

A modified fall risk assessment tool that is specific to physical function predicts falls in community-dwelling elderly people

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Conflicts of Interest and Source of Funding: The authors declare no conflict of interest and source of funding.

Previous presentation of the research: None to report.

Running head: A modified fall risk assessment tool specific to physical function

ABSTRACT

Background and Purpose: Developing a practical fall risk assessment tool to predict the occurrence of falls in the primary care setting is important because investigators have reported deterioration of physical function associated with falls. Researchers have used many performance tests to predict the occurrence of falls. These performance tests predict falls and also assess physical function and determine exercise interventions. However, the need for such specialists as physical therapists to accurately conduct these tests limits their use in the primary care setting. Questionnaires for fall prediction offer an easy way to identify high-risk fallers without requiring specialists. Using an existing fall assessment questionnaire, this study aimed to identify items specific to physical function and determine whether those items were able to predict falls and estimate physical function of high-risk fallers.

Methods: The analysis consisted of both retrospective and prospective studies and used 2 different samples (retrospective, n=1871; prospective, n=292). The retrospective study and 3-month prospective study comprised community-dwelling individuals aged ≥ 65 years and elderly people using community day centers. Number of falls, risk factors for falls (15 risk factors on the questionnaire), and physical function determined by chair standing test (CST) and timed up and go test (TUGT) were assessed. The retrospective study selected fall risk factors related to physical function. The prospective study investigated whether the number of selected risk factors could predict falls. The predictive power was determined using the area under the receiver operating characteristic curve (AUC).

Results: Seven of the 15 risk factors were related to physical function. The AUC for the sum of the selected risk factors of previous falls plus the other risk factors was 0.82 ($P = 0.00$). The best cutoff point was 4 risk factors, with sensitivity and specificity of 84% and 68%, respectively. The mean values for the CST and TUGT at the best cutoff point were 12.9 and 12.5 seconds, respectively. In the retrospective study, the values for the CST and TUGT corresponding to the best cutoff point from the prospective study were 13.2 and 11.4 seconds, respectively.

Discussion: This study confirms that a screening tool comprising 7 fall risk factors can be used to predict falls. The values for the CST and TUGT corresponding to the best cutoff point for the selected 7 risk

factors determined in our prospective study were similar to the cutoff points for the CST and TUGT in previous studies for fall prediction. We propose that the sum of the selected risk factors of previous falls plus the other risk factors may be identified as the estimated value for physical function.

Conclusions: These findings may contribute to earlier identification of high-risk fallers and intervention for fall prevention.

Key words: falls, risk assessment, predictive value of tests, physical fitness, elderly

INTRODUCTION

Approximately 30% of individuals aged ≥ 65 years fall at least once per year, and about half of those do so recurrently.¹ Fall-related injuries and associated mortality in elderly individuals are major health-care problems worldwide and show increasing incidence,¹ making fall prevention a health-care priority. Fall prevention requires early identification of high-risk fallers (elderly individuals with a number of risk factors for falls) and intervention. It is therefore necessary to develop a practical fall risk assessment tool to predict the occurrence of falls in the primary care setting.

Many studies have identified risk factors for falls. Internal factors, such as deterioration of physical function and disease, and external factors, such as life environment, have been shown to be related to the occurrence of falls.² Investigators have reported that muscle weakness, balance disturbance, and gait limitation are major fall risk factors, which suggests that deterioration in physical function is associated with the occurrence of falls.²⁻⁴ Exercise interventions, such as balance training and muscle strength exercise, have been used for fall prevention, with a significant reduction in the number of falls reported.^{1,5,6} Consequently, a fall risk assessment tool focused on physical function is required.

Researchers have found many performance tests to be predictive of falls. Some studies found the chair standing test (CST) to be a predictive assessment, with sensitivities and specificities of 55%–66% and 55%–65%, respectively.^{7,8} Other studies employed the timed up and go test (TUGT) as a predictive test, with sensitivity and specificity of 80%–89% and 67%–87%, respectively.⁹⁻¹¹ Performance tests such as the Berg Balance Scale and Four Square Step test have also been reported as predictive tests, with sensitivity and specificity of 77%–89% and 85%–86%, respectively.^{10,12} Furthermore, Tinetti et al¹³ screened for high-risk fallers using the performance-oriented mobility assessment (POMA), which assesses both balance and gait with very little equipment through direct observation of task performance; the sensitivity and specificity of the POMA were 80% and 74%, respectively. These performance tests not only predict falls but also assess physical function and direct exercise interventions. However, the need for specialists such as physical therapists to conduct these performance tests accurately limits their use in the primary-care setting.¹⁴⁻¹⁶ In fact, their use is particularly limited in Japan, where there is a shortage of

