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Baseball Throwing Speed and Base Running Speed: The Effects of Ballistic Resistance Training

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ABSTRACT

Ballistic resistance training involves explosive movements against resistance at the fastest velocity possible. This study examined the effect of a ballistic resistance training program on baseball throwing and base running speed. Eighteen National League baseball players from two teams took part in the 10-week training study in conjunction with their normal preseason baseball training. Nine subjects from one team served as the control group and did not take part in any form of ballistic resistance training. Nine from the other team served as the training group and performed explosive squat jumps and bench throws with a light load that maximized power output (approx. 30–50% 1-RM). Both groups also participated in normal baseball training. Pre- and posttraining throwing speed and average running speed were recorded. The training group significantly improved throwing speed by 2.0 ± 1.5% ($p \leq 0.05$); no change was recorded for the control group. Both groups increased running speed, but the increases were significantly greater for the training group. It is concluded that ballistic resistance training can increase performance in baseball throwing and base running, thus such training methods should be incorporated in baseball training programs.

Key Words: explosive power, plyometrics, specificity

Introduction

Baseball players and coaches are constantly manipulating training methods to enhance playing performance. Given that baseball is a sport that is very explosive and ballistic in nature, there are many training techniques and theories available from which the coach could develop an effective training program that will enhance performance.

Conventional weight training (1, 13, 14, 18, 19, 27, 38, 40) and plyometric training (9, 12, 25, 32, 39) are two of the more common methods used to develop muscular power and speed. Several researchers have examined overload techniques on various aspects of baseball conditioning (7, 15, 35, 37, 53). In particular the effects of resistance training methods on baseball throwing speed have been studied. Most of the researchers have seen improvements (7, 15, 23, 35–37, 50, 51, 53) while others found no effect (4, 49). There have been mixed results when examining the effects of resistance training on sprint performance, with minor improvements reported by Wilson et al. (52) and no improvements reported by Fry et al. (17) and Potteiger et al. (37).

Many baseball coaches see traditional plyometric training as the link between strength and speed (11). This training generally incorporates traditional upper body exercises such as medicine ball throws, and lower body exercises such as depth jumps. Despite the fact that baseball players train using plyometric techniques, there is little research on the effects of plyometric training on skilled baseball movements such as throwing speed and base running speed. Past research on plyometrics has predominately been confined to the lower body (5, 45), generally in terms of vertical jump performance. It is difficult to make recommendations based on this research concerning training to enhance baseball skills. In particular, the effects of upper body plyometric training have seen minimal investigation (35).

Ballistic resistance training (33) is a relatively new training method that combines elements of plyometric training and weight lifting, and involves the lifting of relatively lights loads at high speeds. Researchers have found loads of approximately 30% maximum to be effective for increasing mechanical power output (20, 28). Others have recommended heavy loads of 80–90% maximum for improving dynamic performance (44, 46). In terms of baseball training, coaches are prescribing conditioning techniques using light loads in the form of medicine ball training, weight-implemented balls and bats, weighted pulley systems, depth jumps and bounding, and heavy resistance training such as traditional weightlifting.

Thus there is mixed opinion as to acceptable training methods for enhancing dynamic baseball performance. The purpose of this study was to evaluate the effectiveness of a training method in the form of ballistic resistance training using a load of 30–50% maximum to develop good baseball throwing speed and base running speed. It was hypothesized that introducing such training to a group of elite athletes who had only undergone traditional baseball and resistance training regimens would result in superior gains in performance.

Methods

Eighteen male baseball players from two National Baseball teams volunteered to take part in a 10-week training study. All had extensive baseball experience, being at least squad members of a National Baseball team, and all had participated in some form of resistance training consisting of conventional weight training as a part of their preseason preparation. After procedures for the study were explained and informed consent was obtained, subjects were assigned to one of two groups, 9 in each group. Mean (±*SD*) age, height, and weight were 24 ± 4 yrs, 183 ± 6 cm, and 84 ± 11 kg.

Testing Procedures

The following tests were performed:

Throwing Speed. Throwing speed was assessed over the distance between the pitcher's mound and home plate (18.44 m). A net was placed between the tester holding the radar gun and home plate. The gun was held at chest height and aimed at the base of the pitcher's mound. This ensured that throwing speed was measured as the baseball passed over home plate rather than the speed of the thrower's hand. Speed was recorded on a handheld ProSpeed-Professional radar gun (Decatur Electronics) (35, 37) situated 2 meters directly behind home plate. The radar gun was calibrated immediately prior to all testing sessions according to the user's manual by recording the vibration of a tuning fork calibrated to 27.8 $m \cdot s^{-1}$. The measurement of throwing speed by this technique has been shown to be reliable with an intraclass correlation of 0.953 between repeat measurements on different days using the same subjects (35).

