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The Effect of Complex Training of Middle School Soccer Players on Body Composition, Basic Physical Strength and Movement Function*

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Abstract

This study conducted 8 weeks of foam roller & mobility, core, and weight training for 9 middle school soccer players 5 times a week for 90 minutes to determine the effect on changes in body composition, thigh circumference, basic physical strength, and functional movement. To analyze the data according to the results of this study, SPSS 25.0 statistical program was used for analysis, and the mean (M) and standard deviation (SD) were calculated to present the descriptive statistics of all dependent variables. In addition, to analyze the difference between before and after exercise, it was verified using a paired t test. The statistical significance level (α) in all reasoning statistics was set to less than 5%. As a result, there were no significant changes in body composition and thigh circumference through 8 weeks of training. However, there were significant changes in agility and muscular endurance, and the total score for functional movement changes was significantly increased, and statistically significant changes were observed in three variables. Therefore, complex training is effective in changing the physical strength and functional movement of middle school soccer players, and further research will be required for a control group and various complex exercises.

Keywords: Foam roller and mobility, Core training, Weight training, Soccer players

Major classifications: Exercise physiology

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1. Introduction

Soccer is an athletic sport that requires performance ability to demonstrate rapid situational judgment and movement during the game due to tactical changes and accelerating game progress. In addition, the head, feet, and body are used to handle the ball, and various physical factors act during continuous movement (Tak, 2014). Physical factors including anaerobic and anaerobic abilities such as agility, balance, and flexibility are required (Kim & Shin, 1992).

During adolescence, physical strength, physique, and motor skills develop at a rapid rate, and the level of athletic ability formed during this period becomes the basis for an athlete's life in adulthood (Kim & Oh, 2010). A systematic and scientific training program has the effect of improving individual physical ability along with team performance for adolescent sports players and preventing injuries that may occur during the game (Yoon & Choi, 2013). This is because adolescence is a period when not only the speed of physical growth is very fast, but also the motor learning ability to convert the motor skills acquired during training or competition into one's own physical ability (Kang & Jang, 2014). As such, well-formed physical abilities in adolescence are very important because they can affect them into adulthood.

On the other hand, the Functional Movement Screen (FMS) is receiving attention as a tool to evaluate an athlete's motor function and predict an injury (Garrison, Westrick, Johnson, & Benenson, 2015; Kiesel, Butler, & Plisky, 2014). The test consists of 7 movements, each of which checks the movement of various joints, symmetry and balance, and stability of the core. discriminated (Cook, 2010). It is reported that a higher functional movement evaluation score is associated with better performance (Lee & Kim, 2019), and a functional movement test was conducted on American professional football players, and serious injuries were reported to players with a total score of 14 or less. It was found to occur more frequently (Kiesel, Plisky, & Voight, 2007). As such, various training methods are required to improve exercise performance and reduce injuries along with accurate evaluation of functional movements.

Weight training has been used as an effective training method for elite soccer players to improve performance, and it has brought positive changes in muscle strength, muscle function, and agility, and improved anaerobic power along with reduction of muscle fatigue (Son, Chung, Kim, Lim, & Kim, 2003; Lee, Lee, & Lee, 2013; Lee, 2018). At the same time, along with stretching, self-myofascial release using a foam roller relaxes tense muscles, stretches the whole body and improves the range of motion (ROM) of joints (Song, 2017), and helps with blood circulation to help recover from fatigue. In particular, it improves the range of motion of the hamstrings and pelvis and helps to recover muscle pain (Healey, Hatfield, Blanpied, Dorfman, & Riebe, 2014), and a foam roller is used as a substitute for massage after physical activity (Macdonald, 2014).