physical therapists working in the community setting.^{15,17}

A number of studies have employed assessment questionnaires to determine fall risk factors. These questionnaires consisted of 22 to 38 items, and the sensitivity and specificity were 59%–71% and 56%–71%, respectively.¹⁸⁻²⁰ Questionnaires for fall prediction offer a convenient way to identify high-risk fallers without requiring specialists. However, these questionnaires may be time-consuming because of the number of question items; as an additional limitation, the sensitivity and specificity of these questionnaires are similar to or lower than those of the performance tests. Furthermore, such questionnaires cannot estimate the physical function of high-risk fallers.

In Japan, exercise classes are provided for frail, elderly people living in the community. This continuity of care makes comparison of this population's activity levels fairly straightforward, as similar exercise programs are available across the country. Suzuki²¹ designed a fall assessment questionnaire comprising 15 fall risk factors, and this is widely used in Japan. The number of risk factors identified by the questionnaire correlates significantly with the number of falls in the previous year, psychological status, and physical function related to muscle strength and balance.²² Demura et al²³ reported that this questionnaire predicted falls with sensitivity and specificity of 59.4% and 83.1%, respectively. However, the researchers did not identify which risk factors among the 15 items related to physical function or indicate how many risk factors in the questionnaire could estimate physical function.

We aimed to identify the items on Suzuki's fall assessment questionnaire that are specific to physical function and determine whether those items could predict falls and estimate the physical function of high-risk fallers.

METHODS

Study design and participants

This analysis consisted of both retrospective and prospective studies. A previous study developed a simple screening scale to predict falls using a single population sample for community-dwelling elderly people.¹⁹ Therefore, the retrospective and prospective studies in the present investigation comprised 2

different samples.

We obtained prior written informed consent from all participants and preserved anonymity. The Research Ethics Committee at Nagasaki University (Nagasaki, Japan) approved the study protocol.

Retrospective study

This study used existing data collected from elderly people who participated in fall prevention exercise classes in Nagasaki, Japan, and its outskirts between April 2003 and March 2009. Participants were aged ≥ 65 years, lived at home, and were able to walk outdoors with or without a cane. Participants who were unable to respond to interview questions because of cognitive impairment were excluded. We also excluded participants who had musculoskeletal, neurological, or cardiovascular conditions that might be aggravated by exercise. In all, 1871 participants met the above criteria.

Prospective study

We investigated the occurrence of falls over a 3-month period. The participants were 292 elderly people who met the above criteria and used community day centers twice a week. They participated in day center programs, including social programs, recreational activities, educational programs, and tea breaks. They did not receive exercise interventions, such as balance training and muscle strength exercises.

Data collection

Retrospective study

We assessed age, sex, number of falls in the previous year, risk factors for falls, physical function, and psychological status of each participant. We defined a fall as “unintentionally coming to rest on the ground, floor, or other lower level in a manner that did not result from a major intrinsic event or an overwhelming hazard.”²⁴

We identified risk factors for falls using Suzuki’s fall assessment questionnaire (Table 1).^{21,25} We took the number of answers consistent with the risk of falls as the number of risk factors. The fall assessment

tool included questions about fall history, walking ability, muscle power, medical disorders, medication, vision and hearing, and fear of falling.^{21,25}

We assessed physical function using 2 performance tests: the CST²⁶ and TUGT.²⁷ These tests were conducted twice by physical therapists, and we selected the better value of the 2 tests as representative.

Psychological status was evaluated using the 15-item version of the Geriatric Depression Scale (GDS-15)²⁸ and the modified Falls Efficacy Scale (FES) translated into Japanese. The FES used the same 10 items reported by Tinetti et al²⁹, and each item was assessed on the following scale: 1, “I have no confidence to do so”; 2, “I have little confidence to do so”; 3, “I have some confidence to do so”; 4, “I have full confidence to do so.” The total score on the FES can range from 10 to 40, with high scores indicating greater confidence. These assessments were self-administered with guidance from the care staff at day centers as needed.

