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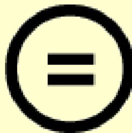

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Effects of body composition and physical fitness on Scoliosis in female middle school students

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Effects of body composition and physical fitness on Scoliosis in female middle school students

A Dissertation Submitted to the
Graduate School of Sungshin Women's University

in partial fulfillment of the requirements
for the degree of
Doctor of Physical Education

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ABSTRACT

The improvement in economic conditions and advancements in science and technology have greatly enhanced the convenience of people's lives. However, negative effects such as increasing rates of obesity among adolescents and spinal disorders have also been prominently observed. Therefore, this study aimed to investigate adolescent idiopathic scoliosis by classifying 186 female middle school students from *S* Middle School in *S* district, *S* City into a normal group and a scoliosis group. The normal group comprised 169 participants, while the scoliosis group consisted of 17 female middle school students with Cobb's angle of 10° or higher. To analyze the influence of body composition and physical fitness on adolescent idiopathic scoliosis, the Mann-Whitney *U* test was employed to examine the differences in body composition and physical fitness. Additionally, Pearson correlation analysis was conducted to assess the relationship between Cobb's angle in the thoracic and lumbar regions and variables related to body composition and physical fitness. Regression analysis was utilized to analyze the factors through which body composition and physical fitness variables affect Cobb's angle in the thoracic and lumbar regions. The following conclusions were drawn:

1. Among 186 female middle school students, 17 students had adolescent idiopathic scoliosis, accounting for 9.1% of the total. Furthermore, the height of students in the scoliosis group was

approximately 1% higher than that of the normal group, while the weight was approximately 4% lower, but these differences were not statistically significant.

2. In terms of body composition, BMI (kg/m^2) and waist-hip ratio (WHR) were significantly lower in the scoliosis group compared to the normal group (approximately 6% and 3% lower, respectively, $p < .05$). Other measures such as percent body fat (BF%), soft lean mass(SLM), body fat mass (BFM), fat-free mass (FFM), and skeletal muscle mass (SMM) were also lower in the scoliosis group, although the differences were not statistically significant.

3. In terms of physical fitness assessment, the scoliosis group had about 39% lower sit and reach and about 4% lower back muscle strength than the normal group, and there was no significant difference in all items.

4. The correlation analysis between Cobb's angle in the thoracic and lumbar regions and body composition, as well as physical fitness, revealed a significant negative correlation between lumbar spine left angle and height ($r = -.539$), and the regression equation was [Lumbar spine left angle=-.930 × height + 154.226].

The results of this study indicate that the decline in students' physical fitness due to COVID-19 is continuing, and it highlights the issues of underweight and decreased muscular strength in adolescents. These findings emphasize the need for multidimensional research focusing on addressing these concerns. It is suggested that

future efforts should aim to maintain a healthy body weight, engage in regular physical activity, and develop exercise programs to prevent and improve adolescent idiopathic scoliosis.

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I. Introduction

1. Necessity of research

According to the Health Insurance Review and Assessment Service in 2021, about 45.6% of spinal diseases under their 20s are scoliosis (Health Insurance Review and Assessment Service, 2021), and 44.4% of scoliosis patients are teenagers, the largest among 13−16 years of age. (Health Insurance Review and Assessment Service, 2015). In 2021, the number of spinal patients among Korean teenagers was 263,679, an increase of 1.09 times compared to 2020 (Health Insurance Review and Assessment Service, 2021). In particular, the incidence of scoliosis in women was 7.2 times that of men (Lonstein, 2006; Konieczny, Senyurt, & Krauspe., 2013), and in adolescents, women were about twice that of men (Health Insurance Review, 2015)

Idiopathic scoliosis is defined as a spinal deformity with Cobb's angle of 10° or more (Korean Orthopedic Association, 2006). Approximately 85% of patients are considered idiopathic and have no known cause, making it difficult to establish definitive preventive measures. Early detection and maintaining proper posture are considered crucial. Posture development revolves around the spine, and during periods of rapid growth such as childhood and adolescence, spinal deformities are more likely to occur. These deformities are influenced by factors such as nutritional status and

physical activity during the growth phase, as well as stress caused by poor lifestyle habits or posture, rather than congenital factors (Kim, 2009; Negrini et al., 2012).

In a study conducted by Choi et al. in 2007, analyzing the correlation between Cobb's angle in the thoracic region and body composition in 128 female middle school students diagnosed with scoliosis in Seoul, significant negative correlations were found between Thoracolumbar spine right angle and weight, body fat mass, and BMI. Additionally, a significant positive correlation was observed between Cobb's angle in the lumbar region and weight and body fat mass.

Furthermore, Kim (2009) found significant differences in fitness, physique, and body composition between normal students and students with scoliosis when measured using middle school physical fitness tests. Lee (2016) analyzed the health-related fitness of female middle school students based on the presence or absence of scoliosis. The scoliosis group showed significantly lower levels of overall endurance, muscular strength, and flexibility compared to the normal group. Additionally, they reported that body fat percentage and body mass index were significantly higher in the scoliosis group compared to the normal group.

Other previous studies have also reported significant differences in fitness (dos Santos Alves & Avanz, 2009), physique (Kim, 2006), and body composition (Tam et al., 2016) between students with scoliosis and normal students. These studies have shown differences

in fitness, body mass index, and obesity rates between students with scoliosis and normal students (Sperandio et al., 2014; Matusik, Durmala, & Matusi, 2016).

The recent limited students' school life and physical activities such as restrictions on daily life due to the global COVID-19 pandemic (WHO, 2020), including school closures, postponed school openings, and online classes, have increased scoliosis and obesity rates. As a result, there has been a lack of physical activity, sedentary behavior, and changes in dietary habits among adolescents, leading to an increase in obesity (Maltoni et al., 2021; Chambonniere et al., 2021; Umano et al., 2022). In particular, the World Health Organization reported that 88.14% of adolescents worldwide are physically inactive, with South Korea being as the country with the highest prevalence of physical inactivity among female adolescents, at 97.2% (Guthold et al., 2020). Research has found that non-physical activity leads to a lack of exercise, unhealthy habits, and inadequate health education contributing to spinal deformities caused by poor posture (Cho et al., 2014; Lee et al., 2011; Lee, 2010). It has been found that performing appropriate spinal correction exercises can increase bone and muscle mass and effectively reduce scoliotic curvature (Choi, 2008).

The elementary and middle school years are a crucial period of vigorous physical development and laying the foundation for lifelong health. The decline in students' physical fitness and reduced physical activity have become significant national and social issues as they are directly linked to overall health deterioration.

Therefore, this study recognizes the need for research on scoliosis, obesity, and physical fitness during adolescence, considering the increase in sedentary behavior and physical inactivity among adolescents due to the COVID-19 pandemic.

2. Research Purpose

The purpose of this study is to investigate female middle school students, compare the body composition and physical fitness of the normal group and the scoliosis group, and examine the correlation between Cobb's angles of the thoracic and lumbar spine. The objective is to assess the level of body composition and physical fitness in adolescents and provide fundamental data for exercise prescriptions aimed at promoting proper growth and development in adolescents.

3. Research Hypothesis

1) There will be differences in the physique (height, weight) between the normal group and the scoliosis group.
2) There will be differences in body composition (BMI, percent body fat, waist-hip ratio, soft lean mass, body fat mass, fat-free mass and skeletal muscle mass) between the normal group and the scoliosis group.
3) There will be differences in physical fitness (agility, muscular endurance, flexibility, muscular strength, cardiovascular endurance) between the normal group and the scoliosis group.
4) There will be a correlation between Cobb's angles of the thoracic and lumbar spine and body composition as well as physical fitness.

5) Body composition and physical fitness will have a certain influence on Cobb's angles of the thoracic and lumbar spine.

4. Research Limitations

This study had the following limitations:

1) The participants of this study were limited to female students in grades 1 and 2 attending S middle schools in S City, S District.

2) Individual characteristics such as environmental, genetic, and psychological differences among the study participants were not taken into consideration.

5. Definition of Terms

1) Scoliosis

Scoliosis is a condition in which the spine twists laterally away from its central axis or deforms the vertebral body. In this study, when X-rays were taken in the coronal plane if the Cobb's angle was more than 10 degrees, it was judged as scoliosis(Korean Orthopaedic Association, 2006; Negrini et al.,2012).

2) Cobb’s angle

Cobb's angle is determined on an upright lateral spine *X*-ray. To establish the range of spinal curvature, parallel lines are drawn on the upper and lower endplates of the most tilted vertebra, which are parallel to each other. Perpendicular lines are then drawn from these parallel lines, and the angle between these perpendicular lines is known as the Cobb angle. The severity of spinal curvature is

generally assessed based on the degree of the Cobb angle (Cobb, J. R., & American Academy of Orthopaedic Surgeons., 1948).

3) Physical fitness

Physical fitness refers to the basic physical abilities necessary to sustain an energetic and healthy daily life (ACSM, 2013). In this study, health-related fitness is defined as cardiorespiratory endurance, muscular endurance, muscular strength, flexibility, and body composition.

4) Cardiorespiratory endurance

Cardiorespiratory endurance refers to the ability of the circulatory and respiratory systems to supply oxygen during sustained physical activity (ACSM, 2013).

