The Criterion-Related Validity of the Ten Step Test Compared with Motor Reaction Time

KENZO MIYAMOTO, RPT, MEd¹, HIDEAKI TAKEBAYASHI, RPT, MS¹, KOIJI TAKIMOTO, RPT, MEd¹, SHOKO MIYAMOTO, RPT, MS¹, YOSHIAKI INOUE, RPT, MEd¹, YUTAKA TAKUMA, RPT, MS¹, TAKAO OKABE, RPT, MEd¹, SHU MORIOKA, RPT, PhD², FUMIO YAGI, PhD³

¹)Department of Physical Therapy, Tosa Rehabilitation College: Kagami Yamakita 2833, Konan, Kochi 781-5453, Japan. TEL +81 88 7-55-0033, FAX +81 88 7-55-0995, E-mail: ptrc.k-miyamoto@tosareha.ac.jp
²)Department of Physical Therapy, Faculty of Health and Science, Kio University
³)Department of Cognitive and Behavioral Neuroscience, Kochi Medical School

Abstract. [Purpose] Agility includes three factors: rapidity of reaction, rapidity of directional change, and velocity of muscle contraction. We proposed the Ten-Step Test (TST) as a new performance test for agility. In our previous study, the criterion-related validity of TST was evaluated by comparing TST with a timed supine-to-stand test which reflects motion speed. However, timed supine-to-stand doesn’t include rapidity of reaction. The purpose of this study was to evaluate the criterion-related validity of TST using motor reaction time (MRT). [Subjects] One hundred fifty-two community-dwelling adults were recruited. [Methods] TST requires the subjects to place one foot at a time, ten times on a block 10 cm in height while standing. TST was conducted twice, and the quickest time of the two trials was used for analysis. MRT was measured as the time between a touch on the malleous and the response of the ankle dorsi-flexion in a sitting position. For evaluating the relationship between TST and MRT, the conformity of the regression formulae of aging changes and correlation coefficients were analyzed. TST was also compared with the Functional Reach Test (FRT) and muscle strength of the knee. [Results] Both TST and MRT showed a quadratic rather than a linear relationship with age. The single correlation coefficient between TST and MRT was 0.59. [Conclusion] Age-related changes of TST and MRT showed a similar curve. These curves showed a significant increase after the age of 50, and the correlation coefficient between TST and MRT was high. The findings suggest that TST includes a factor related to motor reaction.

Key words: Agility, Ten-Step Test, Motor Reaction Time

INTRODUCTION

Though muscle strength and balance are considered important in terms of assessing motor functions in elderly people¹⁻³, at present, there is no specific definition of agility in geriatric medicine and physical therapy. Agility in general is defined in the field of sports science, a combination turning ability, accuracy of motion, and full-body motion⁴⁻⁶. Various indicators have been proposed to evaluate physical fitness in elderly people in the field of geriatric medicine and physical therapy⁷⁻¹¹. According to these proposals, muscle strength of the legs and standing balance are two of the most
important factors in evaluating physical fitness. We would like to suggest, however, that these two factors are not the only useful indicators for evaluating the risk of falls in elderly people. In this study, we would like to illustrate that agility is also a very useful factor. For example, some reports show that agility training reduces the risk of falls\textsuperscript{12, 13}. Since there is no established test for determining agility, in past studies it has not been used as a determining factor of overall physical fitness.

In the field of physiology, agility is commonly defined as rapidity of reaction, rapidity of change of direction and muscle contraction velocity. In the broad sense, it also includes the cognition process and the time required for decision-making.

We developed the Ten-Step Test (TST) as a new clinical performance test for agility in elderly people, and have already confirmed the reliability and validity of the test\textsuperscript{14}. Timed supine-to-stand was used as a criterion of agility in our previous study, but timed supine-to-stand mainly reflects motion speed, and does not include a motor reaction factor, which is a component of agility\textsuperscript{15}. TST requires the subjects to place alternate feet ten times on a block while standing. This task includes rapidly changing direction and velocity of muscle contraction, and includes few of the reaction factors. It was the purpose of this study, to compare TST and motor reaction time (MRT) in order to confirm the criterion-validity of TST. If TST reflects a factor of motor reaction, it would be strong evidence that TST measures agility.

**SUBJECTS AND METHODS**

*Subjects*

This study was planned as a part of a physical check-up for elderly people living in Konan city. One hundred fifty-two men and women (49 males and 103 females; mean age 71.8 ± 13.4 years) who were community-dwelling adults in Kochi Prefecture, Japan participated in this study. Of the subjects, 1 was between 30 and 39 years of age, 13 were between 40–49 years of age, 13 were between 50–59 years of age, 34 were between 60–69 years of age, 40 were between 70–79 years of age, 42 were between 80-89 years of age, and 9 were between 90–99 years of age. None of the subjects were living at facilities for the aged or had illnesses which might affect the test. All subjects consented to measurement of agility and MRT after they had been informed of purpose of this study.

*Methods*

TST and MRT were measured for the 152 subjects. TST is performed as follows. The subject steps one foot onto a block 10 cm in height, and then quickly retracts the foot the block. Next, the subject places their opposite foot on the block and then quickly retracts it again. The time required for the subject to complete 10 repetitions of this motion is measured. The subject is instructed to perform the stepping sequence as quickly as possible (Fig. 1). TST was conducted twice after a preparation trial by all subjects, and the quickest time of the two trials was used for analysis. There was always an examiner near a subject. A stop-watch was used to measure the time in units of 0.1 seconds. If a subject failed to perform the task accurately, the test was repeated.

