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The Effect of the Active Release Technique on Balance and Functional Movement in Youth Basketball Players

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Abstract

Background: This study was conducted to apply active release techniques to male youth basketball players to help improve physical development and damage prevention and improve performance through improved balance and functional movement.

Design: Randomized control trial.

Methods: The subjects included 33 youth basketball players who were randomly assigned to the experimental group (*n*=17) and the control group (*n*=16). For the experimental group, the active release technique was applied to the hip muscles, calf muscles, posterior thigh muscles based on the distribution of injuries surveyed in youth basketball players in the Korean Basksetball League. The Y-balance test and the functional reach test (FRT) were used to assess balance and the Functional Movement Screen (FMS) was used to assess functional movement. Interventions were conducted twice a week for 4 weeks at 40 minutes per session. The experimental group was the active release technique group, and static stretching, a common exercise therapy technique, and self-myofascial release using a foam roller were applied for 20 minutes. The control group received general exercise therapy and placebo active release technique. The placebo active release technique applies pressure only.

results: The experimental group showed a greater improvement in balance, as evidenced by the FRT, compared to the control group, which received general exercise treatment. However, there was no statistically significant difference in improvement between the 2 groups. In the case of the experimental group, the difference in the Y balance test before and after the intervention was larger than that of the control group, but there was no statistically significant difference. Significant improvement was found in functional movement, as evidence by the FMS, for the trunk stability test (p < 0.05), in-line lunge test (p < 0.05), rotational stability test (p < 0.05), total score (p < 0.05).

Conclusion: In this study, the active release technique improved the balance and functional movement of young basketball players more than general exercise therapy. The application of the active release technique is therefore expected to assist in physical development, prevent damage, and improve the performance of youth basketball players.

Key words: Active release technique; Basketball; Functional Performance; Postural Balance

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Ⅰ. Introduction

Youth athletes have higher developmental plasticity than adult athletes. Physically and emotionally, they grow and develop rapidly. In terms of physical characteristics, muscle strength in young athletes is about 30% that of adults, and motor nerves comprise approximately 70% that of adults. Even though strength is lower, coordination movements that appear in harmony with muscles and nerves develop at the adult level. Therefore, relatively difficult body movements can be performed more easily (Lee, 2008), and the coordination required for playing with a ball is particularly helpful for physical development.

In addition, participating in sports activities as youth can lead to the development of social skills and physical strength, which is closely related to future athletic performance (Lee, 2008). A personal and scientific training regimen that is focused on the physical strength and development suited to each sport and at the appropriate age may be necessary (Yoon et al., 2013). It has been argued that in the sports of winning and losing, athletes who are still growing may have disproportionate physical development from excessive training, and that repetitive mechanical tactical training leads to a lack of creativity and lack of basic skills. The reality is that athletes of all ages often focus on tactical and high-intensity physical training rather than physical strength training and skills appropriate for their age (Kang, 2010). Injuries can occur based on injury history, muscle flexibility, and ligament relaxation (Bahr et al., 2003; Wootack Lim, 2023), but these inherent factors cannot be manipulated (Kiesel et al., 2014) 20. However, prior studies have attempted to identify internal factors that may lead to injury as a result of movement dysfunction (Kim et al.,2023; Skoffer et al., 2015).

Physical function refers to the ability of each organ in the body to perform adequately (Lee, 2001) and includes the functions necessary for activities of daily living, such as muscle strength, movement speed, range of motion, coordination, and durability (Hemmerich et al., 2006). Movement dysfunction refers to the simultaneous dysfunction of several joints of the upper and lower limbs when performing a movement (Chun, 2014). Balance is an important function that affects an athlete's performance, and dysfunction can strongly impede improvement in their performance (Choi, 2023; Ondra, 2017).

Self-myofascial release is a commonly used treatment to relieve muscle tension through pressure (Macdonald, 2013). It breaks the adhesion of the fascia in damaged tissue that occurs over the course of a cumulative injury cycle and helps to improve the elongation of the tissue through stretching (NASM CES, 2014).

In a previous study, inducing the artificially delayed onset of muscle soreness through elongational exercises and applying a foam roller resulted in pain reduction and an improvement in exercise performance in adult males (Gregory, 2015). Subsequently, several studies have confirmed the self-myofascial release effect of the foam roller, and since it can be performed without expert assistance, it is used in most sports fields as an efficient method to relieve muscle tension.

