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The core stabilization effect of respiratory muscle training to promote the health of the elderly

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노인 건강 증진을 위한 호흡근 트레이닝의 코어 안정화 효과

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Abstract : This study reviews studies on the core stabilization of respiratory muscle training for the elderly health. Previous research data and presenting basic literature data suggest that respiratory activation is an important mechanism for core strengthening via exercise interventions for the elderly. The review found that first, the mechanism of improving the respiratory muscles weakened by aging to address the loss of core function due to old age sarcopenia among the elderly results entails promoting the autonomic nervous system by focusing on the respiratory muscle activation pattern, the core muscle sensation mobilized for body centering. Second, nerve roots, intraperitoneal pressure, and deep muscles in the trunk of the body can be promoted while controlling respiratory stimulation with cognitive feedback. Effortful inspiration increases the activation of respiratory assistive muscles and effortless exhalation can improve the core muscle mobilization by involving abdominal muscles. Third, through respiratory muscle training, the elderly can increase their awareness of spinal centering and improve the ability to control the deep core muscles that must be mobilized for core stabilization. In conclusion, respiratory muscle training to increase the utilization of the trunk muscles seems to be a useful core stabilization exercise for the elderly with chronic tension and joint degeneration.

Keywords : Elderly, Health, Respiratory Muscle, Training, Core, Stabilization

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1. Introduction

In Korea, the elderly population over 65 years comprises over 14% of the total population, and by 2025, Korea is predicted to become an ultra-aging society, with the elderly population comprising 20.3% of the total population[1]. The increased lifespan of modern people means that the duration of old age, when an individual suffers from aging-related issues and degenerative and chronic disease. Long-lasting old age diseases have a negative effect on the quality of life of an individual until death and also lead to heavy medical expenses. Therefore, it is of utmost importance for the elderly to manage physical health levels for maintaining an independent daily life. For promoting their health, there is a need to identify effective exercise methods for the elderly by reviewing various studies on exercise science.

According to a number of research studies from both Korea and abroad, regular exercise participation among the elderly improves body composition and increases stamina for performing activities, delaying the aging-related reduction of physiological functions[2], especially in preventing the risk of falls and improving muscular dystrophy. It has been suggested that exercise therapies that improve lumbar bone mineral density and balance ability can bring about overall improvement in physical fitness and positive changes in anti-aging hormones, thereby increasing the quality of life and health in old age[3-6].

Accordingly, the core activity of the elderly is to maintain physical function and control the movement posture, so the need for strengthening core muscles is emphasized in exercise for the elderly. However, as degenerative arthritis or sarcopenia have already progressed to a significant degree due to aging in most elderly people, and because there are many restrictions on exercise in reality, core muscle activation effects are often insignificant. A detailed discussion of the studies on movement and related effects is therefore necessary.

The core is a complex of the hip and hip joints that constitutes the central part of the human body and includes all the muscles of the spine and lower limbs, including the abdomen[7]. Therefore, core exercise is a type of exercise that maintains the stability of the spine, pelvis, abdomen, and lumbar region to develop deep muscles that maintain the stability of the trunk[8] and increases joint mobility and nerve muscle control ability to improve muscle coordination. With exercise therapy, interest is increasing in the field of exercise science research.

Previous studies have reported on the importance of maintaining core function and the expected effect of improving health promotion among the elderly. Choi et al.[9] found that a core exercise program for elderly women had a positive effect on body endurance and gait ability. Park[10] showed that weakening of the central muscles of the elderly increased the dynamic balance, gait speed, mobility, muscle strength, and the risk of deteriorating quality of life due to reduced standing and lower extremity muscle function. Therefore, the importance of elderly health and core function improvement needs to be discussed.

In addition, as the risk factors for the health status of the elderly are increasing, attention to respiratory failure and the importance of respiratory training in various diseases is being re-examined[11, 12]. In terms of being able to deepen, it is thought that the respiratory exercise intervention is worth the research activity that can improve the core muscle exercise efficiency of the elderly. However, current respiratory training is mostly being considered as a rehabilitation program for the care of patients with respiratory diseases [13-15]. More research is required given the insufficiency of exercise interventions for the elderly who do not have respiratory diseases and the lack of basic literature data.