5) Muscular endurance

Muscular endurance refers to the ability of muscles to sustain a certain intensity and maintain a consistent level of performance during prolonged muscular work (ACSM, 2013).

6) Muscular strength

Muscular strength refers to the maximum force generated by a muscle or group of muscles during a single contraction (ACSM, 2013).

7) Flexibility

Flexibility refers to the elasticity and elongation capacity of tissues such as bones, muscles, and ligaments around joints, and it determines the maximum range of motion of joints (ACSM, 2013).

8) Body composition

Body composition represents the relative data or percentage of various types of body tissues (bones, fat, muscle) that are related to health (ACSM, 2013).

9) Body Mass Index(BMI)

The definition of Body Mass Index (BMI) is calculated as weight (kg) divided by height (m) squared, and the formula is as follows (WHO, 2000):

BMI = weight (kg) / height (m^2)

II. Theoretical background

1. Scoliosis

1) Spine and Scoliosis

The spine is located in the central part of the human body and serves as a major structure for maintaining the balance of the body. It is composed of the cervical, thoracic, lumbar, sacral, and coccygeal vertebrae. In a healthy condition, the spine acts as a central axis, with muscles, bones, and nerves symmetrically distributed on both sides (Crivellato & Ribatti, 2008). Symmetry is a fundamental characteristic of the morphological properties of the musculoskeletal system in the human body. When symmetry is disrupted and balance is compromised, it can have an impact on functionality. Prolonged imbalance can lead to deformities or rotations of the body, resulting in changes in spinal curvature and even the development of scoliosis (Le Huec et al., 2019; Hefti, 2013).

Scoliosis is the most common spinal deformity, and it is defined as the presence of a spinal curvature of 10° or more when the patient is in an upright position as observed on X-ray imaging (Hresko, 2013). Idiopathic scoliosis is the most common type of scoliosis and it causes lateral curvature in the coronal plane, axial

rotation in the horizontal plane, and changes in the sagittal plane (Negrini et al., 2012; Weinstein et al., 2008).

The progression rate of scoliosis is known to be most rapid at the onset of puberty (Wong et al., 2005; Grivas et al., 2006) and predominantly affects children aged 10-16 (Weinstein, 1999). According to previous studies, patients with immature bones and scoliosis measuring 25-30 degrees or more are at a higher risk of progression, with a greater likelihood of progression in adolescent girls and those with larger scoliotic curves (Hresko, 2013). In scoliosis patients, there can be the transverse offset of the spinous processes, shoulder and scapular imbalance, waist circumference and trunk asymmetry, rib rotation, fusion in the thoracic or lumbar region, physiological thoracic hyperkyphosis, impairments in sagittal and coronal spinal balance (Kotwicki et al., 2013; Hresko, 2013). Untreated patients with idiopathic scoliosis may experience back pain and cosmetic concerns in adulthood (Weinstein et al., 2003; Weinstein et al., 2008). The progression rate of scoliosis is most rapid at the onset of puberty (Wong et al., 2005; Grivas et al., 2006), and untreated patients with idiopathic scoliosis may experience back pain and cosmetic concerns in adulthood (Weinstein et al., 2003; Weinstein et al., 2008).

2) Types and Classification of Scoliosis

Scoliosis is generally classified into structural scoliosis and functional scoliosis. Functional scoliosis refers to secondary scoliosis that occurs as a result of leg length discrepancy or asymmetric tension of the paraspinal muscles, and it typically partially reduces or completely disappears when the underlying cause is addressed (Negrini et al., 2012). Adolescent idiopathic scoliosis belongs to the category of structural scoliosis, and its exact etiology is unknown. It occurs more frequently in adolescents and children during periods of rapid growth and is associated with various factors. Approximately 80% of scoliosis cases are idiopathic scoliosis (Negrini et al., 2018). Lenke classified scoliosis into six types based on the location of the scoliotic curve, including the main thoracic curve, proximal thoracic curve, and thoracic/lumbar curve (Lenke et al., 2001). The four major curve patterns in idiopathic scoliosis are thoracic, lumbar, thoracolumbar, and double major curves (Weinstein, 1999). Research findings indicate that thoracolumbar curves are the most common (40.1%), followed by thoracic curves (33.3%), bilateral or tri-planar curves (18.7%), and lumbar curves (7.9%) (Wong et al., 2005). In a survey of Korean adolescents, thoracic curves were found to be the most common (47.59%), followed by thoracolumbar/lumbar curves (40.10%), bilateral curves (9.09%), and double thoracic curves (3.22%) (Suh et al., 2011).

Scoliosis is classified as mild or severe based on the size of the Cobb angle. In infants, it is considered mild (low) when the Cobb angle at the C6–7 disc in the cervical spine is between 5–20°. In juveniles, it is classified as moderate (moderate) when the Cobb angle at the C7–T1 in the cervicothoracic spine is between 21–35°. In adolescents, it is classified as moderate to severe (moderate to severe) when the Cobb angle from the T1–2 disc to the T11–12 disc in the thoracic spine is between 36–40° (Negrini et al., 2018).

Female curves have been found to progress more commonly in idiopathic scoliosis, and the ratio of affected girls to boys is similar at Cobb angles of 10–20° (1.4:1). The ratio increases to 5.4:1 in the Cobb angle range of 20–30°, and when the Cobb angle exceeds 30°, the ratio increases to 7.2:1 (Lonstein, 2006; Konieczny, Senyurt & Krauspe, 2013). There are gender differences in the Cobb angle, and a higher proportion of females is observed as the Cobb angle increases. When the Cobb angle is less than 10°, it should not be diagnosed as scoliosis, but regular observation is necessary. Patients with scoliosis exceeding 30° after reaching adulthood are at increased risk of curve progression, compromised health, and reduced quality of life. Patients with scoliosis exceeding 50° during adulthood experience health issues and a decrease in quality of life (Negrini et al., 2018).

3) Diagnosis of scoliosis

In the early stages of scoliosis, there may not be prominent physical changes, making it difficult to detect. The goal of early diagnosis is to identify scoliosis at an early stage (Daruwalla & Balasubramaniam, 1985). The most effective treatment is based on early detection through screening (Lonstein, 1988). The key criteria for screening scoliosis are accuracy, reproducibility, sensitivity, and specificity. Screening tests should be fast, cost-effective, safe, feasible, easy to perform, and have clear threshold values (Chowanska et al., 2012). The golden standard for diagnosing scoliosis is Cobb's angle of ≥10° on anteroposterior standing X-ray films (Negrini et al., 2012).

The Adams forward bend test is frequently used, along with the use of scoliosis measurement devices to assess increased sensitivity and specificity, measure the posterior contour, and detect spinal deformities from digital images (Shere & Clark, 2022). Asymmetry in the chest and trunk is the foundation of scoliosis screening (Hresko, 2013). Screening techniques vary based on surface forms, and the Adams forward bend test is well-known among schools and primary healthcare professionals. It is widely used to provide subjective or qualitative assessments of spinal deformities (Bunnell, 2005). The examination involves the adolescent standing in a forward-bending position while the examiner inspects the trunk from the front, sides, and back to

identify any abnormalities such as spinal curvatures or rib humps. The accuracy of visual assessment depends on the experience and proficiency of the evaluator (Kotwicki et al., 2013). During the forward bend test, the student bends forward with their feet approximately 15 cm apart, knees slightly bent, shoulders relaxed, hands placed on the knees or in front of the shins, elbows straight, and palms facing each other (Grivas et al., 2007). Adolescents with trunk rotation measurements of 5° or more undergo a secondary medical evaluation and X-ray examination (Bunnell, 1984). The Adams forward bending test is a commonly used screening method, with a sensitivity of 92% and a specificity of 60% in detecting thoracic curves of 20° or more using the Cobb angle (Kotwicki et al., 2013). The Adams forward bending test was found to be more sensitive than the scoliometer in detecting thoracic curves of 20° or more using the Cobb method (Côté et al., 1998). Additionally, the diagnosis of scoliosis should be combined with assessing skeletal maturity grades (Hresko, 2013). Curve progression occurs primarily during the peak growth period and is influenced by factors such as gender, age, early menarche, curve type, and magnitude of the curve (Bunnell, 2005).

2. Scoliosis and Body Composition

The human body is composed of various components such as bone, fat, and muscle (ACSM, 2013). Body composition can be described using indicators such as BMI, body fat percentage, and fat and lean mass. BMI is calculated by dividing body weight (kg) by the square of height (m).

There are several commonly used methods to assess body composition, including BMI, waist-to-hip ratio (WHR), skinfold thickness (SKF) measurement, underwater weighing (HD), bioelectrical impedance analysis (BIA), near-infrared interactants (NIR), computerized tomography (CT), and magnetic resonance imaging (MRI) (Korean Society of Sports Medicine, 2011). Each method has its advantages and disadvantages, and when selecting an appropriate method, factors such as validity, cost, required technical expertise, accuracy level, participant burden, radiation exposure, and time required should be considered (Kuriyan, 2018).

