

EFFECTS OF ASSISTIVE DESIGN FOR CHOPSTICKS ON FOOD CUTTING

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Abstract Assistive designs of chopsticks have been developed to support various tasks in daily eating. In particular, assistive chopsticks using grip or clip are useful for supporting eating tasks such as pinching, moving, and pulling. However, it is considered possible that these assistive chopsticks interfere other eating tasks such as food cutting because these chopsticks are fixed orientations and range of movement. Thus, the objective of this study was to investigate the effects of assistive chopsticks with grip and clip on food cutting via experiment. In the experiment, the participants cut a thin fish cake by using three types of chopsticks with different designs (“normal”, “clip”, and “clip and grip”). Three types of chopsticks were compared for the activity of flexor digitorum superficialis muscle as musculoskeletal load, comfortability, and operation time as performance in food cutting for thin fish cake. The results showed that there was no significant difference of muscle activity, comfortability, and operation time during food cutting in three types of chopsticks. These results suggest the possibility that assistive chopsticks using clips or grips can assist eating without interfering with food cutting.

Keywords: Chopsticks; assistive design; food-cutting; comfortability; muscle activity; performance.

1. INTRODUCTION

Chopsticks provide various functions such as pinching, moving, pulling, cutting, scooping and holding for food handling in eating [1]. Some people cannot use these functions of chopsticks because of their experience or physical ability [1]. From this background, the assistive designs of chopsticks have been developed to support various tasks in daily eating [2–4]. Pincer-type chopsticks using additional clip and grip could assist eating tasks such as pinching, moving, and pulling in food handling [2–4]. However, it is considered a possibility that these assistive chopsticks interfere other eating tasks such as food cutting because these chopsticks have fixed orientations and range of movement. Thus, the objective of this study was to investigate the effects of assistive chopstick grip and clip on food cutting via experiment. In this study, muscle activity as finger musculoskeletal load, comfortability, and operation time as performance were investigated in food cutting.

2. MATERIALS & METHODS

2.1. Participants

The participants were 10 healthy young males (age 20 years, height 170 ± 5.19 cm, weight 63.1 ± 14.0 kg, mean \pm standard deviation). The participants use normal chopsticks for daily eating. There is no experience in using assistive designed chopsticks with clip or grip in all participants. The experimental procedures were conducted by the Ethics Committee for Human Research of the National Institute of Technology, Hachinohe College (approval number R5-1).

2.2. Chopsticks

In the experiment, three types of chopsticks with different designs (“normal”, “clip”, and “clip and grip”) were compared. Overviews of these chopsticks are shown in Figure 1 to 3. These chopsticks were set by aid of the commercial product (Hashizo-kun L-type, WIND LTD., Japan). The length of chopsticks was 20 cm. The position and orientation of grip can be adjusted by each participant.



Figure 1. Chopsticks in “normal” condition.



Figure 2. Chopsticks in “clip” condition.

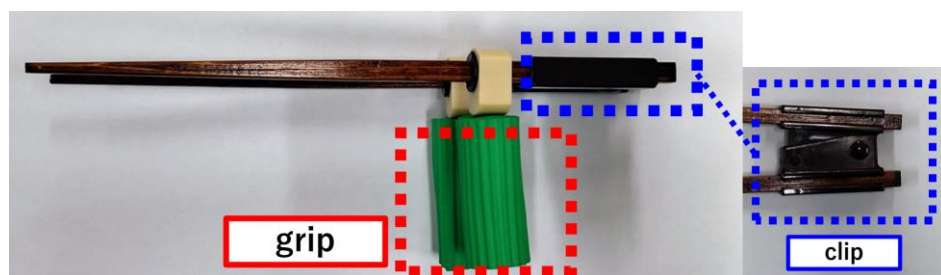


Figure 3. Chopsticks in “clip and grip” condition.

2.3. Procedure

Firstly, the participants practiced how to use assistive designed chopsticks (“clip” and “clip and grip”) for 10 minutes. The participants performed three trials of food cutting by using three types of chopsticks (“normal”, “clip”, and “clip and grip”). Order for types of chopsticks was randomized for each participant. The thin ellipsoid fish cake (semi-minor axis 27 mm, semi-major axis 44 mm, thickness 7 mm) was used as a target for food cutting. The thin ellipsoid fish cake is shown in Figure 4. In food cutting, chopsticks are contacted on the fish cake in the initial posture of each trial. The

participants started food cutting by verbal command from the examiner. The participants cut the fish cake along a minor axis. The completion of the food cutting was confirmed by the examiner.