Prospective study

The occurrence of falls was reported over a 3-month follow-up period in addition to the assessments conducted in the retrospective study. Each participant received a diary with a monthly sheet to record additional falls and filled in the number of falls during the follow-up period. Previous studies have used this data collection method for the occurrence of falls.^{19,25,30} Care staff at the day centers recorded the number of additional falls every week.

Data analysis

Retrospective study

We conducted multiple regression analysis with a stepwise model using the CST and TUGT results as the dependent variables and the 15 risk factors of the questionnaire as the independent variables to select fall risk factors related to physical function. We evaluated multicollinearity among the independent variables in advance using a diagnostic test combining variance inflation factor (VIF) estimates and tolerance. The mean values of VIF and tolerance among the independent variables for the CST and TUGT

were both 1.14 and 0.88, respectively. We used all the variables as independent variables, because there was no collinearity among the variables.

Prospective study

We investigated whether the number of the selected risk factors was able to predict the occurrence of falls. The predictive power was determined using the area under the receiver operating characteristic (ROC) curve (AUC). We calculated the cutoff points, sensitivity, and specificity of the number of the selected risk factors.

We performed all statistical analyses using SPSS 17.0J for Windows (SPSS Inc., Chicago, IL) and considered a 2-sided P value ≤ 0.05 significant.

RESULTS

The baseline participant characteristics appear in Table 2.

Retrospective study

The results of the multiple regression analysis are summarized in Table 1. Seven of the 15 risk factors on the questionnaire showed a significant relationship to physical function as determined by CST or TUGT: history of falls in the previous year (question 1); gait limitation (questions 2 and 3); balance disturbance (question 4); hospitalization in the previous year (question 6); history of stroke (question 8), and fear of falling (question 15).

Prospective study

Forty-six of 292 participants (15.6%) fell during the 3-month follow-up period. Of those 46 participants, 22 (47.8%) fell 2 or more times. We investigated combinations of the 7 selected risk factors identified in the retrospective study to obtain the highest value of the AUC. The AUC for the simple sum of the 7 selected risk factors was 0.73 ($P = 0.00$). The best cutoff point was 4 risk factors, with sensitivity and

specificity of 50% and 86%, respectively.

In cases where participants had the risk factor of “previous falls within the last year” plus the other risk factors (“risk factor of previous falls + other risk factors”), AUC for the sum of “risk factor of previous falls + other risk factors” was 0.82 ($P = 0.00$), which was the highest result. The best cutoff point was 4 risk factors, with sensitivity and specificity of 84% and 68%, respectively. At the cutoff point of 5 risk factors, the sensitivity and specificity were 68% and 83%, respectively (Figure 1). For the participants whose sum of “risk factor of previous falls + other risk factors” for the 7 selected risk factors was 4 or more risk factors, the proportions of each question items were as follows: question 1 (100%); question 2 (52.8%); question 3 (88.9%); question 4 (100%); question 6 (47.2%); question 8 (22.2%); and question 15 (88.9%) (Figure 2).

We investigated the values for the CST and TUGT when the number of “risk factor of previous falls + other risk factors” was 4, which was the best cutoff point from the prospective study. In the prospective study, the mean values were 12.9 ± 3.7 and 12.5 ± 3.7 seconds for the CST and TUGT, respectively. In the retrospective study, the mean values were 13.2 ± 6.1 and 11.4 ± 5.2 seconds for the CST and TUGT, respectively.

DISCUSSION

In our retrospective study, 7 of 15 risk factors identified by the fall assessment questionnaire were related to physical function (Table 1). Consistent with our results, many studies have identified similar fall risks, including history of falls,^{2,20,23,31,32} balance disturbance and gait limitation,^{3,4,19,32} history of stroke,³² and fear of falling.²⁰ Studies have identified the CST and TUGT as measures of lower extremity muscle strength and walking ability, respectively;^{26,27} we feel that these previous findings lend further validity to our use of the CST and TUGT for the retrospective study. Previous investigations have reported that lower extremity muscle strength and the walking ability of participants with a history of falls were significantly worse than participants without such a history.^{30,33} Lower extremity muscle strength has been reported to be associated with balance ability.^{34,35} Rochat et al³⁶ showed that fear of falling was associated with balance

and walking ability. Moreover, participants with a history of stroke may suffer from deterioration of lower extremity muscle strength and walking ability. The risk factor of “hospitalization in the previous year” relates to physical function, because the onset or recurrence of a disease can cause deterioration of physical function.^{21,32} Therefore, we believed the selected risk factors in this study to be valid.

