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Relationships between the Digit Ratio(2D:4D) and Exercise-Related Physical Fitness Components in Males and Females

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Abstract

The relative length of the second and fourth fingers(2D:4D ratio) is a putative biomarker for prenatal testosterone. Low 2D:4D has been known to correlate with morphological, physiological, psychological, and high levels of athletic performance and physical fitness. In this study, it was examined the relationship between the 2D:4D ratio and two important exercise-related fitness components(speed and power) in nonathlete young adults. A total of 108 healthy recreationally active university students(73 male and 35 female, aged 18-20 years) were participated in this study. Body weight and height were measured, and body mass index(BMI) was calculated. The lengths of the second and fourth fingers of the right and left hands were measured, and the 2D:4D ratios were calculated. The difference of the digit ratio between the right and left hands(Dr-l) was also calculated. Speed and power performance were assessed by measuring 100-meter sprint record and handball throwing distance, respectively. Independent t-test was performed to analyze differences between males and females about all variables of physical(height, weight, BMI) and anthropometric(lengths of 2D, 4D, and 2D:4D ratio of both hands, and Dr-l) characteristics. The association between physical and anthropometric characteristics and the speed and power-related performance in each sex(male: speed, power, female: speed only) was determined by the Pearson correlation coefficient. Statistical significance was set at $P < 0.05$. As the main findings of this study, the lengths of the 2D and 4D of males were significantly longer than those of females($P < .001$), while male digit ratios in both hands were significantly lower than females($P < .01$). There was no significant sex difference in Dr-l. In males, significant positive correlations were observed between the handball throwing distances and the body weight($P < .05$) and BMI($P < .01$). In females, there was a significant negative correlation between the length of the fourth digit and 100-meter sprint record($P < .05$). However, the 2D:4D ratio was not correlated with the speed and power performance in males and females. These results suggest that the 2D:4D ratio is not a major parameter in predicting exercise potential in the nonathlete young adult, and more research is needed that focuses on other factors that can affect exercise potential in the population that is similarly affected by prenatal sex hormones.

***[Keywords]* Kinesiology, Finger Length, Digit Ratio, Prenatal Testosterone, Sport Performance**

1. Introduction

Digit ratio is the relative length of the index finger(the second digit, 2D) and the ring finger(the fourth digit, 4D), and in general, 2D:4D ratio for males tends to be lower than for females[1]. It has been known that this digit ratio(or 2D:4D) is influenced by prenatal sex hormones as early as the end of the first trimester, and high prenatal androgens, low prenatal estrogens, or both have been identified as a possible stimulant of a low 2D:4D ratio[2][3]. The

changes of digit ratio influenced by prenatal sex hormones are controlled through Homeobox(Hox) genes which are responsible for controlling the development of musculoskeletal, neurological, and gonadal tissue[4]. As such, the 2D:4D ratio not only indicates the hormonal milieu at the time of development, but can also provide information which has implications for interpreting human behavior and disease. Therefore, there is also important meaning in terms of kinesiology and training related aspects.

Because of the relationships of the 2D:4D ratio with prenatal testosterone concentrations and musculoskeletal development, it was suggested that a low 2D:4D ratio is associated with greater performance in various sports and physical fitness[5][6][7]. Bernet et al.(2010) examined the relationship between the 2D:4D ratio and performance in elite rugby players, and they found high rugby performance correlated with low right hand 2D:4D ratio[8]. Tomkinson and Tomkinson(2017) reported a negative correlation between muscular strength and the 2D:4D ratio in adolescent boys[9]. In relation to the relationship between the digit ratio and the health-related physical fitness components, the digit ratio was shown to have a particularly strong correlation with cardiopulmonary endurance[10][11][12].

In addition, in a study of Mofftt and Swanik(2011), they reported that the 2D:4D ratio of athletes in football and gymnastics, which requires high levels of physical skills, was significantly lower than that of crew(endurance athletes) players and nonathlete[13]. Kociuba et al.(2017) found that the 2D:4D ratio of participants in high-risk sports such as judo or boxing was significantly lower compared to that of aerobic exercise group[14]. Also, according to two different studies of Kilduff et al.(2013a, 2013b), the lower the 2D:4D ratio, the higher the sudden increase in testosterone induced by exercise or by an aggressive video watching were examined[15][16]. The results of these studies indicate that the digit ratio is related not only to physical skills but also to sports interest and motivation.

On the other hand, speed is defined as the magnitude of change in the position of an object between two different points. Power is physically defined as the amount of work accomplished per unit of time, and it is also defined as maximal muscle force exerted by the instantaneous contraction of muscle fibers in exercise physiology aspect. As speed and power are physical fitness components included in the exercise-related physical fitness, these two factors are one of the most important factors that determine how far the shot travels in shot put or how fast someone runs 100-meter sprint[37][38][39]. As mentioned above, the relationship between health-related fitness such as muscle strength and cardiovascular endurance and the 2D:4D ratio has been studied a lot, but the research about the relationship between exercise-related fitness factors and the 2D:4D ratio is relatively scarce.

With this purpose, this research examined the relationships between the digit ratio and the speed and power performance measured by 100-meter sprint record and by handball throwing distance from male and female university students, respectively.

2. Method

2.1. Subjects

A total of 108 healthy men and women(men=73, women = 35) aged 18 to 20 years old were participated in this study. All participants were habitually active in various sports activities. The description of the study's purpose, procedures, and risks was provided prior to participating in this study. This study was conducted in compliance with the guidelines related to research ethics.

2.2. Experimental procedures

Subjects' height was measured to the nearest 0.1 cm using portable stadiometer(Donghwa Science, Korea), which consisted of an anthropometer with a simple headboard. Body weight was measured using Inbody 502(Inbody, Korea) on the barefoot, wearing minimal clothing(T-shirt and trousers). Using the measured height and body weight values, BMI was calculated as weight(kg) divided by height(m) squared.

Finger lengths were measured according to the measurement method described by Manning et al.(1998), and second and forth digits on both left and right hands were measured[1]. The subjects were asked to remove finger ornaments and to keep their hands supine on a flat table surface with the palm facing up and their fingers straight in the same plane. Length of each digit was taken on the ventral aspect of hand from the tip of the finger to the center of the digit crease proximal to the palm. Finger lengths were measured to the nearest 0.01 mm using electronic digital caliper(Wanhanda, China). Length of each finger was measured twice in the same manner, and the average value was used for a statistical analysis. 2D:4D ratio was calculated by dividing the length of the second finger by that of the fourth. Manning et.al.(1998) reported that right 2D:4D ratio showed stronger relationship with testosterone, estrogen, and sperm numbers then did left 2D:4D ratio[1]. It was also reported that right 2D:4D ratio is more sensitive to testosterone/estrogen ratio in the fetus then that of left[17]. Thus, the difference between right 2D:4D and left 2D:4D(Dr-l) has been suggested as an additional indicator for the effect of sex hormones. In this study, Dr-l was also calculated and used to analyze correlations with exercise-related fitness components.

Speed was measured by 100-meter sprint. Subjects performed 100-meter sprint on an outdoor urethane track, and they were asked to run when the wind was as low as possible to minimize the effect of wind. The record of 100-meter sprint was taken to nearest 0.01 second using a laser measuring system(KL sports industry, Korea) that can automatically measure the record through laser sensors installed at the starting and finish lines. Whole body muscle power was measured by handball throwing performance. Handball throwing performance was measured using an international official handball(molten, Japan) with a ball circumference of 58~60 cm and a weight of 425 to 475 g. Subjects took their throw a handball into the legal sector(30°) of the throwing area from inside a marked circle 2-meter in diameter with a stopboard about 10 cm high at the front of the circle. The distance thrown was measured to nearest 0.1 m from the inside of the circumference of the circle to the nearest mark made on the ground by the falling handball using an open reel measuring tape(Colorton measuring tape, Taiwan).

2.3. Statistical analysis

All statistical analyses were analyzed using SPSS version 25.0(IBM, U.S.A), and all data are expressed as mean ± standard deviation(SD). The differences between men and women for the finger lengths, 2D:4D ratios of left and right hands, and Dr-l were analyzed using independent-sample *t*-test. The relationships between the exercise-related fitness components and height, weight, BMI, Dr-l, and the lengths of second and fourth digits, the 2D:4D ratios of both left and right hands were analyzed in each sex by calculating the Pearson correlation coefficients. For all analyses, statistical significance was accepted at $P < 0.05$.

3. Results

3.1. Sex differences in physical and anthropometric characteristics

The subjects' physical and anthropometric characteristics of this study by gender are shown in <Table 1>. Finger length measured from the first measurement was strongly correlated with those measured from the second measurement for the individual subject(left hand 2D: r = 0.991, $P < 0.001$, left hand 4D: r = 0.996, $P < 0.001$, right hand 2D: r = 0.996, $P < 0.001$, right hand 4D:

r = 0.995, $P < 0.001$). There was strong significant correlation between the 2D:4D ratios calculated from the first and second measurement of digit lengths(left hand: r = 0.949, $P < 0.001$, right hand: r = 0.957, $P < 0.001$). The means of left and right hand 2D:4D ratios were also significantly correlated in both gender(male: r = 0.812, $P < 0.001$, female: r = 0.861, $P < 0.001$). These associations mean that there was high test-retest reliability in this data.

In the comparison of the basic components of physical characteristics, men's height, weight, and BMI were significantly higher than those of females. In the comparison of anthropometric characteristics, the lengths of the second and fourth digits on both hands were significantly longer in males than in females. On the other hand, the digit ratios of left and right hands were significantly lower in males. There was no significant difference in the Dr-l between males and females.

Table 1. The differences in physical and anthropometric characteristics between males and females.

Variables	Men(n=73)	Women(n=35)
Age(yrs)	19.07± 0.77	18.86± 0.49
Height(cm)	175.66± 4.58	161.66± 5.06**
Weight(kg)	71.58± 7.41	55.98± 6.38**
BMI(kg/m^2)	23.21± 2.34	21.40± 2.02**
L2D(mm)	72.37± 3.16	66.28± 3.60**
L4D(mm)	75.81± 3.18	68.26± 4.01**
L2D:4D	0.95± 0.03	0.97± 0.03*
R2D(mm)	72.43± 3.15	66.30± 3.75**
R4D(mm)	75.53± 3.19	68.26± 3.95**
R2D:4D	0.96± 0.03	0.97± 0.03*
Dr-l	0.0044± 0.0163	0.0000± 0.0151

Note: Values are presented as mean ± SD. BMI: Body Mass Index., L2D: Left hand second digit, L4D: Left hand fourth digit, L2D:4D: Ratio of left hand second and fourth digit, R2D: Right hand second digit, R4D: Right hand fourth digit, R2D:4D: Ratio of right hand second and fourth digit, Dr-l: Difference between right 2D:4D and left 2D:4D. *p<.01, **p<.001.

3.2. Correlations between physical and anthropometric characteristics and physical performance in males and females

The correlations between physical and anthropometric characteristics and 100-meter sprint and handball throwing performance were calculated from 66 and 49 male subsamples, respectively. <Table 2> depicts the correlations among the variables for each physical performance. All the variables constituting physical and anthropometric characteristics were not significantly correlated with 100-meter sprint performance in males <Table 2>. However, there were significant positive correlations between weight and handball throwing distance(r = 0.328, $P < 0.05$), and BMI and handball throwing distance(r = 0.376, $P < 0.01$) in males <Table 2>. The variables of anthropometric characteristic did not significantly correlate with handball throwing performance <Table 2>.

Table 2. Correlations between physical and anthropometric characteristics and 100-meter sprint and handball throwing performance in males.

Variables	100-meter sprint(n=66)	Handball throwing(n=49)
Height	-0.024	-0.070
Weight	0.038	0.328*
BMI	0.044	0.376**
L2D	-0.052	0.040
L4D	-0.090	0.149

R2D	-0.092	0.027
R4D	-0.064	0.147
L2D:4D	0.062	-0.135
R2D:4D	-0.008	-0.130
Dr-l	-0.147	-0.025

Note: Values are presented as mean ± SD. BMI: Body Mass Index., L2D: Left hand second digit, L4D: Left hand fourth digit, L2D:4D: Ratio of left hand second and fourth digit, R2D: Right hand second digit, R4D: Right hand fourth digit, R2D:4D: Ratio of right hand second and fourth digit, Dr-l: Difference between right 2D:4D and left 2D:4D. *p<.05, **p<.01.

Total 35 women were participated in this study, and 34 cases of 100-meter sprint records were obtained. The result of handball throwing for women was excluded from this study due to lack of cases. Among the female subsamples, there were no significant correlations between the 100-meter sprint performance and either physical characteristics, left hand anthropometric characteristics, and Dr-l <Table 3>. There was a significant negative correlation between the length of right hand fourth digit and 100-meter sprint performance($r = -0.348$, $P < 0.05$) <Table 3>. The other variables on right hand anthropometric characteristics were not significantly correlated with 100-meter sprint performance <Table 3>.

Table 3. Correlations between physical and anthropometric characteristics and 100-meter sprint performance in females.

Variables	100-meter sprint(n=34)
Height	-0.310
Weight	0.104
BMI	0.338
L2D	-0.208
L4D	-0.332
R2D	-0.223
R4D	-0.348*
L2D:4D	0.267
R2D:4D	0.251
Dr-l	-0.027

Note: Values are presented as mean ± SD. BMI: Body Mass Index., L2D: Left hand second digit, L4D: Left hand fourth digit, L2D:4D: Ratio of left hand second and fourth digit, R2D: Right hand second digit, R4D: Right hand fourth digit, R2D:4D: Ratio of right hand second and fourth digit, Dr-l: Difference between right 2D:4D and left 2D:4D. *p<.05.

4. Discussion

In the current study, it was found that males have longer the second and fourth fingers of both hands and have lower 2D:4D values than those of females, and the 2D:4D ratios of both hands were not correlated with the 100-meter sprint and handball throwing performance in both sexes. In addition, in the correlations between the 100-meter sprint performance and physical and anthropometric variables, a significant correlation was found only in females, and the length of fourth finger showed a significant negative correlation with the 100-meter running time.

Hox genes are known to influence on the formation of gonads and the differentiation of the fingers and to control the growth of skeleton and the development of testes or ovaries, which are ultimately responsible for sex differences[18][19][20]. Both men and women are subject to relative effects of male or female hormones in their mother's intrauterine environment. Scientific studies have shown that the female 2D:4D ratio is significantly higher compared to male embryos, and low 2D:4D ratio may be correlate with high prenatal testosterone and low prenatal estrogen concentration[2][21]. In addition, Zheng and Cohn(2011) found the developmental

mechanism underlying sexually dimorphic 2D:4D ratio through a mouse model research[17]. They found that the activity of androgen receptor(AR) and estrogen receptor α(ER-α) is higher in digit 4 than in digit 2 in both sexes, and inactivation of AR causes a higher 2D:4D ratio, whereas inactivation ER-α lead to a lower 2D:4D ratio[17]. In most reported studies, males tend to have a lower 2D:4D ratio compared to females[10][22][23], and these results are also consistent with those of the current study.

Another noteworthy result found in the Zheng and Cohn's study is that the 2D length index(digit length/tibia length) was not affected by a high androgen levels or ER antagonist in females and by a high estradiol or AR antagonist in males, respectively[17]. By contrast, the female 4D length index was increased by androgen enhancing or ER antagonist treatment, and in males, it was decreased by estradiol or AR antagonist treatment[17]. These results suggest that the fourth finger plays a crucial role in the determination of 2D:4D ratio in both sexes, and this result supports the significant correlation result between the women's 100-meter performance and the length of fourth digit found in the current study.

Such as muscle fiber hypertrophy, increased strength, an increase in hematocrit, and power, various factors related to excellence in exercise performance are influenced by testosterone[24][25][26][27]. Therefore, increased prenatal testosterone exposure may be an essential precursor for the success in some sport activities, and it has been suggested that the 2D:4D ratio is a biomarker that determines exercise potential[13]. In fact, many studies have reported that the digit ratio has a significant correlation with exercise performance, physical fitness level, and successful achievement in several sports[10][23][28][29].

However, in the present study, the 2D:4D ratios measured from both hands were not correlated with the speed and power performance in both sexes. This discrepancy between the results of the previous study and the current study seems to be related to the subject's developmental stage, the subject's expertise in physical activity, and the homogeneity of the subject's population. In particular, the difference in the 2D:4D ratio was noticeable between nonathletes and elite athletes. Hsu et al.(2015) compared the 2D:4D ratio of tennis athletes and nonathletes, and they found that the digit ratio of elite tennis athlete group was significantly lower than those of nonathlete group in both males and females[23]. This phenomenon was also observed between elite Greco-Roman wrestlers and nonathlete[30]. In addition to comparisons between athletes and nonathletes, the 2D:4D ratio of prepubertal children who are relatively less affected by sex hormones was found to be significantly related to some athletic performance[7][31]. Lastly, the homogeneity of a group can be considered as a factor that can affect the relationship between the digit ratio and exercise performance. In a study performed by Gallup, White, and Gallup(2007), who studied the relationship between the digit ratio and handgrip strength and sexual behavior from male and female nonathlete college students, the digit ratio of both hands was not related with the handgrip strength performance[32]. Also, in a recent study with adolescent well-trained swimmers, the 2D:4D ratio had no correlation with swimming performance[33], and a similar result was reported in female young adult rowers[10]. All of these results suggest that the higher the homogeneous group, the higher the probability that the digit ratio does not correlate with exercise performance.

As another major finding of the present study, male handball throwing performance was not correlated with all anthropometric variables, but was significantly positively correlated with body weight and BMI, respectively. These results indicate that the higher the weight or BMI, the better the handball throwing performance. As a recent study similar to the results of the current study, Ozen, Atar, and Koc(2019) reported a significant negative correlation between swimming records(50m, 100m, 200m, 400m) and BMI in adolescent swimmers[33]. It was suggested that high BMI levels reflect low testosterone levels with a result of a positive association between the digit ratio and BMI in males[34]. Indeed, Jensen et al.(2004) showed

a negative association between BMI and testosterone levels from the data of 1,558 male subjects[35]. However, a significant decrease in testosterone levels was only observed in the high BMI group(BMI > 25kg/m^2) in this study[36]. In addition, Dongen(2009)[36] reported a significant negative correlation between the digit ratio and BMI in nonathlete males(age of 22.6±2.66) with higher sample size than Fink, Neave, and Manning(2003)[34], and there was an indirect relationship(but not significant) between the digit ratio and body mass in a study of Jurinae et al.(2008)[22]. In the current study, the 2D:4D ratios were not correlated with BMI(left 2D:4D: r = 0.206, *P* = 0.097, right 2D:4D: r = 0.140, *P* = 0.263). Above all, since BMI is a relative measure of body weight to height, high muscle mass or body fat can all contribute to a high BMI, and BMI is particularly inaccurate for people who are very fit or athletic[40]. Thus, it seems more desirable to compare it with detailed body components such as muscle mass and body fat rather than BMI.

In conclusion, the result of this investigation revealed no relationship between the 2D:4D ratio and the speed and power-related performance in males and females. In this respect, this result suggests that the digit ratio is not a major parameter in predicting exercise potential in the nonathlete young adults, regardless of gender. However, in the current investigation, it was also found that there was a positive relationship between female speed performance and their digit length, and male power performance and the body weight and BMI, respectively. Thus, these results also suggest that more research will be required to gain insight into which other factors that can affect exercise potential in the population that is similarly affected by prenatal sex hormone, as well and how these factors could potentially relate with expected associations with digit ratios.

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6. Contribution

6.1. Authors contribution

	Initial name	Contribution
Author	CCM	-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 ☑

6.2. Authors profile

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Analysis of the Relation between Female SOFTBALL PLAYERS Field Test and Anaerobic Exercise Ability and Isokinetic Muscle Function

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Abstract

This study analyzed the relation between field test(field skills: bat speed, throw distance, base running) and anaerobic exercise ability and isokinetic muscle function related to the performance improvement in 22 female softball players in "D" metropolitan city. The data processing was conducted using SPSS 25.0 to produce the average and standard deviation of all measured items, and the correlation between field skills and anaerobic exercise ability and isokinetic muscle function was measured with the Pearson's correlation analysis. An analysis of the correlation between field tests and isokinetic muscle function showed a significant correlation in the left extensor and bat speed(p<.05) and in weight ratio left extensor and left extensor and throw distance(p<.01). The base running ability showed a significant inverse correlation between the right flexor and 1st base(p<.01), 2nd base(p<.01), and home(p<.05) and between the right flexor/extensor ratio and 1st base(p<.05) and 2nd base(p<.05). For anaerobic exercise ability and isokinetic muscle function, there was a significant correlation between right extensor and peak power(p<.05), average power(p<.05), and total energy(p<.05). Based on the results of this study, it is believed that the bat speed and throw distance of female softball players are related to the left extensor and the base running ability is related to the right flexor and right flexor/extensor ratio.

[Keywords] ***Softball, Bat Speed, Throw Distance, Anaerobic Exercise Ability, Isokinetic Muscle Function***

1. Introduction

Softball is similar to baseball, but throwing underhand rather than overhand is a feature different from baseball[1]. In softball, a pitcher throws a ball, a hitter hits the ball, and defenders catch and throw it. The official ball in softball must be rubber or leather, weighing 177.19-198.45g, lighter and larger than baseball, with a diameter of 9.6-9.8cm, and a bat length less than 86.36cm and 5.72cm or less in diameter of the thickest part with the material of metal, bamboo, plastic, graphite, magnesium, carbon, magnesium, glass-fiber, or a composite of those, but recently mainly aluminum[2]. Softball games have a similar mechanism of bat swing and ball throwing movements. In muscular contraction, it is characterized by the movement of core muscles centered on the torso and hip muscles rotating on the axis and stretching the muscles[3]. The offense requires the ability to judge the pitched ball and accurately hit it with the bat[4], and defenders need the ability to catch and throw the ball accurately[5]. Softball, like baseball, requires four skills: throwing, catching, batting, and base running[4]. Depending on how much these skills are used in the game, they will directly affect the team's victory. Methods for measuring these field skills(throw, bat speed, base running) have been widely practiced in other sports[6][7]. The defense has different physical factors depending on the position[4][6][7]. For players in all positions, throwing the ball is important, and these

movements have the characteristics of the motion in which the muscles contract and then stretch with the rotation of each segment, similar to the hitting[3]. For players in all positions, including pitchers, fast and accurate throw movement is important, and power and myofunction are important factors in this regard[4]. Draw action is the most basic ability of softball, and depending on the strength of the throwing action, there may be a risk of injury, and the beginning of the movement is in the order of each segment of the lower body, the truncus, and the upper limbs[8][9][10][11]. The coordination of the muscles used in the throwing motion produces delicate movements, and the strength of the ball and the posture of the throwing action are determined as the sum of the momentary power and myofunctions of each segment[12]. In particular, since the thrust is obtained from the ground, the mechanism of the upper limbs through the pelvis and the truncus appears at the angular speed of the shoulder, the angular muscle power at the lower body becomes the source of force of the throwing motion and is important to prevent injury[3].