In particular, the relationship between core

activation and breathing is important for changes in intra-abdominal pressure. It can, therefore, be expected to improve the ability to utilize the hardened trunk while reducing the burden of joint load during exercise for the elderly, and thus, can be suggested as an important mechanism for stabilizing the core of the elderly.

Therefore, in this study, we reviewed previous studies that have discussed the respiratory muscle activity recovery, and presented research data supporting the theoretical basis of core function improvement through respiratory muscle training for the elderly via exercise, an important mechanism of respiratory muscle activation and core stabilization in the elderly.

2. Main subject

2.1. Respiratory muscle action and aging

The role of breathing is largely based on the biomechanical effect of stabilizing posture and maintaining body balance; the biochemical effect of maintaining life and homeostasis through gas exchange; and the psychosocial effect of stress, anxiety, and depression[16, 17]. The main pulmonary functions of this respiration function are slightly different between men and women, but after reaching the peak before and after the age of 25, they gradually begin to deteriorate 20% reduction [18].

Respiratory muscle strength involves muscles such as the diaphragm, lateral intercostal muscle, rectus abdominis muscle, transverse abdominis muscle, and abdominal muscles involved in breathing[19]. Holland et al.[20] suggested that among elderly with cardiovascular disease, chronic degenerative diseases, or musculoskeletal disorders, it is difficult to maintain respiratory system health through general physical activity or aerobic exercise. These prior studies indicate the need for more active methods of strengthening and reinforcing respiratory muscles via exercise interventions for the elderly with muscular dysfunction. A recent study that discussed disease improvement and health-promoting effects through breathing exercises suggested that respiratory stimulation is controlled by cognitive feedback, which promotes neuromuscular muscles, pressure in the abdominal cavity, and deep muscles in the trunk of the body. In addition, in terms of clinical study findings on breathing exercise methods, Bae et al.[21] published the results of proprioceptive neuromuscular facilitation (PNF) based on the performance of breathing exercises. Kim et al.[22], Seo[23], Lee[24], and Yoo[25] have presented the effects of breathing movement feedback according to posture change. In particular, the study by Kim[26], which indicated that the resistance of thoracic mobility exercise showed an improvement in PNF during respiratory activity, offers the details of the respiratory muscle stimulation system and presents its effect as exercise therapy in detail.

Adler et al.[27] stated that PNF breathing exercises are aimed at enhancing the respiratory function by improving the motility of the chest and improving the strength of the main respiratory muscles. The isotonic complex technique in breathing exercises is a technique in which the afferent and centrifugal contractions of cooperative muscles are sequentially performed without muscle relaxation, and coordination and active motor control ability are improved. This technique is effective for functional activity, particularly centrifugal control. Specifically, when the isotonic complex technique is applied, the mobility of the chest is improved and there are positive effects on strengthening the respiratory muscles.

In terms of the breathing activity of the human body, during inhalation, the volume of the thoracic cavity expands due to the stimulation of the diaphragm and the intercostal muscles, and the process of air inflow occurs due to the change in the

internal pressure. The lung tissue causes recoiling of the lung after inhalation, as the diaphragm and intercostal muscles relax, and the resultant pressure difference leads to exhalation. Enright and Unnithan[28] reported that respiratory muscles consist of skeletal muscles, which can increase muscle strength through exercise. As the ground responds according to the training[29], the adjustment of the respiratory center according to the respiratory muscle coordination supports the mechanism of the respiratory muscle training.

The movement of the chest cage, which is directly related to the ability to breathe, is regulated not only by the movement of the spine and ribs, but also by the movement of several joints around them[30], and the reduction of the range of movement of the chest cage increases body alignment and breathing over time, which has a negative effect on function[31, 32]. The dome-shaped diaphragm is a muscle that divides the chest cavity and the abdominal cavity. When the diaphragm contracts, the dome flattens and moves in the direction of the abdominal cavity to expand the volume of the thoracic cavity[33]. In particular, the contraction of the dorsum muscles increases the abdominal pressure to press the organs, and the increased pressure pushes the relaxed diaphragm strongly into the upper chest[34]. As such, all the abdominal muscles are attached to the lower ribs to reduce the size of the intercostal space during exhalation and increase the intra-abdominal pressure. When inhaling, as well as the holding role against the diaphragm contraction, the abdomen is pushed upwards, resulting in lung volume at the end of exhalation. Reducing the diaphragm length can support continued core strengthening activity.