In our prospective study, we investigated whether the selected 7 risk factors could accurately predict the occurrence of falls. The AUC for the sum of “risk factor of previous falls + other risk factors” was the highest among the combinations of the 7 selected risk factors. This result would appear to reflect findings that indicate that the history of falls highly influences the risk of future falls.^{2,20,23,31,32} The sensitivity and specificity were 84% and 68% at the best cutoff point of 4, respectively. These values were higher than those in previous studies using questionnaires,¹⁸⁻²⁰ but they were similar to those obtained using performance tests that showed good results, such as TUGT and POMA.^{9,10,13} Therefore, it would appear that the sum of “risk factor of previous falls + other risk factors” among the 7 selected risk factors could indeed predict future falls with high sensitivity and specificity. In addition, for the participants whose sum of “risk factor of previous falls + other risk factors” for the 7 selected risk factors was 4 or more risk factors, many participants were subject to gait limitation (question 3), balance disturbance (question 4), and fear of falling (question 15) (Figure 2). Therefore, it is important to assess balance, walking ability, and fear of falling in identifying high-risk fallers.

With higher sensitivity, fewer people incorrectly classified as non-fallers go on to fall (false negatives); with higher specificity, fewer people incorrectly classified as fallers do not go on to fall (false positives). Russell et al³⁷ reported that the screening tool used in the community setting must have higher specificity. In the ROC for the sum of “risk factor of previous falls + other risk factors”, the best cutoff point was 4. However, the specificity of the cutoff point of 5 was much better than that of the best cutoff point of 4 (Figure 1). Therefore, the cutoff point of 5 rather than 4 may be the better option to employ in the community setting.

We investigated whether the questionnaire for risk factors selected in the retrospective study also identified estimated values for physical function. In the retrospective study, the mean values for the CST

and TUGT were 13.2 and 11.4 seconds, respectively, when the number of “risk factor of previous falls + other risk factors” was 4, which was the best cutoff point from the prospective study. In the prospective study, the mean values for the CST and TUGT were 12.9 and 12.5 seconds, respectively, when the number of “risk factor of previous falls + other risk factors” was 4. In previous studies, the CST cutoff point associated with the occurrence of falls ranged from 12 to 15 seconds.^{7,8} The TUGT cutoff point associated with the occurrence of falls ranged from 10.9 to 13.5 seconds.^{9,10,33}

In short, the values for the CST and TUGT corresponding to the best cutoff point for the selected 7 risk factors determined from our prospective study were similar to the cutoff points for the CST and TUGT in previous studies for fall prediction. We propose that the number of “risk factor of previous falls + other risk factors” can be used to estimate physical function. Our screening tool comprising 7 risk factors can be employed to determine exercise interventions, and it may be easily conducted by non-specialists. However, most major clinical practice guidelines on falls have recommended the use of a multi-factorial assessment for older adults with gait and balance problems.^{1,2,38} Thus, it will be necessary to perform further assessments to identify high-risk fallers and determine exercise interventions. The findings in the present study suggest that implementing multi-factorial assessment in addition to this screening tool may contribute to earlier identification of high-risk fallers and intervention for fall prevention.

There are some limitations to this study. The first is that the records of falls were based on self-reporting by the participants. As a result, there may have been some unreported falls. We asked the participants in our study to keep a fall diary, and the care staff at the day centers recorded any additional falls each week. Many reports have indicated that this is the only feasible method for recording falls;^{25,39} thus, this limitation of our study may have had a minimal effect. The second limitation is that this screening tool did not reflect cognitive function. Some studies have reported that cognitive impairment is a high risk factor.^{40,41} Therefore, this screening tool is not suitable for assessing participants with cognitive impairment. The third limitation is that the follow-up period in our prospective study was short. Most prospective studies for fall prediction have investigated the occurrence of falls over a follow-up period of 6–12 months,^{7,11,18,19,30,33} although some studies have investigated the occurrence of falls over a shorter

3-month follow-up period,^{42,43} the same amount of time selected for our prospective study. Further prospective studies are needed to investigate the occurrence of falls over a longer follow-up period.

