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Association between Attentional Function and Blink-Suppressed Pinch Strength

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Abstract
We suggested that dual-task achievement, maximum muscle strength maintenance on pinch strength measurement combined with blink suppression for 5 seconds, is associated with attentional function and blink suppression. The subjects of our previous survey consisted of 27 young and 12 elderly persons. As attentional function reduces with aging, the necessity of a survey involving elderly persons was considered. As previously adopted, we used the Trail Making Test Japanese version (TMT): Part A and Part B for attentional function assessment. Since TMT Part B more accurately reflects cognitive function compared to TMT Part A, this survey was performed, hypothesizing that pinch endurance may reduce in subjects requiring a specific time for Part B. The subjects were 24 healthy elderly persons (74.7±8.1 years, 2 males, 22 females). Before pinch strength measurement, each subject was instructed to stop blinking for 5 seconds, and the number of blinks was counted. The pinch strength measurement time was established as 5 seconds, and changes in strength during that time were examined. On the first session of pinch strength measurement, no instruction was given (no suppression). Before the second session of measurement, each subject was instructed not to blink (under suppression). In a group with blinking under suppression, the maximum muscle strength on pinching was exhibited at 2 to 3 seconds in the absence of suppression ($p=0.04$), whereas it was exhibited at 3 to 4 seconds and at 4 to 5 seconds under suppression ($p<0.046$). In a group requiring a specific time for Part B, pinch strength persisted for 2 to 4 seconds, and significantly reduced ($p\leq0.04$). Measurement of blink-suppressed pinch strength in healthy elderly subjects showed that a reduction in pinch strength at ≥3 seconds was associated with the time required for Part B. This measurement method was useful as a simple screening method.

Keyword: attentional function, dual-task, elderly persons, simple screening

Introduction

Mild cognitive impairment (MCI) is a disorder in which cognitive functions, such as attentional and executive functions, are affected[1)], influencing activities of daily living (ADL)[2)]. In addition, attentional dysfunction is closely involved in a reduction in MCI patients' ADL abilities[3)4)]. For the prevention of ADL reduction in MCI patients, it is significant to focus on attentional function screening. Previous studies set a dual task, such as calculation, during walking in elderly persons[5)6)7)]. In these studies, there was a risk of falling, and it was difficult to secure a flat road on which persons can walk safely. For cognitive function testing to be used in community residents, requirements, such as a short time and the absence of discomfort after testing, should be met[8)9)]. It is important to examine a safe dual task in consideration with psychological aspects.

We suggested the possibility of simple attentional function screening that is safe for subjects and is not psychologically stressful (simple screening)[10)]. In this screening method, a dual task is given to subjects. Establishing the main task as pinch strength measurement, each subject is instructed to suppress blinking for 5 seconds as an accessory task. The subjects consisted of young and elderly persons. As a result, we found that the measurement time for the Trail Making Test Japanese version (TMT) Part A (Part A) was often

prolonged in subjects who blinked during pinch strength measurement. Part A is a scale for evaluating selective attentional function, and it was suggested that attentional function is associated with blink suppression.

Attentional function reduces with aging[11)12)]. In the elderly, the reaction time for TMT Part B (Part B), which is a scale for investigating divided attention function, is prolonged[13)14)]. Part B more accurately reflects cognitive function compared to Part A[15)]. These findings suggested the necessity of examining changes in Part B and pinch strength under a condition of blink suppression for 5 seconds in elderly subjects alone. This survey was performed, hypothesizing that pinch endurance (main task) may reduce in subjects requiring a specific time for Part B.

Materials

The subjects were long-term care insurance coverage-free elderly persons living an independent life in Wakayama Prefecture. Those with neuropsychiatric diseases, including dementia, a history of a disease that influences upper limb motions, or physical symptoms that affect testing were excluded.

To all subjects, the purpose of this study and measurement were explained, and written informed consent was obtained. This survey was anonymized based on the protection of personal information, and approved by the ethics review board of Reiwa Health Sciences University (Issue No.: 23-036).