The active release technique (ART) is a treatment method used for restoring damaged tissue that can affect the mechanical function of the muscles and fascia and can cause pain and muscle weakness (Tak et al., 2013). It is a method of treating soft tissues, such as tendons, nerves, and muscle fibers, with an emphasis on relieving tissue tension through removing fibrosis and adhesion that may occur in tissues as a result of overload caused by repeated muscle use (Spina et al., 2007). It is a treatment method used to reduce pain and restore function by resolving soft tissue adhesion, restoring damaged tissues, and resolving tissue adhesion caused by lactic acid, which cause symptoms such as pain, cramps, and muscle pain (Lee et al., 2014).

ART is a manual therapy technique that is used to break down scar tissue. It involves active stretching from a flexed position, where the muscle is shortened, to a position where the muscle is elongated along with the application of pressure along the fiber grain direction of the shortened soft tissue (Hammer, 2007). Manual contact that combines special motion patterns to heal scar tissue in the fascia, muscles, nerves, tendons, and ligaments (Shamberger, 2002) is known to be effective for recovering soft tissue function in patients with musculoskeletal disorders, such as chronic lower back pain, thoracic outlet syndrome, carpal tunnel syndrome, elbow joint lateral epicondylitis, and Achilles tendinitis (Tak et al., 2013).

The difference between ART and other manual therapy techniques is that it involves active movement. Abbas (2014) studied the effects of passive and active stretching on flexibility in male football players between 18 and 30 years of age with shortening of the hamstring muscles. Active stretching was found to have a better effect than passive stretching, suggesting that methods involving the application of active movement are more effective than the methods applying only passive movement.

There are studies on injury prevention through stretching through active relaxation using ART, but further research on balance and functional movement is lacking. Therefore, in this study, the ART was used on youth basketball players to determine its effect on balance and functional movement. Additionally, through emphasizing the importance of ART to youth basketball players, we aimed to teach them effective intervention methods.

Ⅱ. Methods

1. Subjects

This study was conducted on 33 male youth basketball players who attended W Middle School in Seoul and H Middle School in Anyang-si, Gyeonggi-do. The inclusion criteria for this study were as follows: no current pain due to injury, voluntary agreement to participate in the study, and the presence of physically limited functional movement. The exclusion criteria for the study subjects were as follows: a history of orthopedic surgery within the previous 3 months, neurological damage, and abandonment of the study for personal reasons. Research subjects received a thorough explanation of the research process from the research manager and only those who provided written informed consent were included (Afyon, 2014). The selected study subjects were divided into the experimental group, which received ART, and the control group, which received general exercise therapy. All participants were randomly assigned to one of two groups through a computer program.

The present study was approved by the Institutional Review Board of Sahmyook University (Seoul, Korea, 2-1040781-A-N-012020078HR), and it was registered (KCT0005667) on the Clinical Research Information Service (CRIS) in the Republic of Korea. The objectives and procedures were fully understood by the subjects, and all subjects provided informed consent to be included in the study. Therefore, this study followed the ethical principles of the Declaration of Helsinki.

2. Experimental Procedures

For this study, 33 subjects were recruited and randomly assigned into the experimental group (*n*=17) and the control group (*n*=16). Balance, functional movement, and competition state anxiety were evaluated before and after the 4-week experiment. The experimental group received ART and performed static stretching and the self-myofascial release technique using a foam roller for 20 minutes. ART was applied to the iliopsoas muscle, gastrocnemius muscle, and hamstring muscles based on the distribution of injured areas and problems found in a 2019 survey of youth basketball players in the Korean Basketball League (KBL). ART was applied approximately 10 times per site for 3 to 5 seconds at a time. The control group performed general exercise therapy and placebo ART, which involved only compression, while ART involved both compression and relaxation through active movement.

Before recruiting participants for this study, we performed a power analysis using G*Power Version 3.1.9.7 (Franz Faul, University Kiel, Germany, 2020). The overall effect size index for all the outcome measures was 0.5, with a probability of minimizing type II errors of 0.05 and a power of 80%.