In other words, the mechanism to improve the respiratory muscle action weakened by aging involves awareness about the conscious breathing process, which can be used to improve the respiratory muscle activation pattern, thereby promoting the autonomic nervous system and helping focus on the senses of the core muscles mobilized for body centering. Thus, the promotion of respiratory muscles controlled by cognitive feedback can be expected to have a positive effect on awakening the center of the body weakened by aging.

2.2. Core function in elderly with sarcopenia

A number of studies on the importance of health care for the elderly places the purpose and necessity of research into positive changes in older people's participation in exercise to slow aging and improve physical function. In terms of the detailed discussions on the effects of exercise for the elderly, it was reported that obese female seniors improved their gait, balance, and isokinetic muscle functions in terms of ergonomics as a result of 12 weeks of circuit exercise, which helped prevent falls[35]. After six months of complex exercise treatment, it was the ability to “walk for 6 minutes” to evaluate the muscle strength and cardiovascular system of the legs was improved among the elderly[36]. In addition, the elderly health fitness index showed that 10-week resistance exercise can improve active physical activity by improving the fall-related indicators, including “muscle strength” of the upper arm and “sit up for 30 seconds[37]. These study findings support the rationale that participation in exercise can promote health and functional fitness.

However, sarcopenia in the elderly decreases by 5-10% every 10 years after 50 years of age, muscle strength decreases by 15% every 10 years after 50 years, and decreases by 30% every 10 years after reaching the age of 70 years[38] Decreased muscle function and weakening of cell activation due to age increase joint restriction. Therefore, elderly people who have several chronic diseases and physical activity limitations have difficulty engaging in active physical activity, and accordingly, the expected effect of exercise for the elderly is inevitably lowered.

As such, the negative factors of sarcopenia in old age are reduced physical activity range due

to bone loss and weakening of muscle elongation[39], delay in response time due to loss of intrinsic sensory ability[40], and difficulty in walking due to loss of balance. Difficulties lead to an increase in risk factors for fall[41], leading to a decrease in the ability to perform activities of daily living and an increase in the number of elderly people who have difficulty living independently.

In particular, biomechanical changes due to aging, and decreased balance and performance can lead to loss of core function. According to the study by Anderson and Behm[42], core function provides segment stability to the torso and stabilizes it, and therefore, plays an important role in sports activities. Borghuis et al.[43] said that it is an important factor to improve dynamic balance, as it improves core stability, thereby effectively improving the production, regulation, and transmission of forces during the movement of the torso and limbs. Kendall et al.[44] reported that it maintains the body's structure and function positively through proper control between joints and muscles. Thus, many studies report that balance and functional movements are closely related, and that repeated lifestyles and habits in an unbalanced state create bad postures, and ultimately lead to changes in bones and soft tissues due to reduced flexibility and limited pain and movement[45, 46]. In addition, Hodges and Richardson[47], who analyzed the order in which muscles are activated during body movement, reported that the core stabilizing muscles, the dorsiflexion muscle, the muscles of the rectus muscle, and the abdominal muscles were activated before the limb movement.

Core exercise promotes muscle activation around the spine, which affects the correct posture with pre-constriction of the transverse abdominis muscle when the spine begins to move, and the internal and external oblique muscles and the quadriceps muscle may be involved in the stabilization and functional movement of the spine[48]. The major muscles associated with the core for improving torso stability and body coordination include spinalis, erector spinae, multifidus, internal oblique and external oblique, abdominal muscle, rectus abdominis, transverse abdominis, gluteus maximus, piriformis, biceps femoris, tensor faciae latae, rectus femoris, adductor longus, adductor brevis, semitendinosus, semimembranosus, psoas, quadratus lumborum, sartorius, iliacus, iliotibial band, and gracilis [49].

