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Original Article

Sagittal plane spinal mobility is associated with dynamic balance ability of community-dwelling elderly people

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Abstract. [Purpose] The purpose of this study was to clarify the correlation between the range of spinal mobility on the sagittal plane and the dynamic balance ability of elderly people living in communities. [Subjects and Methods] The persons studied were 31 healthy elderly people living in the community (16 females and 15 males). The range of mobility of the participants' spines in the sagittal plane was measured by using a spinal mouse®. Balance ability was evaluated by using Functional reach (FR), Timed up and go (TUG), and Maximum walking speed (MWS). [Results] A significant positive correlation between the flexion range of the lumbar vertebrae and the FR distance was identified, and a significant negative correlation between the extension range of the thoracic vertebrae and the time required for TUG was also identified. In addition, a significant positive correlation between the extension range of the entire spine and MWS, was identified. [Conclusion] The result of this study have clarified that mobility of the spine in the sagittal plane is associated with dynamic balance ability, which is related to falling.

Key words: Sagittal spinal mobility, Dynamic balance, Elderly

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INTRODUCTION

One social problem accompanying the rapid aging of society is the falling among the elderly, which results in serious complications. External wounds and fractures caused by falls lower elderly people's daily life activity capability, and results in psychological trauma due to easy falling syndrome, further restricting their activities[1)].

A major factor causing elderly people to fall is a decline in the standing balance, including dynamic balance ability, which often occurs during aging[2)]. Methods of evaluating dynamic balance ability, such as the Functional Reach Test (FRT)[3)], Timed Up and Go test (TUG)[4)], and Maximum Walking Speed (MWS)[5)], have been confirmed to be reliable and suitable and can be easily performed; hence, they are widely used in rehabilitation clinics and community health classes for elderly people.

Another physical change people experience as they age are changes in the spine. Kyphosis of the spine, which is mainly an increase in the thoracic vertebrae kyphotic angle, deflects a person's center of mass backwards[6)]; hence, they are more likely to fall backwards. Other changes in the spine caused by aging include degeneration of the vertebral bodies themselves due to osteoporosis, a loss of muscle power of the erector spinae, and degenerative changes in the anterior and posterior longitudinal ligaments and other tissues supporting the spine[7, 8)]. These aging changes presumably impact the mobility of the entire spine, which consists of vertebral bodies, or in other words, impairs the flexibility of the trunk.

The purpose of this study was to clarify the correlation between the range of spinal mobility on the sagittal plane and the dynamic balance ability of elderly people living in communities.

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SUBJECTS AND METHODS

The persons studied were 31 healthy elderly people living in the community (16 females and 15 males). The average age was 72.4 ± 5.1 years; average height, 157.1 ± 5.1 cm; and average weight, 58.4 ± 9.8 kg. The purpose of the experiment was explained to all the test participants, and their written agreements were obtained. The study was approved by the Research Ethics Committee of Chiba Prefectural University of Health Sciences.

The range of mobility of the participants' spines in the sagittal plane was measured by using a spinal mouse (Idiag AG, Volketswil, Switzerland) that can be used to measure the range of mobility of each vertebral body from outside the body's surface. During measurement, the participants stood with the bottom of both feet opened to about their shoulder width to maintain a stable posture, with their arms crossed over their chest. The sensor of the spinal mouse was moved from the head to the cauda of each subject along the side of the spur of the spine from the seventh cervical vertebra to the third sacral vertebra, to measure the sagittal angle between vertebral bodies. The range of mobility of the thoracic vertebrae was calculated as the sum of the range of flexion and extension from the first to the twelfth thoracic vertebrae. The range of mobility of the lumbar vertebrae was calculated as the sum of the range of flexion and extension from the first to the fifth lumbar vertebrae. In addition, to measure the range of mobility of the entire spine, the angle formed by a line connecting the first sacral vertebra to the first thoracic vertebra during maximum flexion forward and extension of the trunk to the same line during quiet standing was calculated. The range of mobility of the entire spine includes the angle of inclination of the pelvis (leaning forward and leaning backwards).

Balance ability was evaluated by using FRT, TUG, and MWS. FRT measured the distance that could move arm forward without moving the foot, which was the base of support. TUG measured the time a subject takes to stand up from a chair, walk around a target 3 m away, and then return to the chair; MWS measures the maximum walking speed over a 10-m course.