1. Active Release Technique

When ART was applied to the iliopsoas muscle, the participant was placed in a side-lying position with the hip joint raised upwards and bent to minimize tension. In a position with the iliopsoas muscles shortened, the practitioner instructed the subject to actively extend the iliopsoas muscles by extending the hip joint while pressure was maintained with the fingers. For the gastrocnemius muscle, the subject was placed in a prone position with the feet in plantar flexion, which is a shortening position. The subject was then instructed to perform active movement through dorsiflexion in which the gastrocnemius muscle was stretched while the therapist maintained pressure. For the hamstring muscles, the subject was placed in a prone position with the knee flexed (a shortening position). The subjects were instructed to extend the knee after pressure was applied, so that the hamstring muscles moved actively in the extended position. Before these interventions, the participants were taught the shortening and stretching movements through passive movements. When the practitioner's fingers were used to apply pressure to the iliopsoas muscle, gastrocnemius muscle, and hamstring muscle, the patient was instructed to press against the fingers at an endurable strength and to make active movements in an elongated position at the same time (Hammer, 2007).

These movements were performed for about 3 to 5 seconds at a time and 10 times per site and took approximately 20 minutes to complete. These sessions occurred twice a week over 4 weeks (Table 1).

Table 1. Active Release Technique

	Training Method	Time/Duration
Iliopsoas	Side-lying position Shorten muscles by flexing the upper hip joint Operator applies pressure and the hip joint is extended Active movements with continued pressure	3~5 sec each time 10 times Both right and left side
Gastrocnemius	Prone position Shorten muscles by using plantar flexion Operator applies pressure and dorsiflexion is used Active movements with continued pressure	3~5 sec each time 10 times Both right and left side
Hamstring	Prone position Shorten muscles by flexing the knee Operator applies pressure and the knee is extended Active movements with continued pressure	3~5 sec each time 10 times Both right and left side

2. General kinesiotherapy

In this study, general exercise therapy involved the application of myofascial release techniques through static stretching and the use of a foam roller. Static stretching of the iliopsoas muscle, gastrocnemius muscle, and hamstring muscle was performed 10 times for each muscle, for 10 to 15 seconds each. The iliopsoas muscle was stretched by shifting weight from 1 knee with anteflexion to the anterior inferior position, and stretching the iliopsoas muscle on the back side of the leg. This was repeated, alternating the left and right side. The gastrocnemius muscle was stretched by placing only the forefoot on the stairway or step, applying weight, and pressing it inferiorly for dorsiflexion. To stretch the hamstring muscle, the subject would lie in the supine position holding the toe with the opposite hand and slowly extending the knee to maintain it. For the myofascial release technique, a foam roller was placed on each muscle and rolled up and down on the left and right side by applying pressure. In the areas where pain or stiffness was stronger, central rubbing was performed for about 20 minutes (Na et al., 2012).

3. Placebo Active Release Technique

In this study, the placebo ART involved an extending movement that made the applied area longer by compressing the muscle in flexion that shortens the applied muscle. Unlike the ART, which requires the subject to move actively, the placebo ART was applied in a way that compressed the applied areas of the iliopsoas muscles, gastrocnemius muscles, and hamstring muscles.

3. Outcome Measurements

1. Balance

In this study, balance was evaluated using the functional reach test (FRT) and the Y-balance test. For the FRT, subjects were instructed to stand upright with their feet shoulder-width apart on a fixed support surface. The subject extended the elbow joints with their fists lightly clenched. In the starting position, the subjects were instructed to place their arms straight out in front of them, at 90°. For the final position, the subjects leaned forward and stretched their arms as far as they could without losing balance and while maintaining the level with the rod installed horizontally at the height of the scapular peak. Using the distal part of the third metacarpal bone as a reference, the evaluator measured the distance between the first and last points 3 times and recorded the average value. The normal range was > 20 cm; 10–20 cm was classified as weak, and ≤ 10 cm was classified as functional decline. The inter-measure reliability was r=.89 (Csuka & McCarty, 1985).

The Y-balance test is a tool used to evaluate 3 of the 8 directions of the star excursion balance test (SEBT): the anterior, posterior medial, and posterolateral directions. The SEBT is commonly used to measure the strength, flexibility, and proprioceptive sensations of the lower extremities and to assess proprioceptive sensation and dynamic balance of the ankles (Plisky et al., 2009).