Methods

Measurement was performed between December 2023 and March 2024 while paying attention to COVID-19 prevention. For attentional function assessment, the Trail Making Test Japanese version[16)] (TMT) was used, and TMT-Part A and TMT-Part B were performed. Each subject was instructed to have a pencil with his/her dominant hand on testing, and the time required for these tests was measured using a digital stopwatch. For pinch strength measurement, each subject was instructed to sit in a chair, bend the bilateral knees at a right angle, make the bilateral soles of the feet in contact with the ground, and bend the elbows at 90 degrees[17)]. Each subject was instructed to pinch a pinch-measuring instrument on the desk at a maximum force with his/her dominant hand. Pinching fingers were established as the thumb, index finger, and middle finger[18)19)]. For pinch strength measurement, an attachment for pinch strength (T.K.K. 1269m, Takei Scientific Instruments Co., Ltd.) was used. The results obtained were digitally outputted (v) using a strain amplifier (T.K.K. 1268, Takei Scientific Instruments Co., Ltd.) and A/D converter (T.K.K. 5721, Takei Scientific Instruments Co., Ltd.). Pinch strength was measured using a digital stopwatch twice, establishing 5 seconds[20)] as an upper limit. The interval between the first and second sessions of measurement was established as 60 seconds[21)]. On the first session of pinch strength measurement, no instruction was given, and measurement was performed (no suppression). Before the second session of measurement, each subject was instructed not to blink[22)23)], and measurement was performed (under suppression). In addition to the maximum pinch strength in 5 seconds, the mean value per second was calculated from the value obtained in 1/100 second.

Examination of subjects' blinks and measurement of pinch strength were performed in a sitting position. The number of blinks was measured using a digital camera (SAMSUNG).

Furthermore, the subjects were divided into a group in which a specific time was required for the results at an intermediate point and a group in which it was not required in accordance with the results of Part B, and the results were compared.

Results

The data obtained by the measurements are shown in Tables 1,2 and 3.

Table1. The difference of social background, pinch strength and TMT with achieved and not achieved.

	ALL	achieved group	not achieved group	p value
N	24	14	10	-
age	74.7±8.1	76.2±7.6	72.4±8.7	0.33
sex(man), n(%)	2 (8.3)	1 (7.1)	1 (10)	0.67
Body Mass Index, kg/m^2	22.1±4.5	21.0±2.2	23.7±6.5	0.30
TMT-A, sec	44.0±16.3	44.1±18.0	43.8±14.3	0.97
TMT-B, sec	82.6±47.5	89.1±56.8	72.6±27.5	0.37
maximum pinch strength, kg(no blink suppression)	31.7±6.4	33.5±6.2	29.3±5.4	0.09
0-1 sec, kg	17.5±5.6	18.1±6.5	16.8±4.2	0.54
1-2 sec, kg	28.5±6.2	30.5±5.2	25.7±6.7	0.07
2-3 sec, kg	28.4±7.0	30.9±6.3	24.8±6.8	0.04
3-4 sec, kg	28.2±7.6	30.5±6.8	24.8±7.8	0.08
4-5 sec, kg	27.7±6.9	29.5±7.5	25.2±5.4	0.12
maximum pinch strength, kg(blink suppression)	-	32.7±6.8	27.0±7.1	0.07
0-1 sec, kg	-	18.6±5.4	16.7±6.1	0.43
1-2 sec, kg	-	29.0±7.3	24.5±8.9	0.20
2-3 sec, kg	-	30.3±7.1	23.3±8.6	0.052
3-4 sec, kg	-	29.5±6.4	22.8±8.1	0.046
4-5 sec, kg	-	28.2±6.0	21.0±7.3	0.02

Values are mean ± SD or n (%). Part A indicates Trail Making Test part A. Part B indicates Trail Making Test part

Table2. Comparison of a group in no suppression and under supression conditions

	no suppression	under suppression	p value
maximum pinch strength, kg	31.7±6.4	30.3±7.3	0.06
0-1 sec, kg	17.5±5.6	17.8±5.7	0.78
1-2 sec, kg	28.5±6.2	27.1±8.1	0.09
2-3 sec, kg	28.4±7.0	27.4±8.3	0.16
3-4 sec, kg	28.2±7.6	26.7±7.7	0.07
4-5 sec, kg	27.7±6.9	25.2±7.4	0.03

