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Corresponding author
E-mail: wk11106@kmu.ac.kr

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Comparison of Body Composition, Physical Fitness, and Knee Joint Isokinetic MUSCULAR FUNCTION of Middle School Soccer Players by Grade

Jusik Park[1]
Keimyung University, Daegu, Republic of Korea
Wookwang Cheon[2*]
Keimyung University, Daegu, Republic of Korea

Abstract

***Purpose**: This study compared the characteristics of body composition, physique, physical fitness factors, and isokinetic muscle function by grade in middle school soccer players.*

***Method**: The results of analyzing differences in body composition and physique, physical fitness factors, and isokinetic muscle function by grade(38 in 1st grade, 46 in 2nd grade, 21 in 3rd grade) targeting 105 soccer players in S city middle school are as follows.*

***Results**: Body composition and physique factors there were significant differences by grade in height, weight, upper limb length, lower limb length, sitting height, and arm span. The post-verification of the main effects showed that height and weight were significantly higher for the second and third graders than for the first graders. For upper and lower limb length, the third graders were significantly longer than the first graders, while for sitting height, the second and third graders were significantly higher than the first graders. Fingertips were found to be significantly longer in the third graders than in the first and second graders. In physical strength factors, back muscle strength, grip strength, push-ups, sargent jump, standing long jump, side steps, shuttle run, and trunk forward flexion, trunk backward flexion, visual perception reaction, lung capacity showed significant differences by grade. As a result of post-hoc verification of the main effects by grade, the second and third graders were significantly higher than the first graders in back strength, grip strength(left, right), push-ups, and standing long jump. Sargent jump and side steps were found to be significantly higher as the grade increased, and shuttle run, visual perception reaction, and lung capacity were significantly higher for the third graders than for the first graders. Compared to the first and second graders, the third graders were significantly higher in trunk forward and backward flexion. In isokinetic muscular functions measured at 60 degrees of angular velocity, there were significant differences by grade in left extensor per weight(%BW), right extensor(Nm), left extensor(Nm), left flexor per weight(%BW), right flexor(Nm), and left flexor(Nm). As a result of the post-hoc verification of the main effects by grade, the third graders were significantly higher than the first graders in left extensor per weight(%BW), and the second graders were significantly higher than the first graders in right extensor(Nm), left extensor(Nm), left flexor per weight(%BW), right flexor(Nm), and left flexor(Nm).*

***Conclusion**: Based on the results of this study, the body composition, physique, physical strength factors, and isokinetic muscle function of middle school soccer players differed by grade, and considering that the less than four years of their career during the fast-growing period, the results of this study should be fully reflected in the planning of the training program.*

[Keywords] ***Middle School, Soccer Players, Body Composition, Physical Fitness, Isokinetic Muscle Function***

1. Introduction

While most people understand that the modern game of soccer is originated from the U.K., Shin Hyeon-gyu(2005)[1] in a prior study titled "Consideration of the Origin and Formation Process of Soccer" suggests that it cannot be denied that modern soccer has developed in the U.K., but considering the Chinese and Islamic cultures already traded with each other through various channels including the Silk Road since before the birth of Christ, soccer might be transferred from China to Europe across the Islamic culture through routes on the sea, grassland, or the Silk Road. Through the FIFA World Cup, which is a worldwide soccer competition, soccer has developed into one of the largest sports events in the world for a single sports event, and the public's interest in soccer has increased significantly in Korea, especially since the 2002 Korea-Japan World Cup. In addition, in the 2002 Korea-Japan World Cup, Korean players advanced to the semi-finals with excellent performance, which led to a large number of players entering the overseas leagues. FIFA, which has 211 member countries, has more than 200 million active players[2], and currently has 163,338 players from 5,054 teams, including professional team and community club members(Korea Football Association, 2020)[2]. Among them, for U15, which includes middle school male athletes, there are 4,404 active players from 119 middle schools (Korea Football Association, 2020)[3]. Stratton, Williams, and Richardson(2004)[4] reported that, based on the age of 13-14 when height growth is at its peak, technique-oriented training before the peak and training for developing physical strength after peak should be organized. They also reported that excessive training focused on developing physical strength during childhood and adolescence can increase the risk of injury, so technique-oriented training at this time is more important to foster successful football players. Bompa(2001)[5] also emphasized that differentiated training approaches are required for each stage by dividing the developmental stage into four stages: initialization stage, athletic formation stage, specialization stage, and high-performance stage.