The Y-balance test was performed using a Y-balance test kit, which consisted of 3 rods, 3 moveable targets, and a center platform. The angles formed by the forward-facing rod and both of the posterior-facing rods (posterior-inward and posterior-outward) are both 135°. The angle between the 2 posterior-facing rods is 45°. The subject was instructed to stand on 1 foot on the middle platform. With the other foot, the subject then pushed the moveable target on 1 of the posterior-facing platforms, extending the leg as far as they possible while maintaining their posture and balance. The distance was measured in centimeters. This was repeated with the moveable target on the other posterior-facing platform. Leg length was measured from the anterior superior iliac spine to the most prominent part of the medial malleolus. The movement was repeated 3 times, and the highest value was recorded. If the subject's supporting foot fell to the ground, if they placed the outstretched foot on the floor to maintain balance, or if they failed to return to the starting position after extending the foot, it was considered a failure and was re-measured (Phillip et al., 2009). A standardized formula was used to compensate for the differences in leg length between the subjects, and the standardized formula was as follows: front + rear outside + rear inside / (leg length × 3) × 100.

2. Functional movement

In this study, FMS was used to measure functional movement. The FMS is used to determine the mobility, flexibility, and balance of the upper and lower limbs and is a measurement tool used to evaluate the type of movement that poses a potential risk of injury (Chorba et al., 2010). There are 7 motion test items for FMS, which include the deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability, and rotary stability. Each movement is scored from 0 to 3 points, and the final score is calculated by summing all the scores. The highest possible score is 21 points. In this study, when the score was 14 points or less, the subject was considered to have a high probability of injury during everyday life (Gray et al., 2010). A score of 3 points meant the required movement was performed completely correctly, a score of 2 points meant compensation measures were necessary, 1 point meant the movement was not performed properly, and 0 points were given when pain occurred during the movement (Gomez, 2010). Five movements (hurdle step, in-line lunge, shoulder mobility, active straight leg raise, and rotary stability) were performed on both the right and left sides, and each score was recorded. When the scores were different, the lower score was recorded as the representative value. The FMS test has a high interclass correlation coefficient (ICC) value of 0.87–0.93, and a reliability of 0.60 in the pre-post analysis (Mitchell et al,., 2015).

4. Statistical analysis

SPSS statistical software (IBM, Chicago, IL, USA) version 20.0 was used for all statistical analyses. The Shapiro-Wilk test was used to analyze the normal distribution of the variables. The independent sample t-test was performed to identify differences between the groups. The paired t-test was used to compare the results before and after the intervention. For all tests, the level of statistical significance was set at 0.05.

Ⅲ. Results

The demographic characteristics of the subjects are shown in Table 2. No significant differences were observed in the baseline values between the ART and GE groups.

Table 2. General characteristics of the subjects (N=33)

	ART group (n=17)	GE group (n=16)	$t(p)$
Age (years)	15.47 (0.87)[a]	14.94 (0.98)	1.635 (0.112)
Height (cm)	181.65 (10.57)	178.06 (11.51)	0.932 (0.358)
Weight (kg)	70.06 (11.21)	67.88 (15.73)	0.461 (0.648)
BMI	21.09 (1.43)	21.19 (3.17)	-0.114 (0.910)

[a]Mean (SD); ART= active release technique; GE= general exercise; BMI= body mass index

1. Balance comparison

Comparisons between the pre-and post-test measurements for the FRT and Y-balance tests between the 2 groups are shown in Table 3. In both the ART and GE groups, a significant improvement in balance was seen after the FRT (p < 0.05). After the intervention, the Y-balance test results significantly improved on both the left and the right sides for the ART group (p < 0.05). For the GE group, however, significant improvement in the Y-balance test results was only observed on the left side (p < 0.05) (Table 3).

Table 3. Comparison of improvement in balance according to group and test (*N*=33)

Parameters		ART group (*n*=17)	GE group (*n*=16)	*t*(*p*)
FRT	Pre	44.53 (5.89)	41.06 (6.56)	1.598 (0.120)
	Post	49.88 (5.67)	45.56 (6.42)	
	Pre-post	5.35 (3.62)	4.50 (5.72)	0.515 (0.610)
	t(*p*)	6.094 (0.000)	3.143 (0.007)	
Y-balance (right side)	Pre	90.41 (6.42)	93.00 (6.24)	-1.173(0.250)
	Post	94.76 (5.80)	94.75 (7.84)	
	Pre-post	4.35 (7.76)	1.75 (7.65)	0.962(0.343)
	t(*p*)	2.312 (0.034)	0.914 (0.375)	
Y-balance (left side)	Pre	90.29 (5.96)	90.94 (7.45)	-0.275 (0.785)
	Post	95.59 (6.65)	95.94 (7.16)	
	Pre-post	5.29 (2.85)	5.00 (6.74)	0.2041 (0.839)
	t(*p*)	9.553 (0.000)	2.966 (0.010)	