The World Health Organization (WHO) generally evaluates and classifies body fat using body mass index (BMI). A BMI less than 18.50 is classified as underweight, a BMI greater than or equal to 25.00 is classified as overweight, and a BMI greater than 30.00 is classified as obese (WHO, 2000). However, BMI and body fat percentage can vary based on factors such as gender, race, and individual differences (Gallagher et al., 2000). Particularly during adolescence, which is a period of growth and ongoing changes in

body composition, the classification of obesity in children and adolescents is relatively complex (WHO, 2000). In South Korea, the criteria for determining obesity in adolescents is based on the 2017 Growth Charts, using the gender-specific and month-specific age body mass index (BMI) percentiles. If the BMI percentile is equal to or higher than the 95th percentile, it is classified as "obesity." If it is equal to or higher than the 85th percentile but less than the 95th percentile, it is classified as "overweight." If it is equal to or higher than the 5th percentile but less than the 85th percentile, it is classified as "normal." If it is below the 5th percentile, it is classified as "underweight" (Korea Centers for Disease Control and Prevention, 2017).

According to previous studies, changes in body composition were observed in adolescent patients with adolescent idiopathic scoliosis, resulting in lower BMI and body fat percentage (Ramírez et al., 2013; Barrios et al., 2011). A low BMI has been shown to hurt muscularity, bone density, stability of the musculoskeletal system, and structural characteristics, thereby increasing the prevalence of spinal deformities and adolescent idiopathic scoliosis (Jeon & Kim, 2021). Additionally, adolescent idiopathic scoliosis has been associated with accelerated skeletal growth during puberty, higher bone turnover, and lower calcium intake (Cheung et al., 2006).

According to research, spinal deformities in adolescents are associated with total body fat percentage, fat mass, and muscle mass (Normand et al., 2022). Patients with adolescent idiopathic

scoliosis tend to have lower skeletal muscle mass and percent body fat (Tam et al., 2016). Decreased muscle mass is typically accompanied by increased infiltration of fatty tissue (Cruz-Jentoft et al., 2010). Patients with adolescent idiopathic scoliosis show differences in lipid metabolism products compared to healthy groups, indicating disrupted glycerophospholipid, glycerol, and fatty acid metabolism (Sun, 2016). Studies have shown that patients with larger scoliotic curves during adolescence are associated with increased secretion and fat mass during puberty, and obese patients have larger thoracic curves compared to those with normal weight, indicating a correlation between scoliotic curves and obesity (Burwell et al., 2009; Margalit et al., 2017). Therefore, further research is needed to investigate the relationship between adolescent idiopathic scoliosis and body composition.

3. Adolescent Scoliosis and Physical Fitness

Physical fitness encompasses five components: cardiovascular endurance, muscular endurance, muscular strength, flexibility, and body composition, and each component is closely related to health (Korean Society for Exercise Physiology, 2011). Cardiovascular endurance refers to the ability of the heart and lungs to sustain exercise without fatigue for an extended period. Muscular strength refers to the ability to exert maximal force, while muscular endurance refers to the ability to sustain a given level of force over a while. Power refers to the ability to generate maximum force in minimal time (Korean Institute of Sports Science, 2009).

Skeletal muscle mass is closely related to muscle strength (Carlsson et al., 2014). According to research, there is a consistent correlation between scoliosis and muscle strength, and scoliosis can lead to changes in the muscles around the spine, especially the weakening of the para-spinal muscles, which can cause spinal instability (Ko & Kang, 2017). Low muscle strength can impair postural balance (Barrios et al., 2011; Kiemel et al., 2008), and asymmetric muscle strength (Kuo, Wang & Hong, 2010) and habitual muscle activity (Kuo et al., 2011) can result in muscle imbalances and asymmetry in the muscles beside the spine. According to studies, there is a negative correlation between adolescent scoliosis and grip strength, indicating a relationship between impaired muscle function in scoliosis (Yu et al., 2012),

sensorimotor integration dysfunction (Domenech et al., 2011), and sensory rearrangement of the motor system in spatial characteristics (Dalleau et al., 2011) related to abnormal postural control in scoliosis.

According to Leong et al. (1999), patients with scoliosis experience a restricted range of motion in the thorax and spine. In a cardiopulmonary exercise test conducted on scoliosis patients, it was found that lung capacity was correlated with the magnitude of thoracic kyphosis and thoracic hyperkyphosis (Lin et al., 2022). In cases of mild to severe scoliosis, limitations in cardiopulmonary function may not be evident under resting conditions, but maximal exercise capacity and cardiopulmonary endurance may decrease (Barrios et al., 2005). In adolescents with Cobb's angle ≥40°, scoliosis can affect the chest and potentially lead to impaired cardiac function (dos Santos Alves & Avanzi, 2009). However, some studies suggest that patients with mild to moderate scoliosis may not exhibit respiratory signs and symptoms (Koumbourlis, 2006). Therefore, more research is needed to understand the relationship between scoliosis and physical fitness in adolescents.

III. Research Methods

1. Research object

The study included 186 female students from grades 1−2 in *S* Middle School in *S* City, *S* District. Cobb's angle was measured in the thoracic, thoracolumbar, and lumbar regions of the spine for each participant. Individuals with Cobb's angle below 10° were classified as the control group, while those with Cobb's angle equal to or above 10° were classified as the scoliosis group. The general characteristics of the study participants are summarized in <Table 1>.

Table 1. General Characteristics of the Study Participants

Variable	Total (*N*=186)	Normal group (*N*=169)	Scoliosis group (*N*=17)
Age(yrs)	14.41±0.49	14.04±0.49	14.47±0.51
Height(cm)	158.41±5.53	158.23±5.56	160.19±5.00
Weight(kg)	49.52±7.04	49.69±7.20	47.71±4.98
BMI(kg/m^2)	19.74±2.33	19.85±2.37	18.63±1.60

M±*SD*

2. Research Procedure

This study targeted 186 female students from grades 1-2 in *S* Middle School in *S* City, *S* District. Measurements were taken to assess physical fitness related to body composition, flexibility, muscular endurance, strength, and the condition of scoliosis. The specific research design is depicted in <Figure 1>.

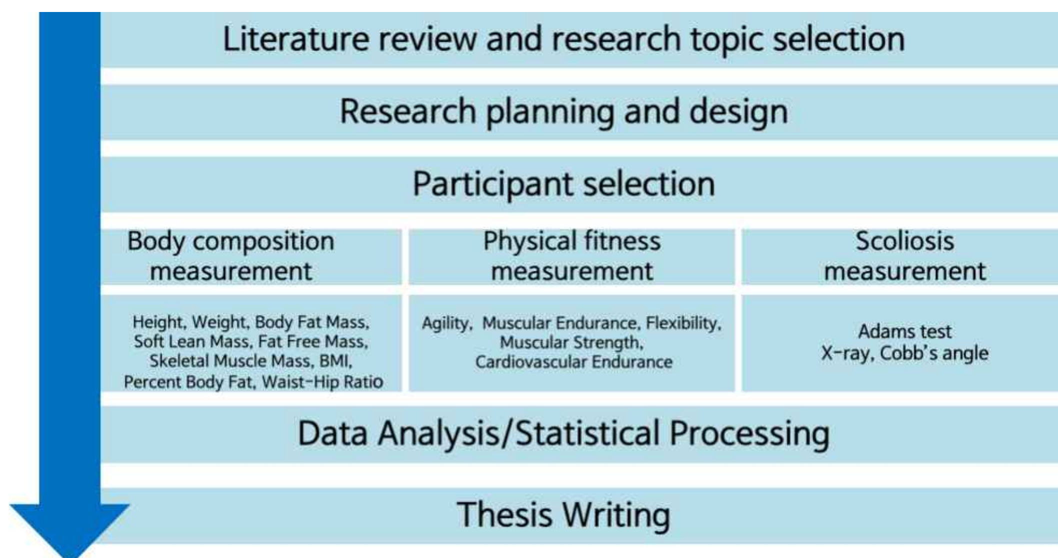

Figure 1. Research procedures

3. Research Duration

The duration of this study is as presented in <Table 2>.

Table 2. Research Duration

Procedure	Period
Literature review and research topic selection	2021.03~2021.12
Research planning and design	2022.01~2022.05
Participant selection	2022.06~2022.12
Body composition, Physical fitness, and scoliosis measurements	2023.01~2023.03
Statistical analysis and result interpretation	2023.03~2023.04
Thesis writing	2023.04~2023.05

4. Measurement Equipment

The measurement equipment used in this study is described in <Table 3.>

Table 3. Measurement Equipment

Category	Measurement Item		Model(Country)
Physique	Height (cm) Weight (kg)		GM-1000 (neoGMTEC, Korea)
Body Composition	Body Mass Index(BMI) Percent Body Fat(BF%) Waist-Hip Ratio Soft Lean Mass(kg) Fat Free Mass(kg) Skeletal Muscle Mass(kg) Body Fat Mass(kg)		Inbody 720 (InBody, Korea)
Physical Fitness	Flexibility	Sit and Reach Test	TKK-5403 (Japan)
	Muscular Strength	Back Muscle strength	TKK-5402 (Japan)
	Muscular Endurance	Sit-ups	
	Cardiovascular Endurance	1200m Run	
	Agility	Standing Long Jump	
Scoliosis	Adams test		Scoliometer, Korea
	X-ray, Cobb's angle		IR-500-125(USA) REM-52575(USA) ICR-1000(USA)

5. Measurement Items and Methods

The specific measurement items and methods used in this study are as follows:

1) Physique Measurement

Height and weight were measured using an automated measurement device (GM-1000, Korea). The measurement was conducted with the participant removing their shoes and socks, standing in a position where their eyes and chin were as levels as possible, facing forward, and measuring the vertical distance from the soles of their feet to the top of their head. Height was measured in units of 0.1 cm, and weight was measured in units of 0.01 kg. As shown in <Figure 2>.