"Maintaining body balance" means "maintaining smooth movements of muscles, skeletons, and joints in a variety of movement postures." The core exercise program strengthens the lumbar, pelvic, and hip joint muscles that maintain the stabilization of the spine, and can contribute to the improvement of muscle strength, endurance, range of motion, and stabilization of body alignment. Brill and Cozen[50] provide double breathing between movement. Their study indicated that muscle tension could be relieved by smoothly supplying oxygen to the whole body and extending the lumbar muscles.

Therefore, by observing the expected effects of applying core exercise to the elderly as revealed in prior studies, strengthening the core function in old age enhances the weakened core to increase the utilization rate of trunk muscles in the elderly with severe sarcopenia and chronic instability. It is thought possible to expect a state of health in which independent living is possible through improved and stable balance and cognitive activities.

2.3. Expected effects of core stabilization for elderly respiratory muscle training

The increase in the aging population with a life expectancy of 100 years could lead to a serious problem of an increasing number of elderly people who have difficulty living independently due to aging-related deterioration of motor function and cognitive function. The main mechanisms that accelerate the degeneration of the musculoskeletal system

in the elderly include the tension and muscle contraction of the joint tissue due to the deterioration of physiological activity function, followed by excessive stress caused by repeated posture for a long period of time, and finally, the depth of physical activity and lack of exercise. Muscle weakness is noted as a representative factor.

Kolar et al.[51] and Frank et al.[52] discuss exercises to balance and activate the diaphragm, pelvic floor muscles, and all abdominal muscles, as well as the deep flexors, orthopedics, upper and lower thoracic and lumbar vertebral muscles in the neck for spinal stabilization. This has been reported to be important for the role of the integrated spinal stabilizing system.

Most elderly people show severe instability pertaining to the difficulty of maintaining the stability of the spine due to the significant progression of core muscle weakness and joint degeneration because of aging. In particular, when misalignment, such as the head anterior stance, the round shoulder posture, and the anterior and posterior radial radius of the elderly occur, chronic joint pain and respiratory function decline appear along with multiple joint diseases. This leads to shortening and weakening of the muscles around the neck such, as the neck muscles, dorsal muscle, and ribs, and the muscles around the shoulders, such as the anterior tooth muscle, the pectoralis major muscle, and the ribs, which in turn increases the energy consumption of breathing and reduces respiratory function[53, 54].

Breathing methods can be largely divided into clavicular breathing, thoracic breathing, and diaphragmatic breathing. Clavicular breathing is the contraction of the ribs, and the chest cage rises upward. During exhalation, the air is discharged from the lungs, the rib cage muscles relax, and the chest cage returns to its original state poor ventilation[55]. On the other hand, thoracic breathing involves the action of the diaphragm; when breathing in, the stomach moves outward, and when exhaling, the stomach moves inward. It is one of the most commonly used breathing exercises and is a breathing type that helps improve lung capacity[56, 57].

Diaphragmatic breathing is a mixed form of expanding the chest and back breathing. Care should be taken to not raise shoulders when inhaling and to inflate your chest during diaphragm breathing[58]. In normal breathing, inspiration is composed of active movements due to contraction of the diaphragm and lateral intercostal muscles, but in general, it is an unconscious breathing state, so the respiratory stimulation is insignificant and cognitive respiratory activity is promoted. The activation of the respiratory assist muscles, as such, is increased. Exhalation breathing is also a manual process that involves the relaxation of the diaphragm and lateral intercostal muscles. When exertion exerts effort, the abdominal muscles, such as the rectus abdominis, abdominal muscles, and abdominal muscles, are involved. It pushes strongly in the direction to mobilize the muscles involved in improving the core function.

Accordingly, the respiratory muscle training that promotes the ability to utilize the respiratory muscles emphasizes the effect of relaxing the respiratory muscles based on cognitive change, so that the elderly can become aware about unstable postures and improve their motor dysfunction, which in turn can have a core stabilization effect.

