

Effects of 16-week functional movement screen training program on strength and flexibility of elite high school baseball players

Hong-Sun Song¹, Seung-Seok Woo², Wi-Young So³, Kwang-Jun Kim¹, Joohyung Lee⁴, Joo-Young Kim^{4,*}

¹Department of Sports Science & Engineering, Korea Institute of Sport Science, Seoul, Korea

²Department of Physical Education, Seoul National University, Seoul, Korea

³Department of Human Movement Science, Seoul Women's University, Seoul, Korea

⁴College of Physical Education, Kookmin University, Seoul, Korea

Functional Movement Screen (FMS) is a way to pretest functional movement. This study examined the effects of the FMS training program on the strength and flexibility of 62 elite male high school baseball players (31 in the training group, 31 in the control group). All players who received less than two points on each FMS test item had to join the 16-week, three times weekly FMS training program. To analyze results among the FMS participants, measures including intraclass correlation coefficient (ICC) and repeated measure ANOVA were utilized. The Kappa coefficient was 0.805 when the intraclass correlation coefficient of the three participants was inspected. Strength showed a significant interaction depending on time and group (hand grip strength: $P=0.011$,

bench press and squat both for one-repetition maximum (1RM): $P=0.001$ and $P=0.008$, respectively). Back muscle strength did not show a significant difference ($P=0.660$). Trunk forward flexion showed no interaction depending on time and groups ($P=0.983$) but trunk extension backward showed significant differences depending on groups ($P=0.004$) and time ($P=0.001$). Splits showed a significant difference depending on time and groups ($P=0.004$). The FMS training program improved the strength and flexibility of elite high school baseball players.

Keywords: Functional movement screen, Strength, Flexibility, Training program

INTRODUCTION

Athletic injury is a major factor in diminished performance and strength. To prevent such injuries, various training programs have been developed and applied them. However, prior to establishing a training program, a test method capable of evaluating functional movement is needed (Cook et al., 2006a, 2006b).

The functional movement screen (FMS) is a way to pretest functional movement. FMS consists of the seven test items: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability. The screen has a maximum of 21 points, with each item rated on a 3-point scale ranging from 0 (pain during the action) to 3 (action performed correctly) (Cook et al., 2006a, 2006b; Kiesel et al., 2007;

Minick et al., 2010).

Kiesel et al. (2007) indicated that athletes whose total FMS scores are < 14 points are more likely to get injured. Chorba et al. (2010) argued that a total score < 14 points confers greater risk of injury than a score ≥ 14 . Minick et al. (2010) opined that the FMS can help identify the risk of potential injury for an athlete. Training programs based on the FMS can improve the FMS score or lower the risk of injury (Kiesel et al., 2011; Peate et al., 2007). Thus, the FMS can be a good pretest to predict or prevent athletes' injuries.

Good functional movement can make complete range of motion and the efficiency of power possible, emphasizing the Optimum Performance Pyramid (Cook, 2003). Stability and mobility, which can be checked by the FMS, are the basis of, and are rele-

*Corresponding author: Joo-Young Kim

College of Physical Education, Kookmin University, 77 Jeongneung-ro, Seongbuk-gu, Seoul 136-702, Korea

Tel: +82-2-910-5254, Fax: +82-2-910-4789, E-mail: hirase1125@hanmail.net

Received: April 2, 2014 / Revised: April 11, 2014 / Accepted: April 16, 2014

This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

vant to, strength and flexibility (Cook et al., 2006a). This indicates that the FMS can contribute to improving strength and flexibility of athletes; however, this has not been directly studied. Rather, injury prediction or verification of reliability and validity has mainly been the subjects of study (Gulgin and Hoogenboom, 2014; Kiesel et al., 2007; Smith et al., 2013).

Accordingly, this study examined the effects of the FMS training program on the strength and flexibility of elite high school baseball players.

MATERIALS AND METHODS

Participants

The participants were 62 elite male high school baseball players (31 in the training group, 31 in the control group). All participants provide written informed consent. The features of the test

Table 1. Subject's physical characteristics

	Group	Mean±SD
Age (yr)	Training	17.0±1.06
	Control	16.62±0.94
Height (cm)	Training	177.40±5.09
	Control	176.76±6.41
Weight (kg)	Training	71.84±8.17
	Control	72.34±13.01

participants are as shown in Table 1.

