Differences of the dietary intake between chopsticks and a spoon from the features of chewing

国際社会系(渡邊ゼミ)

S116128

吉田貴洋

Takahiro Yoshida

Abstract

Differences of the dietary intake between chopsticks and a spoon from the features of chewing

Aim: The purpose of this experiment was to reveal difference of the dietary intake between different eating tools, such as chopsticks and spoon. Methods: Participants participated two experiments in separated days. On first day, each participant ate rice (200g) with chopsticks or spoons. We used wearable device to record feature of chewing and participants were recorded with video camera. Participants were not allowed to speak and to drink during the eating. After the eating, satiety level was measured with visual analogue scale between one and ten. On second day, participants performed same procedure using remaining eating tools, i.e., spoons or chopsticks. Result: There were no significant differences between chopsticks and a spoon in satiety level, total time, total number of chewing, speed of chewing and number of chewing for each picked up rice ($p>0.05$). A significant difference between chopsticks and a spoon in amount of rice for each picked up as expected ($p < 0.05$). Conclusion: From these results, we suggested that a spoon helps increase amount of rice for each picked up.

咀嚼の特徴から考える箸とスプーンの食事摂取量の違い

目的：本研究の目的は、箸とスプーンの食事摂取量の違いを明らかにすることである。方法：中京大学の学生１０名を対象に実験を行った。実験は１人２回行った。１日目、対象者は箸もしくはスプーンの一方を使用し米飯２００ｇを完食した。我々は咀嚼を記録する為に、ビデオカメラとウェアラブルデバイスを使用した。対象者は咀嚼している間飲み物を飲むことや、喋る事を禁止された。対象者は完食して直ぐに満腹度を１から１０の間で示した。２日目、同じ方法でもう一方を使用しご飯を完食した。結果：箸とスプーン間に満腹感、総食事時間、総咀嚼回数、咀嚼速度、一口毎の咀嚼回数の有意な差は無かった（ｐ＜０．０５）。一口の量には有意な差があった（ｐ＜０．０５）。結論：これらの結果から、スプーンは一口の量を増やす助けとなる事を示唆した。

Diferencias de la ingesta dietética entre palillos y una cuchara de las características de masticar

Objetivo: El participante de este experimento fue revelar la diferencia de la ingesta dietética entre palillos y cuchara. Métodos: Los participantes participaron en dos experimentos en días separados. El primer día, cada participante comió arroz (200 g) con palillos o cucharas. Utilizamos un dispositivo portátil llamado Bitescan para grabar la característica de masticar y los sujetos se grabaron con una cámara de video. No se permitió que los participantes hablaran y bebieran durante la comida. Después de comer, a los participantes se les indicó un nivel de sensación de plenitud. Primer día, los sujetos realizaron el mismo procedimiento con palillos o cucharas. Resultado: No hubo diferencias significativas entre palillos y una cuchara en el tiempo total, el número total de masticación, la velocidad de masticación y el número de masticación por bocado ($p> 0.05$). Se observó una diferencia significativa entre los palillos y una cuchara en la cantidad de una mordida como se esperaba ($p <0.05$). Conclusión: A partir de estos resultados, sugerimos que una cuchara ayuda a aumentar la cantidad de una mordida.

Introduction

Recent years in Japan, aging population has been remarkable, and it predicts that will progress in the feature (Cabinet Office, Government of Japan, 2018). Currently, Japan has a total population of 126.71 million, of which 35.15 million are elderly people (Over 65 years old). In other words, elderly people actually account for 27.7% of the population. Accordingly, elderly people who account for a large proportion of the population are considered to affect various markets because it bears the responsibility in consuming society. In addition, the health of them is related to productivity (Nakata, T., 2008). In Japan, the percentage of people with low BMI is high in over the 70s. Undernutrition which one of the causes of low BMI is a problem in older adults (Men: 24%, Women: 37%, BMI standard value: 21.5-24.9) (Ministry of Health, Labor and Welfare, 2018). However, Japan is not the only country with the problem of undernourishment among the elderly. This problem is common in many developed countries. As one ages, several physiological processes may contribute towards the development of protein energy malnutrition. Protein energy malnutrition in elderly people comes at a significant cost to the individual, families, communities and the healthcare system. Failure to address this syndrome is not only unethical and unhealthy, but also costly (Visvanathan, R., 2003). Furthermore, undernutrition also is related to sarcopenia, flail, underweight and depression (Jeejeebhoy, K., 2012). The main cause of sarcopenia is a decrease in skeletal muscle mass, which is suppressed by moderate protein intake and strength training (Morley, J., et al., 2010). Underweight is especially due to lower food intake. Sarcopenia and flail will lead to a decrease in going out and a decline in quality of life.