Figure 4. Fish cake for experiment.

2.4. Measurement

The activity of the flexor digitorum superficialis muscle as a musculoskeletal load during food cutting was measured by surface electromyography (sEMG). The flexor digitorum superficialis muscle is used for finger movements related to chopsticks operation [5]. In the experiment, the activity of the flexor digitorum superficialis muscle during food cutting was measured in each trial by sEMG sensor (EMG-EYE II, G-LINX CO., LTD., Japan). The sampling rate of sEMG was 500 Hz. The measured sEMG was full wave rectified. Furthermore, sEMG was normalized by reference voluntary contraction (RVC) during resting. Finally, the median value was calculated from the processed time waveform of sEMG.

Comfortability was measured on a visual analog scale (VAS). VAS is used to measure of subjective feelings in continuous values [6]. The comfortability of food cutting was measured using a questionnaire with a 100 mm line segment for VAS. The line segment on the questionnaire was defined as 0 mm being the most uncomfortable and 100 mm being the most comfortable. Measurement of VAS was performed after each food cutting trial.

Operation time as performance of food cutting was measured during each trial. Operation time was calculated by the start and end time of each trial. The start and end were recorded by a data logger of sEMG sensor. In this study, we considered that short operation time indicates high performance of food cutting.

2.5. Statistical Analysis

Statistical analysis was performed for muscle activity, VAS of comfortability, and operation time. Outlier values were detected by the Smirnov–Grubbs test. The Kruskal–Wallis test and the Bonferroni method were used for comparison of measured values in three types of chopsticks. A significant level was set as $p < 0.05$. These statistical tests were performed by EZR [7].

3. RESULTS

3.1. Muscle Activity

The results of flexor digitorum superficialis muscle activity are shown in Figure 5. The results of the statistical test showed that there is no significant difference in muscle activity between the three types of chopsticks. These results suggest the possibility that there is no difference in musculoskeletal loads during food cutting between the three types of chopsticks.

3.2. VAS for Comfortability

The results of VAS for comfortability are shown in Figure 6. The results of the statistical test showed that there is no significant difference for VAS values in the three types of chopsticks. These results suggest the possibility that there is no difference for comfortability during food cutting in three types of chopsticks.

3.3. Operation Time

The results of operation time are shown in Figure 7. The results of the statistical test showed that there is no significant difference in operation time between the three types of chopsticks. These results suggest the possibility that there is no difference in the performance of food cutting in three types of chopsticks.