Body composition

After the test participants changed into comfortable clothes, an Inbody 720 bioelectrical impedance analysis device (BioSpace, Seoul, Korea) was used to determine body composition. For a more accurate measurement, the participants were instructed to fast overnight and were banned from making excessive movements and taking a long bath or sauna before the measurement.

FMS

Seven test items were selected based on prior results (Cook et al., 2006a, 2006b). The seven test items of FMS are shown in Fig. 1. According to Minick et al. (2010), a high level of reliability can be secured if the FMS movements are scored by image analysis or direct observation with the naked eye. In this study, two cameras were installed in front of and next to an athlete to monitor all movements. Three testers independently reviewed the filmed images and scored the movements of the athletes in accordance with prior scoring criteria (Cook et al., 2006a, 2006b).

Measurement of strength and flexibility

Participants were instructed to perform the hand grip strength, back muscle strength, bench-press and squat both for one-repeti-



Fig. 1. Seven test items of the FMS. Shown from left to right are deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up and rotary stability.

tion maximum (1RM) to measure strength, and to perform trunk flexion, trunk extension and the splits to evaluate flexibility. Measurements were done in accordance with the Physical Fitness Test Manual of the Korea Institute of Sports Science (Kim et al., 2007).

FMS training programs

Scores ≤ 2 points were recorded for 27 participants for shoulder mobility, 23 for rotary stability, 16 for straight leg raise, 6 for deep squat, 13 for hurdle step, and 14 for in-line lung. No subjects scored ≤ 2 for trunk stability push-up. The FMS training program was developed based on these test results with reference to previous studies (Burkhart et al., 2003; Frederick and Frederick, 2006; Goldenberg and Twist, 2006; Kiesel et al., 2011; Peate et al., 2007) as well as the information available on the official website of the FMS (<http://www.functionalmovement.com>). The FMS training program consists of functional movements related with core stability and shoulder and hamstring flexibility improvement. As there was no one who scored < 2 points in trunk stability push-up, related training were not included. Those who scored < 2 points in certain test items were mandated to follow the training regimen customized to reinforce their shortcomings in these test items, while the form roller and core training were commonly applied to all test participants. The FMS training program was conducted three times per week for 16 weeks. The details of the FMS training program are shown in Table 2.

Statistics

SPSS ver. 18.0 was used to analyze the test results. The reliability test was performed to estimate the intraclass correlation coefficient (ICC) among the three testers, and repeated measure ANOVA was utilized to monitor changes in strength and flexibility due to the FMS training program. Statistical significance was set at 0.05.

RESULTS

Reliability

To boost the reliability of the FMS results about the FMS, inter-reliability testing among the three testers was done. The Kappa coefficient was 0.805, which indicates excellent reliability (Fleiss, 1986).

Changes in strength and flexibility

The changes in strength and flexibility after the 16-week FMS program are summarized in Table 3. Hand grip strength showed a

significant level of interaction between time and group ($P = 0.011$ and $P = 0.001$, respectively), while back muscle strength did not have a significant interaction between time and group ($P = 0.660$). Back muscle strength was not meaningfully different between groups ($P = 0.184$) but was between times ($P = 0.001$). Bench-press and squat both showed significant levels of interaction between time and group ($P = 0.001$ and $P = 0.008$, respectively). With respect to flexibility, trunk flexion did not show a significant level of interaction between time and group ($P = 0.983$), between groups ($P = 0.754$) and between times ($P = 0.754$). In contrast, although the trunk extension did not reveal a significant interaction between time and group ($P = 0.073$) meaningful differences were evident between groups ($P = 0.004$) and between times ($P = 0.001$). Splits showed a significant level of interaction between time and group ($P = 0.004$).

DISCUSSION

Although the FMS has been utilized as an important pretest to predict injuries, its relation with strength and flexibility is unclear. This study analyzed the impact of the FMS training program on the strength and flexibility among high school baseball players. The FMS training program significantly improved strength and flexibility.

