Dual-task Interference in a Grip and Lift Task

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Background & Aims: The aim of this study was to investigate dual-task interference on maximum grip force while performing a grip and lift task. Moreover, the influence of handedness on maximum grip force, and the relationship between maximum grip force and subjective difficulty were also investigated.

Methods: Eleven subjects took part in the study. The study experiment was comprised of one single task and three dual tasks: 1) grip and lift task, 2) grip and lift task with single-leg stance, 3) grip and lift task with eyes closed, and 4) grip and lift task with calculation. The experiment was conducted in both hands separately. Maximum grip force of four fingers (dominant/non-dominant × thumb/index finger) was compared among tasks and between hands. Results: We found that maximum grip force was increased mainly by the cognitive dual task in both hands, and that there was no difference between hands in the same task. There was a positive correlation between the perceived difficulty and maximum grip force in the dominant hand. Conclusion: Our results suggest that maximum grip force could serve as an objective index for evaluating dual-task interference in upper extremity function. (Kitakanto Med J 2014; 64: 309–312)

Key words: Dual task, Grip force, Perceived difficulty

Introduction

It is well known that grip force trace indicates successive phases while performing a grip and lift task. According to Johansson and Flanagan,1 grip force trace can be broken down into distinct phases: reach phase, the digits contacting the object; load phase, the breaking of contact between the object and the surface of the table; lift phase, the time interval between the object lifting off the surface and the object approaching goal height; hold phase, holding the object in the air; replace phase; and unload phase. Maximum grip force (GF max) is composed of the force to lift the weight of the object and a safety margin to prevent slips.2 It is known that GF max is located in the lift phase and adapted for object weight and texture, i.e. greater grip force needed for heavier and/or more slippery objects.

The safety margin is influenced by sensory and sensorimotor systems. Johansson and Westling demonstrated that GF max was increased by local cutaneous anesthesia, and considered that this force change is related to cutaneous afferent input.2 Blennerhassett et al. compared grip force application in stroke patients and matched control subjects, and found fluctuating irregular forces and reduced adaptation of the safety margin in stroke patients.3 The raised safety margin was considered to be a compensatory strategy to maintain grip when sensorimotor processes are deficient.

Some studies used grip force regulation as an objective measurement method in a dual-task paradigm.4,5 Guillery et al. found that GF max was influenced by the cognitive system.6 GF max was significantly increased in a visual search and counting task concomitant to a grip and lift task as compared to a simple grip and lift task. However, in these studies grip force regulation was investigated in only the dominant hand. Therefore, the difference of GF max between the dominant and non-dominant hands has not been adequately discussed.

The aim of this study was to investigate dual-task interference on GF max while performing a grip and lift task. Dual-task interference was assessed in two
balance tasks (single-leg stance and with eyes closed) and a cognitive task (calculation, subtract 7 from 100, 200, or 300). This experimental design allowed us to compare the involvement of balance and cognitive function in the grip and lift task. Moreover, the influence of handedness on GF max and the relationship between GF max and subjective difficulty were also investigated.

**Subjects and Methods**

Eleven subjects (one male and ten females, mean age 21.4±1.0 years) participated in the study. The subjects had no motor or cognitive deficits. Handedness was evaluated with the Edinburgh Handedness Inventory, and all subjects were right-handed. Informed consent was obtained prior to the study. The study was approved by the Epidemiologic Research Ethics Committee of Gunma University Faculty of Medicine (No.25-12).

An iron cube (250g, 31×31×31mm) was custom manufactured for this study. Two pressure sensors (FlexiForce™, sensing area diameter: 9.5mm; measurement range: 0–110 N) were attached to the surfaces of the cube to measure the grip force of each contact surface. The sensor acts as a resistor in the electrical circuit. When the sensor is unloaded, the resistance is very high. When force is applied to the sensor, this resistance decreases. The resistance can be read by connecting an ohm meter to the outer two pins of the sensor connector and applying force to the sensing area. The resistance converted voltage was analog-to-digital converted by using a data logger system (DL 3100, S & ME). Data were sampled at 1000Hz with a resolution of 16-bit.

The subjects stood without shoes in front of a desk supporting the cube and were asked to wipe their finger pulp to reduce inter-individual variability in finger skin friction. Verbal instructions were given to grip the cube using the thumb and index finger, lift approximately 10cm, and hold for 10 seconds. Before lifting, subjects were allowed to touch the cube slightly without exceeding 0.5N.

The experiment session was comprised of one single task and three dual tasks: 1) grip and lift task (“single task”); 2) grip and lift task with single-leg stance (“single-leg stance”); 3) grip and lift task with eyes closed (“without vision”); and 4) pinch and lift task with calculation (“calculation task”). Four tasks were randomly arranged and forty lifts (4 tasks×10 times) were performed in a session.