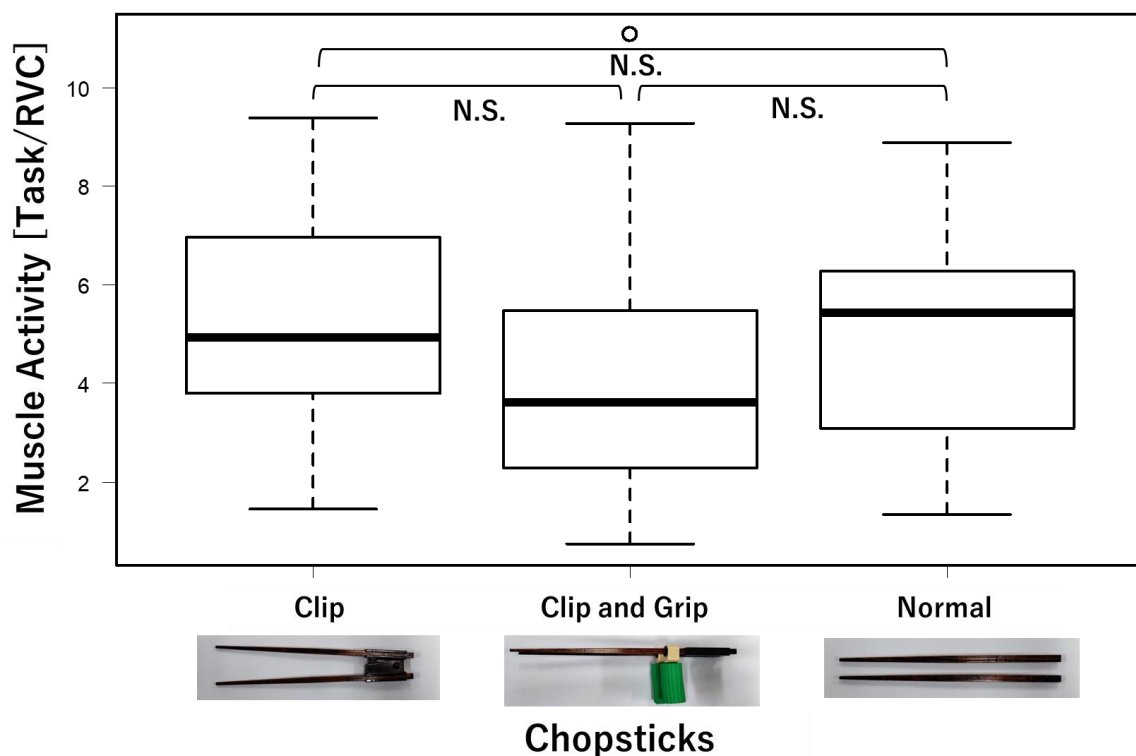


Figure 5. Activity of flexor digitorum superficialis muscle.
(N.S.: no significant difference, RVC: reference voluntary contraction from resting)

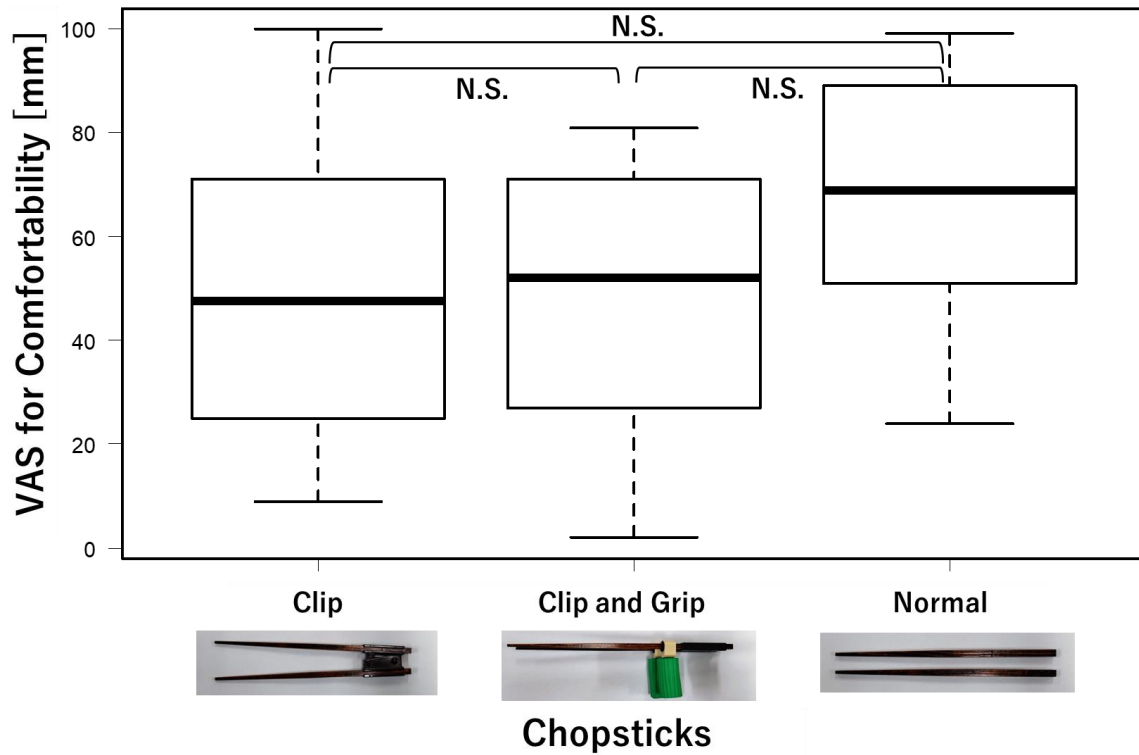


Figure 6. VAS for comfortability (N.S.: no significant difference, VAS: visual analog scale).