Strength is a crucial physical element for athletes. Traditional training programs designed to boost strength have focused on increasing muscle volume rather than on functional movements. More recently, a training program based on functional movements was reported to be more effective in improving strength (Cook, 2003). Presently, the 16-week FMS training program improved hand grip strength and bench-press by 12% and 9%, respectively, compared with pre-test levels. Cook (2003) argued that only when armed with functional movements, an athlete is expected to show an improvement in motion performance capability and techniques, and that if an athlete lacks functional movement patterns, it can deteriorate the efficiency and effectiveness of exercising power. Goss et al. (2009) reported significant levels of improvement in performing the single leg hop, kick-ups and vertical jump after applying a 6-week training program developed based on functional movements. Therefore, the reinforcement of functional movements is considered to be an important factor in improving strength; the present FMS results confirm this view.

Strength can be further increased when training is based on muscle stability (Shinkle et al., 2012), and the most representative training to boost the stability of muscles is core training. Core

Table 2. FMS training program

FMS	Training	Protocol
Self myofascial release (using form roller)	Calf Hamstring Gluteal Quadriceps Adductor Tensor fascialatae Lower back Mid-back	3 set, 30 sec
Deep squat	Standing calf stretch Kneeling hip flexor stretch Upper back stretch Dorsiflexion stretch Quadriceps stretch Squat-with heel raise Mini band squat Wall squat Wall squat with shoulder press Overhead squat	3 set, 30 sec 3 set, 15 rep.
Hurdle step	Brettzel Seated trunk twist Pigeon stretch Piriformis stretch while supine Hip flexor stretch with reach Leg cradle Stride with torso rotation Stride with hip external rotation Single-leg standing hip flexion/extension Standing single-leg 3-phase exercise Standing reaches Single leg deadlift Standing calf raise	3 set, 30 sec 3 set, 20 rep. 3 set, 15 rep. 3 set, 20 rep.
In-line lunge	Hip crossover Rectus femoris stretch Pectineus, adductor brevis, adductor magnus, adductor longus stretches Tensor fasciae latae stretch The warrior lunge stretch, or hip flexor stretch Lateral monster walk	3 set, 30 sec 3 set, 10 rep.
Shoulder mobility	90-90 stretch Arm circles Sleeper stretch Side lying cross body adduction Prone internal rotation stretching with scapula bloked Corner stretch Pectoralis stretch Seated upper-back stretch	3 set, 30 sec
Active straight leg raise	Lying hamstring stretch Seated groin stretch Hamstring stretch in long sitting Sitting hamstring stretch Soleus stretch	3 set, 30 sec

(Continued to the next page)

Table 2. Continued

FMS	Training	Protocol
Rotary stability	Hard roll Russian twist-physio ball Plank on stability ball with alternating hip flexion Plank with hip flexion Quadruped stabilization with resisted hip extension Superman exercise Kneeling superman exercise	3 set, 20 rep.
Core	Curl up Side bridges Bridge with leg lift Static plank with leg raise Bicycle crunch Long lever crunch	3 set, 30 sec
	Side plank with unilateral row Crunch on stability ball Stability ball pitcher squat	3 set, 20 rep.

Table 3. Changes in muscle strength and flexibility after applying the FMS training program

Mean ± SD

Factor	Group	Pre	Post	P
Strength (Hand Grip Strength) Unit: kg	Training	50.12 ± 6.60	56.16 ± 7.91	Time .001**
	Control	51.62 ± 7.25	54.72 ± 8.31	Group .984 Time x Group .011*
Strength (Back Muscle Strength) Unit: kg	Training	132.07 ± 18.00	144.93 ± 20.67	Time .001**
	Control	126.52 ± 19.24	137.74 ± 20.50	Group .184 Time x Group .660
Strength (Bench-press 1RM) Unit: kg	Training	66.35 ± 11.80	76.27 ± 11.92	Time .006*
	Control	67.55 ± 12.49	66.45 ± 18.01	Group .207 Time x Group .001**
Strength (Squat 1RM) Unit: kg	Training	171.04 ± 24.95	161.08 ± 35.06	Time .792
	Control	117.58 ± 27.87	129.68 ± 26.82	Group .001** Time x Group .008*
Flexibility (Trunk Flexion forward) Unit: kg	Training	16.78 ± 6.66	16.68 ± 5.47	Time .754
	Control	14.68 ± 6.97	14.51 ± 7.22	Group .187 Time x Group .938
Flexibility (Trunk Extension backward) Unit: kg	Training	56.79 ± 8.25	62.30 ± 7.12	Time .001**
	Control	53.28 ± 7.87	55.52 ± 7.14	Group .004* Time x Group .073
Flexibility (The splits) Unit: kg	Training	121.21 ± 13.62	133.86 ± 10.90	Time .001**
	Control	118.55 ± 9.93	123.81 ± 8.67	Group .015* Time x Group .004*

