Effects of Exercise Intervention on Physical and Cognitive Functions in Elderly Individuals with Locomotive Syndrome

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In humans, aging is associated with declines in physical and cognitive functions. Physical activity and exercise have received attention as a potential preventive measure against these age-related functional declines. Locomotive syndrome (LS) is a condition manifested by high-risk patients with musculoskeletal disease who are high likely to require nursing care. Physical activity and exercise can enhance motor, cognitive, and social functioning in old age. Nursing home residents are characteristically older and have high prevalence rates of multiple morbidities, frailty, impaired mobility, severe cognitive deficits, and depression. However, little is known about the effects of exercise interventions on the physical and cognitive functions of elderly residents diagnosed with LS. In this paper, we discuss the necessity of exercise interventions for elderly residents with LS.

Key words: aging, locomotive syndrome (LS), exercise intervention, resistance training, cognition

Introduction

Japan is a rapidly aging society and a world leader in longevity. According to the Cabinet Office, as of October 1, 2016, the total population of Japan was 126.93 million; of these, 34.59 million were aged 65 years or older. As the ratio of people aged 65 years or older (i.e., the elderly) is 27.3%1), Japan now faces the advent of a “super-aged” society earlier. By 2025 and 2050, the elderly are expected to account for 30.0% and 37.7%, respectively, of the total population of Japan. An aging population inevitably has considerable impacts on social systems, including public health. To cope with the rapid changes in age demographics in Japan, a nursing-care insurance system was introduced in 2000. The number of elderly requiring nursing care is continually increasing; 5.91 million individuals received such services in 2014, compared to 3.70 million in 20032). The reasons underlying the
provision of these services included stroke (17.2%), dementia (16.4%), frailty (13.9%), falls/fractures (12.2%), joint disorders (11.0%), and others. In approximately of 50% cases, services were provided because of cognitive and physical impairments.

**Locomotive syndrome**

The term locomotive syndrome (LS) was proposed by the Japanese Orthopedic Association (JOA) to indicate a condition experienced by people with musculoskeletal disease in high-risk groups who are highly likely to require nursing care. Individuals with LS face difficulties with standing, walking, running, climbing stairs, and performing other physical functions essential to daily life. LS is caused by the weakening and loss of musculoskeletal tissues, such as bone, joint, and muscle. In particular, sarcopenia is an age-related, degenerative weakening and loss of the skeletal muscle mass and strength, which drastically reduces the quality of life and leads to an increased risk of insulin resistance and various diseases; therefore, maintenance of the skeletal muscle mass is essential to preventing LS in elderly individuals. The concepts of LS, sarcopenia, and frailty share several similarities, and the distinctions among them are ambiguous.

Methods for evaluating LS have recently been established. In 2013, the Japanese Orthopedic Association (JOA) proposed the two-step test, stand-up test, and 25-question geriatric locomotive function scale (GLFS-25) for assessing the risk of LS. The two-step test is a screening tool used to evaluate horizontal mobility (i.e., walking ability), whereas the stand-up test reflects vertical mobility and assesses leg strength as the participant stands up from a specified height, using one or both legs. The GLFS-25 assesses a participant’s physical condition and lifestyle over the previous month. This self-reported questionnaire includes domains addressing pain, physical functioning, basic activities of daily living (ADL), instrumental ADL, and anxiety. These 25 items are scored from 0 (no impairment) to 4 (severe impairment), with total scores ranging from 0 to 100 points. Higher scores indicate worse locomotive function. Per the Japan Orthopedic Surgery Society, a GLFS-25 score of ≥7 points identifies an initial decline in motor function, while a score of >16 points indicates a progressive decline in motor function. According to the JOA, clinical decision limits were established in two stages as follows: Stage 1 (LS-1): (1) two-step test score of <1.3, (2) difficulty in standing from a seat at a height of 40 cm using one leg in the stand-up test (either leg), and (3) GLFS score of ≥7. When a participant meets any of these criteria, the start of mobility decline is diagnosed. Stage 2 (LS-2): (1) two-step test score of <1.1, (2) difficulty in standing from a seat at a height of 20 cm using both legs in the stand-up test, and (3) GLFS score of ≥16. When a participant meets any of these criteria, progressive mobility decline is diagnosed.