Along with the weight training and fascia relaxation technique discussed earlier, core stability exercise is one of the most widely applied training programs in the field. Core muscles are composed of trunk and abdominal muscles that maintain spine stabilization, and core stabilization exercise is known as a very effective exercise method for strengthening muscle strength, flexibility, and improving balance ability (França, Burke, Caffaro, Ramos, & Marques, 2012; Kumar, 2011). It was reported that 9 weeks of core training for soccer players improved muscle strength, sprint, and kick performance (Prieske, Muehlbauer, Borde, Gube, Bruhn, Behm, & Granacher, 2015), and 12 weeks of core training for youth soccer players improved static and dynamic balance control ability (Imai, Kaneoka, Okubo, & Shiraki, 2014). It was reported that a training program including core stability for high school baseball players significantly improved the total score of the functional movement test and decreased the number of players who scored 14 points or less, the criterion for the likelihood of injury (Song, Kim, Park, Woo, Kim, So, & Kim, 2015).

As described above, there are many studies that have verified the effects of weight training, core training, and foam roller & mobility exercise, but studies conducted in parallel are insufficient. Therefore, this study aims to confirm the effect on the body composition, physical strength, and movement function of middle school soccer players through 8 weeks of foam roller & mobility, core, and weight training, and to suggest an effective exercise program for elite youth players.

2. Method

2.1. Subjects

This study was conducted with 9 students in the third grade of middle school in S city. The subjects of the experiment were players who had no current injuries or medical problems and had been registered as a player with the Korea Football Association for more than 3 years. After explaining the purpose of this study and the contents of the experiment to the study subjects, the participants were those who voluntarily wanted to participate and those who submitted the consent form to participate in the study. The physical characteristics of the study subjects are shown in <Table 1>.

Table 1: physical characteristics of subjects

Variable	Total (n=9)
Age(yrs)	15.67±0.35
Height(cm)	172.86±6.19
Weight(kg)	66.23±3.97
Skeletal muscle mass(kg)	31.56±2.29
Percent body fat(%)	15.4±3.60

M±SD

2.2. Research procedures

This study was conducted at B Training Center located in S city for 90 minutes per session 5 times a week for 8 weeks. Pre and Post-test were conducted to evaluate body composition and motor function before training.

2.3 Metrics and Methods

2.3.1 Body Composition Variable

All subjects maintained a fasting state for more than 12 hours and their height (cm) was measured using an extensometer. Bioelectric Impedance Analysis (BIS) was used to measure body weight (kg), skeletal muscle mass (kg), and body fat percentage (%). Measurements were made twice in total, before and after the start of training.

2.3.2 Circumference of the thigh

The circumference of the thigh was measured by measuring the circumference at the center of the thigh. The subjects were measured in an upright position with both feet spread about 10 cm and measured to be perpendicular to the long femoral axis finding the midpoint of the proximal border patella in the inguinal crease on the right femur. A total of two measurements were taken before and after the start of training and were recorded in cm.

2.3.3 Basal physical strength

Basal physical strength was measured in terms of reflex, agility, and muscular endurance, and was measured twice in total before and after training. First, the reflex was measured by standing long jump. The subject stands behind the line so as not to exceed the zero point, stands with both feet parallel, and jumps as far as possible with both feet after sufficient preliminary motion using the bounce of arms, knees, and back. It was conducted twice in total, and the better record was adopted and measured in cm.

And evaluation of agility performed a side step. The measurement method is to stand with both feet on the center line without stepping on the center line, and with a signal, one foot alternately crosses the line at intervals of 120 cm left and right with respect to the center and returns to the center line for 20 seconds. The total number of times was recorded.

For evaluation of muscular endurance, a push-up test was performed. For a push-up, the subjects bring their feet together and place their arms slightly wider than shoulder width so that when a subject bend his/her arms, head, shoulders, back, waist, and feet are in a straight line so that when the subject bend their arms, the angle of your elbows is 90°. When the subject return to the ready position, 1 circuit is counted. It was performed once every 2 seconds using a metronome, and if the posture was disturbed or the exercise could not be performed with the correct posture, or if the exercise could not be performed according to the signal, it was treated as a disqualification.