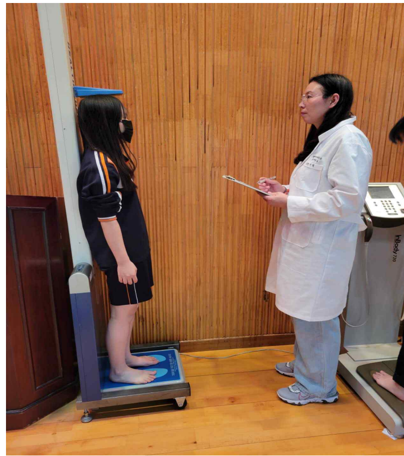

Figure 2. Measurement of Physique

2) Body Composition Measurement

Body composition analysis was performed using a multi-frequency impedance measurement device (InBody 720, Korea). Before the measurement, the participant's name, age, height, and gender were inputted into the device. The participant wiped their hands and the soles of their feet with a tissue soaked in an electrolyte solution. The participant then positioned both feet on the electrodes and held the handles with their hands, ensuring that all four fingers were evenly placed on the lower electrodes and the thumbs were pressed against the upper electrodes. The arms and body were held at an approximately 15° angle and the participant remained still without moving or speaking for 2 minutes during the measurement. As shown in <Figure 3>.

Figure 3. Measurement of Body Composition

3) Physical Fitness Assessment

(1) Flexibility (Sit and Reach Test)

Flexibility measurements are expressed in centimeters (cm). Before the measurement, appropriate warm-up activities were performed to prevent injuries. The participant removed their shoes and sat with their legs extended on a measuring platform at a height of 40cm. Both feet were in full contact with the vertical surface of the measuring device, the legs were straightened, and the back was kept straight (avoiding rounding of the back). Exhaling, the participant leaned forward, bringing the abdomen close to the front of the thighs, extending the chest forward sufficiently, and simultaneously used the fingertips to push the measuring ruler as far as possible. The measurement was taken in 0.1 cm increments, and the measurement reader recorded the point where the fingertips stopped, while the participant maintained the forward-leaning position for at least 2 seconds. Two measurements were conducted, and the best result was selected for recording. As shown in <Figure 4>.

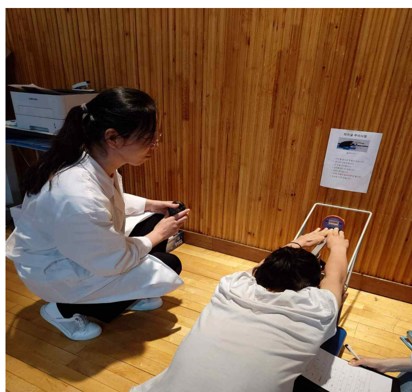

Figure 4. Sit and Reach Test

(2) Muscle Strength (Back Muscle Strength)

The muscular strength assessment is performed using the Abdominal Strength Measurement Device (TKK-5402, Japan). The individual being tested should stand on the footrest of the examination platform with their feet spread apart by approximately 15cm. They should bend their upper body forward by about 30 degrees and flex their knees to a 10-degree angle. With their arms extended, they should grasp the handles and lift their upper body, pulling on the handles with maximum force for about 3 seconds. It is important to ensure that the arms or knees do not bend and that the body does not lean backward during the test. After the first measurement, a rest period of approximately 1 minute should be taken before proceeding with the second measurement. Two measurements should be conducted, and the better result should be recorded. The results are recorded in increments of 0.1kg. As shown in <Figure 5>.

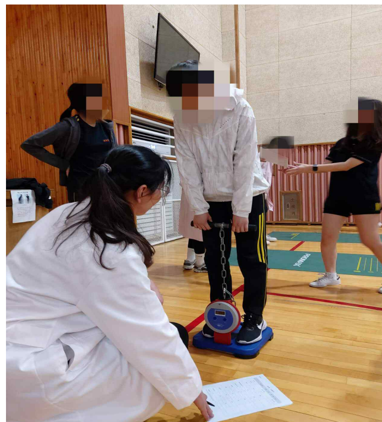

Figure 5. Measurement of Abdominal Strength

(3) Muscular Endurance (Sit-ups)

To measure muscular endurance, sit-ups were performed. After completing appropriate warm-up exercises to prevent injury, two participants formed a group for the experiment. One participant fixed the ankles of the subject being measured, while the subject being measured bent their knees to a 90-degree angle and placed their feet flat on the floor. They crossed their hands behind their head and lay down. When the "start" signal sounded, they used only the strength of their abdominal muscles to bend their upper body forward and rise. When the upper body rises, both elbows should touch the knees, and when lowering, both shoulders should touch the mat. The measurement is conducted for 60 seconds, and after the measurement ends, the number of repetitions performed within one minute is communicated to the measurer, and the record is completed. As shown in <Figure 6>.

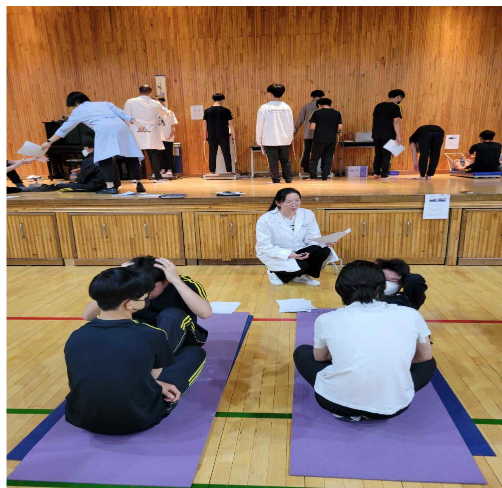

Figure 6. Measurement of Sit-ups

(4) Agility(Standing Long Jump)

In the standing long jump test, the subject should stand with both feet naturally spread apart at shoulder width. The hands should be swung forward, and both legs should remain extended. Then, the hands are swung as far back as possible while lowering the body's center of gravity and flexing both legs. The feet are rapidly pushed off the ground, propelling the body forward. After fully extending the body, the abdominal muscles are contracted, and the knees are flexed to land on the ground. The distance between the starting line and the heel landing point is recorded. This process is repeated twice, and the better result is selected and recorded. The unit of measurement is 1cm. As shown in <Figure 7>.

Figure 7. Measurement of Standing Long Jump

(5) Cardiovascular Endurance (1200m Run)

After completing sufficient warm-up exercises, the participants are divided into groups of six and stand in a ready position for the start of the test. Upon the "start" signal, they begin running or walking at their maximum speed for a distance of 1200 meters while recording the actual time taken. The measurement is conducted only once, and the record is noted in minutes and seconds.

Figure 8. Measurement of 1200m Run

4) Scoliosis test

(1) Adam's forward-bending test

The Adams Forward Bend test was performed in which students bend forward from a standing position, keep their feet apart about 15 cm, support their knees backward, relax their shoulders, straighten their elbows, place their palms in front of their knees or calves, and place their palms together. take (Grivas et al., 2007). Then, the rib hump and the lumbar hump were measured using a scoliometer (Scoliometer, Korea) (Bunell, 1986). If an adolescent with an upper-body rotation measurement of 5° or more is found, a second medical evaluation and X-ray examination are performed (Bunell, 1984). As shown in <Figure 9>.

Figure 9. Adam's forward-bending test

(2) Measurement of Cobb's angle for Scoliosis using X-rays

For students who exhibit a rotation angle of 5° or more during the initial Adams Forward Bend Test, a full-spine X-ray is taken in the standing position to assess the presence of spinal curvature. Cobb's angle measurement method involves drawing a line between the most tilted upper vertebra and the tilted lower vertebra, and then drawing a perpendicular line on each of these lines. The intersecting angle between these lines is measured, and this angle represents Cobb's angle measurement (Ardran et al., 1980; Negrini et al., 2012). In this measurement analysis, Cobb's angle of 10° or more is considered a positive finding for spinal curvature.

6. Data Processing

All data were processed using SPSS 25.0, and the specific analysis details are as follows:

1) Mean (*M*) and standard deviation (*SD*) were calculated for all measured variables.

2) Due to the sample size of the scoliosis group being less than 20, the measurement data did not follow a normal distribution. To analyze the differences in body composition and physical fitness between the scoliosis group and the control group, the Mann-Whitney *U* test was used.

3) Pearson correlation analysis was employed to examine the correlations between height and weight, as well as between Cobb's angle and body composition, in the scoliosis group and the control group.

4) Regression analysis was conducted to identify the variables with the greatest influence among the factors related to Cobb's angle that are suitable for regression analysis, including physique, body composition, and physical fitness. A stepwise selection method was applied.

5) All statistical significance levels were set at $p < .05$.

