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The Effects of Core Strengthening Training on Baseball Throwing

The purpose of this study was to investigate the effects of core strengthening training on baseball throwing. A total of 14 subjects were recruited from among middle school baseball players. The main outcome measures were as follows: speed guns were used to measure the velocity of baseballs thrown; scored targets were used to measure throwing accuracy; and 50m measuring tapes were used to measure throwing distances. It was found that core strengthening training improved the velocity of baseballs thrown and throwing accuracy and distance. Thus, core strengthening training is effective for improving the throwing ability of baseball players.

Key words: *Core Strength, Throwing, Velocity, Accuracy, Distance*

Han Ki Lee[a], Da Eun Jung[b], Jun Cheol Lee[c]

[a]Department of Physical Therapy, Masan university, Masan, Korea, [b]Department of Physical Therapy, Gimhae University, Gimhae, Korea, [c]Graduate School, Daegu university, Daegu, Korea

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Address for correspondence
Jun Cheol Lee, PT, MS.
201 DaeguDae-Ro, Jinryang-Eup, Gyeongsan-Si, Gyeongbuk-Do, Korea
Tel: 82-55-246-3131
E-mail: dunkindonas@naver.com

INTRODUCTION

Baseball is one of the most popular modern sports. It includes all sport motions that can be performed by humans, such as running, throwing, hitting, jumping, and catching. Among the many motions used in baseball games, throwing is the most frequently used, to the extent that it accounts for approximately 70% of the motions performed when games are played(1).

Throwing motions involve moving objects spatially using body segments, in particular, hand and arm segments, which can be classified into overarm throws, sidearm throws, and underarm throws and divided into throwing objects quickly, accurately, and far away(2,3). Many factors are involved in the improvement of throwing ability in baseball, such as the coordination of body segments during the process of throwing(4,5), the levels of contribution of body segments to ball speed(6,7), pitching motions for maximum ball speed(4)(8,9), and upper limb muscle strength (7)(10-12).

Previous studies regarding throwing have mainly involved kinematic and kinetic analyses of the upper limbs, consisting of the shoulders, the upper arms, the forearms, and the hands, as well as analyses of damage to the upper limbs(13-16). There have also been reports that suggested combining mental practice with physical practice to improve accuracy(17,18). In addition, Lee reported that using steps was more effective for distance throws, and throwing while stationary was more effective for accuracy(19).

To make a mechanical identification of motions in order to increase speed and present optimum models, recent studies have analyzed the movements of not only upper limb segments, but also the trunk and lower limbs. In a previous study, it was advised that training to increase power in the femoral muscle was effective for increasing the speed of baseball players' pitches(20). In addition, Cho et al. reported that increasing the flexibility and strength of the femoral muscles of the lower limbs and trunk muscles could help increase ball speed(14), and So reported that core stabilization

exercise programs improved ball speed(21). In a study by, Oh the author indicated data that would enable the use of variables for Tee-Ball throwing motions for ball throwing motion guidance and performance ability improvement using 3D image analysis equipment and ground reaction force equipment(22). In another study, Jin conducted kinematic and kinetic analyses of male and female middle school students' ball throwing motions and reported the results(23).

As mentioned above, most previous studies regarding the improvement of throwing ability have concentrated on the upper and lower limbs, while studies on trunk function and improving throwing ability have been insufficient. In a previous study, Cho reported that although strong shoulders were regarded as an important requirement for good pitchers, during pitching training, pelvic and truncal motions should be considered as important variables for increasing ball speed(14). In addition, Cho et al. reported that lumbar spinal flexor muscle strength and power and extensor muscle strength are important for speed improvement(9). In particular, Hodges and Richardson proved that trunk muscle activities occur before limb activities, regardless of the direction of the limb movements(24) . The trunk is the center and largest part of the body, and trunk muscle activities maintain balance and independent postures against gravity and prepare for limb movements.

Recently, training to strengthen the core, which is the center of the functional kinetic chain, has been emerging as a major matter of concern, not only for rehabilitation from musculoskeletal diseases, but also for improving exercise performance. The core refers to the lumbo-pelvic-hip complex, which is where the center of gravity of the body is located and all movements begin (25,26). Core strengthening training is essentially explained as controlling the muscles that are required to maintain functional stability around the lumbar vertebrae. If limb muscles are strong and the core is weak, the forces necessary to produce efficient movements cannot be generated sufficiently. A weak core is a basic problem that causes damage due to inefficient movements.

Previously, Aaron and Dominguez stated that core-strengthening training would improve dynamic posture control, ensure balance of the muscles around the lumbo-pelvic-hip complex and joint kinematics, and improve neuromuscular efficiency of the entire kinetic chain(27,28). In addition, previous researchers advised that core-strengthening training would provide a stable base of lower limb movements and would be effective in preventing lower limb damage(29-31).