Many reports have suggested that the GLFS-25 score correlates strongly with several measures of physical performance, including the walking speed test, handgrip strength test, unipedal stance test, and the timed up and go test. More recently, two studies reported that a comparative analysis of LS and non-LS subjects revealed significant differences in the degree of depression with age. Moreover, the same study group reported that LS subjects had a higher risk of cognitive impairment, compared to subjects without LS, which suggests a close relationship between these factors. Nakamura et al. (2017) also suggested that data from a cross-sectional study were insufficient to determine the existence of a causal relationship between the physical or cognitive status and LS, and emphasized the need to conduct longitudinal studies to clarify the causal relationships among these factors. Further study is needed to examine the effects of exercise interventions on the differences between LS-1 and LS-2.

**Effects of exercise interventions on physical and cognitive function in elderly**

The American College of Sports Medicine (ACSM) states that participation in regular physical activity elicits several favorable responses that contribute to healthy aging. Accumulated evidence indicates that either aerobic or strength-based physical exercise should be recommended strongly for both healthy older adults and elderly people with chronic diseases and disabilities. In other words, exercise interventions have improved mobility and physical functioning. de Labra et al. suggested that...
Aging is simultaneously associated with declining cognition and an increasing risk of dementia\(^{22}\). A decline in cognitive function is a major factor contributing to disabilities in elderly individuals\(^{23}\). The effects of physical exercise as a preventive measure against age-related declines in cognitive function have received attention\(^{22, 24}\). Recent studies have suggested that both aerobic training and resistance training could effectively promote cognitive functions in elderly populations\(^{25-28}\). These main intervention studies summarized on the table. Perrig-Chiello et al. (1998)\(^{28}\) reported that an 8-week, machine-based resistance training program improved self-attentiveness and memory functioning in 73-year-old men. Cassilhas et al. (2007)\(^{25}\) also reported that moderate- and high-intensity machine-based resistance exercise programs had equally beneficial effects on cognitive performance as assessed by standard neuropsychological tests of short- and long-term memory and verbal reasoning in men aged 65–75 years. Dorner et al. (2007)\(^{27}\) examined the combined effects of a 10-week strength and balance exercise program on cognitive function in frail, cognitively impaired elderly subjects (75 years or older) and observed improvements in muscle strength and Mini-Mental State Examination (MMSE) scores. Although Nakamoto et al. (2012)\(^{29}\) demonstrated that the MMSE scores of healthy elderly subjects (aged 68.7 years) were not significantly improved by a 3-month body mass-based exercise program, the absolute changes in scores significantly correlated with changes in the knee extensor torque. Therefore, an exercise intervention involving resistance training is important step to the delay or prevention of cognitive function declines in the elderly. However, this intervention effect may vary depending on the age of the participants and length of the intervention period (>3 months is required).
A meta-analysis found that programs combining aerobic–based training exercises and resistance training exercises had a greater positive effect on cognition, compared to programs involving only aerobic–based exercise training. Therefore, Liu–Ambrose and Donaldson (2009) suggested that clinicians should consider encouraging patients to undertake both aerobic–exercise and resistance training not only for “physical health”, but also because of the almost certain benefits for “brain health”.

In conclusion, muscle weakness might increase the risk of cognitive decline in the future. Therefore, the maintenance and improvement of muscular strength through the implementation of long–term resistance training is essential not only from the perspective of physical care prevention, but also from the perspective of cognitive function. As suggested by Nakamura et al. (2017), longitudinal studies of the effects of exercise intervention on physical and cognitive functions in elderly residents diagnosed with LS are needed. Further studies are also needed to examine the effects of exercise interventions on the improvements or preventions in physical and cognitive functions between LS–1 and LS–2.

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Conflict of interest

No conflicts of interest, financial or otherwise, are declared by the authors.

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