IV. Research Results

1. Survey on Adolescent Scoliosis

In a preliminary examination of 186 female students from grades 1–2 at *S* City's *S* Middle School, the Adams forward bending test was conducted to assess the presence of adolescent idiopathic scoliosis. Students showing rib hump or lumbar prominence, along with a trunk rotation angle of 5° or more measured using a scoliometer, were selected. After consultation with parents and obtaining their consent, these students voluntarily participated in a second *X*–ray examination. Using *X*–ray imaging, 17 female students were diagnosed with primary adolescent idiopathic scoliosis, defined by a curvature of 10° or more. The overall prevalence rate of scoliosis among the total population surveyed was 9.1%.

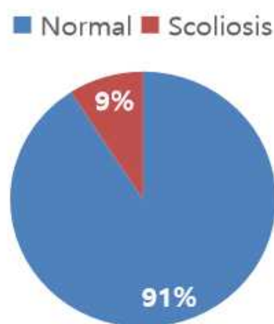

Figure 10. Rate of Scoliosis

2. Comparison of physique between the normal group and the scoliosis group

Mann−Whitney *U* test was used to compare the height and weight between the normal group and the scoliosis group, and the results are presented in< Table 4> and <Figures 11 > to <Figures 12>.

The height of the normal group was 158.23±5.56 cm, while the scoliosis group had a height of 160.19±5.00 cm. The weight of the normal group was 49.69±7.20 kg, whereas the scoliosis group weighted 47.71±4.98 kg. There were no significant differences observed in any of the variables ($P > .05$).

Table 4. Comparison of physique between the normal group and the scoliosis group.

variables	Normal group (n=169)		Scoliosis group (n=17)		*U*	*Z*	*P*
	M±SD	Average rank (Sum of ranks)	*M±SD*	Average rank (Sum of ranks)			
Height (cm)	158.23 ±5.56	91.62 (15484.50)	160.19 ±5.0	112.15 (1906.50)	15484.5	−1.50	.13
Weight (kg)	49.69 ±7.20	94.81 (16023.50)	47.71 ±4.98	80.44 (1367.50)	1214.50	−1.05	.29

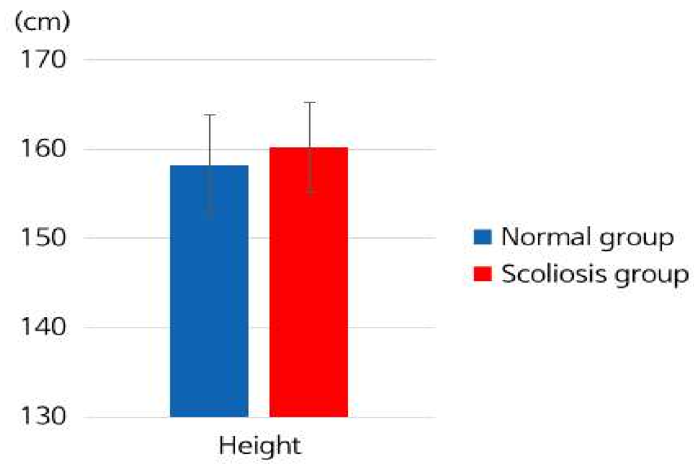

Figure 11. Height Comparison Grap

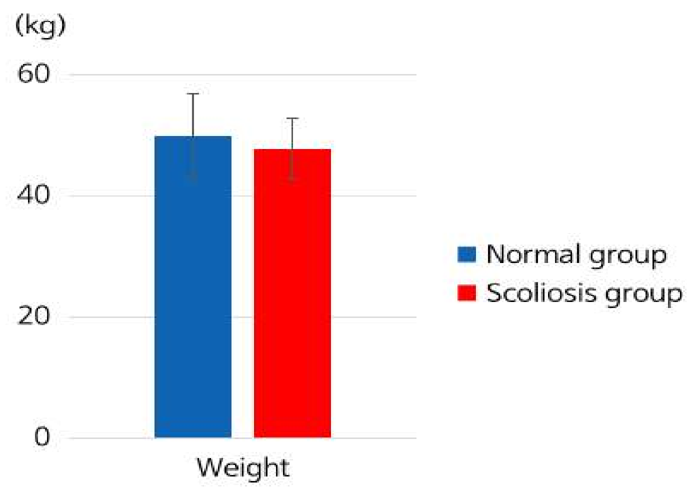

Figure 12. Weight Comparison Graph

3. Comparison of Body Composition between the normal group and the Scoliosis Group

Mann-Whitney U test was used to compare the body composition between the normal group and the scoliosis group, and the results are presented in <Table 5> and <Figures 13 >~< Figures 19>.

BMI in the normal group was 19.85±2.37 kg/m², while in the scoliosis group, it was 18.64±1.60 kg/m², with both measures showing a significant difference (P<.05). In terms of waist-hip ratio, the normal group had .78±.04%, while the scoliosis group had .76±.02%, also showing a significant difference (P<.05). However, percent body fat was 26.73±6.16% in the normal group, 24.24±5.56% in the scoliosis group, soft lean mass was 33.45±3.42kg in the normal group, 33.34±2.45kg in the scoliosis group, body fat mass was 13.63±4.66kg in the normal group, and 11.72±3.73kg in the scoliosis group, fat-free mass was 36.07±3.66kg in the normal group, 35.98±2.63kg in the scoliosis group, skeletal muscle mass was 19.19±2.18kg in the normal group, and 19.12±1.55kg in the scoliosis group, There were no significant differences observed in any of these variables between the two groups (P > .05).

Table 5. Comparison of body composition indicators between the normal group and the scoliosis group

variables	Normal group (n=169)		Scoliosis group(n=17)		*U*	*Z*	*P*
	M±SD	Average rank (Sum of ranks)	*M±SD*	Average rank (Sum of ranks)			
BMI (kg/m^2)	19.85±2.37	96.04 (16230.50)	18.64±1.60	68.26 (1160.50)	1007.5	−2.028	.043*
Percent Body Fat(%)	26.73±6.16	95.38 (16118.50)	24.24±5.56	74.85 (1272.50)	1119.5	−1.498	.134
Waist−Hip Ratio	.78±.04	96.07 (16236.50)	.76±.02	67.91 (1154.50)	1001.5	−2.064	.039*
Soft Lean Mass(kg)	33.45±3.42	93.70 (15834.50)	33.34±2.45	91.56 (1556.50)	1403.5	−.156	.876
Body Fat Mass(kg)	13.63±4.66	95.44 (16130.00)	11.72±3.73	74.18 (1261.00)	1108.0	−1.553	.121
Fat Free Mass(kg)	36.07±3.66	93.66 (15828.50)	35.98±2.63	91.91 (1562.50)	1409.5	−.128	.898
Skeletal Muscle Mass((kg)	19.19±2.18	93.65 (15826.50)	19.12±1.55	92.03 (1564.50)	1411.5	−.118	.906