Values are presented as means (SD); ART= active release technique; GE= general exercise; FRT= functional reach test

2. Comparison of functional movement

Comparisons between the pre- and post-test FMS results for functional movement between the 2 groups. Significant improvements in functional movement were observed in the ART group for the deep squat, hurdle step, in-line lunge, active straight leg raise, trunk stability, and rotary stability. For the GE group, the hurdle step was the only exercise that showed significant improvement ($p < 0.05$). Therefore, the in-line lunge, trunk stability, and rotary stability all showed significant improvements in the ART group that were not observed in the GE group ($p < 0.05$)(Table 4).

Table 4. Comparison of physical functional movements between the groups (*N*=33).

Parameters		ART group (*n*=17)	GE group (*n*=16)	*t*(*p*)
Deep squat	Pre	1.94 (0.55[a])	1.88 (0.80)	0.276 (0.784)
	Post	2.29 (0.47)	1.94 (0.77)	
	Pre-post	0.35 (0.60)	0.06 (0.25)	1.178 (0.085)
	t(*p*)	2.400 (0.029)	1.000 (0.333)	
Hurdle step	Pre	1.94 (0.55)	2.06 (0.57)	-0.617 (0.542)
	Post	2.53 (0.51)	2.31 (0.60)	
	Pre-post	0.58 (0.50)	0.25 (0.25)	2.027 (0.051)
	t(*p*)	4.781 (0.000)	2.236 (0.041)	
In-line lunge	Pre	2.00 (0.79)	2.19 (0.83)	-0.663 (0.512)

	Post	2.65 (0.60)	2.19 (0.65)	
	Pre-post	0.64 (0.64)	0.00 (0.51)	2.776 (0.009)
	t(*p*)	3.395 (0.004)	0.000 (1.000)	
Shoulder mobility	Pre	1.53 (0.80)	1.94 (0.85)	-1.418 (0.166)
	Post	1.53 (0.80)	2.00 (0.89)	
	Pre-post	0.00 (0.35)	0.06 (0.25)	-0.583 (0.564)
	t(*p*)	0.000 (1.000)	1.000 (0.333)	
Active straight leg raise	Pre	2.53 (0.51a)	2.31 (0.79)	0.660 (0.514)
	Post	2.76 (0.43)	2.50 (0.73)	
	Pre-post	0.23 (0.43)	0.18 (0.40)	1.128 (0.268)
	t(*p*)	-2.219 (0.041)	1.861 (0.083)	
Trunk stability	Pre	1.82 (0.80)	2.25 (0.68)	-1.631 (0.113)
	Post	2.47 (0.51)	2.38 (0.71)	
	Pre-post	0.64 (0.70)	0.12 (0.95)	2.320 (0.027)
	t(*p*)	-3.801 (0.002)	0.522 (0.609)	
Rotary stability	Pre	1.35 (0.70)	2.25 (0.68)	-3.717 (0.001)
	Post	2.06 (0.55)	2.38 (0.50)	
	Pre-post	0.70 (0.58)	0.12 (0.61)	2.217 (0.034)
	t(*p*)	-4.951 (0.000)	0.808 (0.432)	
Total score	Pre	13.12 (1.93)	14.94 (2.20)	-2.506 (0.018)
	Post	16.29 (1.64)	16.13 (2.02)	
	Pre-post	3.17 (3.17)	1.31 (2.02)	4.392 (0.000)
	t(*p*)	-7.856 (0.000)	2.553 (0.022)	

Values are presented as means (SD); ART= active release technique; GE= general exercise.

Ⅳ. Discussion

Balance has a major influence on the process of movement and is the most basic and important factor affecting physical activity (Pollock et al., 2000). Factors that influence balance include muscle strength, body sensation, vision, range of motion, vestibular organs, and motor response. Without balance, motor movements cannot be properly performed, and muscle strength and sensory and motor responses are also reduced (Eadric et al., 2007). Balance is very important for youth athletes because it is associated with a reduction in fluctuations in position resulting from body sensation and is necessary for improved performance.