2.3.4 Functional Movement Screen

Functional movement test (FMS) was conducted with reference to the study of Cook (2010), and a dedicated kit (Functional Movement Screen Test kit, Functional Movement System, Inc., USA) was used. The test consists of a total of 7 items, and each item is Deep squat (DS), Hurdle step (HS), In-line lunge (IL), Shoulder mobility (SM), Active straight leg raise (ASLR), Trunk It consists of stability push-up (PU) and rotary stability (RS). Based on the criteria for each test item, a score from 0 to 3 is given, and the total score is 21 points. The movements of the research subjects are recorded by video, and three researchers who have completed the FMS training course and have qualifications analyze the images and give scores according to the standards. The test was performed twice in total before the start of training and after the end of the training. The motion function test items and scores are shown in <Table 2>.

Table 2: Functional movement screen items and score

Items	Total (n=9)
1. Deep squat(DS)	1. Perfect movement/ 3point 2. Normal movement/ 2point 3. Don‘t movement/ 1point 4. Pain/ 0point
2. Hurdle step(HS)	
3. In-line lunge(IL)	
4. Shoulder mobility(SM)	
5. Active straight leg raise(ASLR)	
6. Trunk stability push-up(PU)	
7. Rotary stability(RS)	

2.4. Training Program

The training program to be conducted in this study was carried out for 90 minutes per session 5 times a week for 8 weeks, and the details are: warm-up exercise foam roller & mobility exercise 15 minutes, core training 20 minutes, weight training 45 minutes, cool-down exercise foam roller & mobility exercise 10 made up of minutes. Core and weight training were conducted with increasing intensity every 2 weeks, and using the Rating of Perceived Exertion (RPE), training 1~2 weeks RPE 11~12, 3-4 weeks RPE 13~14, 5~6 Weeks RPE 15-16, 7-8 weeks RPE 17-18. Specific details are presented below.

2.4.1 Foam roller and mobility exercise program

Foam roller and mobility exercise were constructed through a meeting between researchers referring to the foam roller protocol proposed by Prieske, Muehlbauer, Borde, Gube, Bruhn, Behm, and Granacher (2015). The foam roller consisted of 10 types and the mobility exercise consisted of 9 types, and 15 minutes of warm-up and 10 minutes of cool-down were each performed. The warm-up exercise was performed for 45 seconds for each item, and the cool-down exercise was performed for 30 seconds for each item. The foam roller & mobility exercise program is shown in <Table 3>.

Table 3: Foam roller and mobility exercise program

Exercise	Content	time
Foam roller	calf/shin	Warm-up: 45 seconds for each area / Cool-down: 30 seconds for each area
	quadriceps	
	IT-band	
	adductor	
	hamstring	
	hip	
	low/upper back	
	latissimus dorsi	
	pectoralis	
	neck	

Mobility exercise	ankle circle	
	figure4	
	figure4 lunge	
	bent leg straight	
	mixer	
	forg	
	opener	
	world greatest stretch	
	brettzel	

2.4.2 Core training program

The core training applied in this study was set up through a meeting between researchers referring to the protocol of previous studies (Huxel & Anderson, 2013). The core training runs for 20 minutes and consists of a total of three movements, plank, side plank, and bridge, and the program and intensity were changed every two weeks. The intensity of the exercise was applied from both feet to one leg, and the tool was applied in the order of bare body, a gym ball, and Total Body Resistance Exercise (TRX), and the difficulty and intensity were gradually increased. The core training program is shown in <Table 4>.

Table 4: Core training program

Week	Exercise	Protocol	Intensity
1,2	Front Plank	30sec/5set	RPE 11~12
	Bridge	20sec/5set	
	Side plank	Left and right 20sec/5set	
3,4	Front Plank	Gymball, 20sec/5set	RPE 13~14
	Bridge	Gymball, 20sec/5set, 10set/3set(one leg)	
	Side plank	Gymball, left and right 10sec/5set	
5,6	Front Plank	Gymball, 20sec/3set, 10sec/3set(one leg)	RPE 15~16
	Bridge	Gymball, 20sec/3set, 10sec/3set(one leg)	
	Side plank	Gymball, left and right 15sec/5set	
7,8	Front Plank	TRX, 40sec/3set, 20sec/3set(one leg)	RPE 17~18
	Bridge	TRX, 20sec/3set, 10sec/3set	
	Side plank	TRX 30sec/3set	