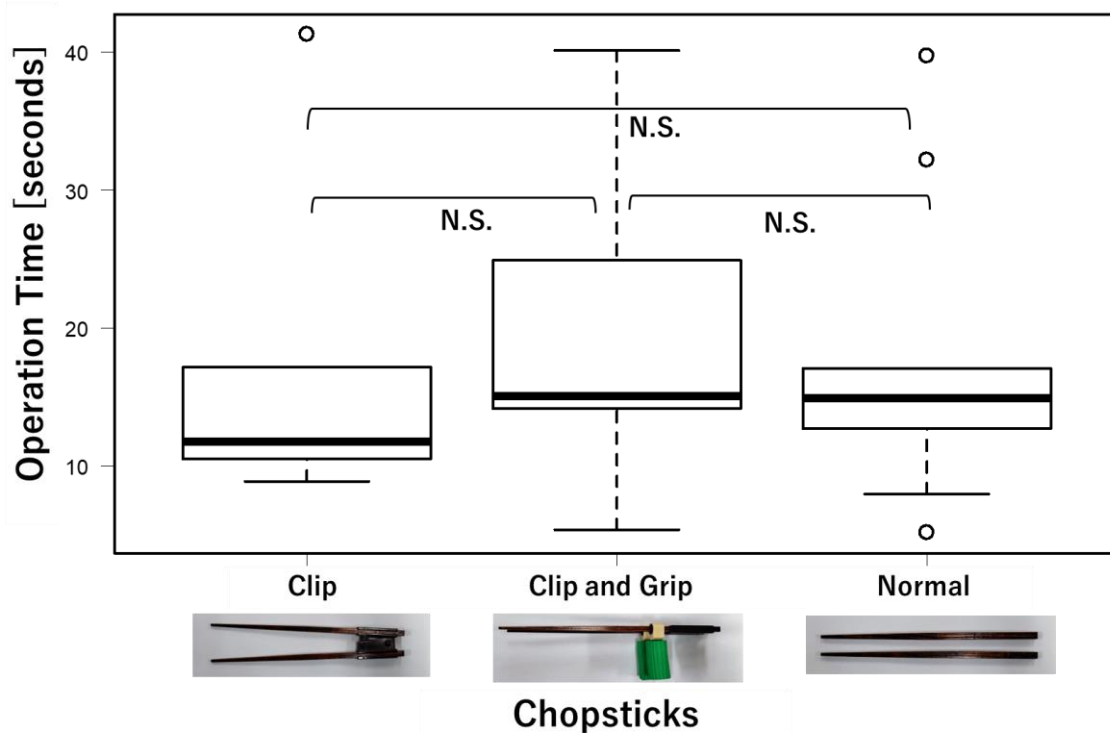


Figure 7. Operation time (N.S.: no significant difference).

4. DISCUSSION

The results showed that there was no significant difference in muscle activity, comfortability, and operation time during food cutting on three types of chopsticks. The results suggest the possibility that limitations of movement due to additional clip and grip do not affect musculoskeletal load, comfortability, and performance in food cutting. The reason for these results is considered that the orientations or rotations of chopsticks between pinching and cutting movements are similar. As mentioned previously, chopsticks using additional clip and grip could assist in eating tasks such as pinching, moving, and pulling in food handling [2–4]. These results suggest the possibility that assistive chopsticks using clips or grips can assist eating activities without interfering with food cutting. Chopsticks are used for various eating tasks such as scooping [1]. Thus, assistive chopsticks will be investigated for other eating tasks. Moreover, future works should measure loads on other muscles and other performances such as accuracy in food cutting.

In the experiment, the participants could select the grip position and holding mode for chopsticks. In future works, a suitable grip position will be explored for assistive chopsticks. If a suitable grip position can be found, the advantage of assistive chopsticks will be greater. The relationships between assistive chopsticks and holding mode should be investigated too, since holding mode affects performance [5]. In this study, the shape and length of chopsticks were constant. Assistive chopsticks will be investigated for various shapes and lengths in future works because there are relationships between these parameters and performance [8–11]. In addition, note the possibility that assistive chopsticks with a limited range of movement due to clip and grip cannot be used in cutting for larger foods than this study.

The limitation of this study was that the participants were only healthy young males. Chopsticks should be investigated for the elderly too, because there are differences in physical abilities such as grasping between the elderly and young [12]. Furthermore, future works should focus on disorders such as progressive supranuclear palsy since these disorders relate to performance of chopstick operations [13].

5. CONCLUSION

In this study, we investigated the effects of assistive chopsticks with grip and clip on musculoskeletal load, comfortability, and performance of food cutting. The results suggested the possibility that assistive chopsticks with clips and grips can assist eating activities without interfering with food cutting. In future works, assistive chopsticks will be tested for other tasks and various conditions.

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