In this study, after training with the FRT, the experimental group showed a significant improvement, from 43.24

cm before the intervention to 48.94 cm after the intervention ($p < 0.05$), and the GE control group showed a significant improvement from 42.44 cm before the intervention to 46.56 cm after the intervention ($p < 0.05$). While this pre- and post-intervention difference was 5.70 cm in the experimental group and 4.12 cm in the control group, the difference was not statistically significant. According to a study conducted by Vijay Kage (2014) on 40 patients aged 17–25 years with hamstring muscle tension, after applying the ART and Mulligan bent leg raise (MBLR), significant improvement was seen in the popliteal angle and FRT in the sitting position ($p < 0.05$). The ART group showed statistically significantly greater improvements in the popliteal angle and FRT in the sitting position than the MBLR group ($p < 0.05$). Based on this, the authors suggested that the ART and MBLR were effective for both improving the popliteal angle and FRT in the sitting position in general for people with hamstring muscle tension, but the ART was more effective for improving balance than the MBLR. As in previous studies, there was no statistically significant difference between the groups. However, the experimental group, which received the ART, showed greater improvement than the control group. During the FRT, the activities of the rectus femoris, biceps femoris, anterior tibialis, and soleus muscles during stretching are important factors for maintaining balance (Shin, 2018), however, in this study, the intervention for the quadriceps femoris muscle, including the rectus femoris and biceps femoris, was not applied. Therefore, the differences in the results seems to be evident in the FRT in the sitting position by applying the ART because it is more advantageous in maintaining balance than the FRT, which measures balance while standing (Shin, 2018).

In this study, there were significant improvements in the Y-balance test results in the experimental group on the right side, from 90.41 cm before the intervention to 94.76 cm after the intervention ($p < 0.05$) and on the left side, from 90.29 cm to 95.59 cm ($p < 0.05$). In the control group, no significant improvement was seen on the right side (93.00 cm to 94.75 cm) or the left side (90.94 cm to 95.94 cm) ($p < 0.05$). However, between the groups, there was no statistically significant improvement on the right side for in the ART group (difference of 4.35 cm) compared to the right side in the control group (difference of 1.75 cm). Additionally, there was no statistically significant difference in Y-balance test results between the groups on the left side (difference of 5.29 cm in the ART group and difference of 5.00 cm on the left side in the control group). In a study by Chae (2019), after 30 people with ankle instability performed proprioceptive exercises, there was a significant improvement in the Y-balance test, from 82.79 cm to 85.05 cm ($p < 0.05$). This increase in balance was attributed to the increase in muscle strength, coordination, and motor control. In another study, Go (2011) reported that there was a strong imbalance as a result of studying the balance index of the plantar flexor and dorsal flexor muscle strength of subjects who showed low Y-balance test results. Since a strong imbalance index is a major risk factor for ankle joint injury, it may be necessary to reduce the degree of imbalance in the balance index by training the dorsal flexor muscles to the plantar flexors to prevent damage. In this study, we hypothesized that the reason significant results were not obtained was that the ART was applied to the gastrocnemius muscle (plantar flexor), but no special intervention was applied to the dorsal flexors. The youth basketball players likely could have achieved more effective improvements in balance by applying the ART to both the plantar flexors and dorsal flexors in this study.

Functional movement tests can reduce the risk of potential injury to athletes, improve performance, and provide important information to lead to efficient training. The ability of an athlete to perform a skill is related to body movement, so an athlete who is not properly trained in movement will develop an imbalance in muscle strength. In addition, since bad habits in movement are not often perceived, functionally inappropriate movements might be present and can lead to a high risk of injury in a sports environment (Lee, 2016). Although youth basketball players spend a lot of time training to improve their performance, they often endure mild pain during training or rationalize it as a natural result of training. Due to this, even athletes who seem to be able to control their movements sufficiently have deficits in balance when performing a functional movement test (Park, 2018). Therefore, muscle imbalance and deterioration of function are closely related, and improvement of functional movement through resolving muscle imbalance is an important factor for youth basketball players.