The bat speed is the most important along with accuracy in softball, with a combination of instantaneous power and myofunction of each segment. The hitting is a complex mechanism, and the fast bat speed means that the nerve system response and the mobilization of the motor units are efficient. Most of the force generated by the swing is generated first from the legs, then transferred to the upper body and activated the torso muscles in the entire swing[3][13][14]. Therefore, activating the lower limb muscles increases the power to the upper body and the torso, therefore the faster bat speed[15]. The relevance of the bat speed to anaerobic exercise skills in the hitting with this mechanism is not clearly known, and studies related to constant isokinetic muscle function have been reported a lot, but research on the relevance of field tests is insufficient. The base running time is an important element in the offensive aspect of softball, and there is a lot of training in strengthening lower limb muscle strength[1]. Base running in the left-hand direction of the ground requires lower limbs and the whole body endurance, especially depending on the foot supported[16]. Anaerobic exercise skills and isokinetic muscle function are affecting the power of lower limb muscles[17], but research related to base running is insufficient. By analyzing the correlation between extensor and flexor muscles in the physiologic factors of anaerobic exercise skills related to these field abilities and the lower isokinetic muscle function, improving the associated fitness factors will have a positive effect on the performance of softball players. Therefore, the purpose of this study is to analyze the relation between field test and anaerobic exercise ability and isokinetic muscle function and to provide the results of this study as basic data for future scientific and systematic training of softball players.

2. Research Method

2.1. Research subjects

The subjects of this study were 22 athletes from women's softball teams in "D" metropolitan city, and field test, anaerobic exercise ability, and isokinetic muscle function were measured. Participants in this study were given a clear explanation of the purpose and content of the experiment in advance, and all studies were carried out after obtaining consent from those who expressed their willingness to participate. The general characteristics of the study subjects are as shown in <Table 1>.

Table 1. The general characteristics of the study subjects.

N	Age	Height(cm)	Weight(kg)	BMI(kg/m^2)
22	24.10 ±5.07	162.95 ±5.64	63.14 ±7.97	23.43 ±3.45

Note: Values are mean±SD.

2.2. Measurement items and method

2.2.1. Field ability

Bat speed: After 10 minutes of warm-up, the bat speed was measured five times at bat. Using the Bushell Velocity Speed Gun(USA), speed was set to be measured at the hitting point, and out of the five swings, average speed(km/h) of three swings was recorded, excluding the highest and lowest value.

Throw distance: The throw distance was measured as the maximum distance that players threw softball from the home plate. A reference line was made at the home plate location for measurement, and an additional 2m line was set rearward to enable two-step run-up. Distance measurements were made by standing on the home plate and using Bushnell pro XE(USA) and marking the spot where the ball fell with a flag. The maximum distance(m) out of five throws was recorded.

Base running: In order to evaluate players' base running speed after hitting, the starting signal was given with a batting position at bat, and the time to return to home through first, second, and third base was measured with a stopwatch. Arrival was based on stepping on the plate at each point, measured twice each, recording the fastest time in seconds.

2.2.2. Anaerobic exercise ability

Anaerobic exercise ability was measured with a Wingate test. It was measured for 30 seconds using a bicycle ergometer(Monark 818E, Sweden). Taking into account the characteristics of this measurement, prior training was conducted on the measurement procedures to reduce the decrease of will and power output in the second half of the test. As a result of the Wingate test, the values for peak power, average power, total energy, and peak drop were calculated.

2.2.3. Isokinetic muscle function

Using an isokinetic muscle measurement system(CSMI, USA), isokinetic muscle function was measured on the knee joints according to the manual. It was measured at angular speed of 60°/sec to verify the muscle strength of the knee joints. After performing three preliminary exercises, the extensor and flexor of the knee joints were performed three times at the angular speed of 60°/sec. Measurements were used to calculate peak torque, average power, total work, left and right ratio(%), and flexor and extensor ratio.

2.3. Data processing

The data processing of this study produced the mean and standard deviation of all measured items using the SPSS 25.0 statistical program. Correlation analysis of Pearson between measurement items was conducted to determine the correlation between field ability and anaerobic exercise ability and isokinetic muscle function, and the statistical significance level was set to $p<.05$.

3. Results

3.1. Results of analysis of the correlation between field ability and anaerobic exercise ability

The results of the analysis of the correlation between field capability(bat speed, throw distance, and base running) and anaerobic exercise ability showed no statistical significance in all measurement items as shown in <Table 2>.

Table 2. Results of analysis of the correlation between field ability and anaerobic exercise ability.

Item	Bat speed (km/h)	Throw distance (m)	Base running(seconds)			
			1st base	2nd base	3rd base	Home
Peak power(W)	0.240	-0.167	-0.067	0.027	0.051	-0.073
Peak power(W/kg)	0.130	-0.249	-0.067	-0.043	-0.020	-0.112
Average power(W)	0.329	-0.043	-0.069	0.069	0.029	-0.050
Total energy(J)	0.325	-0.064	-0.092	0.060	0.028	-0.050
Peak drop(%)	-0.130	-0.002	0.273	0.131	0.126	0.101

3.2. Results of analysis of the correlation between field ability and isokinetic muscle function

Table 3. Results of analysis of the correlation between field ability and isokinetic muscle function(60°/sec).

Item	Bat speed (km/h)	Throw distance (m)	Base running(seconds)			
			1st base	2nd base	3rd base	Home
Right extensor(%BW)	0.161	0.208	-0.103	-0.217	-0.212	-0.236
Left extensor(%BW)	0.246	0.551**	-0.125	-0.170	-0.244	-0.201
Right extensor(Nm)	0.229	0.044	-0.101	-0.105	-0.137	-0.143
Left extensor(Nm)	0.490*	0.636**	-0.209	-0.183	-0.318	-0.238
Left/right extensor(deficit)	-0.119	-0.314	-0.223	-0.055	0.086	-0.016
Right flexor(%BW)	-0.122	-0.181	-0.450*	-0.548**	-0.414	-0.429*
Left flexor(%BW)	0.160	0.396	-0.344	-0.304	-0.220	-0.202
Right flexor(Nm)	-0.010	-0.267	-0.376	-0.377	-0.303	-0.313
Left flexor(Nm)	0.269	0.311	-0.364	-0.255	-0.208	-0.170
Left/right flexor(deficit)	0.077	-0.056	-0.099	0.078	0.085	0.070
Flexor/extensor left ratio	-0.087	-0.272	-0.119	-0.066	0.101	0.036
Flexor/extensor right ratio	-0.275	-0.339	-0.439*	-0.468*	-0.371	-0.329

Note: *p<.05, **p<.01.

The results of the analysis of the correlation between field ability(bat speed, throw distance, base running) and isokinetic muscle function are shown in <Table 3>. The bat speed showed a significant correlation with left extensor(r=0.490, p=0.021), and throw distance showed it with weight ratio left extensor(r=551, p=0.008) and left extensor(r=0.636, p=001). For base running, there was a significant correlation with weight ratio right flexor and the first base(r=-0.450, p=0.036), the second base(r=-0.548, p=0.008), and the home(r=-0.429, p=0.047) and right flexor/extensor ratio and the first base(r=-0.439, p=0.041) and the second base(r=-0.468, p=0.028).

3.3. Results of analysis of the correlation between anaerobic exercise ability and isokinetic muscle function

The results of the analysis of the correlation between the anaerobic exercise ability and isokinetic muscle function are shown in <Table 4>. Significant correlation were found between

right extensor and peak power(r=0.452, p=0.035), average power(r=0.473, p=0.026), and total energy(r=0.448, p=0.037).

Table 4. Results of analysis of the correlation between anaerobic exercise ability and isokinetic muscle function.

Item	Peak power (W)	Peak power (W/kg)	Average power(W)	Total energy(J)	Peak drop (%)
Right extensor(%BW)	0.182	0.245	0.154	0.127	0.025
Left extensor(%BW)	-0.268	-0.005	-0.288	-0.299	0.162
Right extensor(Nm)	0.452*	0.192	0.473*	0.448*	0.072
Left extensor(Nm)	.062	.005	.095	.070	.238
Left/right extensor(deficit)	.143	.154	.137	.157	.046
Right flexor(%BW)	.012	.179	-.146	-.151	.149
Left flexor(%BW)	-.349	-.183	-.364	-.357	-.020
Right flexor(Nm)	.325	.191	.226	.216	.172
Left flexor(Nm)	.029	-.137	.049	.045	.043
Left/right flexor(deficit)	-.012	-.115	.049	.059	.018
Flexor/extensor left ratio	.097	-.081	.074	.092	-.140
Flexor/extensor right ratio	-.159	-.002	-.285	-.269	.082

Note: *p<.05.

4. Discussion

Although domestic softball is said to have achieved qualitative and quantitative growth, it is still one of the most unpopular ball sports that is being distributed to the public, focusing on club members rather than elite players. Citing prior research data from Yang Seung-won and Yeo Chul-hoon(2013)[1] due to the difficulty of collecting the latest data, there are currently 20 domestic softball teams, with fewer than 300 players registered[18]. However, no information on the current status of teams, players, and coaches are available on the official website of the Korea Baseball Softball Association(KBSA). According to the results of the domestic and foreign prior research related to softball, domestic research shows the physical strength of pitchers and fielders[1], the correlation between pitcher's isokinetic myofunction by body segment and pitch speed[19], kinetic analysis of batting motion[15], the relation between batting average and physical strength factors[20], the physical strength comparison according to defense position[14], and dynamic analysis for effective hitting of left-handed batters[21]. Foreign studies were also mostly sports medical or dynamic approaches, such as injury-related studies[8][22][23], pitcher's shoulder and elbow joints alignment[9][11][12], the scope of operation of the shoulder and hip joints[10], the effect of pitchers and catchers on performance[24], and cross-analysis of baseball and softball players[25], and only some field-related research was conducted in relation to the field expertise in baseball[6][7][26]. As mentioned above, this study was conducted to find out the correlation of softball players' field skills, anaerobic exercise ability, and isokinetic muscle function, which were deemed to be very insufficient in domestic and foreign prior research.

The study found no statistical significance in all measurement items in field skills and anaerobic exercise abilities. Due to the characteristics of the Wingate test, which assesses anaerobic exercise ability based on field skills and the lower body, it is believed that there will be some difficulties in explaining the clear correlation and further research will be needed.

The analysis of the correlation between field skills and isokinetic muscle function shows a significant correlation between bat speed and left extensor(p<.05) and in throw distance, a

significant correlation was shown in weight ratio left extensor($p<.01$) and left extensor($p<.01$). In base running, there was an inverse correlation in weight ratio right flexor and the first base($p<.05$), second base($p<.01$), and home($p<.05$) and right flexor/extensor ratio and the first($p<.05$) and second base($p<.05$). These results suggest that the left extensor is involved in the throwing and batting movements. In particular, it is believed that the left leg is related to the left extensor as the movement of the left leg supports the foot and becoming the axis. The kinematic analysis of excellent softball players' batting behavior(Baek Jin-ho and Park Jong-cheol(2008)[14]) also supports this study, which shows that the hitting position of an excellent player is significantly related to bat speed and left extensor, as it is said that the center of the body moves closer to the home plate at the point of impact and leads to a swing with the weight towards the pitcher. A significant correlation between base running and right flexor and right flexor/extensor ratio partially supports the results of previous studies by Jung Jae-hoo and Kim Jung-tae(2012)[27] that the movement of running involves stabilizing the lower limbs as well as the truncus. According to a previous study, the extensor and muscle power with flexor of the lower body has a significant impact on sprint ability[28], and performance improves as muscle power increases[28], and sprinting athletes have a better knee joint muscle power than those in other field events[29]. Although there is no direct discussion of the correlation of field tests and lower limbs isokinetic muscle function, it is thought that the relation between right flexor and right flexor/extensor ratio could be partially explained, given the strength and muscle power required for sprinting abilities as well as the characteristics of base running in softball to dash towards home through the first, second, and third bases in the counterclockwise direction. Muscle groups involved in stabilizing posture generally use more flexor than extensor, and for landing after jumping, flexor is used more than extensor.

The analysis of the correlation between anaerobic exercise ability and isokinetic muscle function showed a significant correlation between right extensor and peak power, average power, and total energy($p<.05$). Studies on the correlation between anaerobic exercise ability and isokinetic muscle function were conducted for several sports, including soccer[30][31][32][33][34], rowing[35], and basketball[36]. According to a prior study of male middle school soccer players, anaerobic exercise ability had a significant correlation with right extensor and peak power and average power of left/right extensor and left flexor at 60°/sec angular speed[35]. A prior study on female soccer players showed that in anaerobic exercise ability, peak power and average power had positive correlation with the lower limbs isokinetic muscle function at all the angular speed[32]. According to a prior study of high school rowers, in peak power of anaerobic exercise ability, it reported a significant positive correlation in all measurement items except left and right extensor with an angular speed of 60°/sec and left flexor with angular speed of 180°/sec in average power[35]. A study of high school cyclists showed that the peak power and average power in anaerobic exercise abilities showed significant positive correlation with left and right extensor[37]. As mentioned above, the correlation between anaerobic exercise ability and lower limbs isokinetic muscle function differed depending on the gender, age, physique, fitness, training type, and sport of the subjects. Considering the results of this study, it is believed that the female softball player's peak power, average power, and total energy of anaerobic exercise abilities are related to right extensor of the lower limb isokinetic muscle function.

5. Conclusion

This study analyzed the correlation between field ability, anaerobic exercise ability, and isokinetic muscle function for female softball players. Studies have shown a significant correlation in bat speed and left extensor, throw distance and weight ratio left extensor and left extensor, base running of first base, second base, and home base and weight ratio right flexor, and base running of the first and second bases and right flexor/extensor ratio. Peak

power, average power, and total energy of anaerobic exercise ability showed a significant correlation with right extensor. These findings are expected to provide useful information on the efficient physical training of female softball players in the future.

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7. Contribution

7.1. Authors contribution

	Initial name	Contribution
Lead Author	CWK	-Set of concepts ☑ -Design ☑ -Getting results ☑ -Analysis ☑ -Make a significant contribution to collection ☑ -Final approval of the paper ☑
Corresponding Author*	PJS	-Corresponding ☑ -Play a decisive role in modification ☑
Co-Author	LSJ	-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 ☑

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Relationship Between Body Composition, Physical Fitness, and Blood Variables in ELEMENTARY SCHOOL GIRLS

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Abstract

The purpose of this study was to investigate the effect of exercise program application and the relationship between physical fitness factors and blood variables according to various obesity evaluation criteria for 73 elementary school girls in D-city. As a result of study, body fat percentage and BMI significantly($p<0.05$) decreased after exercise program application. In the case of physical fitness factors, it was found that the right, left, and upper body strength, long jump, and physical efficiency index were significantly($p<0.05$) increased. In the case of blood variables, insulin, GOT, and GPT significantly($p<0.05$) increased, and glucose and HDL-cholesterol significantly($p<0.05$) decreased. As a result of the correlation analysis between body composition-related indicators and physical fitness factors, body fat percentage, BMI, WC, WHR, and WHtR showed significant($p<0.05$) correlation with back muscle strength, and BMI, WC, WHR, and WHtR had significant($p<0.05$) correlations between right and left grip strength. The body fat percentage showed a significant($p<0.05$) inverse correlation with sit-up, standing long jump, and physical efficiency index, and BMI showed a significant ($p<0.05$) correlation with sit and reach, and a significant($p<0.05$) inverse correlation with standing long jump and physical efficiency index. WHtR showed significant($p<0.05$) inverse correlation with in standing long jump. As a result of correlation analysis of body composition-related indicators and blood variables, body fat percentage, BMI, WC, WHR, and WHtR showed($p<0.05$) significant correlation with blood insulin concentration and GPT. Body fat percentage and BMI showed a significant($p<0.05$) correlation with triglycerides, and a significant($p<0.05$) inverse correlation with GOT and HDL-cholesterol. WC showed a significant($p<0.05$) correlation with triglycerides and a significant($p<0.05$) inverse correlation with HDL-cholesterol. WHtR showed a significant($p<0.05$) inverse correlation with HDL-cholesterol. When the results of this study were put together, the 12-week complex exercise program confirmed the positive improvement effect of physical composition and physical fitness factors of elementary school girls.

[Keywords] ***Elementary School, Body Composition, Obesity, Physical Fitness Factors, Blood Variables***

1. Introduction

Korea's entrance exam-oriented education has been affecting the decrease in the physical activity of children due to the increase in the share of private education as well as the decrease in the proportion of arts and science subjects[1][2]. In addition, previous studies by the Ministry of Education, Science and Technology(2013) and Sang-cheol Han(2003)[3][4] reported that the physique of elementary, middle and high school students improved compared to the past, but the deterioration of physical fitness and physical function due to reduced physical activity was serious. This decrease in physical fitness is reported to be a risk factor that not only reduces metabolic function but also increases the prevalence of various types of metabolic syndrome[5]. Se-woong

Jang and Koo-in Jeong(2010) report that the prevalence of obesity increases and the physical fitness decreases in proportion to the physique improvement of elementary school students[6]. Obesity among children and adolescents, such as elementary school students, is likely to lead to adult obesity, and this obesity has been reported to cause various types of metabolic syndrome and complications and to increase mortality[7][8][9][10][11].

Prevention of obesity in children and adolescents is very important because it can have a negative effect on mental health such as inferiority, anxiety, decreased self-esteem, and depression[6][12][13]. The Korean Society for Obesity(2008)[14] reported that the prevalence of obesity of elementary school students in 2005 increased from 12.1% to 18.3% as compared to 1998. In addition, the prevalence of obesity among children and adolescents aged 6-18 in Korea is reported to be 10% in 2013[15], but males are 12.2% higher than females 7.7% [16][17]. The results of a previous study[18] that investigated the risk of cardiovascular disease in obese children and adolescents reported that obese children and adolescents had a higher risk of cardiovascular disease than children who maintained adequate weight. Obesity is assessed through various methods with abnormally increased fat storage in the body. However, considering the economics and convenience of measurement, a relatively simple method through the human body is used for the evaluation of obesity. Body mass index(BMI), waist circumference(WC), skin-fold method, hip / waist hip ratio(WHR), waist circumference/Waist-to-height ratio(WHtR) has been suggested.

However, it is true that there are many areas to be compensated for compared to the method of assessing obesity using expensive measurement equipment such as computed tomography(CT) or dual-energy x-ray absorptiometry(DEXA). The body mass index has a high relationship with body fat mass and body fat percentage, but it can be evaluated as higher than the actual body fat percentage in children and adolescents in the acute period or in elite athletes with small height. Waist circumference is an indirect evaluation method of the abdomen and visceral fat, and is highly related to the risk of abnormal cardiovascular metabolism. However, whether the increased area of body fat is subcutaneous fat or visceral fat cannot be confirmed by measuring waist circumference.

The skin fold measurement method using a caliper shows a high relationship with the subcutaneous fat and body fat percentage, but the difference in the measured value is large depending on the skill of the tester. Obesity and abdominal obesity are evaluated based on hip / waist circumference, but recently, waist / height ratio has been used as an important index to predict cardiovascular disease[19][20][21][22][23]. Ashwell & Gibson(2016) reported that the risk factors for cardiovascular disease were higher when the waist / height ratio was 0.5 or more[24], and Kim Tae-Nyun(2016) suggested that the waist / height ratio is to be a useful indicator for the risk of obesity and metabolic syndrome in adults as well as children[25]. Looking at various previous studies related to obesity in children and adolescents, Heo Sun and Jang Jae-Hoon(2009) reported positive effects on body composition and blood lipid profiles after applying an 8-week exercise program to 20 obese children[26], Ryu Jae-Cheong et al.(2012) reported positive effects of physical education gifted programs for 2nd-6th graders on physical fitness, physique, and exercise performance[27]. Eunjin Baek and Mangyun Lee(2007) report positive effects of 8-week walking and skipping compound exercise training on body composition, fitness, blood lipids, and growth hormone in elementary school students[28]. Most of the previous studies report the effect of applying a temporary exercise program. Therefore, this study analyzed the effects of exercise measures through the application of exercise programs tailored to the 4th grade physical education progress to increase the likelihood of exercise persistence, and confirmed the relationship between physical fitness and blood variables according to the obesity evaluation criteria through various measurement system of physical structure for the important basis for prevention and management of obesity.

2. Research Method

2.1. Research subjects

Subjects were consisted of 73 elementary school girls located in D city. All subjects participated in the experiment with the consent of the parents and themselves, and were fully explained the purpose, method, and precautions of the experiment before the experiment. Physical characteristics are shown in <Table 1>.

Table 1. Physical characteristics of subjects(N=73).

Age(yr)	Height(cm)	Body weight(kg)	%fat(%)	BMI(kg/m^2)
9.19 ±0.39	138.04 ±7.07	34.18 ±7.74	26.39 ±6.39	18.22±2.76

Note: Values are mean±SD.

2.2. Exercise program

Elementary school students in this study performed a combined exercise program consisting of aerobic and resistance exercise for 12 weeks at a frequency of 3 times per week. Two of the three exercises a week consisted of a combined exercise program in accordance with the physical education progress of the fourth grader in the elementary school. One exercise time was conducted for 40 minutes. The warm-up exercise was performed for 5 minutes, and this exercise was conducted for 30 minutes with an aerobic exercise program and a resistance exercise program that can be performed by couple. The rearranging exercise was performed for two minutes of gymnastics and stretching for 5 minutes, and maintained the RPE of 9-11.

2.3. Measurement

2.3.1. Body composition

Height, body weight, lean body mass and body fat percentage were measured using InBody J50(Biospace, Korea), and body mass index was calculated using body weight and squared height(kg/m^2). The waist circumference measured the horizontal position of the lower part of the ribs and the middle part of the upper part of the iliac crest, and the hip circumference measured the widest part of the hip to calculate the ratio of the waist circumference to the hip circumference. Waist circumference/height ratio was calculated by dividing waist circumference(cm) by height(cm).

2.3.2. Physical fitness

As a measurement item of muscle strength, the maximum muscular strength of the low back was measured using a back muscular dynamometer(Takei, Japan), and the maximum muscular strength of the left and right forearm muscles was measured using a grip strength dynamometer(Takei, Japan). For the muscular endurance measurement, the sit-up was performed, and the maximum number of repetitions was measured for 30 seconds[29]. Flexibility measurement item was bent forward in a sitting position, and power measurement item was measured by the standing long jump. For cardiopulmonary fitness, Harvard's step test was conducted, and after a 3-minute step exercise at a rate of 30 minutes per minute, the heart rate of 1 minute to 1 minute 30 seconds, 2 minutes to 2 minutes 30 seconds, and 3 minutes to 3 minutes 30 seconds was measured. The value was calculated using the formula for calculating the physical efficiency index {[Total exercise time(seconds) / (total of 3 times of heart rate × 2)] × 100}.