After an adequate general warm-up consisting of a 5-min jog and muscle stretches specific to throwing, subjects were allowed an unlimited number of warm-up throws. They then threw from the pitcher's mound into the strike zone at maximum effort with 20 to 30 sec rest between throws. Only the first 5 throws passing through the strike zone were recorded. Throws that did not pass through the strike zone were disregarded. The mean of the 5 throws was recorded in meters per second (35, 53).

Sprint Speed. Sprint speed was assessed over the distance between home plate and first base (27.4 m). Sprint time was recorded using the Kinematic Measurement System (Fitness Technology, Skye, Australia). The timer was started using a hand-release switch and stopped via a signal from an infrared light gate. Subjects started in a crouched position with one hand holding the switch in the downward position. Once the subject began the sprint, the release of the hand switch started the timer, which stopped once the subject passed through the infrared light gate.

After an adequate general warm-up consisting of a 5-min jog and muscle stretches specific to running, subjects were allowed an unlimited number of warm-up runs. They then ran two sprints at maximum effort, with the mean of both times being recorded.

Experimental Design

This experiment was designed as a conventional training study involving a treatment group and a control group. All subjects were tested according to the procedures outlined above. They then completed 10 weeks of training intervention and were retested at the end of the training period. The treatment group consisted of 9 players from one baseball team while the control group consisted of 9 players from the other team. The treatment group performed dynamic ballistic resistance training in conjunction with normal baseball training. The control group underwent just their normal baseball training throughout the 10 weeks. The fact that the players represented two national competitive baseball teams from the same competition ensured that they were evenly matched in skills and experience.

The groups were statistically compared using a one-way ANOVA of pretest throwing speed, running speed, age, height, and weight. There were no significant differences between groups for any of these variables.

Training Procedures

Treatment Group. The treatment group participated in an individually supervised ballistic weight training program consisting of bench throws and jump squats for 3 sessions every 2 weeks over the 10-week period. They completed 15 training sessions on a Plyometric Power System (Norsearch, Lismore, Australia) (52), a device that allowed them to perform dynamic weight training with a load that could be progressively adjusted to maximize mechanical power output. The machine allows only vertical movements and is connected to a rotary encoder that records the position and direction of the bar within 0.001 m. This information is recorded via computer which calculates the movement velocity, work done (mass × gravity × height) and power output (work/time). Training performance was enhanced through instant auditory feedback of height thrown or jumped, based on a predetermined height threshold programmed into the computer. Safety stoppers were placed at the lowest range of movement of the exercise to protect the subject in case of a misjudged throw or landing.

After an adequate warm-up, a specific stretch and 2 sets at submax effort, each subject executed 3 sets of 6–8 max-effort repetitions in the bench throw and jump squat on the Plyometric Power System. Both exercises were performed like traditional bench press and squat exercises except that the bench throw incorporates a release and catching phase of the bar at the end range of exercise while the jump squat incorporates a jump and landing phase at the end range. These exercises train the muscles responsible for throwing and running. Both were performed in the same plane and range of motion as the traditional bench press and squat. The load for each set was continually modified for each individual to maximize mechanical power output as subjects improved over the 10-week training period. A 3-min rest was allowed between sets. All training sessions were completed before beginning normal baseball training, and all subjects participated in normal baseball training throughout the training period.

Control Group. The control group did not participate in any form of ballistic resistance training over the 10-week training period. However, they did participate in normal baseball training consisting of regular batting and throwing practice that was very similar in structure, frequency, and duration of training to that of the treatment group throughout the training period.

All subjects were retested within 1 week of the completion of the 10-week training period in a manner identical to pretesting.

Statistical Analysis

Means and standard deviations for pre- and posttesting throwing and running velocity were calculated for both groups. A one-way ANOVA was used to determine whether there were any differences between groups prior to training. The results for both groups were then compared using multivariate ANOVA with repeated measures on test occasion (within-subjects factor) and a between-subjects factor of group. Because a significant effect of group by test occasion was found, one-way ANOVA was applied to the difference scores (post minus pre) to determine whether the changes in the two dependent variables over the training period differed between groups. The criterion level of significance was set at $p \leq 0.05$.