In this study, functional movement measurements in the experimental group showed a significant improvement, from 2.00 to 2.65 in the in-line lunge test ($p < 0.05$). In the control group, there was no significant improvement, from 2.19 before the intervention to 2.19 after the intervention. A significant difference was also found between the groups according to the intervention method ($p < 0.05$). In the trunk stability test, the experimental group showed significant improvement from 1.82 to 2.47 ($p < 0.05$), and in the control group, there was no significant improvement, from 2.25 before the intervention to 2.38 after the intervention. A significant difference was also found between the groups according to the intervention method ($p < 0.05$). The participants in the experimental group showed significant improvements in the rotational stability test from 1.35 to 2.06 ($p < 0.05$), and in the control group, there was no significant improvement (2.25 to 2.38). A significant difference was also found between the groups according to the intervention method ($p < 0.05$). In the total score, the experimental group showed significant improvement from 13.12 to 16.29 ($p < 0.05$), and functional movement improved. In a previous study by Jeon (2018), after applying mobility and stability exercises to field hockey players, functional movement, which was evaluated using FMS, showed significant improvement in the trunk stability test and rotational stability test ($p < 0.05$). According to a study by Kage (2015), general physical therapy and myofascial release techniques were applied to the control group, and general physical therapy and the ART were applied to the experimental group for 30 patients with plantar fasciitis. In a study that measured the pain index and foot function index on the third and sixth days, the foot function index in the experimental group showed an improvement from 25.55 on the third day to 16.50 on the sixth day, and the control group showed an improvement from 23.82 on the third day to 10.93 on the sixth day. The experimental group, in which the ART was applied, showed better results in the pain index and foot function index than the control group, in which the myofascial release technique was applied, and improved pain and functional ability ($p < 0.05$). According to a study by Thind (2019), targeting a 22-year-old man who had suffered repetitive femoral injuries for 2 years, when the SLR was applied after the ART for 2 weeks to measure the pain level, there was a decrease in the pain index. The improvement of muscle dysfunction was confirmed through the increased range of motion of the hamstring muscle after the intervention, as evidenced by the straight leg test and the popliteal angle ($p < 0.05$). In a previous study by Feland (2001), the application of the ART to the hamstring muscle for 6 weeks resulted in a significant increase in the range of motion of the hip joint ($p < 0.05$), which was further improved while relaxing the tissues around the joint and alleviating the uniaxial tension of the muscles, which had a positive effect on the functional movement. The in-line lunge test assesses the movement of the hip joint, and it is understood that both the movement and stability of the hip joint are simultaneously required (Lee, 2019). Hip joint dysfunction can cause impingement of the iliopsoas muscle and hamstring muscle syndrome, which can lead to weakness of the gluteus maximus, leading to dysfunction of the hip joint (Ibrahim, 2007). The in-line lunge test is a difficult, complex exercise of functional movements requiring the subject to maintain balance on a narrow plate while flexing the knee (Lee, 2019). This test has had significant results in relieving dysfunction caused by intervention in the iliopsoas muscle and hamstring muscles, which are the muscles surrounding the hip and knee joints. In this study, the application of the ART to the iliopsoas and hamstring muscles of youth basketball players improved muscle function around the hip joint. The trunk stability test contributes to the stability of the body through pelvic stability, hip joint, knee, and ankle mobility and stability (Park, 2018). In this study, we found that ART led to improved function in the iliopsoas and hamstring muscles (which increased movement and stability of the hip and knee joints) and to improved function of the gastrocnemius muscles, which contributed to increased mobility and stability of the ankle. The ART improved stability and mobility by resolving dysfunction in the muscles surrounding the hip, knee, and ankle joints, as shown in previous studies (Thind, 2019). The results showed significant increases in the in-line lunge, trunk stability, rotational stability, and total FMS score. These results suggest that the ART is effective at improving the functional movement of youth basketball players, and the ART can be an effective intervention method for improving the functional movement of youth basketball players.

One limitation of this study is that it was not possible to compare groups of participants that had restrictions at the same site. Therefore, it was difficult to clearly differentiate the effect of the ART, which is an experimental technique, by applying a rather short intervention to youth athletes that change rapidly and continuously. In addition, due to the COVID-19 outbreak, all competitions were canceled, and the competition status could not be confirmed. The degree of team training applied to the test subjects was also not controlled equally, and the intervention was applied only to specific muscles of the lower limbs. As a result, many of the results regarding whole-body functioning were not significant.

Ⅴ. Conclusion

The results of this study showed that the ART improved the balance and functional movement of youth basketball players more than general exercise therapy, though the difference was not statistically significant. This study also showed that the ART was effective at improving balance and functional movement in youth basketball players. Therefore, it is expected that the application of the ART in future clinical practice will improve the balance and functional movement of youth basketball players, thereby helping to prevent physical damage and improve performance.

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