**Results**

Fig. 2 shows grip force trace for a representative subject. It was possible to visually identify reach, load, lift, and hold phases in grip force trace as suggested by Johansson and Flanagan.1

GF max of four fingers and the results of the comparisons are shown in Table 1. GF max of thumbs (dominant: \( F_{3,40} = 4.4, \ p < 0.01 \); non-dominant: \( F_{3,40} = 3.4, \ p < 0.05 \)) and index fingers (dominant: \( F_{3,40} = 3.6, \ p < 0.05 \); non-dominant: \( F_{3,40} = 5.2, \ p < 0.005 \)) significantly increased in the dual tasks. GF max of four fingers in the calculation task were higher than that of the single task. GF max of the thumb on the dominant hand in the single-leg stance was higher than that of the single task. More-
over, GF max of the thumb and index fingers on the non-dominant hand in the calculation task was higher than that of the without vision task. However, GF max between dominant and non-dominant hands in the same task was not significantly different in all tasks.

There was a positive correlation between the perceived difficulty and the sum of GF max (thumb + index finger) in the dominant hand (rs=0.33, p<0.01). However, we did not observe a significant correlation in the non-dominant hand (rs=0.19).

**Discussion**

We found that GF max in the grip and lift task was increased by the cognitive dual task. Although a previous study already reported increased GF max in the dominant hand, to our knowledge, this study provided the first assessment of increased GF max in the non-dominant hand. We also identified that there was no GF max difference between the dominant and non-dominant hands in the same task.

Dual-task interference was shown in the cognitive dual task. In other words, the subjects increased the safety margin of GF max in order not to let the cube slip during the cognitive dual task. The influence of the cognitive dual task in the results was in good accordance with the previous study. Therefore, we suggest that GF max is a stable component influenced by a cognitive task in the grip and lift task.

Contrasting with interference of the cognitive task on GF max, there was no significant interference from balance tasks. Before the experiment, based on previous studies, we had expected that closed eyes and single-leg stance would decrease postural control and that accordingly, GF max would be increased. However, postural control was not affected by closed eyes. This may be explained by our experiment conditions. In the without vision task, we did not control the base of support. All the subjects stood with a wide base of support. Therefore, their balance level was not reduced by closing their eyes. The single-leg stance also did not increase GF max, which means the subjects had enough somatosensory information available even with the small base of support.

There was no GF max difference between the dominant and non-dominant hands in the same task.

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**Table 1 Maximum grip force (N) of four fingers in four tasks**

<table>
<thead>
<tr>
<th></th>
<th>Thumb</th>
<th>Non-dominant</th>
<th>Dominant</th>
<th>Non-dominant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single task</td>
<td>2.4±1.7</td>
<td>2.6±0.9</td>
<td>3.1±1.4</td>
<td>3.1±1.8</td>
</tr>
<tr>
<td>Single-leg stance</td>
<td>2.7±1.9</td>
<td>2.8±1.2</td>
<td>3.2±1.5</td>
<td>3.3±2.1</td>
</tr>
<tr>
<td>Without vision</td>
<td>2.7±1.7</td>
<td>2.6±1.0</td>
<td>3.2±1.4</td>
<td>3.1±1.9</td>
</tr>
<tr>
<td>Calculation task</td>
<td>2.7±1.9</td>
<td>3.0±1.3</td>
<td>3.5±1.6</td>
<td>3.6±2.3</td>
</tr>
</tbody>
</table>

* p<0.05
The results should be discussed from the aspect of upper limb symmetry. Generally a dominant arm advantage is known to be the basis of upper limb asymmetries. For example, the dominant arm has advantages in the generation of motor output, including increases in strength, speed, and consistency of movement. Grip strength in the dominant hand was 10% stronger in the majority of right-handed persons. Dominant hand superiority in rate of rapid tapping was observed at finger, wrist, and shoulder joints. Moreover, the amount of time was significantly shorter for the dominant hand in a peg board task. Unlike these studies, there was no GF max difference between the dominant and non-dominant hands in the results. This may be explained by a multidimensional description of handedness proposed by Steenhuis and Bryden. They asserted that skilled activities, such as inserting a pin in a piece of material, are strongly lateralized. In contrast, less skilled activities, such as picking up objects, are less lateralized. In this study, the subjects performed a simple grip and lift task. Therefore, no GF max difference in the results is consistent with Steenhuis and Bryden’s suggestion.

A positive correlation was found between the perceived difficulty and the sum of GF max in the dominant hand. It is not difficult to imagine that the subjects required more concentration to perform dual tasks. We think the additional concentration may be associated with perceived difficulty. Perceived difficulty or subjective mental load is related to task difficulty. Similar to that previous study, we found perceived difficulty is related to the sum of GF max only in the dominant hand.

In conclusion, our results suggest that GF max could serve as an objective index for evaluating dual-task interference in upper extremity function.

**Conflict of Interest**

None of authors have any conflicts of interest associated with this study.

**References**