocity whatsoever. This finding was unexpected in light of all the baseball teams at all levels of competition that use medicine ball training in their program. Let us examine the performance factors that could lead to an increase in throwing velocity.

First, practicing the throwing action should lead to improved coordination of muscle contraction and the development of a more efficient open kinetic chain movement (21). The training movement, however, would have to be similar to the throwing skill tested. This has been proven in previous research which found that ball throws with over- and underweight balls (7, 12, 39) helped increase throwing velocity.

The movement patterns in the weight training exercises used in this study differed from the throwing action and thus would not be expected to improve the skill component of baseball throwing. Due to the size of the balls used, the subjects in the medicine ball training group could not use a normal baseball throwing action. The movement patterns chosen were the chest pass and overhead throw in order to be comparable to the weight training exercises of bench press and pullover. Similar to the weight training, these movements may have been too different for the medicine ball training to elicit a favorable adaptation of the baseball throwing action.

Second, greater force output and rate of force development have been shown to result in improved power output and velocity of movement (18, 36). An important factor that contributes to force production and rate of development in activities such as throwing is the stretch-shorten cycle (SSC) (20). As the muscle is rapidly stretched and then undergoes a powerful concentric action, additional force is derived from the storage of elastic energy and facilitation of the muscle contraction due to the stretch reflex (20). As such, improvement of force output and rate of force development in the appropriate muscles should result in increased throwing velocity.

In comparing medicine ball training and weight training, the main difference is that of the load used. Both involve the SSC, but the medicine ball training, being a plyometric exercise with a light load, involves a more rapid SSC and a faster velocity of movement. The results of this study suggest that the use of heavier loads has been more effective than the medicine ball training.

Kaneko et al. (18) determined that training with heavier loads of 100% MVC resulted in increases not only in strength but also in unloaded movement speed. Similarly, a training study by Schmidtbleicher and Buehrle (36) found that the use of relatively heavy loads of 80–90% MVC enhanced the performance of powerful dynamic movements more effectively than light loads. This is despite the fact that several studies (22, 25) have shown velocity-specific training effects, and that the use of heavy loads does not produce velocity-specific adaptations in the neuromuscular system conducive to increasing throwing velocity.

A recent review by Behm and Sale (3) concluded that ballistic movements such as throwing and jumping are preprogrammed and that maximum limb velocity is determined principally by the rate of force development and overall force output. Improvement in these factors does not seem to require low load, high velocity training, but rather heavy loads or even isometric contractions (34). Research by Behm and Sale (2) demonstrated that it may be the *intention* to move quickly that determines the velocity-specific response.

In terms of this study, the weight training may have produced an increase in throwing velocity due to an increase in strength. The subjects in this study had never been involved in regular weight training, and several were of relatively low strength. The weight training group produced a large increase in 6-RM strength of 24%; however, there was no relationship between the increases in strength and the increases in throwing velocity, suggesting that other factors may influence the performance gains.

Rate of force development was not measured in this study, so it cannot be determined whether this also contributed to the improvement. The weight training group was instructed to complete the lifts using relatively slow, controlled movements. Previous research (35) would suggest that weight training must be performed explosively to improve rate of force development and elicit gains across the force-velocity curve. However, Komi and Hakkinen (20) suggest that depending on one's training status, the response may not always follow this principle. Subjects who have a low level of force and velocity to begin with may see improvements throughout the force-velocity spectrum regardless of the training load used (20). Further research is required as to whether similar increases in throwing velocity can be produced when subjects who are already relatively strong undergo weight training.

The medicine ball training may not have improved throwing velocity because it did not improve the neuromuscular qualities of force output and rate of force development. Perhaps the overload on the muscle when accelerating a 3-kg medicine ball is not enough to induce a training adaptation. This would be compounded by the fact that the load did not progress from 3 kg over the course of the training period. This finding is similar to that of Kaneko et al. (18), who determined that the greatest strength increases are produced using heavier loads and that strength increases are minimal when using light loads, even if they are accelerated rapidly. Although the medicine ball trained group did increase in strength, it was significantly less than for the weight training group.

The effect of medicine ball training on rate of force development has not been reported elsewhere and was not measured in this study, but it is possible that no positive effects were produced in this performance variable either. Rate of force development is approximately equal at all resistances above 25% of maximum isometric force (35); however, a 3-kg medicine ball is well below this relative load. Rate of force development has been shown to be increased by explosive type training (2, 15), but the relative loads used were much higher than 3 kg.

Further, to improve SSC performance an adequate stretch load must be placed on the musculature (5). Cross-sectional research has demonstrated that during drop jump tests, increasing the height of the drop improves subsequent jump height. This occurs only up to a point, after which jump height decreases due to the inhibitory effect of too high a stretch load (6). Based on this finding, it could be argued that the optimal load to train the SSC is that which maximizes SSC performance. The medicine ball training may have placed stretch loads on the neuromuscular system that were not sufficient to produce a training stimulus to the SSC.

Certainly, throwing a 3-kg medicine ball is a very different training stimulus from that of traditional weight training. These methods were compared in this study because they are commonly used at all levels of baseball training. Although explanations have been suggested for the superior results exhibited by the weight training group over the medicine ball group, there has been little research on the effects of training with loads spanning the force capability of muscle. In particular, how do load-specific adaptations impact on dynamic performance in which an athlete may manipulate a resistance as light as a baseball or as heavy as jumping with the weight of the body?

In conclusion, weight training was more effective at increasing baseball throwing velocity, possibly due to significant increases in strength of the muscles involved in the throwing action. Although medicine ball training is more similar to baseball throwing in terms of movement speed and load used, its differences would appear too great and its stimulation of force output and rate of force development too small to improve throwing velocity.

Practical Applications

In terms of the age and level of training of the baseball players involved in this study, it would be more effective to implement a weight training program than a medicine ball program to increase throwing velocity. Although the efficacy of medicine ball training cannot be dismissed altogether, some recommendations are in order: (a) If the baseball players are of low strength and have not been actively weight training, they should undergo a weight training program to increase strength. Once adequate strength has been achieved, the coach may be able to use medicine ball training after or in conjunction with weight training in a periodized model. (b) It appears that the weights of the balls used in medicine ball training are insufficient and should be selected based on the strength and size of the athlete and increased in weight according to the principle of progressive overload.

As mentioned, the medicine ball cannot be dismissed altogether as a useful training tool. However, coaches and players must take into account the above considerations during medicine ball training if they are to maximize the proposed benefits.

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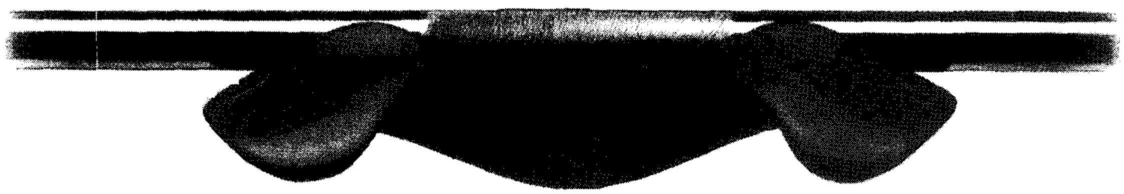

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