* $P < 0.05$. ** $P < 0.001$.

training actually contributes to enhanced strength in athletes (Segal et al., 2004; Sekendiz et al., 2010). Core stability enables stabilization of the body during movement, which is a crucial prerequisite to muscle development. Otherwise, a compensation effect will occur, which can increase body imbalance in the long-term. Ultimately, the imbalance of strength has a negative impact on athletic performance and increases the possibility of injuries (Askling et al., 2003). Core stability can be measured through functional movements (Leetun et al., 2004; Liemohn et al., 2005).

Presently, the functional movements of the baseball players were evaluated after performing the FMS training program developed based on the study (Cook et al., 2006a, 2006b). In general, participants lacked core stability. However, a 7-week training program developed in consideration of the FMS scores of American football players and which included core training reportedly improved FMS scores (Kiesel et al., 2011). Based on this fact, it is thought that the reinforcement of core stability can contribute to enhanced body balance and improved overall strength. However,

in relation to strength, the training group actually displayed a significant decrease in the squat test compared with the control group. One of the possible (and unconfirmed) reasons for this result may be because physical strength deteriorated as they had to perform the training program and still play regular season games.

With regard to flexibility, all factors except for body flexion showed significant improvements after the 16-week FMS training program. The training program included many static stretching, which are effective in enhancing the mobility of joints. In particular, static stretching of the shoulder joints including the 90-90 stretch and sleeper stretch are effective in improving flexibility (Laudner et al., 2008). Also the self-myofascial release after using a foam roller seemed to have a positive influence and, indeed, has gained wide acceptance by athletes as it can reduce adhesion of fascia and muscle spasm (Okamoto et al., 2013) and is usually included in a FMS training program (Cook et al., 2010). An athlete suffers from repeated micro-traumas during games or drills, and an inflammatory response can form scar tissues over time, which can in turn deteriorate flexibility (Cantu and Grodin, 2001). It is presumed that the self-myofascial release using the foam roller, which is part of the FMS training program, helps reduce scar tissue and so helps enhance flexibility (MacDonald et al., 2013).

The collective data indicate that the FMS training program positively contributed to altered strength and flexibility. In addition to the benefit of predicting injuries athletes reported by the previous FMS studies, this study indicates that the FMS training program may improve physical strength if the FMS results are utilized as basic data in formulating a training program. Strength and flexibility have long been considered to be essential in improving athletic performance and sports techniques, and especially flexibility is closely related to injuries (Bradley et al., 2007). In this regard, although a training program designed to improve strength and flexibility is extremely important, it can increase the risks of more severe injuries or overtraining, if it ignores the weakened functional movements or previous scar tissues. In the future, after functional movements are correctly evaluated, a training program must be developed based on the results. When developing a training program designed to boost strength and flexibility of athletes at a field site, their shortcomings in terms of functional movements need to be identified through the FMS, and if it includes appropriate training in consideration of these results, it can contribute to enhanced athletic performance.

Future studies should evaluate how much an improvement in strength and flexibility can actually contribute to reducing or preventing injuries and to enhancing athletic performance of a player

during the season.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ACKNOWLEDGMENTS

This work was supported by the sports promotion fund from Korea Institute of Sport Science, Korea Sports Promotion Foundation (KISS-2012-15).