Statistical processing was performed to study the correlation between the spinal range of mobility and dynamic balance ability (FRT, TUG, and MWS) by applying Pearson's product-moment correlation coefficient to analyze the correlation between these. The level of significance was set at 1%.

RESULTS

The resulting range of spinal mobility in the sagittal plane and dynamic balance indices are shown in Table 1. The results of the correlation analysis of the range of spinal mobility and dynamic balance indices are shown in Table 2. A significant positive correlation between the flexion range of the lumbar vertebrae and the FR distance was identified, and a significant negative correlation between the range of extension of the thoracic vertebrae and the time required for TUG was also observed. In addition, a significant positive correlation between the range extendibility of the entire spine, including the backward inclination of the pelvis and MWS, was evident.

Table 1. Average values of spinal mobility in the sagittal plane and dynamic balance indices

Range of spinal mobility						Dynamic balance indices		
Flexion (°)			Extension (°)			FRT (cm)	TUG (s)	MWS (m/s)
Thoracic	Lumbar	Inclination	Thoracic	Lumbar	Inclination			
16.0 ± 8.2	37.0 ± 11.5	90.8 ± 21.8	10.3 ± 7.9	7.8 ± 6.6	22.8 ± 12.2	31.0 ± 5.3	6.3 ± 0.8	1.9 ± 0.2

Mean ± SD
FRT: functional reach test, TUG: timed up and go, MWS: maximum walking speed

Table 2. Pearson correlation between the range of spinal mobility and dynamic balance indices

	Flexion			Extension		
	Thoracic	Lumbar	Inclination	Thoracic	Lumbar	Inclination
FRT	−0.186	0.469*	0.144	0.443	−0.141	0.277
TUG	0.051	−0.262	−0.117	−0.542*	−0.036	−0.427
MWS	−0.224	0.187	−0.026	0.209	−0.219	0.507*

*Significant correlation p<0.01.
FRT: functional reach test, TUG: timed up and go, MWS: maximum walking speed

DISCUSSION

A significant positive relationship between the flexion range of the lumbar vertebrae and the FR distance was recognized. FRT is an index of the ability of a person on a fixed supporting foundation to move the center of mass of his body forward[3]. It is reported that a movement control strategy used by the elderly when voluntarily moving their center of mass is to quickly change from an ankle strategy with their ankles as the axis of motion to a hip strategy with their hip joint as the axis of motion[9]. The present results suggested that during the FRT, they bend their lumbar vertebrae in cooperatively with the flexion of their hip joint, clearly showing that the range of flexion of the lumbar vertebrae contributes to the distance they move their center of mass forward.

A significant negative correlation between the range of extension of the thoracic vertebrae and the time required by TUG was identified. A characteristic posture of elderly people is a kyphotic posture of the spine consisting mainly of kyphotic deformity of the thoracic vertebrae[7]. Maintaining flexibility of the thoracic vertebrae is considered important for preventing kyphosis of the spine. The TUG is an index of balance and walking ability when a person stands up from or sits down on a chair or changes direction, and it is reported that it is also correlated with the falling among elderly people[10]. In results of our research, it is very interesting that a significant correlation between TUG, which has been shown to be correlated with falling, and flexibility of thoracic vertebrae extendibility, which is considered to have an important role in preventing kyphosis of elderly people, was identified. This result shows the importance of training to maintain and improve extendibility of the thoracic vertebrae of elderly people.

In addition, a significant correlation between the range of extendibility of the entire spine, including the backward inclination of the pelvis, and MWS, was shown. MWS is an index of the decline in the walking ability as a person ages, and it is reported that it is also related to the survival rate of elderly people[11]. The step length is cited as a factor related to MWS. The hip joint extension during the terminal stance of a gait cycle, or in other words, the positions of the backward incline of the pelvis and extension of the trunk relative to the Femur, moves the swing leg forward. The range of extendibility of the entire spine, which was the index for this research, shows the total extendibility of the trunk, which is the extendibility range of the thoracic vertebrae and lumbar vertebrae plus the backward inclination of the pelvis. Therefore, it is assumed that the larger the range of extendibility of the entire spine, the wider the stride while walking, and as a result of this, a significant correlation with MWS was recognized.

The results of this research have clarified that mobility of the spine in the sagittal plane is clearly correlated with dynamic balance ability, which is related to falling. It also shows that instruction in exercises intended to improve the health and prevent nursing care of elderly people must be provided, guided by an awareness of the maintenance and improvement of spinal mobility in the sagittal plane.

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