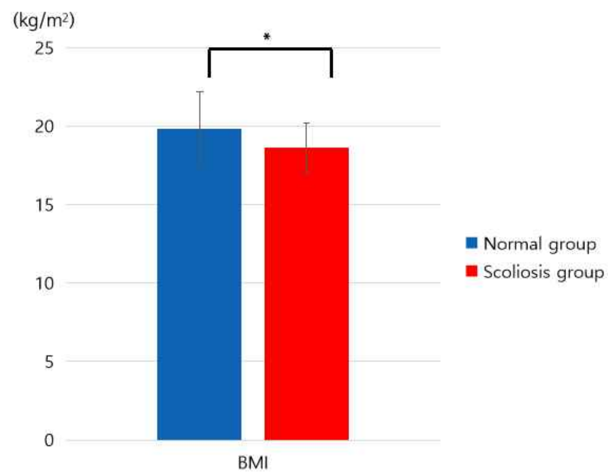

Figure 13. BMI Comparison Graph

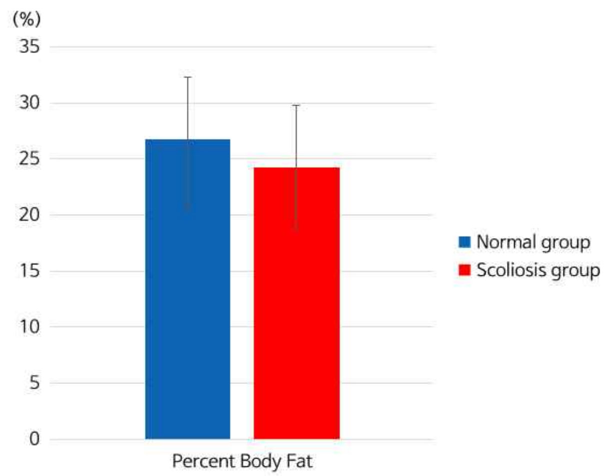

Figure 14. Percent Body Fat Comparison Graph

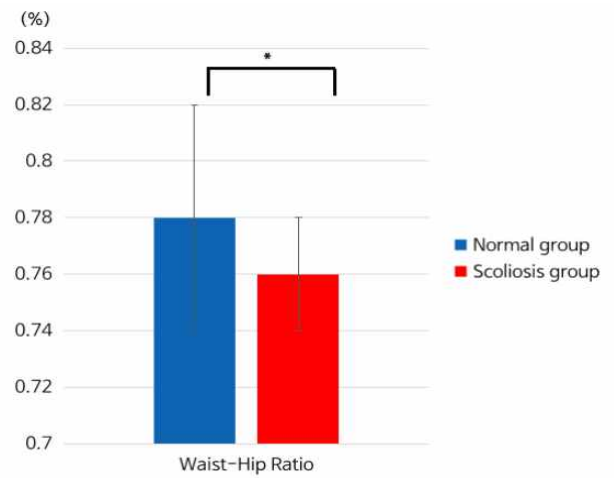

Figure 15. Waist-Hip Ratio Comparison Graph

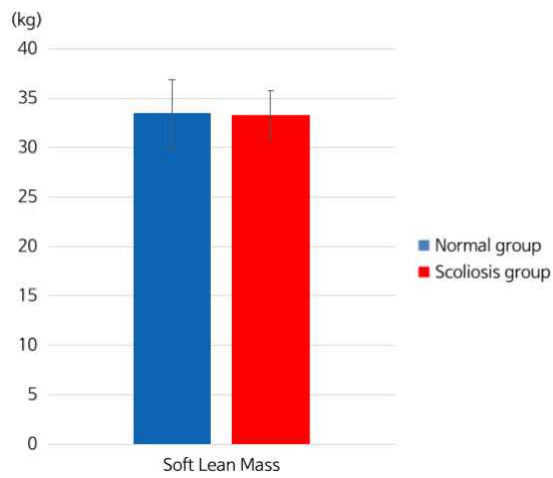

Figure 16. Soft Lean Mass Comparison Graph

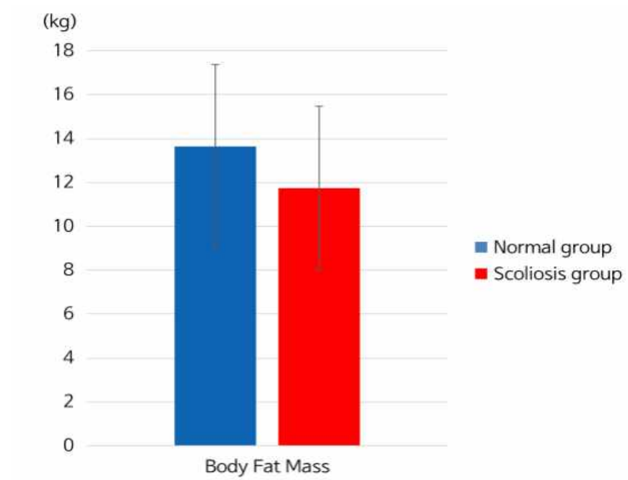

Figure 17. Body Fat Mass Comparison Graph

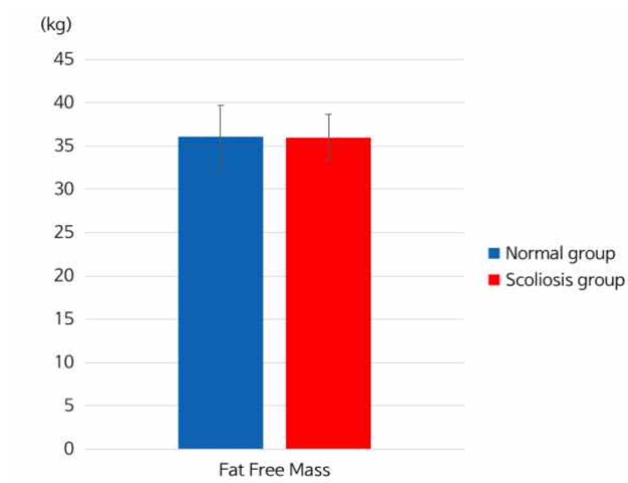

Figure 18. Fat Free Mass Comparison Graph

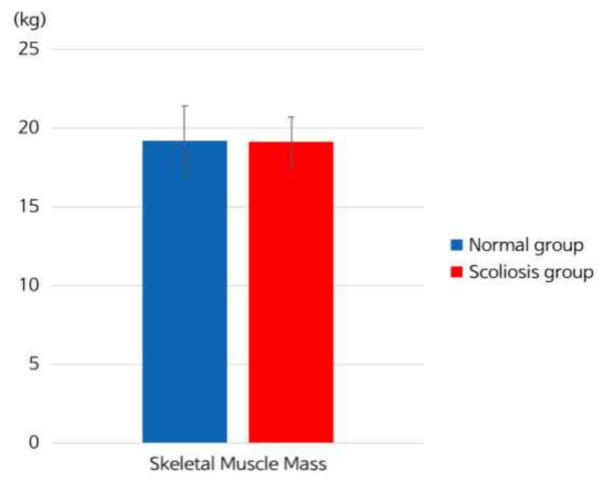

Figure 19. Skeletal Muscle Mass Comparison Graph

4. Comparison of Physical Fitness between the Normal Group and the Scoliosis Group

To compare the physical fitness between the normal group and the scoliosis group, the Mann-Whitney *U* test was conducted. The results of the test are shown in <Table 6> and <Figure 20> to <Figure 24>.

In the standing long jump test, the normal group achieved an average distance of 143.07±20.88 cm, while the scoliosis group achieved 145.29±22.81 cm. For the sit-up test, the normal group performed an average of 26.60±9.12 repetitions, while the scoliosis group performed 29.41±11.94 repetitions. In the sit and reach test, the normal group achieved an average distance of 13.89±8.38 cm, whereas the scoliosis group achieved 8.49±13.23 cm. The Back Muscle Strength was 46.56±12.30 kg in the normal group and 44.56±13.55 kg in the scoliosis group. In the 1200m run test, the normal group completed it in 467.15±86.46 seconds, while the scoliosis group completed it in 458.13±56.37 seconds. However, there were no significant differences in any of these parameters between the two groups (P>.05).

Table 6. Comparison of physical fitness indicators between the normal group and the scoliosis group.

variables	Normal group(n=169)		Scoliosis group(n=17)		U	Z	P
	$M \pm SD$	Average rank (Sum of ranks)	$M \pm SD$	Average rank (Sum of ranks)			
Standing Long Jump(cm)	143.07 ±20.88	92.91 (15701.5)	145.29 ±22.81	99.38 (1689.5)	1336.5	−.474	.636
Sit−up (repetitions)	26.60 ±9.12	92.80 (15683.0)	29.41 ±11.94	100.47 (1708.0)	1318.0	−.561	.575
Sit and Reach(cm)	13.89 ±8.38	95.59 (16135.5)	8.49 ±13.23	73.85 (1255.5)	1102.5	−1.589	.114
Back Muscle strength(kg)	46.56 ±12.30	94.18 (15916.5)	44.56 ±13.55	86.74 (1474.5)	1321.5	−.544	.587
1200m Run(second)	467.15 ±86.46	93.71 (15837.5)	458.13 ±56.37	91.38 (1553.5)	1400.5	−.170	.865