Values are mean ± SD

Table3. Comparison of a group in which a specific time was required for Part B

	much time group	little time group	p value
n	12	12	-
age	77.3±7.3	72.5±8.3	0.18
sex(man), n(%)	1	1	1.00
Body Mass Index, kg/m^2	20.4±1.9	23.4±5.6	0.11
TMT-A, sec	47.2±16.1	41.0±16.6	0.37
TMT-B, sec	115.7±50.6	52.3±8.8	<0.01
maximum pinch strength, kg(no blink suppression)	30.5±6.1	32.9±6.2	0.35
0-1 sec, kg	19.3±5.0	15.7±5.7	0.12
1-2 sec, kg	27.5±7.0	29.5±5.3	0.44
2-3 sec, kg	26.6±7.9	30.2±5.8	0.21
3-4 sec, kg	26.0±8.6	30.3±6.0	0.17
4-5 sec, kg	25.5±7.3	29.9±6.0	0.12
maximum pinch strength, kg(blink suppression)	28.1±7.9	32.6±6.3	0.13
0-1 sec, kg	17.6±5.7	18.2±5.4	0.76
1-2 sec, kg	23.5±8.6	29.6±6.8	0.07
2-3 sec, kg	22.8±8.7	30.5±6.3	0.02
3-4 sec, kg	22.3±8.3	29.6±5.6	0.02
4-5 sec, kg	21.8±9.0	27.5±4.7	0.07

The subjects were 24 persons (74.7± 8.1 years, 2 males, 22 females). The mean body mass index (BMI) was 22.1±4.5 kg/m^2.

The mean results of Part A and Part B were 44.0±16.3 and 82.6±47.5 seconds, respectively. There was no difference in the maximum pinch strength between the “no suppression” and “under suppression” conditions (31.7±6.4 vs. 30.3±7.3 kg, respectively, p=0.06). The mean values (no suppression, under suppression) in 5 seconds from the time of start for examining force exertion are presented. There was a difference in the mean value at 4 to 5 seconds between the “no suppression” and “under suppression” conditions (27.7±6.9 vs. 25.2±7.4 kg, respectively, p=0.03) (table2).

Comparison of a group in which blink suppression was achieved under suppression with a group in which it was not achieved (table1)

Under blink suppression, it was achieved in 14 subjects (blink-free group), but not in 10 subjects (blink group). The number of blinks was 2.7±2.2 times. There were no differences in the results of Part A or Part B between the blink-free and blink

groups (Part A: 44.1±18.0 vs. 43.8±14.3 sec, respectively, Part B: 89.1±56.8 vs. 72.6±27.5 sec, respectively, p≥0.37). There was no difference in the maximum pinch strength between the two groups (33.5±6.2 vs. 29.3±5.4 kg, respectively, p=0.09).

When measuring pinch strength under suppression, there was also no difference between the two groups (32.7±6.8 vs. 27.0±7.1 kg, respectively, p=0.07).

The mean pinch strength per second was stronger in the blink group at 2 to 3 seconds under the "no suppression" condition (30.9±6.3 vs. 24.8±6.8 kg, respectively, p=0.04). Under suppression, it was stronger in the blink group at 3 to 4 seconds and at 4 to 5 seconds (29.5±6.4 vs. 22.8±8.1 kg, respectively, 28.2±6.0 vs. 21.0±7.3 kg, respectively, p<0.046).

Comparison of a group in which a specific time was required for Part B

The intermediate results (time) of Part B in the subjects were compared between a group in which a specific time was required for Part B (much time group, n=12) and a group in which it was not required for Part B (little time group, n=12). There was no difference in the number of blinks during blink suppression between the two groups (0.8±0.4 vs. 1.4±0.5 times, respectively, p=0.48). There was no difference in the number of blinks between the two groups regardless of blink suppression (p=0.13). There was no difference in the maximum pinch strength measured in the absence of blink suppression between the two groups (32.9±6.2 vs. 30.5±6.1 kg, respectively) (table3).