There may be some differences depending on the positions or the level of the opposing team[6], but soccer is a ball game that requires 90 minutes of dribbling, passing, shooting, and fast and continuous movement to defend the opponents. Therefore, physical strength[7][8][9][10], muscle endurance, muscle power, cardiopulmonary endurance, anaerobic power[11][12][13][14], as well as balance[14] and physical coordination for ball handling, are important physical strength factors as reported in a number of prior studies. In addition, while there have been prior studies comparing and analyzing the differences between physical factors affecting soccer players' performance[2][6][15][16][17][18][19][20][21], studies comparing the physique and physical strength characteristics of middle school soccer players who are growing rapidly in physique and physical strength are insufficient. Therefore, this study aims to provide basic data for the composition of optimized training programs by analyzing the physique and physical characteristics of middle school soccer players by grade.

2. Research Method

2.1. Research subjects

This study was conducted to compare the body composition, physical strength factors, and the characteristics of isokinetic muscle function by grade(38 first graders, 46 second graders, and 21 third graders) in 105 S city middle school soccer players. To the research subjects, the purpose and contents of the experiment were clearly explained in advance, and it was conducted after getting their written consent. The general characteristics of the study subjects are shown in <Table 1>.

Table 1. General characteristics of research participants(N=105).

Items	Height(cm)	Weight(kg)	BMI(kg/m2)	%Fat	Career (years)

Grade	1(38)	161.99 ±8.65	51.53 ±8.54	19.39 ±2.02	12.42 ±3.89	3.13 ±0.99
	2(46)	167.77 ±7.13	57.31 ±9.44	20.99 ±2.14	12.66 ±3.30	3.39 ±0.88
	3(21)	171.76 ±7.49	59.28 ±11.22	19.87 ±1.39	12.04 ±2.82	3.62 ±0.97

Note: mean±SD.

2.2. Measurement items and methods

2.2.1. Body composition

Body weight, body fat percentage, and BMI were measured using InBody 720 (Biospace, Korea). In order to increase the reliability of the measurement results, all metals attached to the human body were removed, and the measurement posture suggested in the equipment manual was maintained, and measurements were taken at rest.

2.2.2. Physique measurement

Height was measured in centimeters using a height meter, and the forearm and thigh were measured in centimeters using a tape measure. The circumference of the thickest part of the forearm was measured as the forearm circumference, and the area perpendicular to the femur at the center of the greater trochanter and the knee joint was measured as the thigh circumference. The length of upper and lower limbs, sitting height, and both fingertips was measured in centimeters using a Martin-type human measuring instrument. For the length of the upper limb, the straight line distance between the acromion point and the middle finger was measured in an upright position. The length of the lower extremities was measured from the bottom to the superior anterior iliac spine. The sitting height was measured by measuring the vertical distance from the sitting side to the apex while sitting on the left altimeter. Arm span collected both feet, attached the shoulders and hips to the wall, stretched both arms to the sides as much as possible at the height of the shoulders, and measured the length to the ends of the middle fingers of both hands.

2.2.3. Physical fitness factor

To check the differences in physical strength factors between groups, muscle strength(back muscle strength, grip strength), muscle endurance(sit-ups, push-ups), muscle power(sargent jump, standing long jump), agility(side steps), systemic reaction(sound), cardiopulmonary endurance(shuttle run), balance(one leg standing with eyes closed), flexibility(trunk flexion, trunk extension), coordination(visual perception), lung capacity were measured. All measurements were performed twice and better values were used as actual values[22][23][24].

2.2.4. Isokinetic muscle function test of the knee joint

For the isokinetic muscle function test, the isokinetic muscle function measurement system(CSMI, USA) was used to measure the muscle function of the knee joint according to the manual. The muscle strength of the knee joint was measured by performing flexion and extension movements of the knee joint three times at an angular velocity of 60°/sec and five times of the muscle power at 180°/sec. After performing three preliminary exercises, measurements were made, and peak torque, average power, total work, ratio of left and right(%), and flexor and extensor ratio were calculated through the measurement results[20].

2.3. Data processing

The data processing of this study was performed using the SPSS 26.0 statistical program to obtain the mean and standard deviation of each measurement item. One-way ANOVA was performed to verify the difference in measurement items by grade(the first, second, and third

graders), and the Tukey HSD method was used for post-test. The statistical significance level was set to p<.05.