2.4.3 Weight training program

The weight training program was established through a meeting between researchers by referring to the protocol of Kim, Lee, and Lee (2013). For weight training, it is desirable to measure 1RM and set the exercise intensity. However, since most of the subjects of this study are middle school students who are growing up, especially athletes who learn weight training for the first time, it is difficult to measure 1RM due to concerns about injury. The training was carried out using Weight training was performed 4 times a week (Mon, Tue, Thu, Fri), 4 sets for 45 minutes each. On Monday and Thursday, lower body push and upper body pull training were performed, and on Tuesday and Friday, lower body pull and upper body push training were performed. On Wednesday, the subjects didn't do weight training for recovery. The training was conducted with the aim of improving muscular endurance, muscle strength, and muscle power by applying the principle of gradual overload. The intensity setting was started at subjective exercise intensity (RPE) 11-12 and increased to 17-18 by adjusting the weight and repetitions every 2 weeks, and in weeks 1-2, 4 sets of 15 repetitions at RPE 11-12, 3 Weeks ~4 performed 4 sets of 12 reps with RPE intensity of 13-14, weeks 5-6 performed 4 sets of 10 reps with RPE intensity of 15-16, and weeks 7-8 performed 4 sets of 8 reps with RPE intensity of 17-18. The weight training program is shown in <Table 5>.

Table 5: Weight training program

Part		Exercise	Protocol / Intensity			
			1~2w	3~4w	5~6w	7~8w
Lower body	push	squat	4set/ 15reps RPE 11~12	4set/ 12reps RPE 13~14	4set/ 10reps RPE 15~16	4set/ 8reps RPE 17~18
		lunge				
		calf raise				
	pull	dead lift				
		single leg dead lift				
		kettlebell swing				
Upper body	push	B bench press				
		cable chest press				
		shoulder press				
	pull	lat pull down				
		cable row				
		D one arm row				

2.5. Data analysis method

The data obtained in this study were analyzed using the SPSS 25.0 statistical program, and the mean (M) and standard deviation (SD) were calculated to present the descriptive statistics of all dependent variables. To examine the effectiveness of 8 weeks of complex training for youth soccer players, the paired t test was used to analyze the difference between before and after exercise. The statistical significance level (α) in all reasoning statistics was set to less than 5%.

3. Results

3.1 Changes of body composition

The change in height increased from 172.86±6.20 cm before training to 173.41±6.04 cm at the end of training, and increased statistically significantly. The change of body weight showed a tendency to increase from 66.23±3.97kg before training to 66.80±3.76kg after training, respectively, but there was no significant difference. Also, skeletal muscle mass increased statistically and body fat decreased. Specific details are as presented in <table 6>.

Table 6: Changes of body composition during 8 weeks of exercise training

Variables	Pre-test M±SD	Post-test M±SD	t-value	p
Height (cm)	172.86±6.20	173.41±6.04	-3.436	.009**
Weight (kg)	66.23±3.97	66.80±3.76	-1.196	.196
Skeletal Muscle (kg)	31.58±2.29	32.87±2.31	-7.392	.000***
Body fat (%)	15.40±3.60	13.22±3.27	3.884	.005**

* Significantly different between pre- and post-test, **p<.01, ***p<.001.

3.2 Changes of thigh girth

The change in the circumference of the left thigh showed a tendency to change from 53.47±1.73 cm before training to 53.66±1.38 cm for training, and there was no significant difference. The change in the circumference of the right thigh showed a tendency to change from 53.80±1.92 cm before training to 54.07±1.58 cm after training, and there was no significant difference.