Results

Means and standard deviations for pre and posttesting results, as well as percentage changes, were as follows:

	Pre ($m \cdot s^{-1}$)	Post ($m \cdot s^{-1}$)	% Change
Throwing speed			
Control	34.7 ± 1.2	34.5 ± 1.2	–0.4 ± 3.2
Treatment	33.7 ± 1.4	34.3 ± 1.2	+2.0 ± 1.5*†
Running speed			
Control	6.22 ± 0.26	6.60 ± 0.30	+6.1 ± 2.7*
Treatment	6.13 ± 0.27	6.68 ± 0.30	+9.0 ± 3.0*†

Signif. diff., $p < 0.05$, *pre to posttraining; †between groups.

There was no difference between groups for either throwing or running speed at pre or posttesting. There was a significant effect of test occasion as well as an interaction of group and test occasion according to the pre and posttesting results across all subjects. There was no change in throwing speed for the control group; however, the treatment group had a significant increase. Both groups had significant increases in running speed; this increase was significantly greater for the treatment group than the control group.

Discussion

The results of this study suggest that ballistic resistance training can enhance performance in baseball throwing and base running. The treatment group increased both throwing and running speed, the latter significantly more than the control group. The control group did not increase throwing speed but did increase running speed. Thus it appears that ballistic resistance training produces adaptations in the neuromuscular system beyond the effects of normal baseball training undertaken over the same period. The increases in running speed further support the findings of Wilson et al. (52), who reported improvements in sprint performance as a result of ballistic resistance training. To our knowledge, there is no published research on the effects of ballistic resistance training on upper body sports movements such as throwing. However, we have previously reported a nonsignificant change in throwing speed following medicine ball training (35). The significant improvement reported in the current study may have been a result of the greater load and provision of feedback we have previously suggested as limitations of medicine ball training.

It should be noted that at posttraining there was still no significant difference between groups in either throwing or running speed. This may be due to the fact that the treatment group was somewhat slower prior to the training period and improved significantly to become faster, though not significantly so, than the control group after the training period. Although not possible in this study, greater subject numbers may have yielded stronger trends and thus significant posttraining differences between groups.

Given the competitive level of the athletes and their many years of training, it is interesting that an increase in performance, especially throwing speed, can be induced. Therefore it is pertinent to discuss why this novel training stimulus was effective. A number of possibilities should be considered:

1. The bench throws and squat jumps used in this study were characterized by fast velocity of movement resulting from the relatively light loads used. The improvements in throwing and running speed are supported by other researchers (22, 26), who also demonstrated such velocity-specific training effects. Resistance training with heavy loads and slow velocity of movement may not result in adaptations of the neuromuscular system conducive to increasing throwing speed (4).

Other researchers have concluded (3) that maximum limb velocity is determined mainly by the rate of force development and overall force output, and that improvement in these factors does not seem to require low load/high velocity training, but rather heavy loads or even isometric contractions (43). Behm and Sale (2) suggested it may be the "intention" to move quickly that determines the velocity-specific response. Further research is needed to determine the best load for developing explosive power and whether fast movement speed must actually occur in training to improve performance in light resistance or even unloaded limb movements.

In the current study the subjects were encouraged to jump or throw as rapidly as possible. As they all trained at a load that maximized mechanical power output (30–50% 1-RM), it cannot be determined whether heavier loads (>60%) may have been more effective. Certainly on current evidence, regardless of the load used, it would seem important to work as explosively as possible against the resistance and develop force rapidly.

2. The subjects who performed ballistic movements in this study emphasized not only the speed of muscle action but also the velocity profile throughout the entire movement. Several studies (20, 24, 28, 52) have shown the explosive lifting of light loads (30-50% 1-RM) to be effective for increasing dynamic athletic performance. These results are in contrast with research by Schmidtbleicher and Haralambie (46) and Schmidtbleicher and Buehrle (44), who found light loads to be ineffective for improving dynamic performance. Schmidtbleicher and coauthors (44, 46) attributed their findings to the size theory of motor unit recruitment (42) which implies that only heavy-load training ensures the recruitment of the fast twitch motor units (45), which are predominately responsible for powerful dynamic performance (43), and that light loads do not overload the muscle enough to induce an adaptation.

Schmidtbleicher and coauthors' (44, 46) training protocol, like that of all traditional weight training exercises, involved lifting techniques in which the load must decelerate to a stop at the end of the movement (16). Newton et al. (34) found that the force and muscle activation decrease toward the end of the movement as the bar slows to a stop at the end range of the exercise. This is incongruous with typical powerful movements in athletic performance in which the load is accelerated throughout the range to produce a high release, takeoff, or impact velocity. Thus the kinetic and kinematic profiles of ballistic vs. traditional weight training contrasted by Newton et al. (34) may have been partially vindicated by this training study.

