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Original Article

Reliability of measurement reliability and optimal number of measurements for mental arithmetic reaction time test

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Abstract. [Purpose] The main objective of this study was to assess the reliability of the method for testing the attention distribution ability of the elderly using mental arithmetic response time. [Participants and Methods] The participants included in the study were 30 healthy elderly people (over 65 years old), 11 males and 19 females, eight of whom had experienced falls in the past year.In the quiet standing position and the free walking state, we recorded the mental calculation response time of the participants by calculating the two-digit plus or minus one-digit values within 100. The test of the two states were tested in 24 hour intervals. [Results] In the quiet standing and free walking state, the correlation coefficient of the mental arithmetic response time group of the elderly was excellent. The intra-group correlation coefficient of mental arithmetic response time of more than three tests under free walking was greater than 0.9. [Conclusion] We found that the mental arithmetic response time can be used to objectively evaluate the ability of attention distribution in the elderly.

Key words: Mental arithmetic response time, Attention distribution, Elderly

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INTRODUCTION

With the aging of the global population, falls have become an important cause of accidental injuries to the elderly[1)] and have attracted considerable research attention. A 2018 report by the World Health Organization (WHO) stated that 28–35% of the world's elderly population were at risk of falling each year[2)], and nearly half of all fall events caused injuries[3)].

The causes of falls are many (One leg standing ability, Lower limb muscle strength, Foot joint mobility), one of which is the inability to adequately distribute attention[4)]. Attention distribution refers to the ability of a person to direct attention to two or more activities or objects at the same time, which helps to actively adjust the direction of attention according to the needs of the current activity[5)]. However, with the increase of age, the total amount of attention decreases, and the effective allocation of attention resources becomes difficult[6)]. Thus, the performance of the elderly are of multiple tasks is worse than that of a single task[7)]. As a result, falls in elderly people occur not only while walking, but also when walking while performing secondary tasks (such as talking, calculating, or manipulating objects)[8–12)].

Trail Making Test (TMT) is a widely used method to measure attention distribution[13)]. Evidence exist that the falls of the elderly are associated with poor TMT test performance[14–17)]. However, findings on the relationship between falls and while performing secondary cognitive tasks while walking in dual participants have not been reported. Carry out a dual subject

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will increases the risk of falling by five times[7], therefore, Misae et al. suggested that the attention distribution ability of elderly people should be evaluated in a dual subject[6]. Mental arithmetic, which includes addition and subtraction, can divert attention, so mental arithmetic can be used as a cognitive task in a dual task[18].

In recent years, the response time test has been applied to conduct research on dual participants, including falls in elderly adults and impaired gait adaptability in elderly[19–22]. Many methods and test devices have been utilized for reaction time testing, but the reliability of the reaction time test methods has been scarcely studied. Therefore, the main purpose of this research was to explore the reliability of a simple and convenient response time test method to be used in the elderly.

PARTICIPANTS AND METHODS

The participants were 30 healthy seniors (11 males and 19 females) over 65 years old, eight of whom had experienced falls in the past six months to one year. The following exclusion criteria were applied: cerebrovascular accidents, a history of head trauma, hearing difficulties or hearing aids, and intake of sedatives, tricyclic antidepressants, or barbiturates. We have listed in detail the characteristics of the participants in Table 1.

Table 1. Participants characteristics (n=15)

Age (years)	19.9 ± 1.3
Height (cm)	161.8 ± 7.7
Weight (kg)	55.1 ± 7.5
TMT-A (sec)	133.4 ± 10.6

Mean ± SD.

The purpose and content of this research were explained to the participants, and all participants gave their informed consent to participation in the study. The IRB approval number for this research is 18-Io-133, and the research was approved by the Research Ethics Committee of the International University of Health and Welfare (Ōtawara, Tochigi, Japan).

Before testing, the attention distribution of the participants was assessed for using TMT-A, to make sure the participants don't have serious attention distribution disorder. In the states of quiet and free walking, the mental arithmetic response time of the elderly was recorded twice; at the same time, the probe reaction time was measured according to the method of Huo Ming et al.[22]; the test was performed every 24 hours.

In the mental arithmetic test, we used a simple two-digit addition and subtraction of one digit (For example: 13 + 5=? Or 67–8=?). We then, recorded all mental arithmetic problems into sound files, imported them into the computer after numbering, and sorted them using a random-number table. A total number of 20 mental arithmetic questions were edited, with an interval of 30 sec between the questions, and a notice signal "Pi" (3,000 Hz, 50 msec) was given 2–3 sec before the question was asked. We further utilized DigiOnSound5 (DigiOnAudio2) sound editing software to edit the audio files and stored them in the MP3 format. A portable reaction time test system (Ming Huo, Franchise 2009-101116) was used to test the mental arithmetic response time. The test device consists of a recording pen (Panasonic, Japan), MP3 reader (SONY, Japan), and headset (ELECOM, Japan). The test was performed in a quiet rehabilitation center.

