

Significance of the Elderly Living in the Community Being Able to Stand on One Leg with Eyes Open –A Study of Physical, Cognitive, and Psychological Functions–

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Abstract. [Purpose] This study was conducted to examine the significance of standing on one leg with eyes open. [Subjects] We categorized the subjects into two groups: 304 people who were able to stand on one leg with eyes open for fifteen seconds or longer and 203 people who were unable to do so. [Methods] We conducted age-adjusted covariance analyses of physical, cognitive, and psychological functions between the two groups. [Results] All scores for muscle strength and walking ability were markedly lower in the unable group. No significant differences in the cognitive functions were noted between the two groups. Scores for a subjective sense of well-being and the purpose in life were lower in the unable group. [Conclusion] Measurement of the time of being able to stand on one leg with eyes open served as a simple test which identified a decrease in the physical functions of the elderly. In addition, the inability to stand on one leg for fifteen seconds was associated with a decrease in subjects' psychological functions.

Key words: One-leg standing time with eyes open, Elderly community resident, Physical, cognitive, and psychological functions cognitive function

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INTRODUCTION

The functional balance scale and stabilometry are commonly used methods for testing the balance function of elderly people^{1, 2)}. The simplest form of balance function test is to measurement of the time of being able to stand on one leg. Several studies have reported that a decrease in the ability to stand on one leg increases the risk of fallings, and measurement of the time of standing on one leg is widely used as an item for the assessment of the physical functions of the elderly^{3, 4)}. For elderly people, maintenance of the balance function is closely associated with the prevention of a decrease in the quality of life (QOL) including the ability to move and other capabilities required in daily life and for leisure and sporting activities⁵⁾. Japan, which has a rapidly aging society, in which approximately 23% of the population was 65 years or older in 2010, has placed emphasis on improving the QOL of elderly people, and an examination of the ability to stand on one leg has been incorporated in physical tests^{6, 7)}. Bohannon et al.⁸⁾ conducted a survey of the time of being able to stand on one leg with eyes open, among

subjects of various ages, and reported that the mean time in the seventies group was about fourteen seconds. Okumiya et al.⁹⁾ suggested that a time of shorter than sixteen seconds is a risk factor of falling. Further, the ability to stand on one leg with eyes open for 15 seconds has been used as a diagnostic criterion for musculoskeletal ambulation disability symptom complex in all age groups.

Although measurement of the time of being able to stand on one leg with eyes open is of significant convenience as a test of the balance function, few studies have been conducted to investigate the validity of the measurements as a criteria on judgment, or to examine its relationships with physical, cognitive, and psychological functions in a comprehensive manner.

In this study, which is based on the criteria established in previous studies^{8, 9)}, we examined the significance of being able to stand on one leg for 15s by the elderly (with a mean age in the seventies) living in the community in a comparison with their physical, cognitive, and psychological functions.

SUBJECTS AND METHODS

Subjects

A total of 507 (99 males and 408 females) independent elderly community residents of Town A, aged 60 and over, whose cooperation was obtained every August and September during the period from 2008 to 2010, were studied. Subjects' mean age, height (cm), and weight (kg) were 73.6 ± 6.8 years, 150.6 ± 7.9 cm, and 52.7 ± 9.3 kg, respectively. All subjects were able to access the site of the study by car, bicycle, or on foot, and were provided with an explanation of the study objectives and details, as well as ethical considerations, which included privacy protection and completely voluntary participation and withdrawal, before receiving obtain their consent to participation. This study was conducted with the approval of the Research Ethics Committee of Nishikyushu University.

Methods

Following the acquisition of information of the individual attributes of the subjects, we measured the time of being able to stand on one leg with eyes open, and assessed subjects' physical, cognitive, and psychological functions. Measurements were taken twice for each leg for up to 120 seconds in accordance with the procedures for the new physical tests for the elderly developed by the Ministry of Education, Culture, Sports, Science and Technology⁷⁾, and the maximum time for each leg was recorded.

A digital hand dynamometer (Takei Scientific Instruments) and a hand-held dynamometer (isometric strength measuring device: ANIMA Corp.) were used to measure grip and quadriceps strengths, respectively, and the maximum values were normalized as a percentage of body weight.

A strain gauge developed by Yagami Inc. was used for the measurement of the foot-grip strength. The subjects sat on the bed while the measurements were taken. Measurements were taken twice, and the maximum value was recorded.

To perform sit-ups, subjects were required to touch their thighs with their elbows in accordance with the procedures for the new physical tests for the elderly developed by the Ministry of Education, Culture, Sports, Science and Technology⁷⁾. The number of sit-ups performed in thirty seconds was recorded.