This line of thought has been supported by many strength coaches who believe that the closer the movement pattern and velocity of the training exercise is to the actual sporting movement, the greater the transference of training gains to athletic performance (29, 30). Hence the popularity of Olympic-style lifts for developing explosive power. Similar to the ballistic resistance training used in this study, load can be rapidly accelerated throughout the movement and thus the velocity profile is much closer to the sport movement to be developed.

3. An important factor that contributes to explosive power output in activities such as throwing and running is the stretch-shortening cycle (SSC) (21). 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 (21). To improve SSC performance, an adequate stretch load must be placed on the muscles (5). Cross-sectional research has led some researchers to conclude that during drop jump tests, increasing the height of the drop improves subsequent jump height. This occurs only up a point, after which jump height decreases due to the inhibitory effects of too high a stretch load (6).

Based on this finding, it could be argued that the optimal load for training the SSC is that which maximizes SSC performance. In the current study, training loads were selected that maximized the subject's power output. Thus it could be assumed that the contribution from the SSC during training was substantial and possibly even maximized. Although SSC ability was not assessed in this study, improvement of this attribute in the muscles trained may have also contributed to the increases in throwing and running speed.

4. Another factor that may have led to the significant improvements in dynamic performance may have been the instant feedback on height achieved and power output. This is unlike traditional plyometric training such as depth jumps and medicine ball throws, where performance feedback comes in the form of a vague perception of height jumped or distance thrown, which may make it difficult for athletes to motivate themselves to continually strive for improved performance, since they get no real feedback on their progress. Feedback has been shown to be an important factor for enhancing training performance (8). This may explain why Newton and McEvoy (35) found no effects of medicine ball training on baseball throwing speed in their previous research, as feedback was not objectively provided except for a vague perception of how far the ball had been thrown. This aspect of power training calls for further study.

In conclusion, ballistic resistance training was effective at enhancing baseball throwing and base running speed beyond that attained with traditional baseball training alone. This improvement most likely was due to velocity-specific improvements in strength, increases in rate of force development, and improved SSC performance. These changes in neuromuscular function resulted from specific adaptation to the explosive and ballistic nature of the training movements employed.

Such exercises were characterized by (a) a load that allowed the muscles to produce maximum power; (b) the resistance could be accelerated rapidly throughout the movement; and (c) release of the load in the throw, or takeoff in the jump squat, was achieved. The specificity of the training, the provision of feedback, and the fact that this training was novel for these subjects contributed to the positive and significant improvements in baseball throwing and base running velocity.

Practical Applications

Given these results, we suggest that ballistic resistance training is effective for increasing the baseball skills of throwing and running. The crucial characteristic of this type of training is that the movement must involve acceleration to the end of the concentric phase and the athlete must try to move the load as rapidly as possible throughout the range of motion. Although not determined in this study, it may also be important to achieve a high movement velocity. Ballistic resistance training may be best incorporated in a training program after a substantial strength base has been established.

An adequate strength level may reduce the risk of injury during explosive SSC movements (10, 11, 31), and furthermore, there seems to be a strong relationship between strength and power in that one cannot have a high degree of power without first being relatively strong (41, 47). Theoretically, ballistic resistance training will convert the gains in strength into speed (11) and could be included in the later power stages of a periodized strength training model (48).

As most coaches do not have access to a Plyometric Power System, ballistic resistance training can be implemented in the form of free-weight squat jumps, Smith machine squat jumps, and bench throws. Hydraulic and pneumatic machines may also be used for ballistic resistance training and may have less risk of injury. Many aspects of Olympic-style lifts are similar to the training used in this study, hence their effectiveness for increasing explosive power. In all cases extreme care must be taken, as this form of training can be highly stressful to the joints that absorb the load during the landing and catching phase of the lift. Possible ways to minimize the impact forces and increase safety are to use a shock-absorbing landing surface, wear good footwear for jumps, and use safety catches at the bottom end of the exercise in case of a fall or missed catch. Most resistance training machines are not designed for ballistic resistance training, thus special care must be taken when improvising.

Traditional resistance training equipment does not provide instantaneous feedback on height, velocity, or power output. This may be overcome by attaching a movable clip on the vertical guide rod of a Smith machine to give feedback on height jumped or thrown. Timing lights can also be used to measure the speed of movement of the load, and there are computer programs that provide auditory feedback. An alarm with a magnetic switch can be purchased at most electronics stores and mounted on a Smith machine to sound a beep or bell when the athlete jumps or throws to a certain height. The feedback used in this study may have contributed significantly to the effectiveness of the program.

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