CONCLUSION

We developed a modified screening tool comprising 7 fall risk factors related to physical function to identify high-risk fallers, using an existing fall assessment questionnaire. The best cutoff point for the sum of “risk factor of previous falls + other risk factors” (4 risk factors) was able to predict falls with high sensitivity and specificity. Moreover, this screening tool can identify the estimated value for physical function and be used to predict falls. These findings may contribute to earlier identification of high-risk fallers and interventions for fall prevention in the primary-care setting.

ACKNOWLEDGMENTS

The authors are grateful for the cooperation of all participants in this study. The authors would also like to express their gratitude to Dr. Hironobu Koseki and Dr. Ryota Nakao for guidance in this research and to Rieko Nakao, PhD and Ryoko Kawasaki, MS for their kind assistance. The authors have no conflicts of interest to declare, financial or otherwise.

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FIGURE LEGENDS

Figure 1: Receiver operating characteristic (ROC) curves of the questionnaires for predicting the occurrence of falls. The area under the curve (AUC) values are as follows: the sum of “risk factor of previous falls + other risk factors” in the selected risk factors (closed circles) = 0.82 ($P = 0.0001$; 95% confidence interval [CI], 0.70–0.95); the simple sum of the selected risk factors (open circles) = 0.73 ($P = 0.0001$; 95% CI, 0.62–0.83).

Figure 2: Percentages of the question items for participants whose sum of “risk factor of previous falls + other risk factors” in the 7 selected risk factors was 4 or more risk factors.

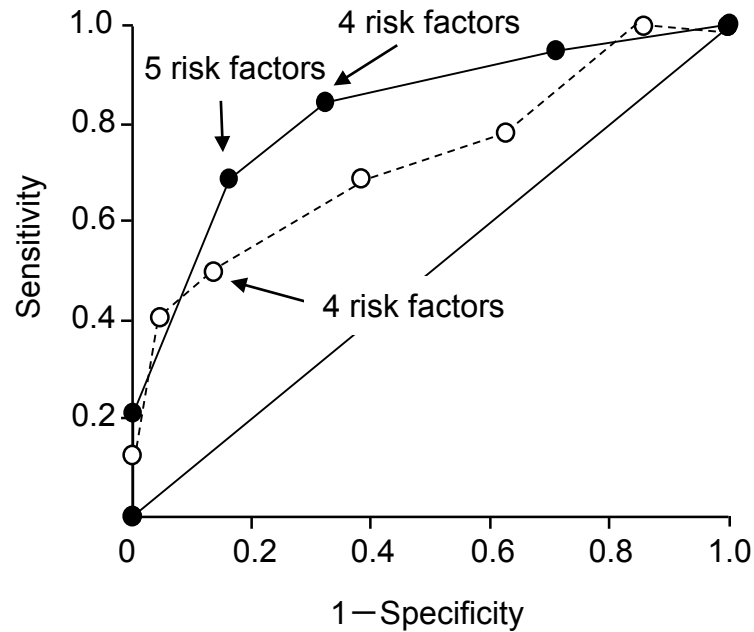


Figure 1: Receiver operating characteristic (ROC) curves of the questionnaires for predicting the occurrence of falls. The area under the curve (AUC) values are as follows: the sum of “risk factor of previous falls + other risk factors” in the selected risk factors (closed circles) = 0.82 ($P = 0.0001$; 95% confidence interval [CI], 0.70–0.95); the simple sum of the selected risk factors (open circles) = 0.73 ($P = 0.0001$; 95% CI, 0.62–0.83).