2.3.3. Blood variables

Subjects in this study were kept on a fasting for 12 hours, and 10 ml of blood was collected from the brachial vein. The concentrations of glutamic oxaloacetic transaminase(GOT), glutamic pyruvic transaminase(GPT), triglyceride(TG), total cholesterol(TC), high density lipoprotein cholesterol(HDL-C), low density lipoprotein cholesterol(LDL-C) are pre-treated using the respective analysis kits(CHOD-PAP Sys 1, TG GPO-PAP Sys 1, HDL-C plus), followed by a spectrophotometer(COBAS MIRA PLUS) with analyzing the sample and the standard on the absorbance of a wavelength of 500 nm, 550 nm, and 580 nm. Blood insulin concentration was analyzed by Radio Immuno Assay method using Insulin IRMA(Biosource, Belgium). Blood glucose concentration was measured by using a kit(GLU-HK, Asan Pharmaceutical, Korea) using the enzyme-based Hexokinase(HK) method to react 320 µl of GLU-HKR-1 and 80 µl of GLU-HK R-2 with 3 µl of the sample. After the absorption, the absorbance was measured at a main wavelength of 340 nm and a sub-wavelength of 415 nm. GOT and GPT were mixed with 260 and 130 µl of serum samples 15 µl and enzyme reagents A and B(Asan Pharm, Co. 706, Korea), respectively, using an absorbance analyzer(Hitachi 7170, Japan) were measured under a dominant wavelength of 340 nm and sub wavelength of 600 nm conditions.

2.4. Statistical analysis

Mean and standard deviation of each measurement variable were calculated using the SPSS 21.0 program. Paired t-tests were conducted to analyze the differences between before and after exercise program application, and Pearson correlation coefficients were calculated to analyze the relationship among body fat percentage, body mass index, waist circumference, hip/waist circumference, waist circumference/height ratio, health related physical fitness, and blood variables. The statistical significance level was set to $p < .05$.

3. Result

3.1. Body composition

The changes of body composition before and after the application of the exercise program are shown in <Table 2>.

Table 2. Changes of body composition between before and after exercise program.

Items	Pre-exercise(N=73)	Post-exercise(N=73)	t	P
Body weight(kg)	34.18±7.74	34.45±8.03	-2.514	.014**
%fat(%)	26.39±6.39	24.27±7.70	4.265	.001**
BMI(kg/m^2)	18.22±2.76	17.95±2.86	3.814	.001**
WC(cm)	57.14±7.37	57.55±7.42	-1.367	.176
WHR	0.80±0.05	0.79±0.04	1.595	.115
WHtR	0.418±0.04	0.417±0.04	0.731	.467
% fat of skinfold(%)	21.57±6.21	21.76±6.19	-0.941	.350

Note: Values are mean±SD, ** p<.01(as compared to pre-exercise)
BMI: body mass index; WC: waist circumference;
WHR: Ratio of waist circumference to hip circumference; WHtR: waist-to-height ratio.

3.2. Physical fitness

Changes in physical fitness factors before and after the application of exercise programs are shown in <Table 3>.

Table 3. Changes of physical fitness between before and after exercise program.

Items	Pre-exercise(N=73)	Post-exercise(N=73)	t	P
Back muscular strength(kg)	28.54±7.63	26.66±6.80	2.543	.013*
Right grip strength(kg)	12.45±2.92	15.09±3.01	-10.172	.001**
Left grip strength (kg)	12.37±3.05	14.39±3.37	-7.865	.001**
Sit-up(frequency)	17.99±5.42	21.16±4.44	-6.457	.001**
Sit and reach(cm)	9.49±6.94	9.89±6.70	-1.065	.290
Standing long jump(cm)	102.33±15.74	115.76±17.58	-7.623	.001**
Physical efficiency index(%)	55.85±7.90	57.92±8.83	-2.229	.029*

Note: Values are mean±SD, * p<.05, ** p<.01(as compared to pre-exercise).

3.3. Body composition blood variables

Changes in blood variables before and after application of exercise programs are shown in <Table 4>.

Table 4. Changes of blood varables between before and after exercise program.

Items	Pre-exercise (N=73)	Post-exercise (N=73)	t	p
Insulin(μIU/ml)	8.66±9.02	12.03±15.63	-2.371	.020*
GOT(mg/dL)	23.42±5.22	24.32±4.91	-2.170	.033*
GPT(mg/dL)	12.82±4.39	14.70±5.04	-4.036	.001**
Glucose(mg/dL)	87.10±5.10	82.34±5.24	6.751	.001**
TC(mg/dL)	173.30±23.51	169.38±36.72	1.772	.081
HDL-C(mg/dL)	58.23±10.54	52.67±10.49	7.027	.001**
LDL-C(mg/dL)	99.65±23.61	95.69±24.62	1.979	.052
TG(mg/dL)	77.08±52.13	80.81±36.77	-0.775	.441

Note: Values are mean±SD, * p<.05, ** p<.01(as compared to pre-exercise).

3.4. Analysis of correlation between body composition and physical fitness factors

<Table 5> shows the results of analyzing the correlation between body composition-related indicators and physical fitness factors.

Table 5. Relationship between physical fitness and body composition.

	Back muscular strength	Grip strength (Right)	Grip strength (Left)	Sit-up	Sit & reach	Standing long jump	Physical efficiency index
%fat	.238*	.089	.060	-.298*	-.016	-.398**	-.272*
BMI	.315**	.378**	.281*	-.107	.240*	-.252*	-.294*
WC	.345**	.450**	.420**	-.102	.179	-.217	-.219

WHR	.290*	.240*	.273*	-.027	.125	-.128	-.012
WHtR	.304**	.275*	.242*	-.106	.165	-241*	-.197

Note: Values are Pearson correlation coefficients, * p<.05, ** p<.01.

3.5. Analysis of correlation between body composition and blood variables

<Table 6> shows the results of analyzing the correlation between body composition and blood variables.

Table 6. Analysis of correlation between body composition and blood variables.

	Insulin	GOT	GPT	Glucose	TC	HDL-C	LDL-C	Triglycer-ide
%fat	.337**	-.284*	.279*	-.028	.064	-.372**	.165	.261*
BMI	.529**	-.326**	.251*	-.061	.039	-.436**	.196	.248*
WC	.551**	-.155	.234*	-.046	.041	-.364**	.184	.245*
WHR	.368**	.001	.319**	-.106	.146	-.125	.225	.058
WHtR	.433**	-.111	.344**	-.053	.130	-.367**	.276*	.200

Note: Values are Pearson correlation coefficients, * p<.05, ** p<.01
TC: total cholesterol; HDL-C: high density lipoprotein-cholesterol; LDL-C: high density lipoprotein-cholesterol.

4. Discussion

The purpose of this study was to provide basic data for the prevention and management of obesity in elementary school girls by analyzing the effects of exercise program application for elementary school girls and checking the relationship between physical fitness factors and blood variables according to the obesity evaluation criteria. Youfa Wang(2002) reported an increase in obesity among elementary school students by 6.4 times for men and 4.7 times for women for 18 years[30], and the World Health Organization(2012) reported that childhood and obesity was a serious public health problem in the 21st century. It is recognized as[31]. As the most effective management method for obesity, many previous studies have suggested exercise and correct eating habits[32][33][34][35]. As a result of this study, the application of a regular exercise program significantly($p < .01$) decreased body fat percentage and BMI with a significant($p < .01$) increase in body weight. The effect of reducing body fat percentage and BMI after exercise program was consistent with the results of a number of previous studies[36][37][38][39][40][41].

However, a significant increase in body weight($p < .01$) was somewhat different from the results of previous studies, but considering the significant reduction effect of body fat percentage and BMI, it could be evaluated as a positive effect due to a decrease in body fat and an increase in muscle mass. In the case of physical fitness factors, it showed a tendency to increase in all the measurement items except the back muscular strength. Especially, the grip strength left and right($p < .01$), the sit-up($p < .01$), the standing long jump($p < .01$), and the physical efficiency index($p < .05$) showed a significant increase. In many previous studies have analyzed the effect of applying exercise programs on children, most fitness factors such as muscle strength, muscular endurance, balance, agility, and cardiorespiratory endurance are

reported to be significantly improved or improved tendency after applying exercise programs[42][43][44], therefore these previous results supported to this results.

However, the decrease in back muscle strength, which is a measure of muscle strength, is not considered to have a positive effect on the composition of the combined exercise program in this study, or the intensity and duration of exercise, and it is necessary to improve and supplement the exercise program in the future. Physical activity and participation in exercise programs are known to reduce the prevalence of cardiovascular disease through positive changes in body composition and blood variables[40][41][45]. Blood glucose concentration showed significant decrease($p < .01$) after exercise program in this study, and it appears to be consistent with the results of previous studies. Although blood insulin levels, GOT, and GPT were found with statistical differences, these changes of all items were shown within the normal range, and HDL-C concentration was found to have decreased within the normal range.

Changes in blood lipid profiles require changes in dietary habits and exercise program for a relatively long time, and in view of this, previous studies of Kraus et al.(2002)[46] positive changes in blood lipids have a longer duration of exercise than exercise intensity. It is thought that some of the results of this study could be interpreted by this previous study[46]. In other words, it is considered that the duration of exercise program in this study is not sufficient for positive improvement of blood lipids, especially HDL-C concentration. It has been reported that obesity in children and adolescents has a negative effect on blood lipid changes, increasing various complications and mortality, including cardiovascular disease[6][7][8][11][47]. In addition, stress on appearance and negative physical image have adverse effects on mental health[12][13], and socio-economic costs are also incurred[48]. The obesity of children and adolescents is likely to lead to obesity in adults, so it is considered that continuous solutions should be sought.

As a result of analyzing the correlation between body composition-related indicators and physical fitness factors, body fat percentage showed a significant($p < .05$) correlation with back muscle strength, and significant($p < .01$) inverse correlation showed between sit-ups and standing long jump. BMI showed a significant correlation with back muscle strength, right grip strength($p < .01$), left grip strength and sit and reach($p < .05$), and showed significant inverse correlation with standing long jump and physical efficiency index($p < .01$). WC showed a significant($p < .01$) correlation with the back muscular strength and grip strength. WHR showed a significant($p < .01$) correlation with the back muscular strength and grip strength. WHtR showed a significant($p < .05$) correlation with back muscular strength($p < .01$) and grip strength, and showed a significant($p < .05$) inverse correlation with standing long jump.

These results confirmed that the positive correlation between body composition-related factors and muscular strength measurement items, whereas body composition-related factors were inversely correlated with muscular endurance, power, and cardiopulmonary endurance, and the difference among body composition-related factors could not be confirmed, respectively. As a result of analyzing the correlation between body composition-related indicators and blood variables, body fat percentage showed significant correlation with blood insulin concentration($p < .01$), GPT and TG($p < .05$), and GOT($p < .05$) and HDL-C($p < .01$). BMI showed a significant correlation with blood insulin level($p < .01$) and GPT and TG($p < .05$), and it was significant inverse correlation with GOT($p < .01$) and HDL-C($p < .01$). WC showed a significant correlation with blood insulin concentration($p < .01$), GPT and TG($p < .05$), and showed a significant inverse correlation with HDL-cholesterol($p < .01$). WHR showed a significant($p < .01$) correlation with blood insulin levels and GPT.

WHtR showed a significant correlation with blood insulin level, GPT($p < .01$) and LDL-C($p < .05$), and showed a significant($p < .01$) inverse correlation with HDL-C. After applying the aerobic and resistance exercise program in many previous results[49][50][51][52][53], the effects of exercise training on the changes of blood variables were not consistent. As a result of this study, the 12-

week combined exercise program significantly increased most of the physical fitness factors, whereas no positive changes in blood variables were found. However, although the body weight of most elementary school girls in this study falls within the normal range, and considering that exercise intensity and duration were not sufficient due to the application of an interest-oriented exercise program to motivate participation in exercise programs, these results in this study can be regarded as a sufficiently meaningful results.

5. Conclusion

The purpose of this study is to suggest basis data for the prevention and management of obesity in elementary school girls by the analysis of the effects on physical fitness factors and blood variables and the association among of body composition, physical fitness, and blood variables after applying exercise programs in elementary school girls. As a result of analyzing body composition, physical fitness factors, and blood variables in 73 elementary school girls in metropolitan cities, the 12-week combined exercise program could not confirm positive changes in blood variables, but significantly increased physical fitness factors. Therefore, the combined exercise program with aerobic and resistance exercise applied in this study is considered to be an effective exercise program for improving physical fitness in elementary school girls. As a suggestion, further research is needed to analyze differences between more subjects and gender.

6. References

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7. Contribution

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A Narrative Study on the Preparation Period for the Performance Improvement of the Winner of TAEKWONDO Demonstration Competitions

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Abstract

This study examines the empirical meaning of the winners of the breaking events at taekwondo demonstration competitions through these narratives, identifies the psychological characteristics of the winners through the psychological technology model of Vealey(1988), and captures the stories in the winning experiences. The purpose is to share ways to improve the performance and to provide the necessary information for the psychological training of the field leaders and athletes through the psychological characteristics of the elite athletes of the taekwondo demonstration competitions.

Participants for the narrative research were selected through the purposed sampling, and four athletes who had won the championship in the last three years were selected and interviewed from the Taekwondo Hanmadang competition and university president's flag competitions organized by the Korea National Sport University and Yongin University.

First, in the preparation for the competition, the basic techniques were repeated practice, strategic composition, basic physical strength, diet control, and protective mats. Basic techniques included self-efficacy, and psychological techniques included stress management, image training through relaxation, motor-sensory image training, inner mental training, and leadership, encouragement, conditioning, and communication.

Second, in the stories of the competition venue, repeated practice appeared as a basic technique among psychological techniques. Self-efficacy and sports confidence were shown as basic skills, and during the practice process, mental image training, subjective goals, cognitive strategies, internal mental training, self-talk, and objective goals were shown as psychological techniques. Interpersonal orientation was a facilitation technique, and performance technique included adaptation to the environmental factors, strategic analysis, and focus.

[Keywords] ***Taekwondo, Demonstration, Competition, Narrative, Breaking***

1. Introduction

With the founding of the Kukkiwon Demonstration Team in 1974, taekwondo demonstration played a significant role in promoting and disseminating taekwondo not only in Korea but also around the world. And since Taekwondo Hanmadang, the first taekwondo demonstration competition, in 1992, the taekwondo demonstration began to draw attention every year, and it has now become a culture beyond just a means of promoting taekwondo. As a result, many exhibition competitions began to take place, including the KTA Breaking King Competition in 2009 and the President's Flag competitions of various universities. Quantitative increases in demonstration competitions have led to an increase in the number of taekwondo trainees and studios[1].

Currently, taekwondo demonstration events are directly related to the university entrance exam depending on the organization responsible for the competition and the revitalization of the competition, increasing the number of athletes participating in taekwondo demonstration competitions, and the difficulty of the technology performed has rapidly heightened. Kim JS[2] said that the technical difficulty of the participants has improved significantly through many changes in competition rules and is similar to gymnastics and figure skating. Breaking(such as pine board) demonstration should capture free expression based on the principle of attack that taekwondo kicks, and participants make efforts and passion because their proficiency in natural movements and skills is important. It is just as hard work as a mason grinding and polishing numerous stones to make a single work of art. Both physical and psychological strength, technology, and skills play a major role in perfecting these high-level skills[3][4]. Therefore, demonstration competition participants will have to do their best to improve their performance through steady training for their physical and psychological strength and skills.

The research on the performance in taekwondo demonstration events so far includes a study on the failure factors of the technical performance[5], a study on the performance level by events[8], and a study on the slump of the demonstration team members[6], and studies on the psychological perspectives have also been conducted consistently[7][8][9]. Psychological skills are a part of sports science, which has recently been considered important for improving performance. This study aims to identify the empirical meaning of the winners applying a narrative approach among qualitative research methods and to understand the psychology of the preparation process for taekwondo demonstration competitions. Narrative analysis is a method that emphasizes the various opinions of the results found through the narrative exploration method from[10], where researchers collect narratives about events that occurred and present them as new narratives through researchers' unique interpretations[11].

Accordingly, this study examines the empirical meaning of the winners of the breaking events at taekwondo demonstration competitions through these narratives, identifies the psychological characteristics of the winners through the psychological technology model of Vealey[12], and captures the stories in the winning experiences. The purpose is to share ways to improve the performance and to provide the necessary information for the psychological training of the field leaders and athletes through the psychological characteristics of the elite athletes of the taekwondo demonstration competitions.

2. Research Method

2.1. Research participants

Participants for the narrative research were selected through the purposed sampling, and four athletes who had won the championship in the last three years were selected and interviewed from the Taekwondo Hanmadang competition and university president's flag competitions organized by the Korea National Sport University and Yongin University.

Table 1. Research participants.

Name	Age	Education	Level of dan	Career
Participant a	28	Graduate school student	5	Winner of world taekwondo hanmadang breaking event (2018)

Participant b	25	College student	5	Winner of world taekwondo hanmadang breaking event (2017)
Participant c	20	College student	4	Winner of the taekwondo demonstration event organized by Korea National Sport University (2018)
Participant d	20	College student	4	Winner of the taekwondo demonstration event organized by Yongin University (2018)

2.2. Material collection and research process

In this study, due to the close personal contact between researchers and research participants, the researchers considered the following issues to be cautious about a number of ethical issues that may arise in the course of the study.

First, the research participants were fully explained in the process of selecting a research participant, and the consent was obtained and the consent of the research participant was signed.

Second, the researchers made efforts to protect the personal information of the research participants, used aliases, and kept the contents of personal information among the collected data confidential.

The researchers mainly used interviews with research participants to collect data and supplemented the contents of interviews by collecting various literature related to research topics.

For efficient data collection, the research needs, research problems, interview questionnaires, and protocols were set up in advance based on the areas that were not clearly addressed after understanding the concept of breaking competitions presented in the preceding study and the researchers' assumptions.

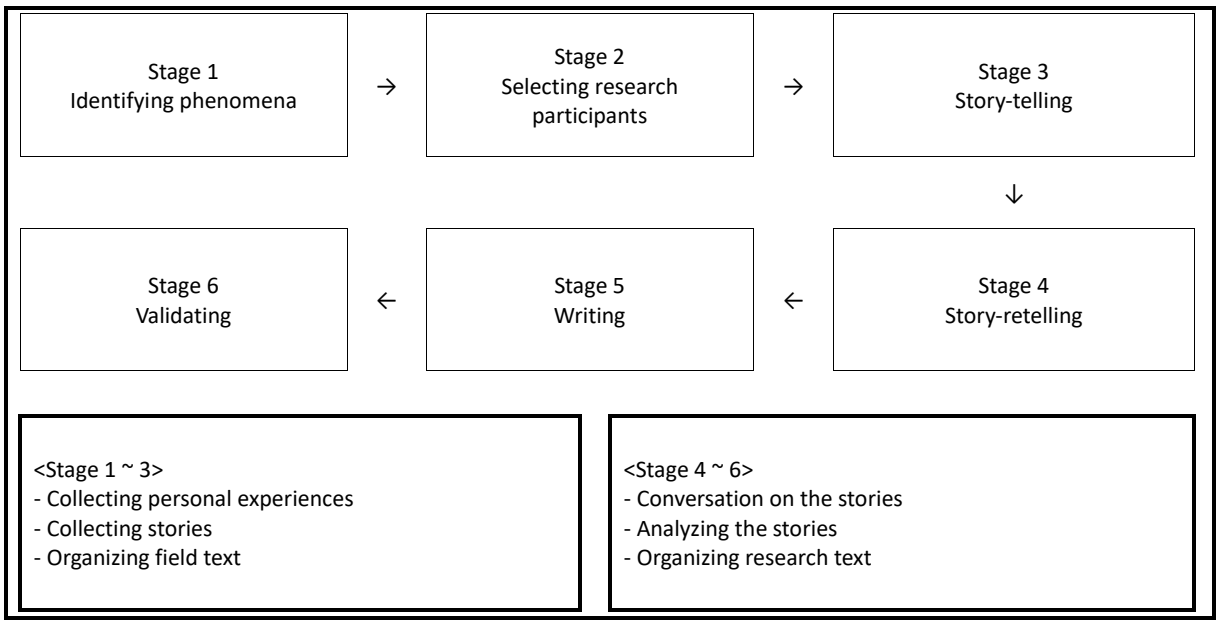
After conducting the interview, a group of experts with Ph.D.s in related fields verified the necessity of research and the validity of research questions, and the interview protocol and final questionnaires were organized. The contents are as shown in <Table 2>.

Table 2. Interview protocol.

Protocol	Questions
Training process	- Training starting process - One's unique strategy - The average amount of training per day, training method - Setting goals - Solving problems during training - Worries while training - Teamwork during training - Staying in shape
A day before the competition	- Psychological training for the competition - Psychological training for the skills - How to control one's condition - Self-control and management - Emotional control - Daily routine

The day of the preliminary round of the competition	- Overcoming possible mistakes during the competition - How to overcome the pressure and anxiety to advance to the final - Spectators - Overcoming failures during rehearsals - Psychological conditions just before the event
The day of the final of the competition	- Overcoming pressure, tension - Daily routine - Anxiety about technical mistakes - Anxiety about winning - Psychological conditions just before the event

Figure 1. Research process.



2.3. Data analysis

Data analysis corresponds to "organizing research texts." Depending on how much the participants in the study represent themselves, the subject story of the researcher can appear, or it can be a study that appears from the perspective of the participants. The process of analysis and interpretation is as follows.

First, the researchers have read the collected text[13] emphasized and planned the research topic, the purpose of the study, and the direction of analysis and interpretation.

Second, while reading the field text, the researchers summarized each of the important contents of the research participants according to the purpose of the research, categorizing and organizing them with the contents.

Third, the researchers analyzed specific factors related to the participants' performance by identifying key factors among the important contents of the research participants and separating the psychological skill and psychological method from the training process through the psychological technology model from Vealey[12].

3. Research Results

This study attempted psychological analysis and interpretation of the experience of winning the breaking event at taekwondo demonstration competition using the narrative research method, and the result was as follows.

3.1. Winners' preparation process before the competition

Table 3. Preparing for the competition.