3. Results

3.1. Comparison of characteristics of body composition and physique by grade

The results of comparing the characteristics of body composition and physique by grade of middle school soccer players are shown in <Table 2>. For height(p<.001), weight(p<.01), upper limb length(p<.01), lower limb length(p <.05), sitting height(p<.001), and fingertips(p<. 001), there were significant differences for each grade level. As a result of post-hoc verification of the main effects, the height and weight were significantly higher in the second and third graders than in the first graders. Arm span was considerably longer in the third graders compared to the first and second graders.

Table 2. Comparison of characteristics of body composition and physique by grade.

Items		Grade(n=105)			F Value	Post-hoc
		1(38)	2(46)	3(21)		
Height(cm)		161.99±8.65	167.77±7.13	171.76±7.49	11.772***	a<b, c
Weight(kg)		51.53±8.54	57.31±9.44	59.28±11.22	5.803**	a<b, c
%fat(%)		12.42±3.89	12.66±3.30	12.04±2.82	.237	-
BMI(kg/m2)		19.39±2.02	20.99±2.14	19.87±1.39	1.332	-
Forearm circumference (cm)	L	22.94±1.12	23.13±1.08	22.76±0.54	.962	-
	R	23.21±1.38	23.64±1.20	23.92±1.55	2.079	-
Thigh circumference(cm)	L	49.29±2.44	49.70±2.39	48.85±1.25	.997	-
	R	49.00±3.66	49.88±2.83	50.55±3.45	1.603	-
Arm length(cm)		71.61±4.19	73.78±3.58	74.93±4.04	5.717**	a<c
Leg length(cm)		86.17±4.11	88.01±4.51	89.16±4.18	3.697*	a<c
Sitting height(cm)		87.69±3.19	89.94±3.86	91.17±2.95	7.666***	a<b, c
Arm span(cm)		164.46±9.97	168.86±7.69	174.63±8.12	9.421***	a, b<c

Note: values are mean±SD, a: 1st graders, b: 2nd graders, c: 3rd graders, * p<.05, ** p<.01, *** p<.001.

3.2. Comparison of characteristics of physical fitness factors by grade

The results of comparing the characteristics of physical strength factors by grade of middle school soccer players are shown in <Table 3>. Back strength(p<.001), grip strength (left, right)(p<.001), push-ups(p<.001), sargent jump(p<.001), standing long jump(p<.001), side steps(p<.001), shuttle run(p<.05), trunk forward flexion(p<.001), trunk backward flexion(p<.001), visual perception response(p<.01), and lung capacity(p<. 05) showed significant differences between grades. As a result of post-hoc verification of the main effects by grade, the second and third graders were significantly higher than those of the first graders in back strength, grip strength(left, right), push-ups, and standing long jump. Sargent jump and side steps were significantly higher as the grade increased, and shuttle run, visual perception response, and lung capacity were significantly higher in the third graders than in the first graders. Trunk flexion and trunk extension, which are evaluation items of flexibility, were significantly higher in the third graders than in the first and second graders.

Table 3. Comparison of characteristics of physical fitness factors by grade.

Items		Grade(n=105)			F Value	Post-hoc
		1(38)	2(46)	3(21)		
Back strength(Kg)		69.83±16.94	85.23±15.99	86.33c±23.58	9.253***	a<b, c
Grip strength(kg)	L	26.94±6.19	32.82±6.47	35.36c±7.49	10.000***	a<b, c
	R	27.87±6.17	33.99±5.67	32.53c±6.63	10935***	a<b, c
Sit-ups(reps)		47.53±7.44	49.39±10.00	50.90±13.24	.840	-
Push-ups(reps)		22.34±11.43	33.15±12.02	39.14c±13.60	14.994***	a<b, c
Sargent jump(cm)		35.68±3.84	38.85±5.02	42.62c±4.06	16.846***	a<b<c
Long jump(cm)		196.05±15.52	207.30±13.48	215.05c±10.93	13.971***	a<b, c
Side steps(reps)		41.53±2.88	44.52±3.35	47.38c±3.89	22.170***	a<b<c
Sound reaction(sec)		0.27±0.03	0.26±0.03	0.26±0.02	2.590	-
Shuttle run(reps)		80.83±10.88	86.67±13.62	90.05c±10.70	4.481*	a<c
One leg standing with eyes closed(sec)		46.15±35.42	64.79±34.97	55.41±40.46	2.722	-
Trunk flexion(cm)		8.11±5.41	11.05±5.95	16.29c±5.07	14.449***	a, b<c
Trunk extension(cm)		42.10±7.23	45.56±6.85	50.01c±7.11	8.399***	a, b<c
Visual perception reaction(total time)		53.65±6.61	50.33±4.17	48.94c±5.73	5.917**	a<c
Lung capacity(ml)		3328.76±689.63	3579.97±484.90	3787.22c±643.52	4.152*	a<c