During the tests, we first used 3–5 questions to adjust the volume to the most appropriate level for the subject to ensure that the subject can hear clearly and answer mental arithmetic questions. During the test, the mental arithmetic questions and the participants' answers were simultaneously recorded by the recording pen. Finally, the audio after the test was analyzed again using DigiOnSound5, eliminating the subject's repeated questions or protracted answers and choosing 10 valid answers. ICCs were used to assess the reliability of measurement times and of mental arithmetic response time re-testing results. The data obtained were analyzed using SPSS for Windows (ver. 22.0; SPSS Incorporated, Chicago, IL, USA). The test flow is illustrated in Fig. 1.

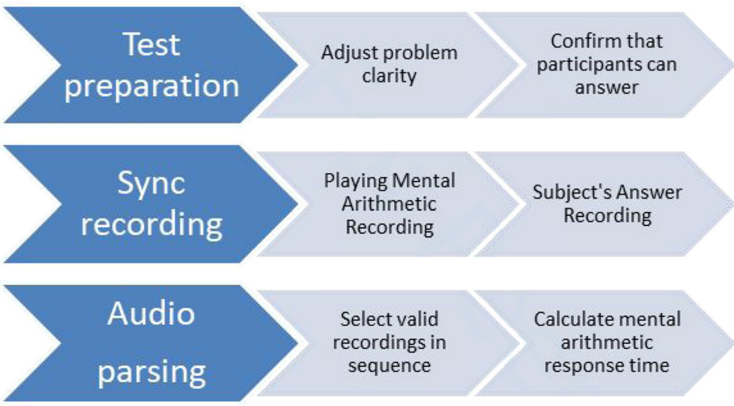

Fig. 1. Mental arithmetic response time test flow.

Table 2. Results of repeated tests and ICC (1,1) (n=30)

	Probe reaction time (msec)	Mental arithmetic response time in quiet standing (msec)	Mental arithmetic response time in free walking (msec)
First measurement	341.1 ± 91.1	1,154.0 ± 532.2	1,468.2 ± 616.2
Second measurement	373.8 ± 112.2	1,160.3 ± 538.4	1,493.5 ± 618.1
ICC	0.96*	0.92*	0.97*

Mean ± SD, p<0.01.

Table 3. ICC of different condition of repetitive movements (n=30)

Times of measurement	Quiet standing	Free walking
1	0.56	0.62
2	0.78*	0.89*
3	0.83*	0.88*
4	0.84*	0.92*
5	0.86*	0.94*
6	0.89*	0.96*
7	0.90*	0.96*
8	0.91*	0.97*
9	0.91*	0.97*
10	0.92*	0.97*

*p<0.01.

RESULTS

We have presented the probe reaction time and the mental arithmetic response time of the 30 included in Table 2 and the mental arithmetic response time during quiet standing and free walking in Table 3. The Kolmogorov-Smirnov test was applied to test the normality of data distribution before the statistical analysis. In quiet standing and free walking, the ICCS (1.1) of the mental arithmetic response time of the elderly was greater than 0.92. More than 3 groups were tested in the free walking state, with a mental arithmetic response time greater than 0.90.

DISCUSSION

Although, mental arithmetic when walking can affect walking stability in the elderly[23)], but it can also awaken attention[24)]. Therefore, this research uses 2-digit mixed addition and subtraction calculations as mental arithmetic problems. The benefits of using the mental arithmetic problems are: 1. The problem is easier, and the elderly can also use it. 2. The number of questions is not easy to repeat, which can avoid the subject's judgment in advance, to ensure the accuracy of the test results.

The purpose of this research was to verify the reliability of the test of mental arithmetic response time in different types of repetitive movements. Mental arithmetic response time can be accurately measured in a quiet position or when walking freely. Another purpose of the research was to determine the optimal of measurement time when measuring mental arithmetic response time in the different types of repetitive movement used in the experiment. During free walking, the ICC value of the mental arithmetic response time of the test groups 3 exceeded 0.9. For stability of the test results, we measured 10 groups of valid questions and answers. Therefore, mental arithmetic response time can be used as an objective assessment of the attention distribution of the elderly.

The test method used in this research is simple to operate, the device is easy to carry, and the use is not restricted by the venue. In the future, it can be considered as a training method to prevent falls in the elderly.

Funding and Conflict of interest

None.

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