Participants	Category	Subcategory	Key ideas
A	Winner's training strategy	Repeated training	I try to improve my confidence psychologically through repeated training and practice.
	Problems and countermeasures during the training	Prevention of injury based on basic physical strength	I exercise including physical and weight training to prevent injury.
	Self-management in everyday life	Self-management through diet control	I care a lot about what I eat, so I try not to eat instant food or flour based food as much as possible and try to have a balanced diet.
	The importance of teamwork	Leadership	Rather than worrying about mistakes, we talk a lot like, "Just think you'll succeed no matter what."
	Image training	Stress management	I can't sleep often when I imagine myself participating in the competition.
	Emotional control	Self-efficacy through repeated training	I think I'm relieving tension and anxiety through repeated practice on the work I've prepared.
B	Winner's training strategy	Strategic component	I organize my breaking routine considering psychological and physical factors.
	Problems and countermeasures during the training	Prevention of injury with protective mats	I always use protective mats to prevent possible injury when I perform dangerous techniques.
	Self-management in everyday life	Self-management through diet control	I think I always gained strength by eating meat(protein).
	The importance of teamwork	Encouragement	We tried to boost the team spirit and morale by encouraging each other and saying that we're doing well.

	Image training	Motion sensory image training for success	We imagine that we're delighted after successfully performing the skills that we've been anxious and worried about.
	Emotional control	Relieve anxiety through internal mental training in the course of practice	I try to relieve anxiety by imagining myself pulling off a much better performance than I have practiced so far and through image training.
	Winner's training strategy	Strategic component	I practice breaking routines that I can do fast at the start and spend a lot of time on high-level new technologies at the end.
	Problems and countermeasures during the training	Image training through rest	I take a short break for about 30 minutes and sometimes take a day or two for a break, keep doing the image training, and try to solve the problem after the break.
	Self-management in everyday life	Unique ways to control one's condition	I think I get enough sleep to create the best condition.
	The importance of teamwork	Communication	I'm trying to polish my skills by talking to my colleagues about the problems I have.
C			
	Image training	Motion sensory image training for success or failure	I'm thinking about winning, and also the worst performance I've ever had.
	Emotional control	Relieve anxiety through internal mental training in the course of practice	When I watch a video of a successful performance, I feel relaxed and think I can do well in the competition.
D	Winner's training strategy	Strategic component	I increase the performance level by placing the skills of which I'm confident and then placing high-skill kicks in the end.

	Problems and countermeasures during the training	Prevention of injury based on basic physical strength	I'm doing a lot of muscle exercises that are necessary for the performance.
	Self-management in everyday life	Unique ways to control one's condition	I keep in shape with washing with warm water, massage, and stretching.
	The importance of teamwork	Communication	I try to make up for my shortcomings as much as possible by communicating with my colleagues.
	Image training	Motion sensory image training for success or failure	I do image training by repeatedly thinking about the image when I succeed and fail.
	Emotional control	Relieve anxiety through internal mental training in the course of practice	I do the image training by watching the performance video and telling myself "I will not make the same mistake tomorrow."

3.2. Winner's preparation for the day of the competitions

Table 4. Participants' stories at the venue.

Participants	Category	Subcategory	Key ideas
A	Overcoming anxiety about technical failure during the rehearsal on the day of the competition	Adaptation to environmental factors	Since the performance might fluctuate depending on the circumstances at the venue, I try to adapt to them as soon as possible to find psychological stability.
	Overcoming anxiety about mistakes during the performance (preliminary round)	Overcoming anxiety through strategic analysis	I try to overcome the anxiety by analyzing the preliminary round and compensate for the shortcomings.

	Overcoming anxiety about mistakes during the performance (final)	Mental image training through the training process	I usually do image training while watching videos that I practiced before performing.
	Overcoming the spectator pressure	Sports confidence	I've been doing my best since the preliminaries so that the players around me can think, "You've prepared a lot and you have that much confidence!"
	Psychological state just before the Performance (preliminary round)	Focus to overcome anxiety	I don't think about anything else and try to focus on the situation as much as possible.
	Psychological state just before the performance(final)	Performance with subjective goals	I go in with the thought of doing my best so that I don't regret it.
	Overcoming anxiety about technical failure during the rehearsal on the day of the competition	Repeated practice and internal mental training	I practice my skills until I succeed and imagine that I succeeded at the end before entering the competition.
	Overcoming anxiety about mistakes during the performance (preliminary round)	Overcoming anxiety through interpersonal orientation	When I get anxious, I talk to people around me a lot and try not to think about the mistakes.
B	Overcoming anxiety about mistakes during the performance(final)	Sensory internal mental image training	When I feel anxious, I think about the feelings that I had when I did well when practicing.
	Overcoming the spectator pressure	Sports confidence	I tend to enjoy the eyes of the spectators. Because I have confidence in my skills, it wasn't that hard to have spectators.
	Psychological state just before the Performance (preliminary round)	Self-efficacy to overcome state anxiety	I'm nervous but I try to enjoy it as much as I can. I want to show them what I've been working hard on, and I think I can do well.
	Psychological state just before the performance(final)	Self-efficacy through self-talk	Just before the competition, I go like, "This is it! It's fun! Let's go!"

	Overcoming anxiety about technical failure during the rehearsal on the day of the competition	Repeated practice and internal mental training	I'm trying to find a space in the competition venue and overcome the anxiety by repeating image training and technical training.
	Overcoming anxiety about mistakes during the performance (preliminary round)	Positive thinking with self-talk	"Let's just do what we've practiced!" and "Let's not worry about other participants!" make me less mistake-prone.
C	Overcoming anxiety about mistakes during the performance(final)	Sensory internal mental image training	I think about the skills that I practiced and successful situations.
	Overcoming the spectator pressure	Selective focus	If I think about myself and my team, I can't feel the eyes of people around me, thus getting rid of the anxiety.
	Psychological state just before the Performance (preliminary round)	Performance with objective goals	I'm just going to show them what I've practiced and try not to think about doing super well.
	Psychological state just before the performance(final)	Performance with subjective goals	I think about performing without regret, thinking that the training to prepare for the competition was done through the competition.
	Overcoming anxiety about technical failure during the rehearsal on the day of the competition	Interpersonal orientation of social cohesion	I ask the team members about the cause of the failure and try to solve the problem through a conversation.
D			
	Overcoming anxiety about mistakes during the performance (preliminary round)	Self-efficacy in the preliminary round	I try to go through the preliminary round relaxed.

Overcoming anxiety about mistakes during the performance(final)	Interpersonal orientation of social cohesion	I tend to get rid of my anxiety when I hear compliments and encouragement from coaches and team members.
Overcoming the spectator pressure	Interpersonal orientation of social cohesion	I think the words of encouragement from the coach and team members may have helped to overcome the anxiety.
Psychological state just before the Performance (preliminary round)	Performance with objective goals	I keep thinking that I should do my best.
Psychological state just before the performance(final)	Overcoming anxiety with self-talk	I enter the competition, thinking, "If I do the same as I did in the preliminaries, I will win."

4. Discussion

This study conducted a narrative study on the winning experience of the athletes who won taekwondo demonstration competitions. By organizing the winning experience of the participants, as shown in the research process, the participants' experience is understood in context, and based on the psychological technology model of Vealey[12], the common psychological characteristics of the winning experience of the taekwondo demonstration competition are explored and the discussion of the analyzed results is as follows.

4.1. Factors for performance levels presented by winners' narratives in the preparation of the competitions

The breaking event of the taekwondo demonstration competition has a time limit of 50 to 60 seconds, which requires all of the skills to be showcased within a given time, and the performance is scored according to how perfectly one expresses one's skills. The participants prepare strategically and train repeatedly for the skills to be presented in the competition, and these players' strategic composition and repeated practice were applied as strategies to improve confidence and to maintain the physical and psychological stability. These results were similar to those in the study by Lee YJ[14] that repeated practice becomes a habitual behavior and one needs to consciously train until one reaches a point where the skills are performed unconsciously.

Injuries are major problems in the study participants' training sessions. They try to prevent injuries with protective mats, training for basic physical strength, taking a break, and conducting image training on problems. It is the basic technique of psychological techniques to use protective mats and to train basic physical strength along with conducting image training to cope with injuries. Using protective mats is to minimize the impact on joints during high-level technical training. The basic techniques were applied as a strategy to solve their problems while taking a rest by conducting image training on the problems that the participants themselves recognized. A study by Kim HJ[15] showed the highest frequency of image training in cognitive areas as a

way to improve the condition of high school gymnasts before the competitions, which was similar to the results of previous studies.

Due to the nature of the taekwondo demonstration, aerial movements are carried out, so problems with injuries and conditioning are required. Research participants were practicing self-control in their private lives to prevent injuries and keep in shape, which included diet, warm water, stretching, massage, and sleep to lessen the fatigue.

Diet from the self-management methods is a basic technique among psychological techniques, and participants' unique way of conditioning is a facilitation technique among psychological techniques, and these results coincide with the results of the study of Kim JS[9] that managing the lack of nutrition as an intervention strategy to demonstrate the best performance of the national demonstration team and that life control plays an important factor in conditioning.

Taekwondo demonstration competitions require teamwork among team members. Research participants showed leadership by leading team members according to their respective positions, communicating problems with team members and encouraging each other, and maintaining good relationships with one another. The leadership, communication, and encouragement all affect the improvement of teamwork as facilitation technique among psychological skills, and these results are similar to the research by Kim JS[9] that showed that the team's high sense of belonging and the teamwork was always important when performing demonstrations.

Contradictory results showed that participants in the study may relieve anxiety or on the contrary may feel anxious through image training. Some research participants felt stressed when doing image training on the eve of the competition and applied stress management as a strategy to maintain psychological stability. These results are in part consistent with previous studies done by Lee YC[16] showing that gymnasts suffered sleep deprivation, physical degradation, and anxiety due to the strain on the competition. In contrast to these results, other participants were conducting image training for success in pulling off high skill moves, motor-sensory image training to imagine success and failure, and image training for these successes, which were applied as a confidence-boosting strategy as a psychological technique. These results are similar to studies of Cho EJ & Park BY[17] showing that positive images block negative thoughts about mistakes and help improve concentration and that individual mental images of perfect performance increase confidence when performing in the actual competition.

The anxiety that participants feel in the events is competition anxiety. It depends on how the external stimuli are accepted and how the internal factors accept the stimuli. The participants minimized anxiety with improved confidence through repeated practice and emotional control by watching what they did well. The self-efficacy of these participants is a basic skill among psychological skills, and the relaxation of anxiety through mental training during the practice process was being used as a method of controlling their emotions. These results showed that technical strength and skill understanding factors affect performance level in the study of Kang IP[18] on the taekwondo Poomsae(forms) performance determinants, showing that confidence has increased through repeated training by research participants. A study by Kim JS[9] is also similar in that it found that members of the national team continue to imagine when performance went well as a positive thinking factor.

4.2. Factors for performance levels presented by winners' narratives at the competition venue

Most of the athletes participating in the taekwondo demonstration competition visit the venue from dawn to practice. Research participants adapted to environmental factors as a way to overcome technical failures during rehearsals on the day of the competition, minimized anxiety through repetitive practice, internal mental training, and asking team members about their problems. Adapting to environmental factors is a performance technique among psychological

technologies, and repeated and mental training is a basic technique, and interpersonal orientation that solves problems through team members is a facilitation technology, and participants are applying these methods widely. These results are a "Jeon MW[19]" study of obstacles and countermeasures affecting performance. Psychological obstacles in the competition environment are the schedule, the way the competition is conducted, the facilities, the clothing, and the adaptation to the competition venue, and the countermeasures are the focus, physical relaxation, adaptation, and conditioning. It is in line with this study in that the hindrance to social support include expectations from other people, coaches, and oneself, and countermeasures like advice work effectively.

At the breaking event, the anxiety of athletes competing in the competition is very high because small mistakes may determine the result. As a way to overcome anxiety about mistakes during the competition, participants were analyzing them according to the characteristics of the competition and dealing with them strategically in a spontaneous manner and minimizing the thoughts on the mistakes through conversation with acquaintances they meet at the competition. They tend not to care about the surroundings, tried to have positive thoughts, and had high confidence in the preliminary round. The strategic analysis of these participants showed that it was a performance technique among psychological techniques as a way to cope with anxiety. The interpersonal orientation to meet acquaintances and overcome anxiety is facilitation technique, positive thinking through self-talk is psychological technique, and self-efficacy based on high level of confidence is applied by participants as a strategy to solve these problems. These results showed that autosuggestion accounted for the largest portion of the psychological techniques mentioned by Jeon MW[19]. In terms of the size of the event, the more highly skilled competitors there were, the more nervous they became, and as a countermeasure, it was mentioned to become not too focused on winning or losing. For the research participants, who are taekwondo practitioners, it is believed that a combination of obstacles that occur inside an individual and external factors played a role.

In sporting events, the presence of spectators can promote or inhibit athletes' performance. About 1,500 athletes participate every year in the taekwondo competition events by Korea National Sport University and Yongin University, and about 5,000 athletes from 60 countries around the world participate in the World Taekwondo Hanmadang competition. The research participants confidently showed their trained skills based on the sheer amount of practice, and because of the nature of the demonstration, they enjoyed the eyes of the spectators while also improving their confidence and emphasized the teamwork and focused on the performance without paying attention to the crowd. They also overcame anxiety through advice from the coaches, increased confidence through repeated practice, and enjoyed the attention from others, which constitutes sports confidence that is considered a basic technique of psychological techniques. A study by Kim SO & Kim HP[20] reported that the presence of spectators in sports events may either promote or inhibit athletes' performance.

The most anxious moment during the competition is the moment just before the event. The participants in the preliminary round were confident that they would focus on the situation as much as possible, thought that they would do well on the skills they practiced, and meditated on their goals with the thought of showing as much as they practiced as a way to overcome their psychological anxiety. Focusing on the situation as much as possible to overcome anxiety is a performance technique of the psychological techniques, the self-efficacy based on the confidence of one's practiced skills is a psychological technique of the psychological techniques, and the performance with objective goals is a psychological technique, which all helped the participants overcome psychological anxiety just before the preliminary round.

To overcome anxiety, the participants in the final were found to have engaged in the competition with a subjective idea that they would devote all their energy to the last minute, thinking about hard training just before the competition and positively converted the anxiety about the

final through a determination to perform the same mind as in the preliminary round. These are psychological techniques that the participants used just before the final match to positively transform and overcome anxiety through subjective goals that encouraged them to the last minute, thinking about hard training. The results are consistent with a study by Jeon MW [13] that showed that a total of 17 countermeasures were used to cope with the situation, including change of mind, confidence, breath control, image training, autosuggestion, ordinary state of mind, focus, advice, positive thinking, tactical action, training, practice, temporary treatment, physical stimulation, adaptation, and conditioning, and the athletes' know-how was accumulated depending on various situation and experience.

5. Conclusion

This study aimed to understand the performance factors and direction of the taekwondo breaking event of the demonstration competition contained in the narratives of the winners, and the conclusion of the study was as follows.

First, in the preparation for the competition, the basic techniques were repeated practice, strategic composition, basic physical strength, diet control, and protective mats. Basic techniques included self-efficacy, and psychological techniques included stress management, image training through relaxation, motor-sensory image training, inner mental training, and leadership, encouragement, conditioning, and communication.

Second, in the stories of the competition venue, repeated practice appeared as a basic technique among psychological techniques. Self-efficacy and sports confidence were shown as basic skills, and during the practice process, mental image training, subjective goals, cognitive strategies, internal mental training, self-talk, and objective goals were shown as psychological techniques. Interpersonal orientation was a facilitation technique, and performance technique included adaptation to the environmental factors, strategic analysis, and focus.

The winners indicated through this study that it was time to think positively and reflect on themselves. It is expected that this research would affect the development of taekwondo demonstration competitions and decided that only if these studies continued would it help improve the performance of athletes who perform taekwondo demonstrations.

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7. Contribution

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	Initial name	Contribution
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Corresponding Author*	SHC	-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 ☑

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Exploring the Nature of Genius Loci in SPORT Stadiums Based on Collective Memory in CHINA

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Abstract

The genius loci of sport stadium is the main element for the public to feel the sport atmosphere and experience its function as the city architecture, and it is also the foothold and significance of sport stadium. However, with the change of architectural concept, advanced technology and new building materials gradually become the architectural theme of sport stadium, and the nature of sports carried by it is gradually covered by these phenomena, leading to the weakening of the public's cognition of sport stadium. If this phenomenon exists for a long time, it will not only affect the function of sport stadium and its role in urban development, but also eliminate the nature of it. Therefore, to reconstruct and maintain the genius loci, this paper analyzes the genius loci of sport stadium in China with the main elements of the collective memory, explores the nature of genius loci, and provides suggestions for its spread and continuation in the future. This paper explores the construction of genius loci of Chinese sport stadium based on collective memory through literature review. It fosters to spread and consolidate genius loci of Chinese sport stadium through reconstruction of memory.

According to the results from this study, there are three factors of collective memory. 1)Sport fans as the subjects of memory in the construction of collective memory. 2)Sport events and activities as the carrier in the construction of collective. 3)Stadium carrying Genius Loci as the object in the construction of collective memory. However, there are still some existing problems of genius loci of sport stadiums for the construction of collective memory. Lacking chance to enter into sport stadium hinders interaction between people and stadium. The formation of Genius Loci of stadium needs people deeply interact with stadium. The feeling of subject is the first step to identify Genius Loci of stadium. At present stage, the openness of the stadium is low, and the opportunity for people to feel sports and have emotional resonance is reduced, so it is difficult to interact with Genius Loci of stadium. In addition, low continuity of sport events and activities which causes sport stadium idling impedes the spread of Genius Loci of sport stadium. The number of stadiums has been increasing with the rapid development of sport industry in China but the number of sport event generated is relatively limited. Moreover, location trend from city to suburb blocks the spread of Genius Loci of sport stadium. Most stadiums in China are located in the suburbs of the cities. Although they can be satisfied with the harmony of the surrounding natural environment, the interaction between stadiums and people is severely restricted by the inconvenient traffic and other conditions.

Based on the results from this study, there are several suggestions to keep collective memory of Genius Loci perceive from the stadiums by sport fans. 1)As the subject of the memory, the public's intuitive feeling and experience of sport stadium is the key to the spread genius loci. 2)Sport events are the main ways for the public to interact with Genius Loci. 3)The construction of sport stadium should focus on the integration of the surroundings and become an integral part of urban construction.

[Keywords] ***Collective Memory, Sport Stadium, Architectural Theme, Genius Loci, Public's Cognition***

1. Introduction

Place is the specific space in which a sort of events and activities occur and emotions and behavior can be connected by them here[1]. Stadium is the place where sport events and activities are held. Genius Loci is generated from place and becomes the existence foothold of an architecture. It not only makes the building functional on tangible level, but also gives culture to a building on intangible level[2]. Once a space has Genius Loci, it lives more than a tool. What happened in stadium has gradually formed history of itself and a city. Thus, stadium is a record of history and a city. History is the past which impresses people deeply and can be the reference for the development of contemporary era. While collective memory is an accumulation of the past. It is shared by a group people to acquire identification in society. The number of stadiums has increased for the development of sports. As a valuable resource, collective memory can be sustained in the process of urban development through explicit matter and potential culture. It is one of the most important bases for carrying forward and recording urban history and constructing urban spirit[3]. Stadium is constructed as a part of urban history. However, the stadiums that people are familiar with or even can just remember is only few. Some of them even are not kept in people' memory. Genius Loci of stadium determines whether a stadium exists in city or memory. Losing Genius Loci makes building be a tool just for a certain use. The core of Genius Loci is integration with environment, city and history and kept by the memory[4]. This paper aims to foster the development of stadium; it employs collective memory to analyze Genius Loci of stadium to explore the existence meaning of contemporary stadium.

2. The Three Factors of Collective Memory

2.1. Sport fans as the subject of memory in the construction of collective memory

The subject of collective memory is a group of people sharing common experience. It is the constructor and conservator of collective memory. The subject of collective memory in Genius Loci of stadium is a group of sport fans who watch or experience sport events and activities directly or indirectly in stadium. It is a place to hold sport events and experience the atmosphere of sports for the public. Genius Loci is the foundation of stadium, and also the embodiment of the unique characteristics, which provides orientation for people to identify themselves in such an environment[5]. Therefore, as the subject of collective memory and the direct perceiver of Genius Loci, the construction of collective memory indirectly fosters Genius Loci of stadium, so as to maintain the stable performance of the function of stadium. The construction of collective memory depends on the group's representation of the spatial structure and events of stadium in the past, thus forming the characteristics of it, which is the spirit of the place[6].

The subject of memory is divided into direct participation type and indirect participation type[7]. Direct participants refer to those who have directly experienced the atmosphere brought by sport events in stadium, and these people have much clearer feelings about Genius Loci of stadium. In general, these subjects are sport fans who are willing to invest time and experience in watching sport events in stadium. While the indirect participants refer to the group who never watch sport events in stadium but get impression of stadium for the events and history. These people have relatively less feelings about stadium. Feeling Genius Loci of the stadium need to take advantage of sport events and activities to establish relationship with stadium[4][5]. The increase of events provides more opportunities for direct participants to enter into the stadium and have a visual experience, providing space for them to experience Genius Loci here. Meanwhile the non-match opening of stadium provides the indirect participants with the opportunity to experience Genius Loci of the stadium, combining with the cognition of the stadium through historic records and news reports. Stadium is a typical kind of sport architecture and also a part of urban public buildings. Genius Loci is the soul and meaning of existing

stadium, which provides the orientation and identification for people in stadium. Orientation guarantees people not lose themselves in a new place and identification makes people feel comfortable instead of resisting a place[8]. It fosters the construction of collective memory. Collective memory is an accumulating construction of the past and people can compare the current Genius Loci with the one in different periods by collective memory. Therefore, as the direct perceiver of Genius Loci, the public's participation affects the spread of Genius Loci of stadium.

2.2. Sport events and activities as the carrier in the construction of collective memory

The construction of collective memory depends on the carrier. It is a presentation form of collective memory. Maurice(1992) defined collective memory as the process and result of past shared by people from a specific social group[9]. Paul(1989) used social memory instead of collective memory in how societies remember. He thought that memory should be passed and maintained by ceremony. Commemorative ceremonies and bodily practices are the important method of inheritance[10]. Pierre(1996) believed that space is beneficial to arouse collective memory[11]. In the space of memory, both historical and modern are reflected. In such a space, the memory of people exists in both the space and the self-constructed emotional space, which reflects the complex social relations and local construction between people and space[12]. Genius Loci is the emotional space which is the result of the connection between people and space. Stadium is the place to arouse the memory of people to feel Genius Loci, while sport events and activities are the form of commemorative ceremonies and bodily practices to stimulate people's memory deeply.

The commemorative ceremonies can arouse the resonance of a group of people about a certain period of history in the past, which forms the collective memory and are shared by these people. The memory of stadium of these people is constructed by famous sport events or activities that took place in stadium. Meanwhile stadium, as a memory place, provides spatial support for the construction of collective memory. It is an accumulation to the past, also the presentation of people' cognition of stadium in a certain period which impressed people most. It depends on the orientation and identification originated in Genius Loci of stadium. As a carrier, the sport events and activities in stadium provide space for people to fully experience Genius Loci.