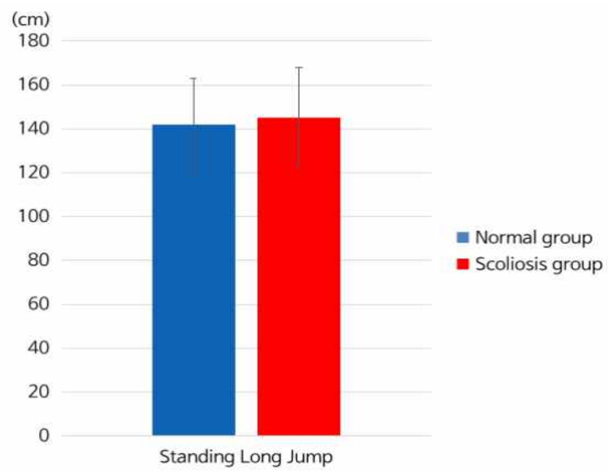

Figure 20. Standing Long Jump Comparison Graph

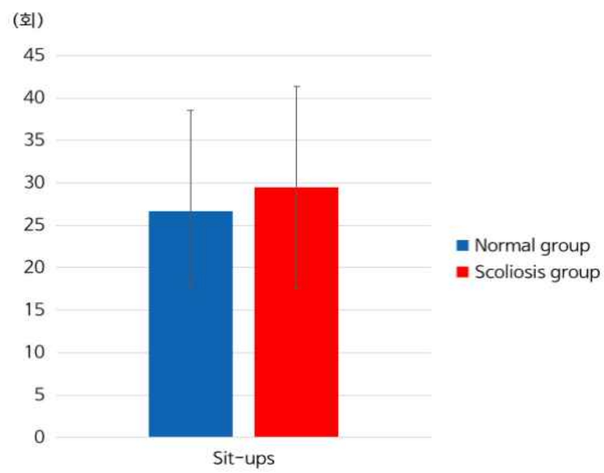

Figure 21. Sit−ups Comparison Graph

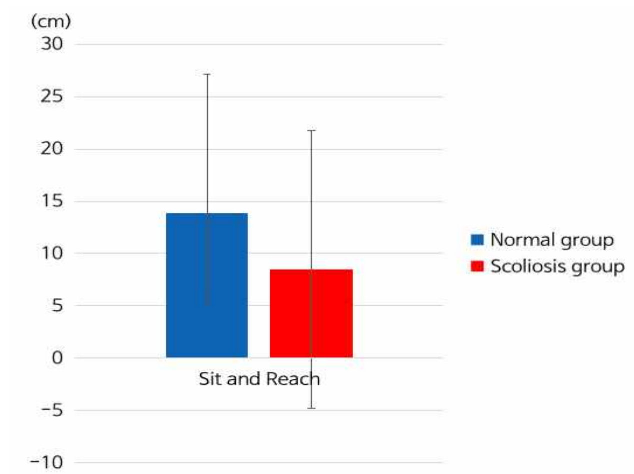

Figure 22. Sit and Reach Comparison Graph

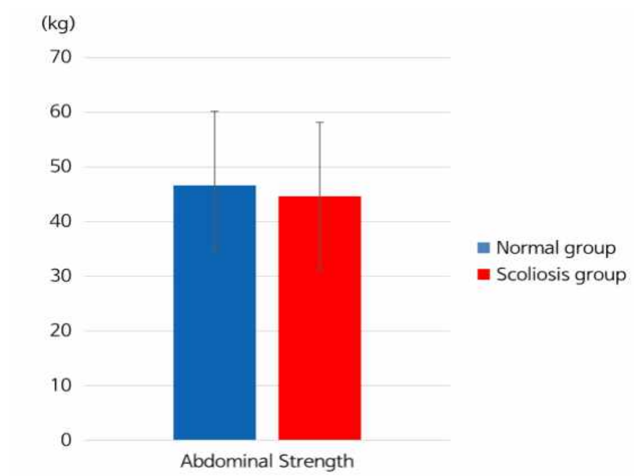

Figure 23. Abdominal Strength Comparison Graph

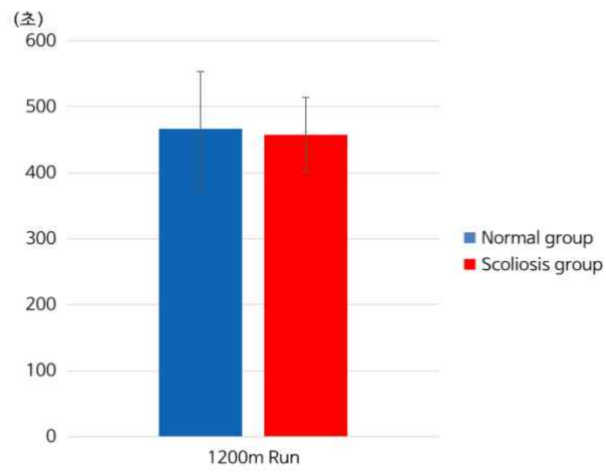

Figure 24. 1200m Run Comparison Graph

5. Correlation between Thoracic and Lumbar Cobb's angles with physique, body composition, and physical fitness

The analysis results of the correlation between Cobb's angles in the thoracic and lumbar regions and physique, body composition, and physical fitness are shown in <Table 7>.

he thoracic spine right angle, thoracolumbar spine left angle and lumbar spine left angle showed negative correlations with height and weight in all categories. The Lumbar spine left angle showed a significant negative correlation with height (r=−.539, P<.05), while the Thoracolumbar spine right angle showed a positive correlation with height (r=.237) and a negative correlation with weight (r=−.056). The Lumbar spine right angle exhibited negative correlations with both height (r=−.185) and weight (r=−.239).

The Lumbar spine's right angle showed a negative correlation with all components of body composition. The Thoracolumbar spine left angle exhibited significant positive correlations with BMI (r=.053), percent body fat (r=.100), and body fat mass (r=.108), as well as negative correlations with waist−hip ratio (r=−.107), soft lean mass (r=−.104), fat−free mass (r=−.096), and skeletal muscle mass (r=−.114). The Thoracolumbar spine right angle also showed negative correlations with BMI (r=−.104), percent body fat (r=−.015), and body fat mass (r=−.007), as well as positive correlations with waist−hip ratio (r=.421), soft lean mass (r=.117), fat−free mass (r=.114), and skeletal muscle mass (r=−.122). The

lumbar spine left angle exhibited a negative correlation with all components of body composition except BMI (r=.045), while the lumbar spine right angle showed negative correlations with all components of body composition. However, there were no significant correlations between Cobb's angles of the thoracic and lumbar spine and body composition.

The thoracic spine right angle showed negative correlations with standing long jump (r=−.024), Sit−ups (r=−.173), and endurance running (r=−.185), while exhibiting positive correlations with sit−ups (r=.038) and back muscle strength (r=.045). The Thoracolumbar spine left angle displayed negative correlations with standing long jump (r=−.195), sit and reach(r=−.354), and 1200m running (r=−.097), and positive correlations with sit−ups (r=.089) and back muscle strength (r=.063). The Thoracolumbar spine right angle showed positive correlations with standing long jump (r=.017) and sit and reach (r=.210), and negative correlations with sit−ups (r=−.013), back muscle strength (r=−.345), and 1200m running (r=−.055). The Lumbar spine left angle exhibited negative correlations with all components of physical fitness except for 1200m running (r=.102), while the lumbar spine right angle showed negative correlations with standing long jump (r=−.060) and back muscle strength (r=−.239), and positive correlations with sit−ups (r=.185), sit and reach (r=.245), and 1200m running (r=.018). However, there were no significant correlations between Cobb's angles of the thoracic and lumbar spine and physical fitness.

Table 7. Correlation between Thoracic and Lumbar Cobb's angles with physique, body composition, and physical fitness.

variables	Thoracic spine right angle	Thoracolumbar spine left angle	Thoracolumbar spine right angle	Lumbar spine left angle	Lumbar spine right angle
Height(cm)	−.102	−.051	.237	−.539*	−.185
Weight(kg)	−.129	−.029	−.056	−.298	−.239
BMI	−.151	.053	−.104	.045	−.151
Percent Body Fat	−.028	.100	−.015	−.022	−.028
Waist−Hip Ratio	−.238	−.107	.421	−.157	−.238
Soft Lean Mass	−.299	−.104	.117	−.365	−.299
Body Fat Mass	−.105	.108	−.007	−.138	−.105
Fat Free Mass	−.302	−.096	.114	−.369	−.302
Skeleta lMuscle Mass	−.285	−.114	.122	−.360	−.285
Standing Long Jump	−.024	−.195	.017	−.049	−.060
Sit−up	.038	.089	−.013	−.247	.185
Sit and Reach	−.173	−.354	.210	−.028	.245
Back Muscle Strength	.045	.063	−.345	−.230	−.239
1200m Run	−.185	−.097	−.055	.102	.018

6. Regression Analysis of Cobb's Angles of the Thoracic and Lumbar Spine with Each Variable

Based on the results of the correlation analysis between Cobb's angles of the thoracic and lumbar spine and various variables, it was found that the Lumbar spine left angle has a significant correlation with height. However, there were no significant correlations observed between Cobb's angles of the thoracic and lumbar spine and variables such as body weight (kg), BMI, percent body fat, waist-hip ratio, soft lean mass, body fat mass, fat-free mass, skeletal muscle mass, standing long jump, sit-ups, sit and reach, back muscle strength and 1200m running.

A regression analysis was performed between the lumbar spine left angle and height, and there was no multicollinearity in the data (VIF=1.00). The results showed that R^2=.274, indicating that height (X) harms the lumbar spine left angle (Y) (P<.05). The regression analysis results for the lumbar spine left angle and height are presented in Table 8. The regression equation is as follows:

$Y = -.930X + 154.226$

Table 8. Regression analysis of lumbar lordosis angle and each variable.

	Unstandardized coefficient		Standardized coefficient	t	P	R^2	VIF
	B	Standardized error	Beta				
Constant	154.23	54.424		2.83	.01	.27	1.00
Height (cm)	−.930	.338	−.524	−2.75	.01		

V. Discussion

According to the results of this study, out of 186 female middle school students, 17 of them had scoliosis, accounting for 9.1% of the total. This figure represents an increase of approximately 1% compared to a previous study conducted by the GangDong Office of Education in Seoul in 2009 (Choi, 2009). Research on adolescent scoliosis began in 1947 in Minnesota, USA, through school-based screenings (Lonstein, 1977), and it has shown a consistent upward trend, which is also true in South Korea (Lim et al., 2014). According to the Health Insurance Review and Assessment Service in 2021, the number of spinal patients among adolescents increased by 1.09 times to 263,679 compared to 2020. It is worth noting that this period coincided with the global outbreak of the novel coronavirus, known as '2019-nCoV.' During this time, remote learning led to a decrease in students' physical activity, limiting their physical activities both inside and outside of school. Consequently, adolescent health issues have become a significant concern (Yu, 2021). Thus, comprehensive research on the health of adolescents before and after the COVID-19 pandemic is necessary.

In this study, the difference in height between the scoliosis group and the normal group was approximately 1%, but it was not statistically significant. Francis (1998) reported a higher occurrence of scoliosis in women who had a slender physique and above-average height. In the Utah study, scoliosis was more

prevalent among women with an outwardly convex shape, particularly those with an average height of 166.4 cm, which was taller than the overall average height of 163.3 cm. Correlation analysis revealed a negative correlation between height and the lumbar spine left angle, but there was no correlation with the thoracic spine right angle, thoracolumbar spine left angle, thoracolumbar spine right angle, or lumbar spine right angle. This finding is consistent with the research conducted by Choi (2011), although previous studies have shown conflicting results, with some indicating a significant correlation between height and scoliosis (Poussa, Harkonen & Melli, 1989).