Table 7: Changes of thigh girth during 8 weeks of exercise training

Variables	**Pre-test(a) M±SD**	**Post-test(c) M±SD**	**t-value**	**p**
LTG (cm)	53.47±1.73	53.66±1.38	-.804	.445
RTG (cm)	53.80±1.92	54.07±1.58	-.936	.376

3.3 Changes of basic physical fitness

Agility change after compound training improved from 44.89±2.85 before training to 47.89±2.98 after training, and a significant difference (p=0.001) was found.

Changes in reflex improved from 227.00±8.76 cm before training to 230.11±9.29 after training, but there was no significant difference. The muscle endurance results improved from 26.44±6.69 before training to 37.44±11.06 after training, with a significant difference (p=0.002).

Table 8: Changes of basic physical fitness during 8 weeks of exercise training

Variables	**Pre M±SD**	**Post M±SD**	**t-value**	**p**
Agility	44.89±2.85+	47.89±2.98	-4.992	0.001**
Reflex	227.00±8.76	230.11±9.29	-1.269	0.240
Endurance	26.44±6.69	37.44±11.06	-4.702	0.002**

**p<.01 significant difference between times

3.4 Changes of movement function screen

Changes in movement function before and after compound training are as follows. Deep squat (DS) change improved from 1.89±0.78 before training to 2.22±0.44 after training, and there was no significant difference. The hurdle step (HS) result improved from 2.00±0.00 before training to 2.56±0.53 after training, and a significant difference (p=0.013) was found.

The change in in-line lunge (IL) improved from 2.00±0.00 before training to 2.89±0.33 after training, with a significant difference (p=0.000). The change in shoulder mobility (SM) results improved from 2.67±0.50 before training to 2.78±0.44 after training, and there was no significant difference.

Active straight leg raise (ASLR) result change improved from 1.33±0.50 before training to 2.11±0.33 after training, with a significant difference (p=0.001). The change in trunk stability push up (PU) results improved from 2.44±0.73 before training to 2.67±0.50 after training, and there was no significant difference.

Rotary stability (RS) result change improved from 1.89±0.33 before training to 2.11±0.33 after training, and there was no significant difference. Total score result change improved from 14.22±1.64 before training to 17.33±1.41 after training, and a significant difference (p=0.001) was found.

Table 9: Changes of functional movement screen during 8 weeks of exercise training

Variables	Pre M±SD	Post M±SD	t	sig.
DS	1.89±0.78	2.22±0.44	-1.414	0.195
HS	2.00±0.00	2.56±0.53	-3.162	0.013*
IL	2.00±0.00	2.89±0.33	-8.000	0.000***
SM	2.67±0.50	2.78±0.44	-1.000	0.347
ASLR	1.33±0.50+	2.11±0.33	-5.292	0.001**
PU	2.44±0.73	2.67±0.50	-1.512	0.169
RS	1.89±0.33	2.11±0.33	-3.758	0.087
Total	14.22±1.64	17.33±1.41	-5.518	0.001**

* Significantly different between pre- and post-test, *p<.05, ***p<.001.

5. Discussion

This study was conducted to investigate the differences in changes in body composition, thigh circumference, basic physical strength, and functional movement after 8 weeks of foam roller & mobility, core, and weight training for male middle school soccer players. Based on the results of observing any differences and changes before and after training, discussion was made as follows.

The age of the subjects in this study was 15.67±0.35 years, which can be said to be the most active period of physical change. It is known that the increase in height and weight and the decrease in body fat are most evident in the adolescent period between the ages of 14 to 16 (Lee & Lee, 1999). As a result of 8 weeks of complex training, height, weight, and skeletal muscle mass increased, and body fat percentage decreased in comparison before and after training. Weight, body fat, and muscle mass were significantly improved by 12 weeks of training for middle school soccer players (Sung, 2018), showing similar results.