Genius Loci is the sense of space, which is produced from the process from identifying the place to establish deep connection with the place. The formation of Genius Loci is to use the character of architecture to establish intimate relationship between people and architecture[13]. The overall structure of stadium provides material instructions, sport events and activities provide a strong sport atmosphere for Genius Loci. The continuity of sport events and activities connects different times and forms memory fragments of different periods. The fragments at different periods recorded the development of Genius Loci in stadium and indirectly reflected the essential functions of stadium and the functions of it as public architecture in the process of social development. The essential function is presented through sport activities and sport events, which determines the existential foothold of people and stadium. Sport events and activities foster memory fragments constructed and shared by people. The memory fragments make people feel the continuous development of Chinese sports and generate a strong sense of identification. Constructing collective memory through sport events and activities can deepen impression of stadium and keep it in people' mind. Sport events and activities held in different period improve the feelings of Genius Loci of stadium.

2.3. Stadium carrying Genius Loci as the object in the construction of collective memory

The object of collective memory is what the subject of memory remembers when the memory is constructed. Genius Loci of stadium is a kind of ideology, which is a subjective feeling given

by stadium. It is the result that people find their identification in a new space. People construct collective memory of Genius Loci based on the whole structure of stadium. Therefore, the object of memory in the construction of collective memory is Genius Loci in stadiums. It shows through the overall structure of stadium. It provides a specific space and a specific sport atmosphere through internal and external environment and collective memory is formed through individual's different feelings towards stadium. Genius Loci is an important way to measure whether people have a deep impression on stadium and determines whether stadium has architectural vitality[5][13].

In the process of constructing collective memory, Genius Loci of stadium is the embodiment of existence of the stadium in different periods, and the change of it also reflects the change of the historical mission and function in different periods. Therefore, although the collective memory is the construction of the past, people' memory of Genius Loci of stadium is the embodiment of the demands for stadium. Genius Loci of stadium creates a sport atmosphere for people through the facilities in the stadium. People obtain orientation and identification and then generate sense of belonging. Genius Loci makes people and stadium harmony. The harmonious coexistence guarantees the stable development of Genius Loci and also makes collective memory profound. Conversely, the construction of collective memory of Genius Loci of stadium reflects the real meaning of stadium in people' mind, which is not only the full realization of the stadium functions, but also the inheritance and display of culture. Nowadays stadium has gradually been the product of the games. Ignoring the actual remand of stadium makes it become lifeless consumption objects, which are discarded after use and Genius Loci of stadium begins to weaken[14]. The collective memory is constructed in a certain period with clear Genius Loci stadium. Genius Loci is originated from the space. It leads people to establish the relationship between themselves and stadium through the characters of stadium. If Genius Loci is the soul, stadium is the body to carry it and sport events and activities are the decoration to show the soul. Therefore, stadium is the most important condition to produce Genius Loci. While economic benefit is the most important aspect to be paid more attention than how to keep a stadium alive in the construction of stadium. Collective memory shows the memory of the past, but it serves the reality. Collective memory is only constructed when Genius Loci of stadium is clear. Weakening Genius Loci of stadium directly reflected the memory of stadium is vague and it hardly forms a memory fragment shared by a group of people. The loss of Genius Loci in stadium causes the decline of cognition to stadium for people at the present stage. It makes stadium lose its foothold in the process of social development. Moreover, it cannot provide reference for the formation or improvement of Genius Loci of sport stadium.

3. The Existing Problems of Genius Loci of Sport Stadiums

3.1. Lacking chance to enter into sport stadium hinders interaction between people and stadium

The formation of Genius Loci of stadium needs people deeply interact with stadium. The feeling of subject is the first step to identify Genius Loci of stadium. At present stage, the openness of the stadium is low, and the opportunity for people to feel sports and have emotional resonance is reduced, so it is difficult to interact with Genius Loci of stadium. Opening hour determines whether people have opportunity to enter into stadium. Few sport events held in stadium limit the times that people can get into stadium to feel Genius Loci. The openness except sport events is the main chance for indirect participants to get in touch with stadium. No matter sport events and activities or just a space for mass sports, the maintenance and operation costs of some mega stadiums are relatively high. Therefore, some stadiums would be idle than open to the public. These stadiums once held mega sport events, condensing a certain sport atmosphere, is not only an important segment of the public memory, but also an important carrier of the

construction of collective memory. The indirect participants lack the field experience in stadium and lose the way they construct the initial memory of the stadium through the events or reports. The memory without space supporting hinders people' perception of stadium to some extent. Genius Loci rooted in sport context of the specific group has gradually weaken due to the lack of continuous interaction through sport events[15].

3.2. The low continuity of sport events and activities which causes sport stadium idling impedes the spread of Genius Loci of sport stadium

The construction of collective memory of Genius Loci of stadium needs the help of a certain carrier. The material carrier is the stadium where Genius Loci is formed, while the non-material carrier is the sport events that take a place in the stadium. Sport events at each period guarantee the continuity of memory fragments, which is also an important guarantee for the spread of Genius Loci of sport stadium. However, due to the rapid development of sports in China, the number of stadiums began to increase rapidly, but the number of sport events is relatively limited. Some stadiums have the lack of reasonable planning at the beginning of construction, and the starting point of construction is to build for a certain sport events. After the game, the imperfect construction appeared gradually[15]. The number of sport events that some stadiums can undertake is very limited, and idling has become the daily condition. This situation leads to a decrease in the number of direct participants involved in Genius Loci of sport stadium. A stadium without events is like an empty city, unable to create a sense of belonging and identification for people, so Genius Loci of stadium cannot be formed, and it becomes an urban building without a soul. The continuity of sport events is an important way to construct the collective memory, and also creates a special sport atmosphere for stadium. Genius Loci of stadium relies on the continuous sport atmosphere to make people have enough cognition and then develop steadily[6].

3.3. The location trend from city to suburb blocks the spread of Genius Loci of sport stadium

Most stadiums in China are located in the suburbs of the cities. Although they can be satisfied with the harmony of the surrounding natural environment, the interaction between stadiums and people is severely restricted by the inconvenient traffic and other conditions. In collective memory of Genius Loci of stadium, the construction of the stadium itself, as the place for the construction of the collective memory and the basis for the presentation of Genius Loci of sport stadium, is of great significance. In order to relieve the pressure of urban development and meet the scale of sport events and activities, some newly built stadiums are located in the suburbs, so as to reduce costs and promote the development of new urban areas. However, there are relatively few traffic and auxiliary facilities in the suburbs, and the phenomenon of post-game idling is serious[16]. The overall layout shows the trend of extending from the city to the suburbs, such as Guangdong Olympic Stadium, Shenyang Olympic Sport Center into and so on. The problems caused by living areas far away from urban residents and the inconvenient transportation make people pay less attention to stadium. Genius Loci of stadium is the result of deep communication between people and place. Stadium located in the suburb fails to bring a sense of belonging and identification to people. There are fewer and fewer opportunities for people to experience the stadium. Without interaction with people, there is no recipient of Genius Loci of stadium. This phenomenon causes stadium in people' potential memory more and more fuzzy, even if there are the sport events as memory stimulation. In such cases, the transmission of Genius Loci of sport stadium will be hindered.

4. Suggestions

4.1. As the subject of the memory, people's intuitive feeling and experience of sport stadium is the key to the spread of Genius Loci

Increasing the opening hours of stadium so that the public can fully experience the atmosphere of the inside stadium is critical for the spread of Genius Loci. At the same time, constructing museum of stadium or related publicity provide the public with the opportunity to participate in the specific history of stadium. Compared with indirect participants, direct participants have more opportunities to enter into stadium, and can deeply feel Genius Loci through sport events and the environment inside stadium. However, there are relatively few opportunities for indirect participants to enter into stadium, and their cognition of stadium comes from the different platforms. Therefore, it is difficult for them to interact with stadium. The impression of stadium becomes weaker and weaker, leading to problems in the continuation and dissemination of Genius Loci of stadium. The dissemination of it should be based on a process from the recognition of stadium to the stadium and the opening of stadium are important factors to promote the continuation of Genius Loci of stadium. People's cognition of stadium can be strengthened by sport events and the continuous sport events can stimulate deepening of the memory. In addition, history and culture are effective aspects that can arouse the resonance of people' memory[17]. By exploring the historic and cultural attributes of stadium, people can acquire identification and belonging in their own culture system to a certain extent. In this case, it is particularly important to establish the historic museum of stadium itself, so that people can understand the history of it and its role in social development. These glorious histories constitute many memory fragments shared by people in collective memory, and draw this memory to the cognition of the stadium. The continuation of Genius Loci of stadium also creates life for stadium and enriches the history of it. According to the memory place of Pierre Nora's, it points out that place can help awaken the collective memory. Therefore, increasing opening time of stadium, creating chance to experience stadium can foster the history and culture of stadium and the internal external environment combined to promote the construction of collective memory. Genius Loci of stadium can be continued by the existence of stadium more clearly felt by people. The process of collective memory construction is the process from recognition to the establishment of a deep connection with the stadium, and also the process from Genius Loci pointing out the orientation to feel sense of belonging. The continuous construction of the collective memory of stadium is the way to constantly consolidate Genius Loci of stadium and leave a deep impression on the memory of people[17][18].

4.2. Sport events is the main way for the public to interact with Genius Loci

Sport events and activities are the carrier to connect people and Genius Loci. Therefore, making full use of existing stadium and continuity of sport events provide the public with the opportunity to experience the sport atmosphere and overall environment. It will promote the recognition and continuation of genius loci of stadium. Sport events is the carrier of memory to construct Genius Loci of stadium. Therefore, the development of sport events can greatly affect the cognition of people to Genius Loci. The construction of collective memory is also an important means to strengthen the people's cognition of Genius Loci. Stadiums provide places for people to construct memories, while sport events provide opportunities for them to interact with Genius Loci[15][17][18]. As a social activity, the continuity of sport events can gradually stimulate the subject's impression of memory deeply, thus deepening people's cognition of stadium. Deep impression of stadium brought by sport events is a public desire to know more about stadium, providing an opportunity to identify Genius Loci of stadium and establish a deep connection with it. In this context, existing stadiums should be fully utilized instead of constructing new stadiums to realize the function maximization. To some extent, existing stadiums are historic and cultural heritage, such as Beijing workers' stadium, Shenyang Wulihe Stadium, Shanghai Stadium, or other stadiums that have hosted some famous sport events, such as Beijing

National Stadium, Nanjing Olympic Sport Center, etc. Collective memory of Genius Loci of stadium is constructed based on these two aspects. Existing stadiums can avoid the disadvantages brought by building new stadiums, and is more conducive to the continuation and dissemination of the spirit of the place. Sport events or activities in different periods connect the people's memory of stadium and contributes to the construction of collective memory. The increase of sport events in the stadium provides the opportunity for people to enter into stadium to experience Genius Loci of stadium, and promote the continuation of it[19].

4.3. The construction of sport stadium should involve in surroundings and be a part of city

The basic function of stadium, as a sport architecture, is to hold sport events. However, stadium is also an urban building, participating in social development. As the object of memory, Genius Loci of stadium makes a deep impression on people and forms collective memory through the symbiosis between stadium and environment. The deep memory of Genius Loci depends on integration of stadium and environment, not only the integration of the inside of stadium and sport atmosphere, but also the integration of outside and overall urban environment. The internal environment of stadium can arouse the perception of the participants to Genius Loci of stadium. The collective memory of the past history or events in stadium is also aroused to promote the stable development. The external environment includes natural environment, urban environment, and the historic and cultural environment, which reflects the attribute of stadium as an urban building[5][7][15]. For the indirect participants, Genius Loci of stadium reflects not only the characteristics of sports, but also how a building perfectly integrates into the environment, bringing people orientation and identification recognition. Therefore, the construction of Genius Loci of stadium should pay more attention to the integration of environment. Internal environment of stadium should be oriented to arouse the collective memory of people, and present the memories of the past in the form of materialization, so as to get the resonance of people' memory in a specific period and establish their identification. At the same time, the potential urban architectural function of stadium should be explored reasonably to highlight the historic recording function of stadium. Sport events and activities at a specific time evoke a retrospective view of a city[19]. The historical review is a means for people to explore their own identity in the city, and the process building a sense of belonging as the owner of the city is also the process in which Genius Loci of stadium plays its role. The integration of stadium with the natural environment and the overall urban environment is reflected on a certain sense of existence in the environment. It can become a landmark building to give the public a sense of direction in the environment. The mega construction of event-oriented stadium makes the formation of Genius Loci of stadium limited by the realization of sport functions. Single architectural function limits the vitality of stadium to events, and stadium without the support of events and the integrated environment hinders the construction of collective memory. However, perfect function fosters the construction of people's perception in stadium. It arouses the memory of Genius Loci of stadium through the details of the external environment, and strengthens the memory by sport events. The real meaning of existence of stadium as a building can be realized, if the process of collective memory of Genius Loci in stadium is more solid[15][17].

5. Conclusion

Stadium is the place of sport atmosphere, and also the carrier to record history. Genius Loci is the existence foothold of stadium in the city and people's memory. Inevitably, people always move in the place full of various memories, which are condensed and stored in various architecture[20]. Collective memory of Genius Loci of stadium is what people actually remembered about stadium. This memory is kept by people and deepened through sport events. As the material presentation, the development of stadium will influence the spread of Genius Loci. The

construction of collective memory is a way to foster Genius Loci of stadium. Stadium provides the space for people to create collective memory and Genius Loci. Sport events and activities helps record history of stadium, as a reminder. People constructs memory about stadium, so as to feel Genius Loci of sport stadium.

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A Korean Poly-Herbal Medicine, SMO16, Regulates the RANKL/OPG Bone Remodeling in OVX Rat Model

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Abstract

Bone mass is regulated by bone resorption(osteoclast) and bone formation(osteoblast), and an imbalance between both processes results in osteoporosis. Osteoporosis is characterized by a loss of bone density and regulation of bone remodeling is crucial for the treatment of osteoporosis. In this study, we investigated whether SMO16, a Korean polyherbal medicine containing 5 herbal components, could regulate bone remodeling in an ovariectomized(OVX) rat model. To test the effect of SMO16 in the OVX model, the rats were divided into 3 groups: a control group, OVX group, and OVX + SMO16(2.25 g/kg) for 8 weeks(ST group). The expression of osteocalcin(OPC), receptor activator of nuclear factor kappa-B ligand(RANKL), and osteoprotegerin(OPG) were measured in the femur using specific antibodies. The bone mass was analyzed using dual-energy X-ray absorptiometry. In the OVX group, protein expression of OPC was decreased; however, in the ST group, OPC expression was significantly increased when compared with the OVX group. SMO16 significantly reduces RANKL-positive cells in the OVX rat femur. Additionally, SMO16 increased OPG expression levels. Importantly, SMO16 significantly increased bone density. These data suggest that SMO16 increases bone remodeling by regulating OPC, RANKL, and OPG signaling. SMO16 could be a potential alternative treatment for osteoporosis.

[Keywords] ***Osteoporosis, Osteocalcin, RANKL, Osteoprotegerin, Korea Herbal Medicine***

1. Introduction

Osteoporosis is a disease characterized by loss of bone mass and weakened bone strength owing to qualitative changes in bones, classified into primary and secondary osteoporosis. Primary osteoporosis includes postmenopausal osteoporosis attributed to a decrease in female hormones, and senile osteoporosis occurs owing to a decrease in bone formation induced by hormonal, calcium, and dermal vitamin D deficiencies. Additionally, secondary osteoporosis can result in several diseases, including chronic kidney failure, thyroid-related diseases, rheumatoid arthritis, and diabetes, and can be induced by an overdose of steroids, anticonvulsants, or anticancer drugs[1][2].

For osteoporosis, Vitamin D and calcium intake are recommended as standard prevention and treatment strategies. Additionally, weight training, yoga, Pilates, jogging, sports dancing, and tennis have been recommended[3]. For the pharmaceutical management of osteoporosis, bone resorption inhibitors such as bisphosphonate and risedronic acid, or calcium and vitamin preparations, and hormone inhibitors are employed[4]. However, when osteoporosis progresses, bone formation accelerators are extremely crucial, and recombinant parathyroid hormone, teriparatide, has been utilized; however, this drug has is accompanied by severe side effects[5].

Furthermore, it is well known that osteoblasts play an important role in bone formation. In particular, osteoblasts express osteocalcin(OPC), receptor activator of nuclear factor kappa-B ligand(RANKL), and

osteoprotegerin(OPG). RANKL/RANK signal transduction regulates osteoclast formation, activation, and survival under diverse pathological conditions characterized by normal bone modeling and remodeling, as well as increased bone remodeling[6]. OPG binds to RANKL and prevents the bone from binding to RANK, thereby preventing excessive bone resorption[7]. Our previous study has demonstrated that SMO16(a Korean polyherbal medicine, including extract of *Carthamus tinctorius, Caragana sinica, Achyranthes aspera, Phlomis umbrosa, Eucommia ulmoides, and Drynaria fortunei*) regulates bone mass in ovariectomized(OVX) rat osteoporosis models[8]. However, the underlying mechanism by which SMO16 inhibits osteoporosis remains unclear. Thus, we investigated the molecular mechanism of SMO16 in an OVX rat model.

2. Materials

2.1. Chemicals

Vectastain ABC kits and DAB kit were obtained from Vector Laboratories(Burlingame, CA, USA). The antibodies used in this study included anti-OPC, anti-RANKL, and anti-OPG, purchased from Santa Cruz(Santa Cruz, MA, USA).

2.2. Plant material and water extraction of SMO16

The SMO16 extract was prepared according to the methods described in our previous study[8]. Briefly, *C. tinctorius*(30 g*), C. sinica*(30 g), *A. aspera*(30 g), *P. umbrosa*(30 g), *E. ulmoides*(30 g), and *D. fortune*(30 g) used in the experiment were placed in 2,000 mL of distilled water, preheated for 3 h, and then filtered. The filtrate was reduced to 50 mL using a rotary evaporator, then concentrated and lyophilized to obtain 27 g of extract(yield: 15%). The dose was determined as 2.25 g/kg.

2.3. Preparation of osteoporosis model

Female Wistar rats(Orient bio Inc., Seongnam, Korea) were maintained at 22°C with a 12 h light/dark cycle. All experiments and animal care were performed in accordance with institutional guidelines(SEMCARE 16-06-01). The experimental animals were divided into 3 groups: untreated group, ovariectomized(OVX) group, and OVX with SMO16(2.25g/kg) treatment for 8 weeks. According to the procedure established by Cao H et al[9], the rats(n=15) were anesthetized using isoflurane, and bilateral ovaries were removed.

2.4. Histochemistry and immunohistochemistry

The femurs were fixed using the 10% formalin and treated with a decalcification solution for 12 h. Next, the bones were embedded in paraffin and sectioned. The sections were treated with xylene and a series of ethanol concentrations(100 % to 60%). The tissues were incubated in 5% bovine serum albumin(BSA) in phosphate-buffered saline for 1 h and stained with specific antibodies such as anti-OPC, anti-RANKL, and anti-OPG. The representative images were obtained using microscopy(K1-fluo, Nanoscope system Deajeon, Korea).

2.5. Dual-energy x-ray absorptiometry analysis

After 8 weeks, the rats were sacrificed and the bone mass was measured. The bone mass was analyzed using dual-energy x-ray absorptiometry(DXA, Medikors Inc., Seoul, Korea).

2.6. Data analysis

Immunohistochemical results were quantified(means ± standard deviation) by image analysis using Image-Pro Plus(Media Cybernetics, USA). The mucosa, randomly selected from each group, was imaged at a 400× magnification and at positive pixels/50,000,000 pixels. Statistical analysis

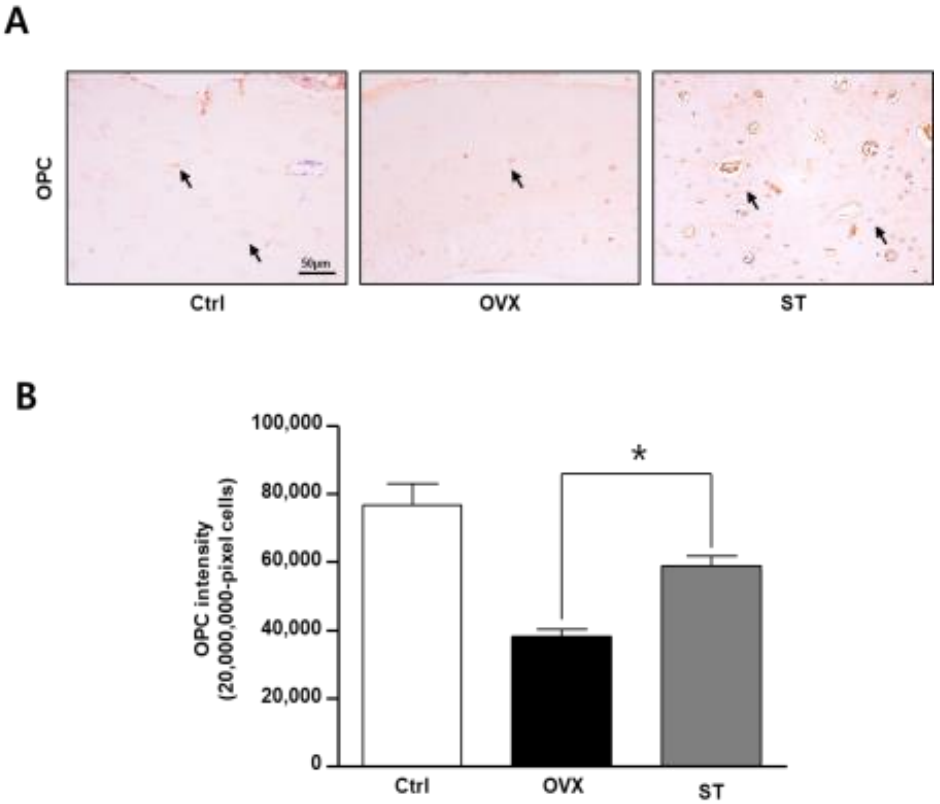
was performed using SPSS ver. 23.0(IBM Corp., Armonk, NY, USA). One-way ANOVA was performed to verify significance(P <0.05), followed by the least significant difference(LSD) test.

3. Results

3.1. SMO16 increased the protein expression of osteocalcin in the OVX model

To investigate the effect of SMO16 on bone loss in the *in vivo* model, we analyzed OPC expression in the femur.As shown in <Figure 1>, the level of OPC in the control group was 76,667 ± 6,110 pixel. In the ovariectomized rat(OVX group), the OPC level was, on average, 38,333 ± 2,081 pixel lower than the control group. However, OPC levels in the ST group were 58,933 ± 2,685 pixel higher than in the OVX group.

Figure 1. Effect of SMO16 on femur histomorphometry.