Note: values are mean±SD, a: 1st grade, b: 2nd grade, c: 3rd grade, * p<.05, ** p<.01, *** p<.001

3.3. Comparison of characteristics of 60° isokinetic muscle function by grade

<Table 4> shows the comparison of the knee joint isokinetic muscle function characteristics by grade of middle school soccer players. Of the knee joint measured at an angular velocity of 60 degrees there were significant differences between grades in left extensor(%BW)($p < .01$), right extensor(Nm)($p < .01$), left extensor(Nm)($p < .01$), left flexor (%BW)($p < .05$), right flexor(Nm)($p < .001$), and left flexor(Nm)($p < .001$).

Table 4. Comparison of characteristics of 60° isokinetic muscle function by grade.

Items	Grade(n=105)	F Value	Post-hoc

	1(38)	2(46)	3(21)		
Right extensor(%BW)	260.01±27.32	273.14±35.84	273.01±11.61	2.295	-
Left extensor(%BW)	243.36±23.59	256.38±38.83	275.48±27.72	6.571**	a<c
Right extensor(Nm)	139.03±23.95	159.19±30.66	150.13±4.86	6.475**	a<b
Left extensor(Nm)	134.54±21.92	154.88±31.49	144.60±5.65	6.710**	a<b
Left/right extensor(deficit)	2.72±7.39	2.45±9.97	2.96±1.00	.029	-
Right flexor(%BW)	156.77±25.52	156.35±22.25	153.87±12.78	.121	-
Left flexor(%BW)	144.15±14.95	155.67±23.57	150.68±10.55	3.874*	a<b
Right flexor(Nm)	82.29±13.19	93.30±14.59	88.01±1.13	7.706***	a<b
Left flexor(Nm)	78.50±13.95	92.64±15.09	86.30±1.99	11.630***	a<b
Left/right flexor(deficit)	4.58±8.09	0.42±8.81	1.94±1.13	2.993	-
Flexor/extensor left ratio(%)	58.99±6.44	61.99±12.91	60.86±0.35	1.017	-
Flexor/extensor right ratio(%)	59.92±5.97	59.81±7.69	59.46±1.28	.034	-

Note: values are mean±SD, a: 1st graders, b: 2nd graders, c: 3rd graders, * p<.05, ** p<.05, *** p<.001.

4. Discussion

This study compared and analyzed the characteristics of the physique, physical strength factors, and isokinetic muscle function of middle school soccer players by grade. According to the study, in terms of body composition and physique, height, weight, and sitting height were significantly higher for the second and third graders than for the first graders. For upper and lower limb length, the third graders were significantly longer than the first and second graders, and for fingertips, the third graders were significantly longer than the first and second graders. These results were partly consistent with a longitudinal study on the development of the physique and physical strength factors of adolescent soccer players[25]. Prior studies compared the difference between 13-14 years old, 14-15 years old, 16-17 years old, and 17-18 years old with middle and high school soccer players as the subjects and reported that height and weight grow the most at 14-15 years old and sitting height at 13-14 years old. Those aged 13-14 are in the sixth grade of elementary school and first grade of middle school, while those aged 14-15 are in the second and third years of middle school. The results of this study also support the results of the second and third graders significantly higher than in the first grade. However, in the case of left and right thighs, the statistical significance was not identified in this study, unlike the prior study which reported the greatest growth at the age of 14-15[25]. In the length of fingertips, nothing was reported in the prior study results, so a direct comparison could not be made.