Obayashi et al.[59] suggested that breathing exercises play an important role in postural stability and stabilization of the spine, thus helping maintain a good posture. In terms of the recent studies that reported the effects of breathing exercises in relation to musculoskeletal system damage, Kim et al.[60] reported that using back breathing exercises for patients with lower back pain was effective in activating trunk muscles and improving muscle strength. Ki[61] reported that breathing exercises for patients with chronic lower back pain helped them lift objects and increase flexibility. The provided explanation was that repetitive back

breathing relaxes the rigid chest cage and has a positive effect on improving spine posture. In addition, Lee[62] notes the contribution of breathing training to maintain correct posture and to increase abdominal and lumbar muscle strength and equilibrium and the ability to maintain breathing for a long time. Systematic and consistent breathing training controls inefficient breathing habits and enhances correct breathing. This report supports the expected effects of core stabilization of respiratory movement intervention.

These preliminary research data indicate that the respiratory muscle action and core stabilization mechanism during exercise in the elderly increase the usability of the trunk muscles with reduced activity stimulation for a long period of time in the aging phase; in particular, the transverse abdominal muscles due to changes in the abdominal muscles and the changes in abdominal pressure through stimulation of the diaphragmatic breath. These findings are significant for stimulating deep muscles such as the rectus abdominis muscle and pelvic floor muscles.

In addition, an important part of the upper limb utilization motion should be the improvement of ligament, tendon, and muscle extension around the shoulder joint. Exhalation in respiratory muscle training actively regulates changes in abdominal pressure to improve the utilization ability of the core central muscle and muscle atrophy. The upper trapezius and scapula muscles can be stretched to stabilize the scapula. In other words, it is thought that if the elderly continue to train via core exercises to recognize the torso respiratory muscle stimulation, they can promote the segmentation of the trunk and awaken the center of the body with balanced movements of the upper and lower legs, thereby stabilizing their physical activity.

3. Results and Discussion

Breathing is the most important life activity for the survival of the human body and breathing promoting activities are an important mechanism for improving health by promoting awareness of the breathing sensations that occur with the body's respiratory muscles. Recently, in the field of neurophysiology, it has been revealed that respiratory action is closely related to physiological phenomena and cognitive activity. Applying an integrated approach involving body movements and cognitive feedback, respiratory muscle movement in the elderly affects chronic muscle tension and unbalanced body movements, Physical balance recovery leads to reduced mental stress, leading to improved physical and mental health in old age.

Therefore, the findings of the review revealed that in general, the unconscious breathing activity was limited to the physiological action of gas exchange in a state in which the elderly were not breathing correctly, but respiratory muscle movement due to respiratory muscle promotion and cognitive stimulation contributed to the stabilization of body centering in the elderly. The purpose of this study was to examine basic theoretical data pertaining to a positive effect on core muscle activation.

In elderly people, weakening of inspiration and exhalation due to respiratory muscle dysfunction causes lung disease, and physical activity constraints are increased along with changes in factors such as lack of physical activity, stress, and nutritional imbalance. These health conditions lead to chronic diseases, cardiopulmonary dysfunction, and pain neurological complications, which can lead to a decrease in the quality of life of the elderly and a shortened lifespan. In particular, if the elderly

chronically maintain an incorrect posture in which the core muscle stabilization has collapsed, the bodies of the elderly with degenerative diseases may undergo a change in biomechanical structure, and structures necessary for breathing may not function properly. Eventually, if unconscious breathing is performed for a long period of time through an incorrect breathing pattern, complex diseases such as chronic pain, autonomic ataxia, anxiety, and depression become intensified and cannot then be improved.

By improving the movement of the torso so that the chest can be expanded sufficiently during breathing, the depth and shape of breathing can be adjusted, and breathing ability can be improved[34]. Promoting core activation according to respiratory muscle training can improve the ability of core muscle utilization by promoting the internal and external abdominal muscles, transverse abdominal muscles, and pelvic floor muscles, wherein changes in intraperitoneal pressure improve diaphragm contraction and relaxation, thereby weakening respiratory function in the elderly[52].