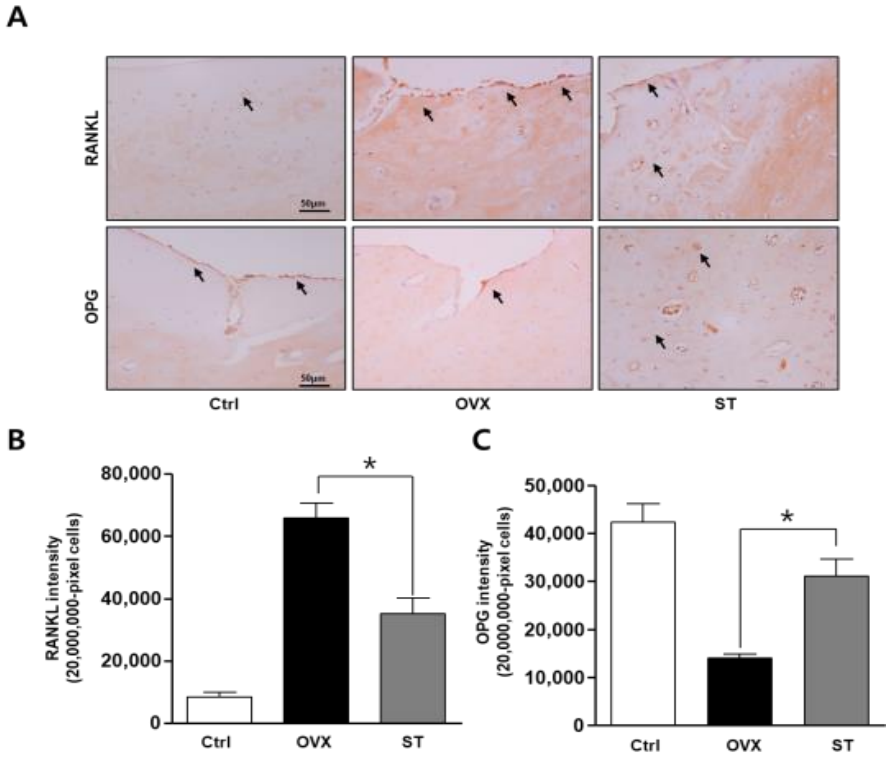


Note: (A)Representative photographs of osteocalcin(OPC) immunohistochemical staining in the rat femur. The arrow indicates OPC positive. (B)Bar graphs indicate the brown intensity of each photograph in a panel(A). Data are expressed as means ± standard deviation. *p < 0.05 vs. the OVX group. Ctrl; control group, OVX; ovariectomized group, ST; SMO16 treated group.

3.2. Effect of SMO16 on protein expression levels of RANK and OPG

To determine whether SMO16 can regulate osteoclastogenesis, we performed immunohistochemistry using specific antibodies. As shown in <Figure 2>, RANKL expression in the OVX group increased by 65,666 ± 4,932 pixel when compared with the control group. SMO16 significantly decreased RANKL expression in the OVX group. Regarding OPG expression, protein levels in the OVX group were decreased by 28,399 ± 2,883 pixel; in the ST group, OPG expression was increased by 11,333 ± 180 pixel.

Figure 2. Immunohistochemistry analysis for RANKL-OPG.

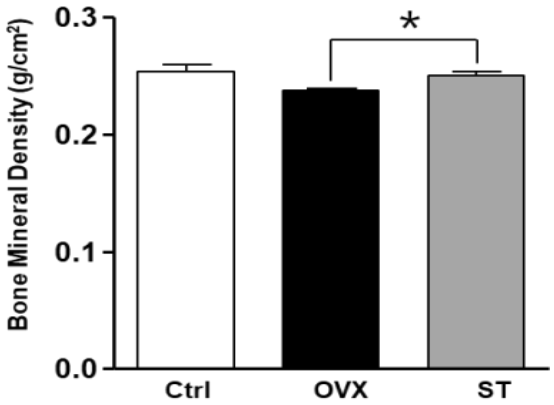


Note: (A)Representative photographs of immunohistochemical staining for RANKL and osteoprotegerin(OPC) in the rat femur. The arrow indicates RANKL and OPC positive, respectively. (B-C)Graphs indicate the brown intensity of each photograph in panel(A). Data are expressed as means ± standard deviation. *p < 0.05 vs. the OVX group. Ctrl; control group, OVX; ovariectomized group, ST; SMO16 treated group.

3.2. Effect of SMO16 on bone density in the OVX rat model

To confirm whether SMO16 promotes bone density, we measured the femur density using the dual-energy X-ray absorptiometry. In the control group, bone density was 0.25 ± 0.05 g/cm^2; in the OVX group, bone density was reduced to 0.23 ± 0.02 g/cm^2. SMO16 significantly increased the bone density to 0.25 ± 0.02 g/cm^2.

Figure 3. The bone mass density.



Note: The bone mass was measured using dual-energy X-ray absorptiometry. Data are expressed as means ± standard deviation. *p < 0.05 vs. the OVX group. Ctrl; control group, OVX; ovariectomized group, ST; SMO16 treated group.

4. Discussion

It is well known that osteoporosis is associated with improper bone formation such as excessive osteoblast activation and inadequate osteoblast functions[10]. In this study, we demonstrated that treatment with SM016 regulated bone remodeling in an OVX rat model. Furthermore, these results were confirmed by OPG/RANKL/OPC expression. Notably, SM016 induced OPC expression. Furthermore, in the OVX rat model, SMO16 treatment significantly downregulated RANKL and upregulated OPG expression. RANKL is associated with osteoclast coupling[11]. Reportedly, RANKL-deficient mice exhibit osteoporosis as a phenotype of immature osteoclasts[12]. In osteoblasts, high levels of OPG expression have been documented[13]. Furthermore, OPG-deficient mice spontaneously develop severe osteoporosis[14]. These results indicated that osteoblastic activation was induced by SMO16. Therefore, we propose SMO16 as a candidate for osteoporosis therapy regulating bone remolding.

Osteoporosis progresses without demonstrating specific symptoms and often remains asymptomatic until the appearance of fractures. Generally, osteoporosis results in fractures of the spine, wrist, and hip joints. In these patients, the RANKL /RANK factor, involved in the process of inducing bone regeneration, is altered. Furthermore, it has been reported that RANKL/RANK/OPG signaling could be a potential therapeutic target in bone cancer. As RANKL/RANK/OPG controls the abnormal response of bone remodeling and maintains bone homeostasis, it could play a key role in therapeutic approaches for bone cancer. Although our results have not been investigated in bone cancer models, key factors such as OPC, RANKL, and OPG were significantly altered by SMO16. Therefore, we speculate that SMO16 may have anticancer benefits against bone cancer.

Notably, unofficial statistics suggest that the bone density in adult Korean women is lower than that observed in women in Western countries, highlighted by the lack of physical activity. Some studies have reported that exercise and bone formation are closely related. We suggest SMO16 as a candidate prescription for promoting bone mass.

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6. Contribution

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The Structural Relationship among Safety Climate, Motive to Participate, and Leisure Satisfaction Level of Marine SPORTS Participants

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Abstract

The purpose of this study is to analyze the actual relationship between the linkage structure and the structural model of participation motive and leisure satisfaction in situations where the safety of marine sports is guaranteed.

The total of 217 subjects was selected by convenience sampling technique among those who enjoy marine sports such as windsurfing, scuba diving, kayak, jet ski, and motor boat with the survey questionnaire developed for this study. The validity and reliability of the measurement tools used in this study were verified by a group of four experts. The validity of the tools was verified by confirmation factor analysis, and the reliability was verified with Cronbach's α coefficient. Analyzable data were processed according to the purpose of the study using SPSS 18.0 and AMOS 18.0. Internal consistency was verified through confirmatory factor analysis and reliability analysis, and structural equation modeling(SEM) was performed for correlation analysis and to examine the causal relations among the variables.

The research model set up in this study was tested to be fit, and the hypotheses according to the research model were verified and the results were obtained as followed. (1)The marine sports safety climate utilized in this study was found to have a positive effect on motives to participate meaning that ensuring safety will further boost participation in marine leisure sports and bring about a lot of development. (2)Safety climate in marine sports has been shown to have a positive effect on leisure satisfaction. Providing a better safety climate for those who enjoy leisure activities is thought to be a natural way to enhance satisfaction. The water leisure facility, where safe climate is set, provides a foundation for participants to enjoy the activities with confidence and further promotes vitality. (3)Motive to participate was found to have a positive effect on leisure satisfaction. Leisure satisfaction has a significant effect depending on the degree of participation in marine sports.

It could be concluded that individuals participating in marine sports programs chosen as a way of leisure gain great satisfaction through marine sports activities. However, facilities, equipment, program operators, leaders, and managers related to high-risk sports should prioritize ensuring safety through system-wide safety and thorough education and must recognize that educational actions that value the importance of safety are paramount. If safe and beneficial programs are continuously provided through this, the participation rate and satisfaction will improve, resulting in quantitative and qualitative development of the marine sports industry.

***[Keywords]* Safety Climate, Participation Motive, Leisure Satisfaction Level, Structural Relationship, Marine Sports**

1. Introduction

Sports activities in everyday life can induce increased leisure time into more constructive and creative activities, and prevent various modern diseases to improve health and physical strength

to adapt to modern society. In addition, it plays a major role in the development of the welfare society by promoting the awareness of the common people through participation in sports activities. Sports as a leisure activity are also an important tool for improving the quality of life by leading a life in society and making people feel happy[1].

Marine sports have continued to develop with the spread of leisure culture due to the recent five-day workweek settlement and economic growth, and the number of opportunities for people to pay attention to and participate directly in marine sports has also increased[2].

Marine sports are thought to be high-risk and therefore have the image of being a sport with a high probability of safety accidents[3] and are also classified as sports with serious risks that could impede safety[4]. The causes of the marine sports accidents are various, but in particular, the lack of safety facilities and education are considered to be the most important factors among the many variables affecting safety behavior since the recent 'Ferry Sewol' incident. This highlights the importance of safety climate in providing marine sports facilities and programs[5].

Safety climate can be defined as individuals' awareness of safety issues felt by members in a system[6], in which accidents decrease as individuals become more aware[7]. The leading factors in system safety can be considered to play an important role in preventing various safety accidents by influencing educators' interest in safety and improving awareness through thorough training of marine sports participants[8]. In other words, educational actions that value the value and importance of safety are the top priority.

It is not easy to grasp the motive of those who participate in high-risk sports. Whatever the motive, it is not easy to decide to participate in such sports. However, if safety is guaranteed, the perceptions of those participating may change[9]. According to humanist psychologist Abraham Maslow, people's actions are motivated in order to achieve certain needs. Motive refers to a trigger that causes something to happen[10], and based on this, it is thought that there is a high relevance between securing safety and participating in high-risk sports. A safe state is a peaceful state from danger or threat and everyone wants to be in a safe state[9][10]. But if there is motive or safety to act at risk, as Maslow claims, people's interest in achieving high-level needs will increase.

The previous studies related to marine sports mainly include one related to safety[11], one related to the revitalization of marine sports[12], and one related to leisure life[13][14]. These studies identify and analyze the behaviors and thoughts of participants in the actual field, but research on the linkage structure and structural model between the factors is insufficient. Therefore, the purpose of this study is to analyze the actual relationship between the linkage structure and the structural model of participation motive and leisure satisfaction in situations where the safety of marine sports is guaranteed. Through this, the researchers hope to help establish a safety culture for marine sports, prevent accidents, increase participation, and revitalize the marine sports industry.

2. Research Methods

2.1. Research subjects

The subjects of this study were 217 samples that were significant in a survey of 250 participants selected by convenience sampling among those who enjoy marine sports such as windsurfing, scuba diving, kayak, jet ski, and motor boat.

Table 1. Characteristics of the research subjects.

Variables	Description	Frequency(%)	Total(%)

Gender	Male	118(54.4)	217(100)
	Female	99(45.6)	
Education level	High school	13(6.0)	
	Junior college	72(33.2)	
	College	105(48.4)	
	Graduate school	27(12.4)	
Sports type	Windsurfing	78(35.9)	
	Scuba diving	53(24.4)	
	Kayak	38(17.5)	
	Motor boat	48(22.2)	

2.2. Measurement tools, validity & reliability

The validity and reliability of the measurement tools used in this study were verified by a group of four experts(two marine sports experts, one professor of sports psychology, and one doctor of sports psychology). The validity of the tools was verified by confirmation factor analysis, and the reliability was verified with Cronbach's α coefficient.

The criteria for the GFI(goodness-of-fit-index) of the confirmatory factor analysis were set by the study of Bagozzi & Dholakia(2002) and Hong(2000)[15][16], and the criteria for deleting the questions were set by the study of Song(2011)[17]. Song(2011) deleted the questions with low SMC(squared multiple correlations) value based on that the closer to 1 the value, the more explanation power and that the latent variables of 0.4 or below cannot explain the measurement variables[17].

2.2.1. Safety climate for marine sports

To test the safety climate for marine sports, the test questionnaire developed by Kim & Choi(2018) for those participating in marine sports were used[18]. The questionnaire consisted of 16 questions on four factors: communication, practice awareness, safety environment, and safety attitude, with the five-point Likert scale. As a result of the confirmatory factor analysis, two questions with low SMC(squared multiple correlations) were deleted. The GFI for 14 questions was TLI = .909, CFI = .910, and RMSEA = .065, indicating the fitness, and the Cronbach's α coefficient was .821 to .896.

2.2.2. Motives to participate

To test the motive to participate in marine sports, the test questionnaire used in research by Lee, Hyeon & Lee(2015) for those participating in marine sports were modified for this research and used[19]. The questionnaire consisted of 23 questions on five factors: skill, joy, society, fitness, and external display, with the five-point Likert scale. As a result of the confirmatory factor analysis, two questions with low SMC(squared multiple correlations) were deleted. The GFI for 21 questions was TLI = .910, CFI = .914, and RMSEA = .070, indicating the fitness, and the Cronbach's α coefficient was .856 to .897.

2.2.3. Leisure satisfaction level

To test the leisure satisfaction level, the test questionnaire used in research by Im(2010) was modified for this research and used[20]. The questionnaire consisted of 19 questions on five factors: education satisfaction, social satisfaction, psychological satisfaction, physiological satisfaction, and environmental satisfaction, with the five-point Likert scale. As a result of the confirmatory factor analysis,

eight questions with low SMC(Squared Multiple Correlations) were deleted(physiological and environmental satisfaction). The GFI for 11 questions for the remaining three factors was TLI = .922, CFI = .935, and RMSEA = .065, indicating the fitness, and the Cronbach's α coefficient was .901 to .925.

2.3. Data collection and processing

In order to collect data, researchers consulted with and visited windsurfing and marine sports centers to conduct the survey. They explained the contents of the test to the study subjects(n=250), letting them self-administer the survey, and analyzed based on the completed survey(n=217), excluding the insincere responses(n=33) from the analysis. Analyzable data were processed according to the purpose of the study using SPSS 18.0 and AMOS 18.0. Internal consistency was verified through confirmatory factor analysis and reliability analysis, and structural equation modeling(SEM) was performed for correlation analysis and to examine the causal relations among the variables.

3. Results

3.1. Correlation analysis

Pearson's correlation analysis conducted to examine the correlation among each variable showed that there was a statistically significant positive correlation between safety climate subvariables and participation motive factors. The safety climate and leisure satisfaction were also found to be statistically positively related. There was a positive correlation between motive for participation and leisure satisfaction too. Also, because the value of the correlation coefficient did not exceed .85, discriminant validity was obtained, and there was no problem with multicollinearity as all variables showed less than .80, which is the standard value for multicollinearity.

Table 2. Correlations among variables.

Factors	1	2	3	4	5	6	7	8	9	10	11	12
Communication	1											
Practice consciousness	.550***	1										
Safety environment	.399***	.352***	1									
Safety attitude	.221***	.430***	.185*	1								
Skill	.433***	.409***	.605***	.173**	1							
Joy	.411***	.342***	.344***	.201***	.580***	1						
Society	.390***	.314***	.599***	.233***	.637***	.573***	1					
Fitness	.402***	.514***	.271***	.309***	.309***	.259***	.249***	1				
External display	.553***	.492***	.378***	.206***	.367***	.309***	.342***	.519***	1			
Education satisfaction	.255***	.342***	.256***	.258***	.498***	.347***	.466***	.311***	.297***	1		
Social satisfaction	.455***	.418***	.287***	.392***	.432***	.348***	.415***	.334***	.502***	.600***	1	
Psychological satisfaction	.422***	.374***	.444***	.314***	.513***	.488***	.546***	.329***	.450***	.375***	.427***	1

Note: ***p<.001, ** p<.01, * p<.05.

3.2. Goodness-of-fit of model and hypothesis test

3.2.1. Goodness-of-fit of model

To verify the goodness-of-fit of the theoretical model set up in this study and the empirical data collected, a structural equation model analysis was conducted using AMOS 18.0. As shown in the <Table 2>, the theoretical model and empirical data were found to be fit with TLI= .911, CFI= .921, and RMSEA=.070.

Table 3. Goodness-of-fit of the theoretical model.

Q	TLI	CFI	RMSEA
2.260	.937	.952	.076

3.2.2. Hypothesis test

The research model set up in this study was tested to be fit, and the hypotheses according to the research model were verified and the results were obtained as shown in <Table 4> below.

Table 4. Testing of the proposed hypotheses.

Hypotheses	Path	Estimate	SE	CR(t)	Acceptance
H1	Safety Climate → Motive	.716	.074	9.724***	Accepted
H2	Safety Climate → Leisure Satisfaction	.463	.133	3.490***	Accepted
H3	motive → Leisure Satisfaction	.360	.152	2.370*	Accepted

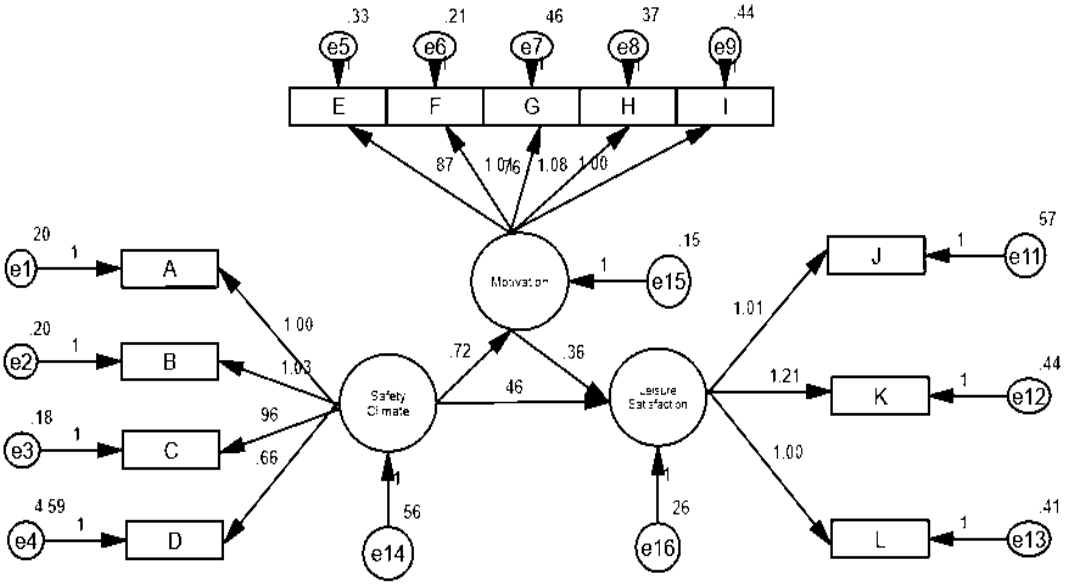
Note: *p<.05, ***p<.001.

First, as a result of the verification of Hypothesis 1, the hypothesis that "the safety climate in marine sports will have a positive effect on the motive for participation" showed the path coefficient of .716(t=9.724, p<.001), which is a statistically significant difference, indicating that the safety climate in marine sports had a positive causal correlation with the motive for participation.

Second, as a result of the verification of Hypothesis 2, the hypothesis that "the safety climate in marine sports will have a positive effect on leisure satisfaction level" showed the path coefficient of .463(t=3.490, p<.001), which is a statistically significant difference, indicating that the safety climate in marine sports had a positive causal correlation with leisure satisfaction level.

Third, as a result of the verification of Hypothesis 3, the hypothesis that "motive to participate will have a positive effect on leisure satisfaction level" showed the path coefficient of .360(t=2.370, p<.05), indicating that motive to participate in marine sports had a positive causal correlation with leisure satisfaction level.

Figure 1. Path coefficient between variables.



Note: A: Communication, B: Practice consciousness, C: Safety environment, D: Safety attitude, E: Skill, F: Joy, G: Society, H: Fitness, I: External display, J: Education satisfaction, K: Social satisfaction, L: Psychological satisfaction.

4. Discussion

The study was conducted with the aim of analyzing the actual relationship between motive to participate and leisure satisfaction, in the situation where the safety of marine sports is guaranteed. To analyze this, 217 participants in marine sports were surveyed using questionnaire after securing goodness-of-fit and reliability. Based on the results, the discussion and conclusions are as follows.

First, the marine sports safety climate utilized in this study was found to have a positive effect on motives to participate. Kim & Choi(2018) claimed that through the development of a safety climate scale for marine sports, the participants must check their safety attitudes that reflect their commitment to safety before carrying out the exercise[18]. They also said that participants should first inform related parties of their physical and psychological conditions and have an attitude of deciding their participation by recognizing the possibility of safety problems. This could also explore the possibility of how it could affect the promotion of participation if it guarantees the safety of marine sports in the high-risk group. Ahn(2005) stated that safety will, which is the attitude of marine sports participants to their own safety, plays a decisive role in preventing marine sports safety accidents as a keyword for marine sports safety, and supports the results of this study because safety attitude has a strong positive effect on safety participation[21]. It is believed that ensuring safety will further boost participation in marine leisure sports and bring about a lot of development.

Second, safety climate in marine sports has been shown to have a positive effect on leisure satisfaction. Providing a better safety climate for those who enjoy leisure activities is thought to be a natural way to enhance satisfaction. Kim & Yun(2011) analyzed the basic psychological needs of participants in marine and water leisure sports and supported the results of this study by saying that safety issues in leisure sports bring vitality to participation[22]. The water leisure facility, where safe climate is set, provides a foundation for participants to enjoy the activities with confidence and further promotes vitality.

Third, motive to participate was found to have a positive effect on leisure satisfaction. Lee(2009) reported that leisure satisfaction has a significant effect depending on the degree of participation in marine sports, supporting the results of this study[14]. In addition, Lee(2005) reported in his study that although there were differences in variables of motive to participate and leisure satisfaction, they all had significant effects[23][24].

5. Conclusions

Summarizing the results of these various previous studies and this study, one can conclude that individuals participating in marine sports programs chosen as a way of leisure gain great satisfaction through marine sports activities. However, facilities, equipment, program operators, leaders, and managers related to high-risk sports should prioritize ensuring safety through system-wide safety and thorough education and must recognize that educational actions that value the importance of safety are paramount.