MRT was determined by measuring the time between touching on the medial malleolus to the contraction of the tibialis anterior, using a modified touch sensor, a hand-held dynamometer and PC. The subject who was in a seated position (hip flexion 90°, knee flexion 90°) was required to respond with an ankle dorsi-flexion as soon as possible after sensing the touch stimulus. This method is a simple measure of MRT which does not require the use of an electromyograph. MRT was measured five consecutive times, then the data of the three best trials were averaged, and the data from other two trials were discarded. Usually light stimulus is used for evaluating MRT, but touch stimulus was used in this study because it more closely simulates elderly peoples’ motions leading...
to missteps and falls.

In addition to evaluating the content validity and construct validity of TST, we evaluated the relationship between TST and other motor factors in 81 subjects over the age of 65 years who participated in a medical examination. They were asked to perform the Functional Reach Test (FRT) in order to determine their balance. Then, the subjects’ muscle strength was evaluated with a handheld dynamometer.

We calculated the data of men and women as one group, because in our preceding study TST didn’t differ with gender. For the purpose of graphic representation of these age-related characteristics, we applied a linear regression formula and a quadratic curve formula to the data. The conformity of TST and MRT with regression formula in age-related changes was compared with coefficients of determination between linear and quadratic curves. For evaluating the criterion-related validity of TST, the single correlation coefficient between MRT and TST was used.

Then, TST was compared with FRT and knee muscle strength using the partial correlation coefficient. FRT and knee muscle strength were determined by the higher value of two trials, and the value of muscle strength was converted to body weight ratio.

RESULTS

The graphic representation of TST shows that the time of TST increased with age (Fig. 2). The correlation coefficient between TST and age with the linear regression formula was 0.72, and the coefficient of determination obtained was 0.52 (p<0.01). The correlation coefficient with the
The quadratic regression formula was 0.74, and the coefficient of determination obtained was 0.55 (p<0.01). The coefficient of determination of TST’s quadratic curve was larger than that of the linear curve. These results mean that agility measured by TST shows an accelerating decline rather than a linear decline with age. The graphic representation of MRT shows that MRT increases with age (Fig. 3). The correlation coefficient between MRT and age with the linear regression formula was 0.63, and the coefficient of determination obtained was 0.40 (p<0.01). The correlation coefficient with the quadratic regression formula was 0.68, and the coefficient of determination obtained was 0.47 (p<0.01). The coefficient of determination of MRT’s quadratic curve was larger than that of the linear curve. MRT shows an accelerating increase with age similar to TST, and the single correlation coefficient between TST and MRT was 0.59 (p<0.01) (Fig. 4).

The relationship between TST and other motor factors was as follows: the partial correlation coefficient between TST and knee muscle strength was –0.35 (p<0.01), the partial correlation coefficient between TST and FRT was –0.42 (p<0.01), and the partial correlation coefficient between FRT and knee muscle strength was –0.02 (Table 1).

**DISCUSSION**

The decline of motion speed is one of the characteristics of motor function in elderly people. For this reason, there are various factors that affect motion speed with age: the decline of nerve conduction velocity, the change of component in muscle fibers, and the decline of cognitive function\(^\text{16, 17}\). In addition, the changes of other motor functions such as muscle strength and balancing function affect motion speed indirectly.

In the view of physical therapy, the decline of motion speed is a problem which requires intervention in elderly people. Physical fitness training has a tendency to emphasize muscle training and balance training rather than speed training. We believe that improvement of muscle strength and balance negatively affects agility. Therefore, it is important to evaluate pure agility separately from muscle strength and balance for the purpose of improving agility by means of physical fitness. Also, if we are able to evaluate agility, it may improve the accuracy of fall prediction. Therefore, it is useful to develop a new performance test for pure agility for elderly people.

In our previous study\(^\text{14}\), the intraclass correlation coefficient of TST showed the reliability of the test was 0.96. Also, the correlation coefficient between TST and the timed supine-to-stand showed the criterion-related validity of the test was 0.63. However, it seems that the timed supine-to-stand is used as physical performance test only in Japan. Perhaps, it is because it is customary for Japanese to sleep on a thin mattress which is laid on the floor. The timed supine-to-stand mainly reflects motion speed, with a much weaker emphasis on motor reaction or muscle contraction velocity. Therefore, it is meaningful that this study showed a significant relationship between TST and MRT (correlation coefficient 0.59). It shows that TST and MRT measure similar motor factors because changes in the results of the two tests with age conform to a quadratic curve rather than a linear curve. TST and MRT decline sharply after the age of 50. Agility is a little different from the characteristics of muscle strength and balancing\(^\text{18}\). Besides, the partial correlation coefficient between TST and FRT and the partial correlation coefficient between TST and muscle strength were low (–0.42 and –0.35). This means that muscle strength, balance, and agility are three separate motor factors. These results serve as evidence for the criterion-related validity and content validity of TST.

A clinical measurement requires not only reliability and validity, but also simplicity and ease. MRT requires measurement equipment and complicated preparation, and it has a tendency to show uncertain values in elderly people. The timed supine-to-stand is difficult for some elderly people to perform because many elderly people have some degree of physical infirmity. In addition, other performance tests\(^\text{19–22}\) for agility (Rapid Step Test, Table 1. Partial correlation between TST and the other tests (n=81)

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*p<0.01
Four-Square Step Test, etc) have some safety or methodology issues.

The present results confirm that TST is a more useful measurement of agility than previous test batteries. TST and agility training should be evaluated in terms of its usefulness in predicting falls for elderly people.

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REFERENCES