For athletes, a well-developed lower body is associated with greater muscle mass, superior strength, and power. Therefore, the circumference of the thigh can also be a part of indirectly evaluating the strength of the lower body for well-developed athletes. In contrast to athletes, the general public who lacks regular exercise tends to have a decrease in thigh circumference due to a decrease in body fat percentage through training. According to a study by Kim (2001), 8 weeks of anaerobic exercise for married women resulted in a decrease in thigh circumference. This study looked at the change in thigh circumference as a result of 8 weeks of complex training for middle school soccer players. There was a slight increase in thigh circumference before and after training, but no significant change was observed. It is thought that there was an increase in the amount of skeletal muscle after training in the skeleton, muscle, and fat constituting the thigh, while a decrease in the percentage of body fat also appeared, indicating that there was no significant increase in the circumference of the thigh. This is inconsistent with the results (Wang, Qian, & Cho, 2019) that the Winggate anaerobic training for one year of female basketball players significantly increased the thigh circumference. This is thought to be because the time for sufficient muscle development was insufficient because this study compared the results of training for 8 weeks.

In the future study on changes in thigh circumference, training for a sufficient period of time for muscle development is required. It is considered necessary to check the relationship between the thigh circumference and lower extremity muscle strength by performing isokinetic muscle strength test of the thigh.

Soccer requires aerobic ability to run without getting tired during game time, anaerobic power such as momentary sprinting, and reflex, and must have abilities such as flexibility, agility, and balance (Park et al., 2014). Agility and reflex are important factors related to running, such as change of direction and lateral movement, jumping, acceleration, and deceleration, which affect the strength of individuals and teams (Vaczi, Tollar, Meszler, Juhasz, & Karsai, 2013). The improvement of these physical elements was faster and more individual, especially in adolescence, so individual and scientific training was required (Ekblom, 1986).

Foam roller & mobility, core, and weight training conducted in this study are exercise methods that are frequently performed to improve the physical strength of athletes in the sports field. Foam roller & mobility exercise relaxes tense muscles and improves flexibility and joint range of motion (ROM) (Song, 2017). Improvement of trunk stability through core training can improve the ability to generate force or transfer the generated force in the upper and lower body during body movement, and improve the ability to control body movement and posture (Silfies, Ebaugh, Pontillo, & Butowicz, 2015). Weight training, in the form of resistance exercise, positively changed muscle strength, muscle function, and reflexes, improved anaerobic power, and reduced muscle fatigue (Choi, 2015). As a result of this training, the results improved in all items of agility, reflexes, and muscular endurance, and as a significant change, agility and muscular endurance were significantly improved. 8 weeks of core stability training significantly improved the speed and agility of soccer players (Kim, So, & Kim, 2016), and It shows the same results that 8 weeks of weight training and plyometric training significantly improved agility (Choi & Yoon, 2013) as the study.

It is considered that the improvement of ROM through foam roller & mobility exercise and of hip, pelvic and trunk strength through core stability training can improve connection between upper and lower bodies. Also, training that improves upper and lower bodies strength can bring better performance to athletes.

Among the FMS items, the deep squat, hurdle step, and in-line lunge items improved results, it is thought that activation of core function and improvement of coordination through foam roller & mobility exercise performed before and after exercise and core training were the main effects. Active straight leg- raise and shoulder mobility, which evaluate flexibility, are considered to have improved scores by improving flexibility by foam roller & mobility exercise before/after exercise. For the trunk stability push up item, it is thought that the improvement of body-centered stability through core training and the improvement of upper body strength through weight training affected the results.

In this study, the improvement of FMS results shows same results as many previous researches. However, the significant difference was not shown from plyometric training effect. It is considered to reduce athlete’s injury by providing corrective exercise program for the low FMS scores. Also, periodic FMS examination and individual corrective exercise program can provide precaution to injuries and improved performance.

Through this study, composite training showed statistically significant changes in the agility, muscular endurance, and functional movement changes of middle school soccer players, and based on this, it can be used as basic data for composite training.

6. Conclusion

The conclusions obtained through this study are as follows. For middle school soccer players, complex training shows positive results in body composition and can bring significant changes in physical fitness factors. However, there was no significant difference in the physical change. In particular, although it has a positive effect on the movement function, it is thought that additional research should be conducted in the future to find the appropriate training intensity through a detailed study design according to the growth period.

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Functional movement test scores improve following a standardized off-season intervention program in professional football players

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