REFERENCES

- Askling C, Karlsson J, Thorstensson A. Hamstring injury occurrence in elite soccer players after preseason strength training with eccentric overload. *Scand J Med Sci Sports* 2003;13:244-250.
- Bradley PS, Portas MD. The relationship between preseason range of motion and muscle strain injury in elite soccer players. *J Strength Cond Res* 2007;21:1155-1159.
- Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology Part I: pathoanatomy and biomechanics. *Arthroscopy* 2003;19:404-420.
- Cantu RI, Grodin AJ. Myofascial manipulation therapy and clinical application. Aspen Publishers, 2001.
- Chorba RS, Chorba DJ, Bouillon LE, Overmyer CA, Landis JA. Use of a functional movement screening tool to determine injury risk in female collegiate athletes. *N Am J Sports Phys Ther* 2010;5:47-54.
- Cook G. Athletic Body in balance. Human Kinetics, 2003.
- Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function - part 1. *N Am J Sports Phys Ther* 2006a;1:62-72.
- Cook G, Burton L, Hoogenboom B. Pre-participation screening: the use of fundamental movements as an assessment of function - part 2. *N Am J Sports Phys Ther* 2006b;1:132-139.
- Cook G, Burton L, Kiesel K, Rose G, Bryant MF. Movement: Functional movement systems: Screening, assessment, corrective strategies. On Target Publications, 2010.
- Fleiss JL. The Design and Analysis of Clinical Experiments. John Wiley & Sons, Inc; 1986.
- Frederick A, Frederick C. Stretch to Win. Human Kinetics, 2006.
- Goldenberg L, Twist P. Strength Ball Training-2nd Edition. Human Kinetics, 2006.
- Goss DL, Christopher GE, Faulk RT, Moore J. Functional training pro-

- gram bridges rehabilitation and return to duty. *J Spec Oper Med* 2009; 9:29-48.
- Gulgin H, Hoogenboom B. The functional movement screening (FMS)TM: an inter-rater reliability study between raters of varied experience. *Int J Sports PhysTher* 2014;9:14-20. <http://www.functionalmovement.com>
- Kiesel K, Plisky PJ, Voight ML. Can serious injury in professional football be predicted by a preseason functionalmovementscreen? *N Am J Sports PhysTher* 2007;2:147-158.
- Kiesel K, Plisky P, Butler R. Functional movement test scores improve following a standardized off-season intervention program in professional football players. *Scand J Med Sci Sports* 2011;21:287-292.
- Kim YS, Ko BG, Kim KJ, Kim JH, Sung BJ, Youn SW, Eom HJ. Physical assessment manual. Korea Sport Science Institute, 2007.
- Laudner KG, Sipes RC, Wilson JT. The acute effects of sleeper stretches on shoulder range of motion. *J Athl Train* 2008;43:359-363.
- Leetun DT, Ireland ML, Willson JD., Ballantyne BT, Davis IM. Core stability measures as risk factors for lower extremity injury in athletes. *Med Sci Sports Exerc* 2004;36:926-934.
- Liemohn WP, Baumgartner TA, Gagnon LH. Measuring core stability. *J Strength Cond Res* 2005;19:583-586.
- MacDonald GZ, Penney MD, Mullaley ME, Cuconato AL, Drake CD, Behm DG, Button DC. An acute bout of self-myofascial release increases range of motion without a subsequent decrease in muscle activation or force. *J Strength Cond Res* 2013;27:812-821.
- Minick KI, Kiesel KB, Burton L, Taylor A, Plisky P, Butler RJ. Interrater reliability of the functional movement screen. *J Strength Cond Res* 2010;24:479-486.
- Okamoto T, Masuhara M, Ikuta, K. Acute effects of self-myofascialrelease using a foam roller on arterial function. *J Strength Cond Res* 2013;28: 69-73.
- Peate WF, Bates G, Lunda K, Francis S, Bellamy K. Core strength: a new model for injury prediction and prevention. *J Occup Med Toxicol* 2007; 2:3.
- Segal NA., Hein J, Basford JR. The effects of pilates training on flexibility and body composition: an observational study. *Arch Phys Med Rehabil* 2004;85:1977-1981.
- Sekendiz B, Cuğ M, Korkusuz F. Effects of Swiss-ball core strength training on strength, endurance, flexibility, and balance in sedentary women. *J Strength Cond Res* 2010;24:3032-3040.
- Shinkle J, Nesser TW, Demchak TJ, McMannus DM. Effect of core strength on the measure of power in the extremities. *J Strength Cond Res* 2012;26:373-380.
- Smith CA, Chimera NJ, Wright NJ, Warren M. Interrater and intrarater reliability of the functional movement screen. *J Strength Cond Res* 2013; 27:982-987.