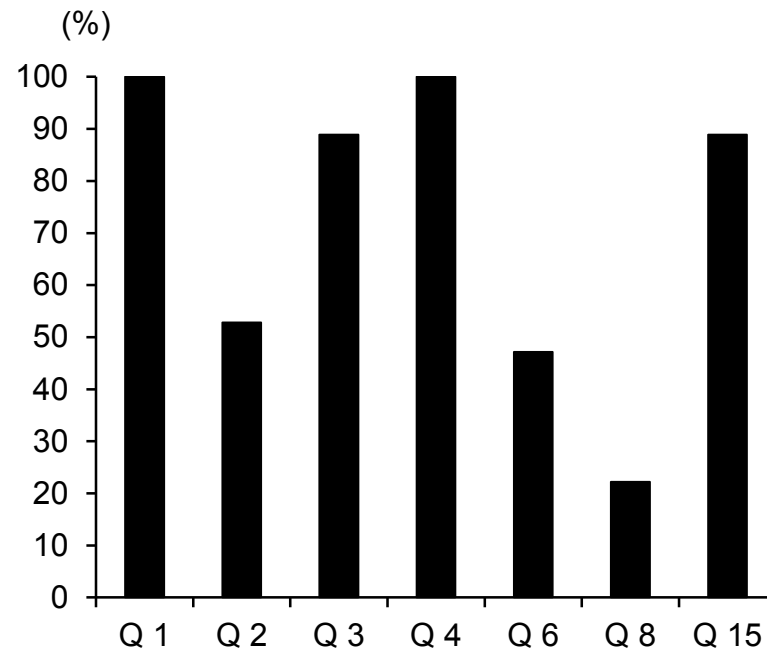


Figure 2: Percentages of the question items for participants whose sum of “risk factor of previous falls + other risk factors” in the 7 selected risk factors was 4 or more risk factors.

Table 1. Fall risk assessment in this study and fall risk factors related to physical function

Predictor Question	CST		TUGT	
	β	<i>P</i> value	β	<i>P</i> value
1. Have you fallen during the past year?	0.09	0.00	0.03	0.18
2. Can you cross the street without resting (during a green traffic signal)?	0.07	0.01	0.18	0.00
3. Can you continue to walk for an entire kilometer?	0.23	0.00	0.22	0.00
4. Can you put on socks while standing on one leg?	0.12	0.00	0.11	0.00
5. Can you wring out a wet towel?	0.03	0.26	-0.03	0.20
6. Have you admitted yourself to a hospital within the past year?	0.06	0.02	0.06	0.01
7. Do you feel dizzy upon standing up?	-0.00	0.87	-0.06	0.15
8. Have you ever had a stroke?	0.08	0.00	0.14	0.00
9. Have you ever been diagnosed with diabetes?	0.04	0.14	0.03	0.19
10. Do you take sleeping pills, antihypertensive drugs, or minor tranquilizers?	-0.01	0.56	0.00	0.70
11. Do you often wear sandals or slippers?	-0.03	0.19	-0.03	0.24
12. Can you see the letters in a newspaper, or a person's face, clearly?	-0.02	0.42	0.00	0.99
13. Can you hear a person's voice during a conversation?	-0.02	0.53	-0.01	0.77
14. Do you often stumble or slip in your own house?	0.04	0.12	0.04	0.06
15. Do you have a fear of falling or do you hesitate to go out because you have a fear of falling?	0.13	0.00	0.19	0.00

β : standardized partial regression coefficient; CST: chair standing test; TUGT: timed up and go test.

Table 2. Baseline participant characteristics

Characteristic	Retrospective study sample (n = 1871)			Prospective study sample (n = 292)		
	Mean \pm SD	Range	95%CI	Mean \pm SD	Range	95%CI
Age (years)	76.5 \pm 7.0	65-95	76.2-76.9	81.6 \pm 6.2	66-92	80.1-82.3
Female, n (%)	1268 (67.8)			240 (82.4)		
Single faller in the previous year, n (%)	273 (14.6)			23 (7.8)		
Multiple faller in the previous year, n (%)	331 (17.7)			42 (14.4)		
No. of falls in the previous year	0.8 \pm 1.6	0-24	0.7-0.8	0.7 \pm 1.7	0-10	0.5-0.9
Risk factors for falls	5.1 \pm 2.7	0-14	4.9-5.2	4.7 \pm 2.6	0-13	4.4-5.0
CST (seconds)	11.3 \pm 5.8	4.0-39.5	11.1-11.6	13.8 \pm 7.5	5.0-45.0	12.9-14.7
TUGT (seconds)	9.7 \pm 5.4	3.8-39.6	9.4-10.0	11.1 \pm 4.8	5.1-34.5	10.6-11.7
GDS-15	4.7 \pm 3.3	0-15	4.4-4.9	5.5 \pm 3.2	0-14	5.1-5.9
FES	32.8 \pm 6.0	15-40	32.4-33.3	34.0 \pm 5.2	20-40	33.4-34.7
Values are means \pm standard deviation (SD).						
CI: confidence interval; CST: chair standing test; TUGT: timed up and go test; GDS-15: 15-item version of Geriatric Depression Scale;						
FES: falls efficacy scale.						