As described above, despite its great effects, studies regarding the effects of core strengthening training on improving exercise performance ability are insufficient, and in particular, the effects of core strengthening training on improving throwing ability have not been verified. Therefore, the purpose of the present study was to verify the effects of core strengthening training on improving the throwing ability of middle school baseball players.

METHODS

Study subjects and period

The present study was conducted with 14 current baseball team members of M Middle School, located in Changwon-si, Gyeongnam, with no damage to the body or pain. Core-strengthening training was implemented for one hour per day, three days per week, for a total of six weeks, from October 17 to December 17, 2015.

Experimental tools and measuring method

1) Speed measurement

Each subject was instructed to throw a baseball three times, at maximum speed, to a Stalker Radar Speed Gun PRO(USA) located at a distance of 27.431m(distance between two bases) to measure pitch speed; the average value of the three pitches was calculated.

2) Accuracy measurement

To measure accuracy, each subject was instructed to throw a baseball, ten times, at a target 1.2m in diameter installed 30cm off the ground in a mesh net, located at a distance of 27.431m. The balls that hit the target were scored and the average value of the scores was used.

3) Distance measurement

KMC-1600/100m Phantom fiber tape measures were used to measure throw distances. Each subject threw a baseball three times as far as possible while in a standing position. The throw distances were measured and the average value of the three measurements was used.

4) Gymnastics ball

Gymnastics balls developed by TOGU Company (Germany) were used. The balls contain air and are helpful for core strengthening and improving sensory motor control ability.

Study procedure

In the present study, middle school baseball players underwent core strengthening training three times per week for six weeks, and pitch speeds, accuracy, and distances were measured before and after the training. The core strengthening training was divided into warm up, main exercises, and sensory motor training. The exercise program is presented in Table 1.

Table 1. Core-strengthening program

	Training program
Warm-up (5~10 min)	1. Abdominal hollowing: 10 reps 2. Cat-camel: 10 reps
Maintain the spine neutral during limb movements (15~20 min)	1. Quadruped opposite arm + leg reach: 10 reps 2. Dead bug unsupported: 10 reps
Maintain the spine neutral during trunk movements (15~20 min)	1. Curl-up: 10 reps 2. Bridging: 10 reps 3. Side bridging: 10 reps
Functional training (5~10 min)	1. Squat: 10 reps 2. Lunge: 10 reps
Sensory-motor training (5~10min)	1. Pelvis bridging on the ball: 10 reps 2. Superman prone exercise on the ball: 10 reps

RESULTS

General characteristics of the study subjects

A total of 14 subjects participated in the study. The subjects' mean age was 14.93±0.83 years, mean height was 164.43±8.37 cm, and mean weight was 59.64±14.79 kg. Thirteen of the subjects were right-handed and one was left-handed (Table 2).

Table 2. General characteristics of the subjects

	(N=14)
Age (yrs)	14.93±0.83
Height (cm)	164.43±8.37
Weight (kg)	59.64±14.79
Dominant arm (%) Left	1 (7.14)
Dominant arm (%) Right	13 (92.85)

Comparison of study subjects' pitch speeds before and after training

To compare changes in pitch speeds before and after the training, each subject was instructed to throw a baseball 27.431 m three times before and after the training, and the pitch speeds were measured using speed guns. The results are provided in Table 3.

Comparison of study subjects' pitching accuracy before and after training

To compare changes in accuracy before and after training, each subject was instructed to throw a baseball ten times at a 1.2m-diameter target installed 30 cm off the ground in a mesh net at a distance of 27.431 m. The balls that hit the target were scored. The results are provided in Table 4.

Comparison of study subjects' throw distances before and after training

To compare changes in throw distances before and after training, each subject threw a baseball three times while in a standing position, and the throw distances were measured using a 50m tape measure. The results are as follows (Table 5).

Table 3. Pre-test and post-test pitch speed comparison

	Group	pre-test	post-test	t	p
Speed	N=14	98.54±9.89	101.88±8.60	-2.457	0.029

Table 4. Pre-test and post-test accuracy comparison

	Group	pre-test	post-test	t	p
Accuracy	N=14	1.06±0.53	1.60±0.52	5.764	0.000

Table 5. Pre-test and post-test distance comparison

	Group	pre-test	post-test	t	p
Distance	N=14	53.04±8.96	55.21±8.24	2.457	0.04

There was a significant increase, from 1.06± 0.53km/h before the training to 1.60±0.52km/h after the training. There was a significant increase, from 53.04±8.96m before the training to 55.21±8.24m after the training.

DISCUSSION

In baseball games, the ability of pitchers to throw the ball accurately at high speeds and the ability of fielders to throw the ball far are important factors that determine the outcomes of the games. The throwing motions are not performed by the arm only, but are complicated motions that use all body segments, beginning from the lower limbs, and require the use of effective and selected accurate muscles. Because all muscles of the body should act in a complex manner, we cannot predicate that muscles in a certain region should be strong.