In the studies conducted by Grivas and Barrios, an association was found between increased height and decreased weight in the scoliosis group (Grivas et al., 2002; Barrios et al., 2011). However, in the present study, the results showed that BMI and waist-hip ratio in terms of body composition was approximately 6% and 3% lower, respectively, in the scoliosis group compared to the normal group, indicating statistically significant results (p<.05). Additionally, compared to the normal group, the scoliosis group exhibited a 9% decrease in percent body fat, a 14% decrease in body fat mass, a 0.3% decrease in soft lean mass, a 0.2% decrease in fat-free mass, and a 0.3% decrease in skeletal muscle mass, resulting in an overall weight reduction of approximately 4%. These observations highlight the serious issue of both obesity and underweight problems in South Korea (Moon & Lee, 2009). The scoliosis group

in this study had an average BMI of 18.6 kg/m^2, which is considered to be close to underweight according to criteria set by various institutions worldwide, including the Korean Society for the Study of Obesity, where a BMI below 18.5 kg/m^2 is generally defined as underweight. This indicates that individuals with scoliosis tend to be closer to the underweight category compared to the normal group. Underweight individuals have weakened resistance to diseases, are more sensitive to cold temperatures, and may experience growth disorders. Particularly during adolescence, underweight issues are recognized as a significant nutritional problem that poses a serious threat to health, alongside obesity (Park & Kwon, 2007).

Low body weight also affects scoliosis. According to a study by Clark et al. (2014), even after adjusting for age, gender, and fat mass, low soft lean mass increases the risk of scoliosis by 20% (Clark et al., 2014). It has been reported that BMI and lean body mass (FFM) are associated with progressive scoliosis (Tam et al., 2016; Ramirez et al., 2013; Wang et al., 2016; Miyagi et al., 2021). Particularly, Wei-Jun et al. (2012) demonstrated that being underweight is an independent predictor in adolescent idiopathic scoliosis, highlighting the need for multidimensional research with a focus on the underweight.

In the case of physical fitness, Flexibility is known to be closely related to the movement and posture of the spine. As the spine undergoes deformations, such as differences in shoulder height and

asymmetrical changes in the curvature of the lower back, decreased flexibility occurs, making it difficult to bend the waist properly (Bruyneel et al., 2010). Therefore, proper posture formation is necessary for increased flexibility, and it has been reported that flexibility-enhancing exercises are needed to achieve correct posture (Lee & Lee, 2010). In a study by Danielsson et al. (2006), it was reported that the strength of the bending and extending muscles of the waist significantly decreased in patients with scoliosis compared to the control group (Danielsson, Romberg & Nachemson, 2010), which is consistent with the research showing that scoliosis can reduce physical fitness (Barrios et al., 2005; Koumbourlis, 2006). According to the study by Lee & Kim (2019), the group with a larger scoliosis angle showed lower flexibility and the flexibility of the 10°-19° group was significantly higher compared to the 20°-29° and 30°-39° groups. This is consistent with the results of this study, where the scoliosis group showed lower flexibility compared to the normal group.

In comparing the back muscle strength between the scoliosis group and the normal group, the scoliosis group showed approximately 4.29% lower strength compared to the normal group. Lee & Kim (2019) reported that as the scoliosis angle increased, there was a significant decrease in muscle strength, and the strength of the 30°-39° group was significantly lower compared to the 20°-29° and 10°-19° groups. In a study by Park & Kim (2022), the prevalence of scoliosis was compared among groups

classified as low muscle strength (LMS), moderate muscle strength (MHS), and high muscle strength (HMS). The study reported that the MHS and HMS groups were 0.88 times (*OR*: 0.88, 95% *CI*: 0.58−1.33) and 0.41 times (*OR*: 0.41, 95% *CI*: 0.24−0.72) less likely to have scoliosis, respectively, compared to the LMS group, which is consistent with the findings of this study.

There are several limitations to this study. Firstly, the study did not investigate the usual level of physical activity or exercise habits that could potentially impact the comparison and analysis of physical fitness levels among middle school students. Secondly, the study only targeted specific grades of middle school students rather than encompassing all grades. Additionally, the study was limited to specific schools in a particular region.

VI. Conclusion

To investigate adolescent scoliosis, this study classified 186 female middle school students from *S* Middle School in *S* district, *S* City into a normal group and a scoliosis group. The normal group consisted of 169 students, while the scoliosis group included 17 female students with Cobb's angle of 10° or higher. To analyze the influence of body composition and physical fitness on adolescent scoliosis, the study employed the Mann-Whitney *U* test to examine the differences in body composition and physical fitness. Pearson correlation was also used to analyze the relationship between Cobb's angle in the thoracic and lumbar regions and body composition as well as physical fitness. Furthermore, regression analysis was conducted to analyze the factors influencing body composition and physical fitness variables on Cobb's angle in the thoracic and lumbar regions. The study concluded as follows:

1. Among 186 female middle school students, 17 students had adolescent idiopathic scoliosis, accounting for 9.1% of the total. Furthermore, the height of students in the scoliosis group was approximately 1% higher than that of the normal group, while the weight was approximately 4% lower, but these differences were not statistically significant.

2. In terms of body composition, BMI (kg/m^2) and waist-hip ratio (WHR) were significantly lower in the scoliosis group compared to the normal group (approximately 6% and 3% lower, respectively, $p<$

.05). Other measures such as percent body fat (BF%), soft lean mass(SLM), body fat mass (BFM), fat-free mass (FFM), and skeletal muscle mass (SMM) were also lower in the scoliosis group, although the differences were not statistically significant.

3. In terms of physical fitness assessment, the scoliosis group had about 39% lower sit and reach and about 4% lower back muscle strength than the normal group, and there was no significant difference in all items.

4. The correlation analysis between Cobb's angle in the thoracic and lumbar regions and body composition, as well as physical fitness, revealed a significant negative correlation between the Lumbar spine left angle and height (r=−.539), and the regression equation was [Lumbar spine left angle=−930 × height + 154.226].

The results of this study indicate that the decline in students' physical fitness due to COVID-19 is continuing, and it highlights the issues of underweight and decreased muscular strength in adolescents. These findings emphasize the need for multidimensional research focusing on addressing these concerns. It is suggested that future efforts should aim to maintain a healthy body weight, engage in regular physical activity, and develop exercise programs to prevent and improve adolescent idiopathic scoliosis.

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국 문 초 록

여중생의 신체조성과 체력이 척추측만증에 미치는 영향

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경제 수준의 향상과 과학 기술의 발전으로 인해 사람들의 삶의 편의는 크게 향상되었지만, 청소년의 비만률과 척추 질환이 연간 증가하는 등 부정적인 영향도 많이 나타나고 있다. 이에, 본 연구는 청소년 척추측만 조사를 위해 *S*시 *S*구 *S*중학교의 여중생 186명을 대상으로 정상군과 척추측만증군으로 분류하였다. 정상군은 169명이며, 척추측만증군은 Cobb’s angle이 10° 이상인 여중생 17명이다. 청소년 척추측만증에 대한 신체 조성과 체력의 영향을 분석하기 위해 Mann-Whitney *U* 검정을 사용하여 신체 조성과 체력의 차이를 분석했다. 또한 Pearson 상관 관계를 사용하여 흉추 및 요추 부위의 Cobb's angle와 신체 조성 및 체력 간의 관련성을 분석하였고 회귀 분석을 사용하여 신체 조성과 체력 변수가 흉추 및 요추 부위의 Cobb's angle에 미치는 영향 요소를 분석하여 다음과 같은 결론을 도출하였다:

1. 중학교 여학생 186명 중 척추측만증은 17명으로 전체의 9.1%를 차지하였다. 그리고 척추측만증군 학생들의 신장은 정상군보다 약 1% 높았고, 체중은 약 4% 낮았지만 유의한 차이는 없었다.
2. 신체조성 중 BMI(kg/m^2)와 복부지방률(WHR)은 정상군보다 척추측

만증군이 유의하게 낮았다(각각 약 6%, 약 3%, p<.05). 그 외 체지방률(BF%), 근육량(SLM), 체지방량(BFM), 제지방량(FFM), 골격근량(SMM)도 정상군보다 척추측만증군이 낮았지만 유의한 차이는 없었다.

3. 체력측정은 척추측만증군이 정상군보다 좌전굴 약 39%, 배근력 약 4%가 낮았으며 모든 항목에서 유의한 차이가 나타나지 않았다.

4. 흉추、요추부위 Cobb's angle과 신체조성, 체력의 상관관계를 분석한 결과, 요추좌각과 신장(r=−.539)이 유의한 부적 상관관계가 있었으며 회귀식은 [요추좌각=−.930×신장+154.226]이다.

본 연구 결과 코로나 19로 인해 학생들의 체력약화는 지속적으로 진행되고 있는 것을 확인할 수 있으며, 본 연구결과에서 문제점으로 나타난 청소년의 저체중과 근력 저하를 중심으로 다각도의 연구가 필요하며 앞으로 적정 체중을 유지하고 건강한 신체활동을 통해 척추측만 예방 및 이를 개선할 수 있는 운동프로그램 개발이 필요하다고 사료된다.