In terms of physical fitness factors, the second and third graders were significantly higher than the first graders in back strength, grip strength(left, right), push-ups, and standing long jump. Sargent jump and side steps were found to be significantly higher as the grade increased, and shuttle run, visual perception reaction, and lung capacity were significantly higher for third graders than for first graders. Compared to the first and second graders, the third graders were significantly higher in trunk forward and backward flexion. Compared to the previous study[26] conducted to develop standards for physical strength assessment for middle and high school students, most of the physical strength factors were evaluated as "fair," among the five levels of "very poor, poor, fair, good, and excellent." In terms of differences by grade, the third graders were "fair" whereas the first and second graders were "poor" in push-ups. However, considering that the results of the prior study were based on the mean values of teen athletes in various sports by grade, it is difficult to make a direct comparison. A prior study done by Lee Young Soo and Ha Min Soo(2001)[25] in part support this study in that

agility increased significantly between the ages of 14 and 15, muscle endurance between 17 and 18, sargent jump between 13 and 14, and standing long jump between 14 and 15, and in particular quick response between 13 and 15. In the prior study, a direct comparison was difficult due to differences in measurement items and methods, but compared in terms of physical strength factors, agility and muscle endurance increased the most between 14 and 15 years old and quick response between 13 and 14, while muscle strength, response time, cardiopulmonary endurance, balance, and flexibility were difficult to discuss directly.

For isokinetic muscle functions measured at angular velocity of 60 degrees, the third graders were significantly higher than the first graders in left extensor per weight(%BW), and the second graders were significantly higher in right extensor(Nm), left extensor(Nm), left flexor per weight(%BW), right flexor(Nm), and left flexor(Nm) than the first graders. A prior study by Lee Young Soo and Ha Min Soo(2001)[25] showed significant differences in right flexor and extensor at 60 degrees angular velocity and reported significant improvement in flexor between 17 and 18 years of age and extensor between 14 and 17 years of age. In detail, flexor was reported to have developed the most between the ages of 17 and 18 and extensor between the ages of 14-15, and compared with this study, there were some differences in the maximum period of increase in isokinetic muscle function measured at 60 degrees angular velocity. What's interesting, however, is that a study on the isokinetic muscle strength comparison of adolescent soccer players by Lee Young Soo and Lee Yong Jin(1999)[27] reported that left and right extensor strength of middle school students measured at 60 degrees of angular velocity was 106.2±20.6 and 106.6±26.6Nm, respectively, and for flexor strength of 64.7±15.1 and 59.9±13.9Nm, respectively. This confirms that more than two decades later, the knee joint isokinetic muscle strength of modern middle school soccer players has increased significantly. Experts in each sport know that the physique and physical strength factors of athletes in various sports events affect their performance beyond the level of skill in each sport. A number of prior studies have reported that such information is very important in discovering outstanding athletes in each sport and planning training to improve their performance[28][29][30]. The results of this study were intended to identify the physique and physical strength factors of middle school soccer players, who are in the fast-growing period, but the results proved to be not sufficient. As a number of prior studies has confirmed[6][17][19][20], given that elite soccer players have different body composition as well as physique and physical strength factors depending on their positions, it is judged that identifying differences by position by grade is suitable for achieving the purpose of this study. Nonetheless, the results of this study have confirmed that there are differences in physique, physical strength factors, and isokinetic muscle function of middle school soccer players by grade, and if these differences are fully considered when planning physical strength training, the training effect will be maximized.

5. Conclusion

This study compared the characteristics of body composition, physique, physical fitness factors, and isokinetic muscle function of middle school soccer players by grade. The study has shown statistically significant differences in body composition, physique, physical fitness factors, and the knee joint isokinetic muscle strength measured at 60 degrees of angular velocity. Although there were some differences depending on the items measured, most of the measurements indicated that the differences between the first and second graders were greater than the differences between the second and third graders. It is believed that the results of this study should be fully reflected in the various training plans for middle school soccer players, and to provide more specific information, follow-up studies comparing the differences by grade according to positions are needed.

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7. Appendix

7.1. Authors contribution

	Initial name	Contribution
Lead Author	JSP	-Set of concepts ☑ -Design ☑ -Getting results ☑ -Analysis ☑ -Make a significant contribution to collection ☑ -Final approval of the paper ☑ -Corresponding ☑ -Play a decisive role in modification ☑ -Significant contributions to concepts, designs, practices, analysis and interpretation of data ☑ -Participants in Drafting and Revising Papers ☑ -Someone who can explain all aspects of the paper ☑
Corresponding Author*	WKC	