The lower limbs and the trunk should provide stable bases for upper limb movements, and most forces generated by the upper limbs are provided by the lower limbs and the trunk. Therefore, it can be said that trunk muscle strengthening is important as a means of improving throwing ability. Attention to core strengthening has been increasing recently, not only for damage prevention and treatment, but also for improving exercise performance ability.

The core can be explained as a region consisting of the abdominal muscles in the front, the paraspinal muscles and gluteal muscles in the rear, the diaphragm on the top, and the pelvic floor muscles on the bottom. For an efficient core, the functional and normal length-force relationships between the agonistic and antagonistic muscles and optimum joint movement roles should be maintained while the lumbo-pelvic-hip complex moves functionally. In addition, the core provides the support necessary to stabilize the trunk and vertebral column, and it is the basis or driving force of all limb movements(32).

Core-strengthening training should be planned to improve muscle strength, neuromuscular control, and the endurance of the lumbo-pelvic-hip complex. To ensure the integrity of the spine and provide stable bases for limb movements, the ability to adapt continuously to changing postures and load conditions should be improved. However, a weak core cannot produce efficient limb movements and leads to various types of musculoskeletal damage(33). Existing studies on throwing in baseball have focused on the upper and lower limbs(19). Therefore, in the present study, core-strengthening training was used to focus on the trunk, which directly affects the upper limbs.

In baseball games, the ability to throw the ball at high speed is required for pitchers. For high-speed ball throwing, many factors should be considered, such as mechanical aspects, coordination, flexibility, and muscle strength. In particular, because throwing motions are continuous motions of body segments made by linked systems, the timing of the actions of all related body segments should be well connected.

In a previous study, Pedegana et al. reported that according to the results of isokinetic muscle strength tests and the ball speeds of eight professional baseball players, elbow joint extensor muscle strength and wrist extensor muscle strength were more closely correlated with ball speed than the muscles around the shoulder joints(11).

In a study of pitchers among university baseball players, Kim and Park reported that training for femoral muscle strengthening for six weeks significantly increased pitch speeds(20). In the present

study as well, core strengthening training for six weeks significantly increased ball speed, from 98.54±9.89km/h to 101.88±8.60km/h.

In general, to increase ball speed, pelvic and truncal motions should be considered to be important elements in addition to strong shoulders. Larger rotation of the pelvis and the trunk is necessary to efficiently deliver the elastic energy generated when related muscles are restored after being stretched to the upper limbs, and the flexibility and strength of the trunk muscles can help increase speed(34,35). In addition, proper shifts in weight are necessary for efficient pitching motions, and they should be made powerfully and quickly(5). In this case, core stability helps smooth the achievement of lower limb balance, which affects upper limb movements as well.

In baseball games, the ability to throw the ball accurately in the desired direction can be said to be important not only for pitchers, but also for fielders. In previous studies,Bae studied factors that affect ball control in baseball(6) and Lee analyzed the physical fitness and anaerobic power of university baseball players and hobby club baseball players(36). In addition,So studied the effects of core stabilization exercises on baseball players' muscle strength and ball speed(21). In studies conducted with baseball players, Kim and Ahn reported that mental practice was effective for improving baseball throwing accuracy and motor learning(17,18). In the present study, baseball throwing accuracy was measured by having each subject throw the ball ten times at a target marked for scores up to five points, and calculating the average value. According to the results, core-strengthening training significantly improved the accuracy from 1.06±0.52 points to 1.60±0.46 points. Furthermore, Yoon reported that when agility and coordination programs were applied to sixth graders for eight weeks, the ability to throw balls far improved significantly(34) . In the present study, core strengthening training significantly improved the ability to throw balls far, from 53.04±8.96m to 55.20±8.24m.

Given these results, it can be seen that core-strengthening training was effective for baseball throwing and helpful for athletic performance improvement. However, the present study has a limitation in that it could not identify changes in muscle strength, endurance, and coordination, as well as kinematic and kinetic changes, but simply verified functional changes. Future studies are necessary in order to do so.

CONCLUSIONS

To examine the effects of core strengthening training on baseball throwing, the present study implemented core strengthening training with 14 current baseball team members of M Middle School, located in Changwon-si, Gyeongnam, with no damage to the body or pain, for six weeks, from October 17 to December 17, 2015.

Baseball pitch speed increased significantly, from 98.54±9.89km/h before training to 101.88±8.60km/h after training($p<0.05$). Baseball throwing accuracy increased significantly, from 1.06±0.52 points before training to 1.60±0.46 points after training($p<0.05$). Baseball throwing distance increased significantly, from 53.04±8.96m before training to 55.21±8.24m after training($p<0.05$).

Given the abovementioned results, core-strengthening training is considered effective for improving baseball players' throwing ability.

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