In terms of the action of the respiratory muscles and the core stabilization mechanism, the volume of the thoracic cavity increases and the negative pressure of the intrathoracic pressure is maintained due to the piston movement, via which the diaphragm descends and the ribs expand upward and outward. Due to this action, inhalation, which is the process of air inflow into the lungs, occurs, and when the muscles relax, exhalation is performed by passively venting air out. At this time, the main muscle of the inhaler is composed of the diaphragm, the quadrangular muscle, and the intercostal muscle.

When the diaphragm contracts, the length becomes shorter, and the abdominal pressure is lowered and compressed, thereby increasing the intra-abdominal pressure. The tension in the abdominal muscles increases the intra-abdominal pressure during diaphragm contraction, thereby promoting the action of the diaphragm to complete inspiration. In addition, the aerobic muscles, the abdominal muscles, the internal and external abdominal muscles, the transverse abdominal muscles, etc. assist exhalation and promote diaphragm contraction, such that active respiratory muscle training contributes to the strengthening of the deep muscle core, which is otherwise inactive.

Kolar et al.[51] and Frank et al.[52] discussed the positive results of increased core muscle activity in double breathing, improved endurance, and reduced muscle compensatory action, such as femoral fasciitis. The results of these studies show that most elderly suffer from the hardening of muscles and soft tissues of the joints; therefore, respiratory stimulation, which increases the utilization of trunk muscles, relieves muscle tension during core exercise and reduces the burden on the lower extremity joints. The results of the review supported the effectiveness of the respiratory action in the core exercise. Concluding, active exercise in respiratory muscle training must be included in elderly exercise, and the research results presented in this study will serve as a basis for positive improvement in core function recovery through respiratory muscle activation.

Therefore, the respiratory muscle training exercise intervention of the elderly can expect to strengthen and stabilize the core muscles necessary for the stability of the body by straightening the lower abdominal contractions and the spine, and further improving the physical, physiological, and psychological health of the elderly. The need for continuous research activities on this topic may increase in various fields in the future.

4. Conclusion

This study examines the literature on the recovery of specific functions of respiratory muscle facilitation activity, and presents basic findings on the improvement of posture

maintenance and mediation of core stabilization and physical balance among the elderly through exercises.

To summarize the results of the study, first, for the human body, "maintaining body balance" means "maintaining smooth movement of muscles, skeletons, and joints in various movement postures." Loss of core function due to old age muscular dystrophy results in respiratory muscle inactivation due to biomechanical changes and reduced balance and performance. As such, when the elderly are unable to exert their proper functions due to muscular dystrophy, the respiratory muscles that are mobilized to the core are weakened.

Second, while regulating respiratory muscle stimulation with cognitive feedback, it can promote neuromuscular muscles, pressure in the abdominal cavity, and deep muscles in the trunk of the body. Effortful inspiration with accelerated cognitive respiratory activity increases activation of respiratory assistive muscles such as sternocleidomastoid, quadriceps, and trapezius. Exhalation breathing is also a manual process that involves the relaxation of the diaphragm and lateral intercostal muscles. When exertion is effortful, the abdominal muscles, such as the rectus abdominis, abdominal muscles, and abdominal muscles become involved. By actively pushing in the direction, active respiratory muscle training increases the mobilization of the deep muscles involved in improving core function.

Third, through respiratory muscle training, the elderly increase awareness of lower abdominal contraction and spinal centering, and the core muscle strengthening and stabilization system, which is a core muscle system required for body stability, contributes to the posture maintenance function of daily life and is expected to improve body balance. In particular, the respiratory muscle relaxation effect by cognitive reconstruction in the core exercise intervention will help stabilize the centralization by increasing the utilization of the trunk muscles with reduced activity stimulation for a long period of time in the aging phase.

In conclusion, since the elderly experience degeneration that hardens muscle joints and soft tissues for many years, deep stimulation of deep muscle breathing, which increases the utilization of trunk muscles, can relieve muscle tension during core exercise and reduce upper and lower joint burdens due to movement. As a core stabilization exercise for improving health, respiratory muscle training is valuable.

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Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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