Based on the results obtained from this study, future researchers can provide a practical approach to research on specific motives of participants in high-risk sports and type analysis of accident cases and future countermeasures through the results. If safe and beneficial programs are continuously provided through this, the participation rate and satisfaction will improve, resulting in quantitative and qualitative development of the marine sports industry.

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7. Contribution

7.1. Authors contribution

	Initial name	Contribution
Lead Author	KSH	-Set of concepts ☑ -Design ☑ -Getting results ☑ -Analysis ☑ -Make a significant contribution to collection ☑ -Final approval of the paper ☑
Corresponding Author*	SHB	-Corresponding ☑ -Play a decisive role in modification ☑
Co-Author	HSJ	-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 ☑

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A Single Case Study on KINEMATIC Correction of the Idiopathic Scoliosis Using Sling and Schroth

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Abstract

Purpose; This study was performed to evaluate the therapeutic effect of correction of idiopathic scoliosis using Sling and Schroth.

Method: A 24-year-old woman who was diagnosed with idiopathic scoliosis was selected as a study participant, and one year Sling and Schroth program were applied to her. Using the thermography photo device and the thermography camera as a measurement tool, this study investigated the tendency of spinal alignment in the baseline(A), duration of treatment(B), and after treatment(A'). This study was analyzed by graphical visual analysis and mean value, and the following conclusions were obtained. First, in analyzing somatotype photos over the third period, this study observed changes in the left and right deviation of the trunk on the front and back sides, rear shoulder angle deviation, and lateral cervical curvature angle.

Results: It was confirmed that the left and right deviation from the front and the rear was reduced, the deviation of the left and right shoulder angles at the rear was also reduced, and that the lateral cervical curvature angle was also reduced. Second, in the analysis of the thermography over three times, temperature changes were observed at the front and back of the upper body, the front of the lower body and the back of the lower body.

Conclusion: This study suggest that long-term exercise correction using Sling and Schroth affects the somatotype photos and thermography of patients with scoliosis. Therefore, it is thought that Sling and Schroth exercise treatment seem to have a positive effect on the treatment of patients with idiopathic scoliosis.

[Keywords] ***Kinematic, Correction, Sling, Schroth, Idiopathic Scoliosis***

1. Introductions

Modern society is getting tame to the lifestyle which minimizes the movement and destabilizes the spine as it is gradually becoming scientific and pursuing convenience in modern life accordingly. As a result, the spine of modern people is exposed to various spinal diseases. According to data from Korea's Health Insurance Review and Assessment Service[1], the number of cases of spinal disease treatment increased by about 41.3 million(88.4%) from about 46.6 million in 2007 to 87.9 million in 2014, and the cost of medical care increased by about 1.889 trillion won(95.2%) to about 3.876 trillion won in 2014 from about 1.986 trillion won in 2007[2]. In congenital idiopathic scoliosis, the incidence is high in the teenage of all ages and the female is more than twice as high as that of the male, and it can be seen that the prevalence rate is high in the adolescence period which is the secondary sexual character period.

If the diagnosis is delayed during the period of rapid progression of scoliosis, the appropriate treatment period is to be missed. Considering the research report[3] that it may be difficult to

correct the curved waist and may require surgery correction, it can be assumed that the timing and method of scoliosis correction in adolescence is very important.

The scoliosis is an anatomically curved or lateral deviation of the vertebra from the axis of the midline, usually accompanied by a rotational deformation of the vertebrae, and a status where a normal curvature of the vertebrae is lost(Seoul National University Hospital, 1994). Treatment for the improvement of scoliosis is usually surgical and conservative treatment, and even after surgery, the curvature of the vertebrae cannot[4]. Therefore, it is necessary to apply conservative treatment method rapidly to prevent further progression of curvature, to correct the progress of scoliosis, and further, continuous treatment with exercise should be performed to reduce the curvature angle.

Spinal scoliosis is classified into two major categories: first, structural scoliosis and second, non-structural scoliosis. Structural scoliosis is classified as idiopathic scoliosis(unclear), congenital(scoliosis resulting from spinal deformity at birth), nerve roots(scoliosis caused by neurological or muscular disorders), which account for 85% to 90% of total scoliosis. Unstructured scoliosis is not a true scoliosis due to trauma, such as traffic accidents, or, more precisely, a scoliosis caused by a disease that does not occur in the vertebra itself due to the difference in leg length[5].

Structural scoliosis has not yet been identified, so no definitive treatment has been proposed, demanding that there should be studies to be continued. Unstructured scoliosis can be caused by a pelvic deviation caused by a severe deviation of leg length, a severe accident in a traffic accident, a twisting of the body, or a complete spinal deformation due to old habits. Although idiopathic scoliosis has been hypothesized for several reasons, its causes have not been clearly elucidated[6][7]. Thus, this study aims to investigate the effects of Sling and Schroth exercises on idiopathic scoliosis through a single case study using data from a 1-year clinical trial to improve idiopathic scoliosis.

Since the introduction of the Sling movement since 1997, physiotherapists have been advancing, recently, the sports center and the professional exercise center have been opened, and the treatment that has been conducted in the center of the hospital has been continuing with various angles. Sling is a device that helps the patient to perform active exercise by using a wobble line. This is a treatment technique that has been used in conjunction with aquatic exercise therapy as a way to treat weakness in polio patients in Europe during World War II[8].

Schroth exercise therapy was developed by Katharina Schroth of Germany. It is an exercise therapy approach which is applied to the spinal defect by applying the basic rule of 3-D scoliosis treatment. This is a exercise method of restoring structure and function by using an inverse three-dimensional approach(de-rotation, counter-flexion, and re-kyphosis) in torsion and spine and thorax and pelvis in three-dimensional surfaces(sagittal, frontal, and horizontal) typically seen in patients with Scoliosis.

To look at the result of a recent study on Sling exercise and a study[9][10][11] on Schroth's treatment, in recent years, non-surgical exercise therapy for musculoskeletal diseases has been actively under way. Also, a study on non-surgical treatment of scoliosis correction with Sling and Schroth[8] is under way, but it is still insufficient. This study was carried out to investigate the effect of exercise therapy using Sling and Schroth on idiopathic scoliosis correction and somatotype change of women employees in their twenties. These findings are expected to provide new clinical data for scoliosis treatment and exercise therapy.

2. Methods

2.1. Participant

The subject of this study is the one who has fully understood the purpose and method of this study, and agreed to participate in the study from among those who has been diagnosed as having idiopathic scoliosis on X-ray at the sports center located in the S city of Korea. A 24-year-old woman with idiopathic scoliosis who had a long sitting and working career was selected for the study. Thus, she was in an environment where the spinal part that was changed was inevitably more twisted. Therefore, the participant was selected for the purpose of the study according to the characteristics of the single case study, the subject without idiopathic scoliosis was selected as subjects.

2.2. Instruments

To accomplish the purpose of this study, thermography photo device and thermography camera were used as a measurement tool. The somatotype camera is the BODY CHECKER of Ghiwell Co., Ltd. with the model name, GHB-1100, and it is used to measure the front, back, and side somatotype photos of the participant. For the thermography camera, T-1000 XD of Mesh co., ltd. was used as a measuring tool for the thermography front, back, upper body, and lower body of the participant in this study.

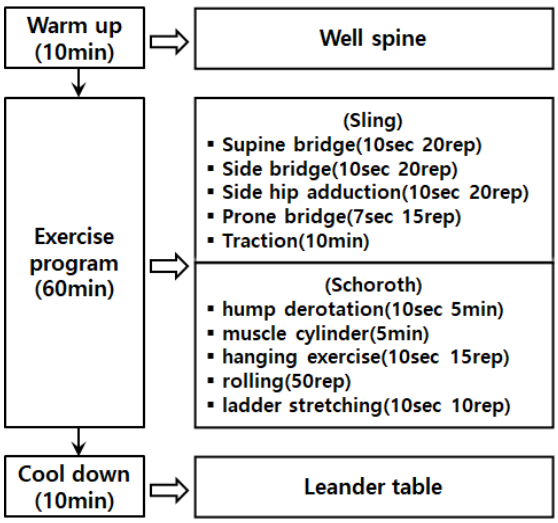
2.3. Procedure and program

To proceed with this study, we conducted a preliminary study and a literature review on research questions, and after selecting the appropriate subject for idiopathic scoliosis, the consent form was written and the contents of the experiment and the treatment process were explained. This study compared one year baseline, treatment, and post-treatment somatotype photos and thermography for analysis and reported the results. The results of this study are summarized as follows. All the motions used in Sling and Schroth programs were reconstructed by referring to the exercise methods used in related literature and previous studies[12][13][14], and were conducted twice a week for the first 3 months, then once a week for 9 months. <Figure 1> shows the posture, name and exercise time of the Sling and Schroth exercise program performed by the participant.

2.4. Data analysis

To investigate the tendency of spinal alignment in the baseline(A), treatment process period(B), and post-treatment(A'), the analysis was conducted using graphical visual analysis and mean values. Data collected for each measurement session were visually analyzed by plotting points on the graph to improve the reliability of the study results and to improve the accuracy of the results analysis, measured somatotype photos data and thermography data were presented, and the change values according to the measurement were tabulated.

Figure 1. Sling and Schroth exercise program.



3. Results

3.1. Comparative analysis of somatotype photos

In this study three different somatotype photos were taken after correction using Sling and Schroth for three times, and the left and right deviation of the body was confirmed on the front and back sides, and the change of the cervical curvature angle was confirmed on the side. As a result, it was confirmed that the lateral deviation from the front and rear sides was reduced, and that the deviation of the shoulder angle from the rear was also reduced. In addition, the cervical curvature angle was found to be reduced on the side. Analysis of participants' somatotype photos is shown in <Table 2> and <Figure 2> below. In comparison of the somatotype photos of the participant, in the front was 97mm and 107mm with 10mm difference in the 1st, 88mm and 92mm with 4mm difference in the 2nd, and 90mm and 92mm with 2mm difference in the 3rd.

Table 1. Participant somatotype photos comparison values of left/right, shoulder symmetry, lateral cervical curvature angle(unit: mm, degree).

Division	1st		2nd		3th	
Front left and right deviation	97mm	107mm	88mm	92mm	90mm	92mm
	Deviation 10mm		Deviation 4mm		Deviation 2mm	
Rear left and right deviation	101mm	150mm	112mm	125mm	103mm	112mm
	Deviation 49mm		Deviation 13mm		Deviation 9mm	
Rear shoulder angle deviation	24.07。	16.92。	32.10。	30.51。	19.13。	18.08。
	Deviation 7.15。		Deviation 1.59。		Deviation 1.05。	
Lateral cervical curvature angle change	27.45。		26.56。		25.68。	
	Change 0.89。			Change 0.88。		

Figure 2. Comparison of change in somatotype photos.

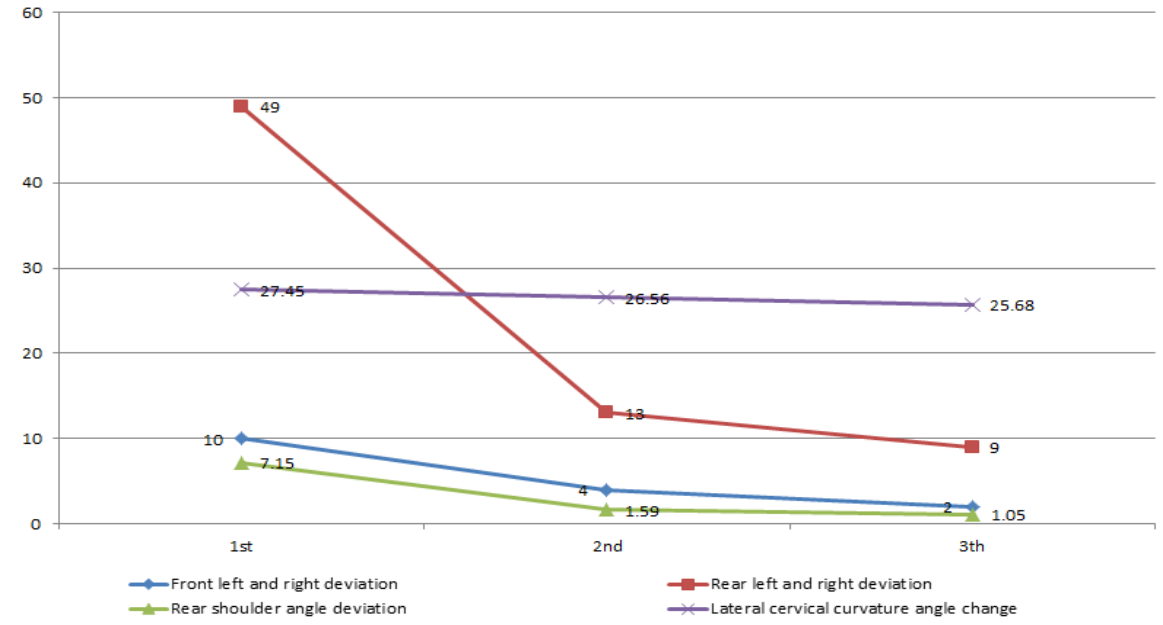
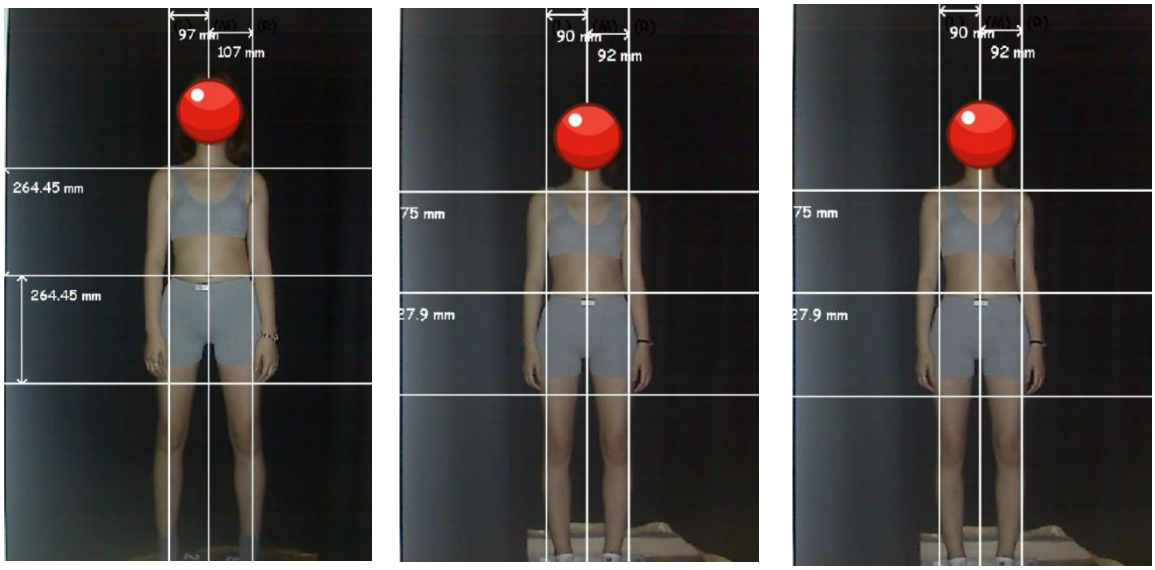


Figure 3. Changes in cervical curvature angle of somatotype photos.



3.2. Comparative analysis of thermography

In this study, we took thermography three times along with somatotype photos. The results of the study can be measured by temperature change, and were divided into first, second and third for the shooting and analysis. In the 1st, there were 27.2 degrees on the upper body, 24.5 degrees and 25.9 degrees on the upper body, 22.7 degrees and 23 degrees on the lower body front, 21.4 degrees and 22.1 degrees on the lower body, 23.8 degrees and 23.7 degrees on the lower body, 23.2 degrees and 22.2 degrees on the lower body. In the second, on the upper body was 28.4 degrees, on the upper body was 26.8 degrees and 28.2 degrees, on the lower body front was 24.3 degrees and 24.4 degrees, 27 degrees and 24.9 degrees, on the lower body was 25.2 degrees and 25.7 degrees. The change in temperature was observed at 31.1 degrees and 31 degrees on the upper body, 28.8 degrees and 29.3 degrees on the upper body, 28.0 degrees and 27.9 degrees on the lower body, and 26.1 degrees and 26.4 degrees on the lower body. <Table 3> shows the comparative values of temperature change of participant's thermography. The following <Figure 4> is the measurement of body temperature change during thermography shooting.

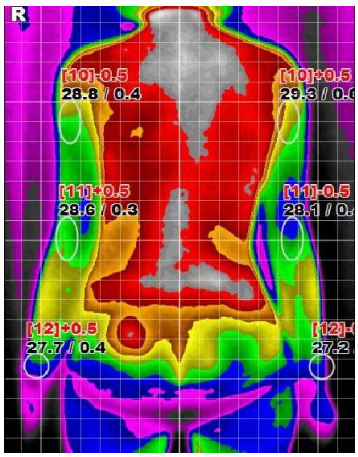
Table 2. Comparison of thermography temperature change of the participant(unit: degree).

Division	1st		2nd		3th	
Front upper body	27.1	27.0	28.3	28.3	30.7	30.8
	27.2	27.2	28.4	28.1	31.1	31.0
	25.8	25.9	26.1	25.2	29.7	28.3
	26.9	26.7	27.6	28.2	29.8	29.9
	25.4	20.8	26.8	25.2	28.2	26.8
Rear upper body	24.5	25.9	26.8	28.2	28.8	29.3
	24.2	24.7	26.3	23.5	28.6	28.1
	24.9	24.9	25.0	27.3	27.7	27.2
Front lower body	22.7	23.0	24.3	24.4	28.0	27.9

	22.0	21.8	24.8	24.4	26.1	26.4
	21.4	22.1	27.0	24.9	27.4	25.7
	20.9	20.7	25.3	25.1	23.4	24.9
Rear lower body	23.8	23.7	25.2	25.7	29.4	29.7
	23.2	22.2	25.0	25.1	27.7	27.8

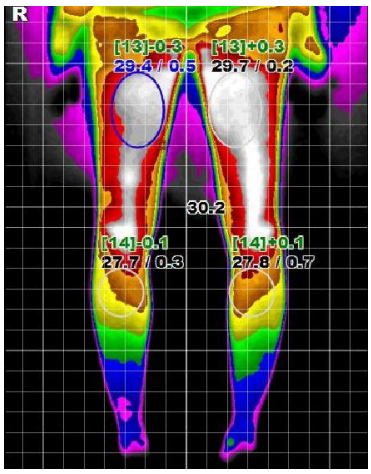
Figure 4. Thermography temperature change of the participant.

Front upper body



Rear upper body

Front lower body



Rear lower body

4. Conclusion

In this study, Infrared Thermal Imaging(ITI), which detects the heat emitted from the surface of the human body, is non-invasive and provides objective image data to diagnose diseases. Thermography, which has advantages of high sensitivity, non-invasive points and simple instrument manipulation, in the case of a diagnosis of spinal nerve root compression symptoms or complaints of diaphragmatic pain in the lower limb not revealed by spinal angiography, is used

as an objective diagnostic and evaluation method for muscle ligament injuries of the lumbar region, inflammation and tumors of the spine. It is used not only for diagnosis but also for post-treatment evaluation, and has also been used as an adjunct to quantitative assessment of pain and assessment of muscle condition, herniated disc, peripheral nerve damage, and diagnosis and treatment of autonomic nervous system disorders[15]. The findings of these studies show that body temperature is an important indicator of symmetry of the body, and the skeletal disorder is to be asymmetric if it has scoliosis.

The problem of vertebral deformity is sitting for a long time in an unsuitable position on the desk, relatively lack of exercise results in muscle weakness supporting the spine, or when the musculoskeletal system is rapidly growing, it may become structurally unstable and may be bent in various ways such as a waist while being taller. The most frequent occurrence is scoliosis[16][6]. In the case of idiopathic scoliosis, the cause of which is unknown, although surgical treatment is considered as treatment methods, but in general, non-surgical treatment methods such as exercise therapy, electrical stimulation therapy, orthosis use, traction therapy, frequency therapy, and Schroth exercise approach are considered as treatment methods[17][18][19].

To date, general scoliosis therapy focuses on changes in strength and spinal morphology that affect the degree and rate of deformation, and there is a lack of research focused on the change in reduced thoracic expansion capacity due to scoliosis caused by scoliosis. Deformation of the vertebral skeleton due to scoliosis results in restriction and imbalance of the thoracic expansion, and severe deformation of thoracic vertebrae may result in increased respiration and reduced pulmonary flexibility resulting in short and shallow respiration.

Thus, to investigate the effect of Sling and Schroth exercises on scoliosis patients, this study applied exercise programs for one year, twice a week for the first three months, eight times a month, and the other nine months, once a week, four times a month, and evaluated and compared changes of somatotype photos and thermography. There was a significant difference in flexibility, strength, and balance ability in the related studies using Sling and Schroth exercise therapy for scoliosis patients, and In a study of comparison of Schroth exercise and correction exercise therapy[20], Schroth and correction exercise programs showed a significant effect on reduction of spine angles and pulmonary function parameters. In a study in which a Sling exercise program was applied to patients with scoliosis[9][13], Sling exercise was found to have a significant effect on body fat, lumbar muscle strength, balance ability, flexibility and vertebral angle. In previous studies that applied Schroth's exercise treatment to scoliosis patients, they focused mainly on the scoliotic angle, but in the studies[8][21] who measured flexibility, there was a significant difference in flexibility before and after Schroth exercise.

It is thought that the Sling and Schroth exercise treatment strengthened weakened muscles and decreased the spinal angles due to muscle imbalance. In addition, both exercise methods were able to perform isolated exercise and whole body exercise, so strengthened muscles weakened by local exercise and using both right and left muscles as a whole body exercise seemed to help to reduce vertebral angle. Lateral curvature due to scoliosis interferes with the growth of the thoracic and lungs, leading to weakness of the respiratory muscles and impaired cardiopulmonary function[14].

This study showed that Sling and Schroth had a significant effect on the correction effect of idiopathic scoliosis. It is difficult to generalize to all subjects because this study is conducted on a single case of one subject, but this study is meaningful in that it is to provide information to help set up and manage the planning and direction of exercise program for patients with idiopathic scoliosis.

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6. Contribution

6.1. Authors contribution

	Initial name	Contribution
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Corresponding Author*	LJB	-Corresponding ☑ -Play a decisive role in modification ☑
Co-Author	KHW	-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 ☑

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Effects of FUNCTIONAL CORRECTION on Foot Pressure Balance, Pelvic Displacement and Spinal Displacement in Patients with Low Back Pain

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Abstract

Purpose: After 8 weeks of functional orthodontic treatment on the subjects of twelve worker patients with back pain in their 30s, this study attempted to investigate the effect of pelvic tilt, pelvic rotation, lumbar lordotic angle and ferguson's angle on pelvic floor balance and pelvic displacement.