In seated forward bending, a digital device developed by Takei Scientific Instruments was used to measure the distance below the level the subject was seated at. Measurements were taken twice, and the maximum distance was recorded.

To measure walking speeds, we asked subjects to walk on a flat, eleven-meter path, five of which comprised the measurement zone, as fast as they could, and the maximum speed over the middle 5 m of the path was recorded¹⁰⁾.

Walking on a ten-meter obstacle course was performed in accordance with the procedures for the new physical tests for the elderly developed by the Ministry of Education, Culture, Sports, Science and Technology⁷⁾. We asked subjects to walk along a straight, ten-meter course on which six 20 cm-high

sponge obstacles were placed at an intervals of two meters. Measurements were taken twice, and the fastest time was recorded.

In the six-minute walking test, subjects were asked to walk as many times as possible around a 30-meter indoor track in six minutes. The distances they covered were recorded¹¹⁾.

The Timed Up and Go (TUG) test was performed in accordance with the method developed by Podsiadlo et al.¹²⁾. In this test, subjects are required to complete the following as fast as they could: stand up from a chair, walk three meters to reach the target and turn around, and return to the chair and sit back down on it, as fast as they can.

The six-minute walking test was performed once for each person. Measurements were taken twice in other tests, and the better scores were recorded.

For the assessment of cognitive functions, we used the Mini-Mental State Examination (MMSE) and the Trail Making Test (TMT); which is designed to assess attentiveness. The reliability and validity of the MMSE and TMT have been established^{13, 14)}.

A visual analogue scale (VAS) was used to the assessment of a subjective sense of well-being, the level of satisfaction with daily life, and purpose in life. The VAS was originally developed for the assessment of pain in the field of anesthesia, but it can also be used to assess of the QOL of elderly living in the community and satisfaction with daily life. Its reliability and validity have been established^{15, 16)}. In the assessment, a subjects marked the point on a 10 cm-scale that best described his/her current psychological status: one end of the scale represented "the best" (100 mm) and the other end "the worst" (0 mm) conditions. We measured the length between 0 and the marked point, and recorded it as a score. For all psychological assessment items, the higher the score, the better the conditions.

For statistical analysis, the subjects were categorized into two groups: elderly who were able to stand on one leg with eyes open for fifteen seconds or longer (able group), and those who were unable to do so (unable group). We conducted the chi-square test and the unpaired (regarding age) t-test to examine the male to female ratio. With age as a covariate, we performed analyses of covariance to examine differences between the two groups for the measurement items. We used SPSS17.0J for Windows for statistical analysis, and chose a level of significance of 5%.

RESULTS

The total number of subjects was 507. The "able" group contained 304 subjects (65 males and 239 females, mean age \pm SD: 70.7 ± 5.6 years old), and 203 were categorized as the "unable" group (34 males and 169 females, mean age \pm SD: 77.9 ± 5.9 years old). There was no significant difference in the male to female ratio between the two groups ($\chi^2=1.7$, $p=0.2$), whereas a marked difference was noted in the age ($p<0.01$).

We then conducted analyses of covariance with the age adjustment to compare the two groups. There were marked differences in the results for physical function tests: grip

Table1. Comparison of measurement values between the Able and Unable groups

Parameters	Able (n=304)	Unable (n=203)	
physical function			
grip strength (%)	48.7 ± 10.5	41.0 ± 9.9	**
quadriceps muscle strength (%)	43.3 ± 11.5	34.8 ± 10.3	**
foot grip strength (kg)	7.7 ± 3.2	4.9 ± 3.1	**
sit-ups test (times)	5.4 ± 5.1	2.7 ± 3.9	**
sit-and-reach flexibility (cm)	37.4 ± 8.7	36.2 ± 8.8	
walking speed (m/sec)	2.1 ± 0.4	1.6 ± 0.5	**
10-m obstacle walk (sec)	6.3 ± 1.8	9.3 ± 4.2	**
6-minute walk (m)	479.4 ± 71.5	355.2 ± 123.0	**
3-m timed up-and-go test (sec)	5.0 ± 1.1	6.9 ± 2.4	**
cognitive function			
MMSE (points)	27.5 ± 2.8	25.4 ± 4.4	
TMT (sec)	57.3 ± 31.3	78.0 ± 43.1	
psychological function			
Sense of health (mm)	64.6 ± 18.3	58.8 ± 19.7	**
Sense of satisfaction with life (mm)	69.1 ± 20.4	67.0 ± 22.5	
Purpose in life (mm)	72.7 ± 19.6	68.8 ± 22.6	*

Data are presented as means±standard deviation. **p<0.01, *p<0.05

The results of analysis of covariance considering the age as covariates. Able: those who could stand for more than 15 s on one leg with their eyes open. Unable: those who could not stand for more than 15 s on one leg with their eyes open. MMSE: Mini Mental State Examination, TMT: Trail Making Test

strength, quadriceps strength, foot-grip strength, sit-ups, walking speed, walking along a 10-m obstacle course, six-minute walking, and TUG. Muscle strength- and walking ability-related scores were lower for the “able” group than for the “unable” group. However, no marked difference was noted in the score for seated forward bending (Table 1).