The mean pinch strength per second was compared between the longer and shorter time groups under blink suppression. It was lower in the longer time group at 2 to 3 seconds and at 3 to 4 seconds (p≤0.02). To examine the association with a group in which a specific time was required for Part B, binomial logistic regression analysis was performed. A specific time required for Part B was associated with a reduction in pinch strength 2 to 3 seconds and 3 to 4 seconds after the start of pinch measurement under blink suppression (p≤0.04) (table4).

Table4. Binomial logistic regression analysis related at time spent on Part B

	p value	Odds ratio
pinch strength(no blink suppression)		
maximum	0.34	0.93(0.81-1.08)
0-1 sec, kg	0.13	1.14(0.96-1.36)
1-2 sec, kg	0.12	0.94(0.82-1.09)
2-3 sec, kg	0.21	0.92(0.80-1.05)
3-4 sec, kg	0.17	0.92(0.81-1.04)
4-5 sec, kg	0.13	0.90(0.78-1.03)
pinch strength (blink suppression)		
maximum	0.14	0.90(0.79-1.03)
0-1 sec, kg	0.75	0.98(0.84-1.13)
1-2 sec, kg	0.09	0.89(0.77-1.02)
2-3 sec, kg	0.04	0.85(0.72-0.99)

This table shows value by simple regression analyses

Discussion

In this study, to develop simple attentional function screening, the main task of a dual task was

established as maximum exertion/maintenance of pinch strength, and its accessory task as blink suppression. In our previous survey[10], a dual task was performed in 27 young (mean age: 31.9±13.8 years) and 12 elderly (mean age: 73.3±5.6 years) subjects. The results showed that the time required for Part A was associated with blinking during pinch strength measurement under blink suppression. As an item showing the same tendency on both the present and previous surveys, there was no difference in pinch strength regardless of blink suppression between the blink and blink-free groups on pinch strength measurement. As an item showing a different tendency, there was a significant reduction in maintenance of pinch strength at 2 to 4 seconds under blink suppression in a group in which a specific time was required for Part B ($p \leq 0.04$).

When subjects accomplish a dual task, they direct attention resources to both main and accessory tasks. Cognitive function corresponds to divided attention function[24)25)]. In the elderly, the reaction time for Part B to examine the divided attention function of the frontal lobe is prolonged[14)26)].

In this study, we primarily investigated Part B and changes in pinch strength in elderly subjects. The mean reaction time for Part B was 82.6±47.5 seconds. As the mean age of the subjects was 74.7 years, this result is better than that (88.8±24.7 seconds)[16)] in persons of the same age (70 to 79 years). Similarly, the mean reaction time for Part A was 44.0±16.3 seconds, being better than the mean value (46.5±10.5 seconds)[16)] in persons aged 70 to 79 years.

This study suggests two points.

First, maximum muscle strength on pinching was exhibited at 2 to 3 seconds in the absence of suppression in the blink group ($p=0.04$), whereas it was exhibited at 3 to 4 seconds and at 4 to 5 seconds under suppression ($p<0.046$). This suggests that the distribution of more attention resources is required for an accessory task, blink suppression, and that attention resources to be distributed for a main task decrease[27)]. It was shown that there was a "blink suppression" task-related difference in the time of pinch strength exertion even in a group in which the reaction time for Part B was better than the mean value.

Second, in a group in which a specific time was required for Part B, pinch endurance significantly reduced in 2 to 4 seconds ($p \leq 0.04$). A study reported that the pinch strength of the elderly was maintained for 15 seconds[20)]. The above reduction in pinch strength immediately after measurement was not consistent with the results of another study[21)]. This suggested that a dual task reduces attentiveness to maintain pinch strength, influencing divided attention function. From the viewpoint of cognitive processing loading, a study pointed out that a cognitive task was more desirable as an accessory task[28)]. In the requirements for discomfort-free testing that we aim at, the "blink suppression" task was considered to be equivalent to a cognitive task.

Conclusion

In healthy elderly subjects, pinch strength was measured under blink restriction, and a reduction in pinch strength at 3 seconds or later was associated with a specific time required for Part B. The usefulness of this measurement method as a simple screening method was suggested. However, it is impossible to obtain detailed results by screening alone. Therefore, it may be necessary to measure Part A and Part B which more accurately reflects cognitive function.

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