Method: First, to investigate the change in foot pressure balance after functional correction of participants, the foot pressure balance was measured by dividing it into three stages before, during, and after treatment. Second, Pelvic AP View and Lumbar Lateral view were measured before and after treatment to examine X-ray changes in pelvic displacement and spinal displacement after functional correction of participants.

Results: To examine the results of analyzing the changes in foot pressure according to the functional correction of the study participants, the changes in the foot pressure of the left and right and the front and back sides showed a more balanced form of foot pressure after conducting functional correction than before conducting functional correction, which is analyzed that there is a statistically significant difference. There was no statistically significant difference between the lumbar lordotic angle's pre and post displacement among the participants' spinal displacement, but the pre- and post-displacement of Ferguson's Angle showed that there was a statistically significant difference(p<.05).

Conclusion: This study confirmed that functional correction treatment had a significant effect on pelvic displacement and spinal displacement overall, positively affecting the balance between the trunk and lower limbs, improving the difference in foot pressure and improving body stability.

[Keywords] ***Functional Correction, Foot Pressure Balance, Pelvic Displacement, Spinal Displacement, Low Back Pain***

1. Introductions

In modern society, due to rapid industrial development and social structure changes, limited physical activity, bad posture and stress in daily life, and long-standing sitting postures cause gradual changes in the musculoskeletal system and diseases. In addition, due to repetition of wrong habits and lack of exercise, the pelvic misalignment, deformation of the natural spinal pelvic curvature, and dysfunction occur, there is difficulty in maintaining the correct posture, and the displacement of the spine and pelvis, and muscle imbalance, etc. cause an imbalance of the body.

In particular, low back pain is a common disease in modern society that is experienced at least once in a life time, and is a widespread disease that can occur around the lumbar spine, including back pain. When low back pain lasts more than several months, physical activity is limited and social and psychological atrophy occurs. According to a report from the Ministry of

Health and Welfare(2015) in Korea, of the total disease treatment(81.8%) classification, lesions of the musculoskeletal system associated with low back pain accounted for more than 22%, with 6.6% of low back pain, 6.7% of lumbar sprains, 4.1% of discs, and 4.6% of neuralgia. Surgery for low back pain is also gradually increasing, which is a serious situation[1], and the incidence of low back pain is on the rise due to poor lifestyle, irregular physical activity, and lack of exercise.

In a study examining the correlation between pelvic displacement and foot pressure in patients with low back pain, it has been reported that foot pressure was found to be high mainly in the left and rear when standing, and that the left-right foot pressure imbalance is greater than the front-rear foot pressure imbalance. In particular, it is said that as in patients with low back pain with instability in the body, changes in the trunk and pelvis cause a change in foot pressure and show an asymmetric weight distribution[2].

In addition, when walking in patients with chronic back pain, the knee joint and hip joint are bent, and the angle of the lumbar lordosis increases, and so the range of motion the front and rear pelvis is reduced and the plantar flexion of the foot is increased, causing changes in normal over and backward motions, which is said to increase the vertical impact and the foot pressure of the forefoot[3].

With regard to the treatment of low back pain, there are self-care such as following advice around, acquiring knowledge through books, and applying heat to the surface, the medical surgery or medication, and the conservative therapy, that is, non-drug treatment such as spine correction, exercise therapy, massage, acupuncture, yoga, and cognitive behavioral therapy[4]. Among them, the conservative therapy can cure back pain within 10 to 12 weeks[5], 90% of patients with low back pain are improving with the conservative therapy, and surgical treatment requires only 1-2%[6].

Manual therapy is one of the most frequently used non-surgical methods of physical therapies for the treatment of low back pain. The treatment of pain and dysfunction caused by disease or injury using physical factors can be referred to as the definition of physical therapy. As a dynamic force among physical factors, manual therapy is the overall process in which physical therapists use their hands for examination and treatment. The characteristic of manual correction therapy is natural therapy that does not depend on drugs or surgery, and it is a study that treats the human body based on the whole rather than a part by finding the root cause rather than treating the symptoms of the disease. It is a medicine that treats nerves, muscles, or skeletons, including exercise, in a complex way, based on prevention purposes and maintaining optimal health, and is a study that treats the pelvic and spinal centers in tissues with the kinematic functions of the human body[7].

Functional correction, a technique of manual therapy used in this study based on basic medicine and anatomical diagnosis, is a study that systematizes seven diagnostic methods such as existing manual therapy techniques, chiropractic diagnostics, ROM analysis, radiographic analysis, and leg length analysis and uses two or more test methods to treat them. The principle of functional correction is to correct the dislocation of the displaced vertebrae to the normal range, thereby increasing the misalignment and mobility of the joint area, smoothing the passage of nerves, and to restore the body normally by maximizing the natural healing power by adjusting the balance of the musculoskeletal system.

Therefore, this study is aimed to explore the effects of the non-surgical functional correction therapy through the existing chiropractic diagnosis method and ROM analysis method on foot pressure balance, pelvic displacement, and spinal displacement for patients with low back pain.

2. Methods

2.1. Participant

This study was conducted on 12 participants(five men, seven women, and an average age of 33 years old) with chronic low back pain who were in their 30s who visited Y Hospital in G-do, Korea. Participants were those who had no history of surgery related to disc prolapse, no neurological abnormalities, and no specific diseases other than low back pain, the purpose of this experimental study was fully explained to them in advance and they agreed to participate in the study, and the changes in foot pressure, pelvic displacement, and spinal changes were compared and analyzed through functional correction treatment three times a week for 8 weeks.

2.1. Instruments

The foot pressure was measured using a foot pressure meter(GHF-550, Korea). The standard of the numerical value is that 50:50 becomes the center of the balance of foot pressure. X-ray analysis was performed using Median International, Inc.'s MS-TSF(D) Model radiograph imaging machine, and participants were photographed in a straight posture and analyzed using the Gonstead technique. To measure pelvic tilt and pelvic rotation, AP view was taken based on sacral number 2(S2). To measure the lumbar lordotic angle and Ferguson's Angle, a lateral view of the lumbar 5(L5) was taken from the standing posture. Wiz Pacs were used for reading after imaging.

2.3. Procedure and program

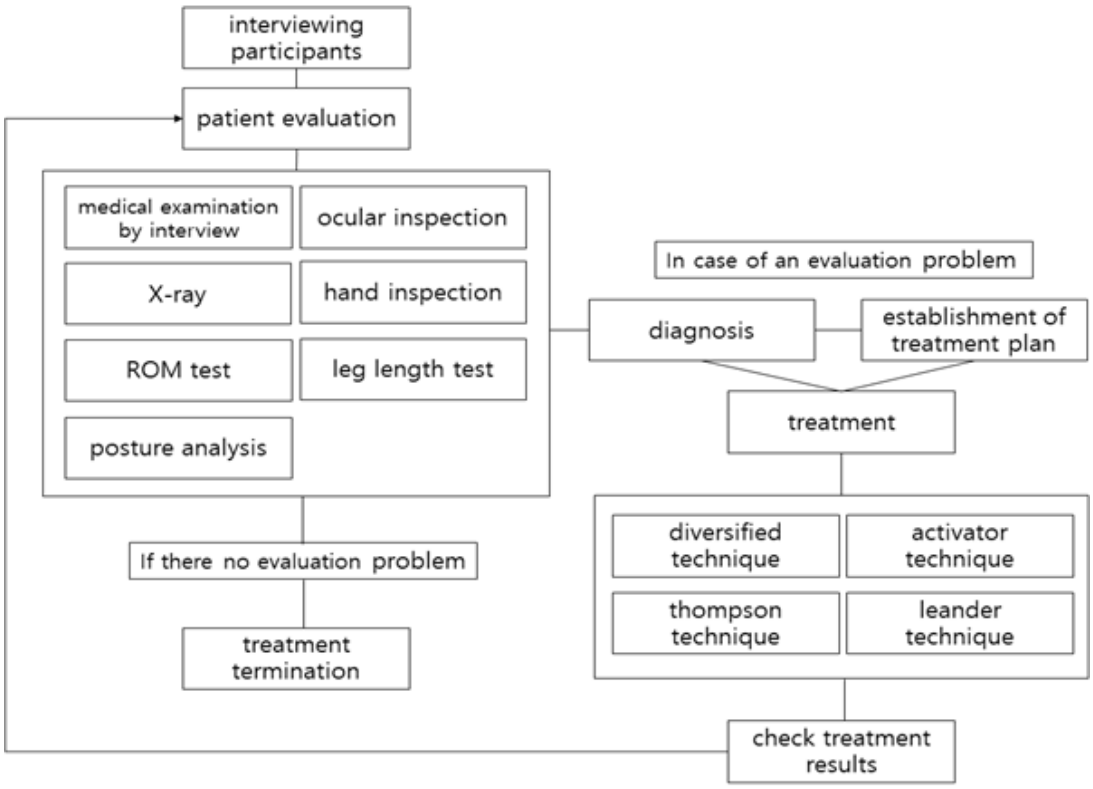
To proceed with this study, first, review of previous studies and literatures on research issues was conducted, and after selecting the participants and filling out the consent form, the contents of the experiment and the treatment process were described. <Figure 1> illustrates the functional correction process conducted in this study[8].

2.4. Data analysis

To compare and analyze the foot pressure balance, pelvic displacement, and spinal displacement after functional correction in patients with low back pain, the foot pressure and X-rays of 12 participants were investigated, and specifically, the methods for data analysis are as follows.

First, to investigate the change in foot pressure balance after functional correction of participants, the foot pressure balance was measured by dividing it into three stages before, during, and after treatment. Second, Pelvic AP View and Lumbar Lateral view were measured before and after treatment to examine X-ray changes in pelvic displacement and spinal displacement after functional correction of participants. Third, a paired sample t-test was conducted to analyze how participants' functional correction affects foot pressure using the SPSS 21.0 statistical program for Windows. Fourth, Pearson's correlation coefficient, which is a parameter test, was used for correlation analysis by indexes. Fifth, all statistical significance levels were $p<.05$.

Figure 1. Therapeutic process of functional adjustment procedure.



3. Results

3.1. Measurement of foot pressure change before and after functional correction

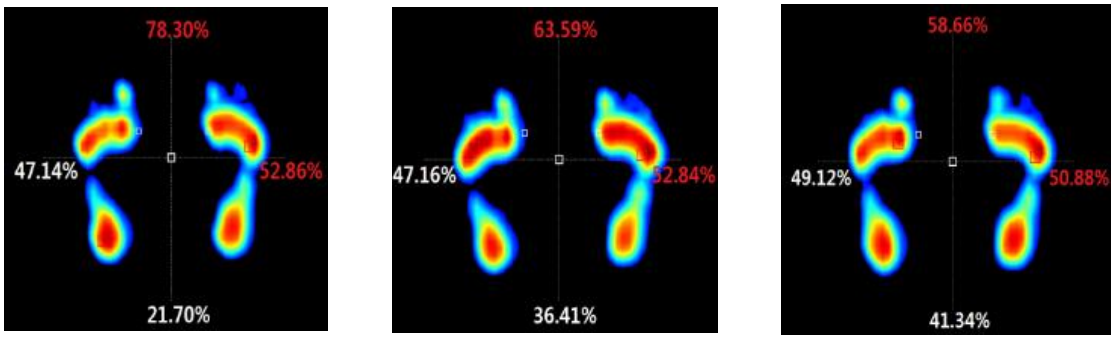
The measures and changes of the left and right foot pressure for the participants in this study before and after treatment, 4 weeks of treatment, and 8 weeks of treatment are as shown in <Table 1>, and the measurements and changes of the front and back foot pressure are as shown in <Figure 2>. To examine the results of analyzing the changes in foot pressure according to the functional correction of the study participants, the changes in the foot pressure of the left and right and the front and back sides showed a more balanced form of foot pressure after conducting functional correction than before conducting functional correction, which is analyzed that there is a statistically significant difference.

Table 1. Analysis of foot pressure change before and after functional correction(unit : %).

Category	Pre	4 weeks	8 weeks	4 weeks		8 weeks	
				t	P-value	t	P-value
Foot pressure (left/light)	10.41±4.70	6.25±3.31	1.70±0.84	4.005	0.002	6.315	0.000
Foot pressure (front/back)	38.25±20.19	27.76±18.02	14.56±12.22	1.972	0.074	4.259	0.001

Note: n=12.

Figure 2. Comparative analysis of foot pressure change of participants 3.



3.2. Measurement of changes in pelvic and spinal displacements of participants

In relation to the pelvic displacement of the participants in this study, the changes of the left and right of the pelvic tilt and pelvic rotation were measured as shown in <Figure 2>, <Figure 3>. In addition, for participants' spinal displacement, the sacrum(Ferguson's Angle) and lumbar lordotic angle were measured. The results of mean, standard deviation, and corresponding sample t-test for the participants' pelvic displacement and spinal displacement are shown in <Table 2> below. There was no statistically significant difference between the lumbar lordotic angle's pre and post displacement among the participants' spinal displacement, but the pre- and post-displacement of Ferguson's Angle showed that there was a statistically significant difference($p<.05$).

Table 2. Pelvic and spinal displacements of participants(unit : mm).

Category	Pre	8 weeks	t	P-value
Left pelvic tilt	222.53±10.60	222.13±11.28	0.479	0.641
Right pelvic tilt	221.86±10.42	222.48±10.65	-7.68	0.459
Pelvic rotation	6.41±3.86	3.38±3.14	3.611	0.004
Ferguson's angle	37.83±5.11	40.50±4.34	-4.257	0.001
Lumbar lordotic angle	37.75±7.88	39.50±5.22	-0.922	0.377

Note: n=12.

Figure 3. Thermography comparative analysis before and after x-ray of pelvic displacement of participant 11.

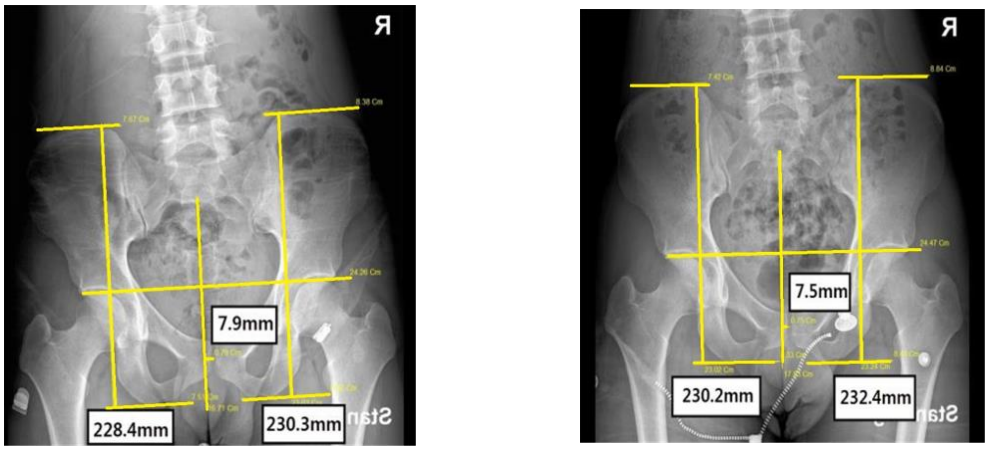
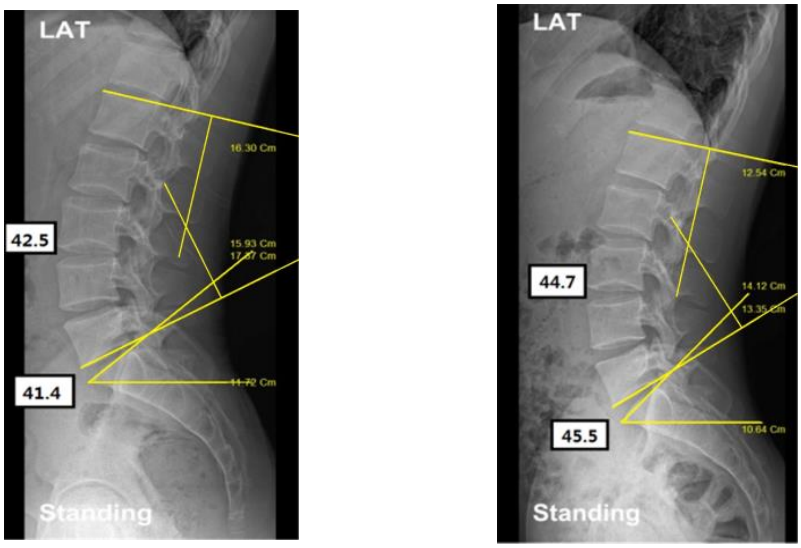


Figure 4. Thermography comparative analysis before and after x-ray of spine displacement of participant 11.



3.3. Correlation between participant's foot pressure, pelvic displacement and spinal displacement

Pearson correlation analysis was performed to examine the relationship between pelvic displacement and spinal displacement and foot pressure ratio left-right, front-back after study participants' functional correction. According to the analysis results, the left pelvic tilt among the pelvic displacements showed a significant relationship with the foot pressure left-right ratio($p<.01$), and there was also a significant relationship with the foot pressure front-to-back ratio($p<.01$, $p<.05$). Among pelvic displacements, the right pelvic tilt showed no significant relationship with foot pressure left-right ratio, and among the front and back foot pressure ratios, there was a significant correlation with the front ratio($p<.05$).

Among the pelvic displacements, pelvic rotation showed a significant relationship in both foot pressure left-right ratio and foot pressure front-to-back ratio($p<.01$). Meanwhile, among spinal displacements, Ferguson's Angle showed a significant relationship in both the foot pressure left-right ratio and the foot pressure front-to-back ratio($p<.01$). The lumbar lordotic angle showed a statistical significance only in the foot pressure left-right ratio($p<.01$).

Table 3. Correlation between participant's foot pressure, pelvic displacement and spinal displacement.

Category		After functional correction			
		Ratio		Ratio	
		Left	Right	Front	Back
Pelvic displacement	Left pelvic tilt	-.233(**) .005	.231(**) .005	-.223(**) .007	.203(*) .015
	Right pelvic tilt	-.151 .071	.148 .076	-.176(*) .035	.160 .055
	Pelvic rotation	.234(**) .005	-.235(**) .005	-.532(**) .000	.530(**) .000
Spinal displacement	Ferguson's angle	-.261(**) .002	.263(**) .001	.315(**) .000	-.314(**) .000
	Lumbar lordotic angle	-.293(**) .000	.293(**) .000	-.117 .161	.105 .210

Note: *p<.05, **p<.01.

4. Conclusion

This study started with the hypothesis that functional correction can bring positive changes in foot pressure and X-rays. About the results obtained for the participants, this study attempts to elaborate them by dividing them into three categories such as changes in foot pressure, pelvic displacement and spinal displacement analysis through X-ray, and changes in the correlation between foot pressure ratio and pelvic and spinal displacement.

First, in the results of conducting the t-test of the corresponding sample to find out the difference between the post-treatment(4 weeks, 8 weeks), it was found that after 4 weeks of functional correction, the left and right foot pressures and after 8 weeks of functional correction, there was a significant difference between the left-right and front-back foot pressures in the pre and post displacements. According to a previous study[9], the greater the degree of scoliosis, the larger the left-right body imbalance, which affects foot pressure, and foot balance is closely related to posture balance, and abnormal movement of the center of gravity affects spinal deformity and postural imbalance. A study comparing weight support rates on both lower extremities when standing up in patients with low back pain[10] showed that weight support rates were lower in the lower extremities with no pain than those of the painless side. According to another study[11], it was reported that supporting the weight mainly toward the painless side appeared to reduce the pain caused by muscle contraction around the lumbar spine and pelvic when standing with the painful lower limb.

Second, this is the content analyzed by numerating in values the changes of pelvic tilt and pelvic rotation among pelvic displacements before and after functional correction. Looking at the results of the study, statistical differences in functional correction treatment were found in measuring pelvic rotation rather than pelvic tilt, and previous studies[3][12][13] also show similar research results.

Among the vertebral displacements, when the angle change for Ferguson's Angle and lumbar lordotic angle is quantified, and the results after functional correction analyzed before and after functional correction are examined, a statistical difference in functional correction treatment was found in the measurement of Ferguson's Angle. The mean of male and female lumbar lordotic angles in Korea is about 41.7°, and that of the normal group's lumbar lordotic angles is 44.5°[14][15].

The increase of the lumbar lordotic angle requires greater weight support for the hip joint, and the reduction of lumbar lordotic angle requires greater weight support on the intervertebral disc, the degree of degenerative change occurs earlier than the other area, and it is said to be an important cause of clinical low back pain[16].

Ferguson's Angle is generally a reference range from 30° to 57°, and this range is so wide that it is known to have little clinical significance. However, increasing Ferguson's Angle increases lumbar lordosis, and its decrease lumbar lordosis and increases shearing force, so that it is a factor inducing back pain by applying pressure to the back ligament and facet joint [17][18]. In this study, however, compared to before the functional correction, the mean of Ferguson's Angle and lumbar lordotic angle increased when it comes closer to the second half, but statistical significance was higher in Ferguson's Angle than in lumbar lordotic angle($p<.05$).

Third, it is about the analysis of the correlation between foot pressure ratio and pelvic displacement and vertebral displacement before and after functional correction. According to studies on the relationship between scoliosis and foot pressure, the deviation of the tendency of the center of foot pressure in both feet was significantly correlated with the degree of scoliosis, and scoliosis only affects foot imbalance[19]. In the relationship between foot pressure distribution and spinal alignment in a static standing position, the lumbar lordotic

angle was significantly correlated with the mean pressure of the right foot and the foot pressure of the area behind the left foot[20]. In this study, the correlation between pelvic displacement and vertebral displacement before functional correction was found to have a significant relationship only with the lumbar lordotic angle, the vertebral displacement item, and the left-right and front-back foot pressure ratios.

What we can derive from the above is that the pelvic indicators in chronic low back pain patients are more related to the foot pressure imbalance in the walking state than the foot pressure imbalance in the standing state[21]. It can be seen that the results of these studies are similar to those of[3][19] as a result of studying the correlation between pelvic displacement and foot pressure in patients with low back pain.

This study confirmed that functional correction treatment had a significant effect on pelvic displacement and spinal displacement overall, positively affecting the balance between the trunk and lower limbs, improving the difference in foot pressure and improving body stability. Low back pain impairs the ability to maintain balance, distorts normal signals from the muscles and the highly soluble sensory organs, leading to an increase in the physiological and mechanical stress of the musculoskeletal system. Due to this, it is judged that the correct performance mechanism for distribution of weight load is different, and more detailed studies will be needed in the future.

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6. Contribution

6.1. Authors contribution

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Corresponding Author*	LJB	-Corresponding ☑ -Play a decisive role in modification ☑
Co-Author	KHW	-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 ☑

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