The results of the MMSE and TMT did not show a significant difference in cognitive functions between the two groups (Table 1).

Regarding psychological functions, there were marked differences in the subjective sense of well-being and the purpose of life. The scores were lower in the “unable” group than in the “able” group (Table 1). No significant difference was noted in the level of satisfaction with daily life between the two groups (Table 1).

DISCUSSION

In this study, aimed at examining the clinical importance of being able to stand on one leg for fifteen seconds or longer with eyes open, we compared the physical, cognitive, and psychological functions of the elderly who were able and unable to perform the task. The results of age-adjusted covariance analyses showed that the results of physical function tests, except that of the flexibility examination, were higher in the “able” group. There were no marked differences in the cognitive functions between the two groups. Regarding psychological functions, significant differences were noted in a subjective sense of well-being and the purpose in life; the scores were higher in the “able” group than in the “unable” group.

Nagasaki et al.¹⁷⁾ demonstrated a relationship between the time of being able to stand on one leg and leg strength. Shumway et al.¹⁸⁾ reported that one-leg standing time may be used to predict the risk of falling. There is also a report of a marked correlation between one-leg standing time and walking ability¹⁹⁾. The results of the present study showed marked differences in the muscle strength and walking ability between the “able” and “unable” groups, and are in agreement with previous studies. However, there was no significant difference in the results of the seated forward bending test between the two groups. Previous studies have reported that measurements obtained in seated forward bending are only an index of flexibility of the body and are not correlated with walking speeds or other physical capabilities²⁰⁾, which is in line with the results of this study.

In this study, marked differences were noted in the results of a variety of physical function tests between the “able” and “unable” groups. This suggests that if an elderly person is unable to stand on one leg for fifteen seconds with eyes open, a decrease in his/her physical functions could be attributable to locomotory disabilities as well as aging. No significant difference in the cognitive functions was noted between the two groups, probably because the subjects of this study had a certain level of physical ability and were able to respond to a variety of stimuli while living an independent life. Katzman²¹⁾ pointed out that exercise habits are a factor that influences cognitive functions. Abbott et al.²²⁾ reported that the rate of developing dementia was lower in the group of elderly who walked longer distances every day.

Regarding the psychological functions, marked differences were noted in a subjective sense of well-being and

the purpose in life, which suggests that the elderly in the “unable” group were more anxious about their own health and lack a set the purpose in life. According to a previous study, a subjective sense of well-being effectively serves as an alternative health index in medical terms²³). LaRue²⁴) reported the relationship between a subjective sense of well-being and life prognosis. The association between the purpose in life and a subjective sense of well-being has also been reported²⁵). On the other hand, there was no significant difference in the level of satisfaction with daily life

between the two groups. According to a previous study, elderly people’s satisfaction with life is related to their interactions with friends and others as well as social participation²⁶). The subjects of the present study were elderly people who were living an active life in the community who agreed to participate in the study of their own free will. Therefore, their level of satisfaction with life was affected by social participation rather than factors related to their physical functions.

We concluded that the test to examine elderly people’s ability to stand on one leg is a simple and effective method for identifying a decrease in the elderly’s physical functions. Our results is also suggested that if an elderly person’s inability is unable to stand on one leg for fifteen seconds with eyes open, it might indicates a decrease in his/her psychological functions, such as a subjective sense of well-being and the purpose in life. Therefore, it is important to conduct comprehensive assessments to examine the psychological as well as physical functions of the elderly in the “unable” group.

The subjects of the study were elderly people who were living an independent life in the community. A study involving the fragile elderly should be conducted to examine whether the results are applicable to the case of physically weak elderly people. It will be necessary to determine the clinically appropriate times of single-leg standing with eyes open by studying a broader range of population groups, and performing multiple regression analysis. Such studies may provide the basis for the development of effective rehabilitation approaches based on the ability to stand on one leg with eyes open.

As this was a cross-sectional study, it is difficult to determine whether the time of being able to stand on one leg influenced the psychological functions or the time was affected by the functions. This point should be clarified by a longitudinal study.

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