Also, percentage of female underweight people (BMI＜18.5 kg/m^2) from their 20's to 50's age group exceeded 10 % in all age groups. Especially in young women (21.7% in 20's group), low protein intake is problem

(Ministry of Health, Labor and Welfare, 2018).

In addition, the problem of undernutrition in young athlete is clear in survey of each of competitions (Ishizaki, Y., 2013; Omi, N., et al., 2005; Simooka, R., et al., 2017; Adachi, T., Yamamoto, M., Saito, A., & Hotta, N., 2004). International Olympic Committee showed the risk of relative energy deficiency in sports and American Dietetic Association described importance of optimal nutrition to enhance physical activity, athletic performance, and recovery from exercise (Margo, M., et al., 2014; Nancy, R., Nancy, D., & Susie, L., 2009). Moreover, student athletes and their advisors often are misinformed or have misconceptions about sports nutrition. Nutritional needs for peak athletic performance include sufficient calorie intake, adequate hydration, and attention to timing of meals. Moreover, proper nutrition for young athletes is critical not only to their athletic success, but more importantly to their growth, development, and overall health (Nancy, C., Connie E, V., & Sheldon, M., 2005).

Recent studies of regarding chewing and a mouthful amounts of foods have shown that when various gels are used, if a mouthful amounts of foods is halved, the chewing time becomes 0.7 times (range is 3g-24g) (Kohyama, K., et al., 2014). Fukuda and Hirakawa (2009) discovered that in the case of rice, if a mouthful amounts of foods increases, both total chewing frequency and total chewing time increase linearly. However, even if a mouthful increased to two times and three times, the chewing frequency and the time including food in mouth did not increase to two times and three times. When rice was chewed well, the postprandial blood glucose level was always higher from 15 min to 150 min than when it was not chewing well and there was a significant difference between chewing well and not chewing well (Fukuda, H., & Hirakawa, T., 2009). Not chewing well is good way to increase the amount of intake because of feeling full when blood glucose level increases (AF, Debons., I, Krimsky., & A, From.,

1970). In fact, there also is a report that mastication helps digestion and absorption, improves cognitive function, and improves blood flow (Kiwako, S., Hiroki, N., & Ryusuke, K., 2008; AM, Pedersen., et al., 2002; Y, Hasegawa., et al., 2007). However, about digestion, there is also a report that the mastication seems to be crucial for gastrointestinal absorption of a number of essential foods like meat and vegetables, but not to others such as bread, cheese, rice, fish, and egg (AM, Pedersen., et al., 2002). There are various positive effects to chewing well but increase the amount of meal may be more important to get the nutrition.

Spoons were used all over the world before chopsticks spread and spoons are still mainly used in many countries. In addition, in also countries where chopsticks are widespread, spoons are used for serving dishes. For these reasons, a spoon is easy to use and suitable to pick up a lot of food at once (Yamamoto, N., 2016; Tsubame shinko Industrial Co., Ltd. 2013). Chopsticks are widely used mainly in Asia and previously were used mainly when grabbing soup ingredients. Namely, chopsticks are suitable to grab a solid that not too small (Yamamoto, N., 2016; Tsubame shinko Industrial Co., Ltd. 2013).

The purpose of this experiment was to reveal difference between the dietary intake of chopsticks and spoon from the satiety level and features of chewing. The results from this study would be useful to improve undernutrition of elderly people and underweight people (BMI＜18.5 kg/m2). Since increasing the amount of meals is essential to improve undernutrition of elderly people and underweight people and young athlete is assisted improving undernutrition and weight control. Improving underweight reduces the risk of death (Shizuka, S., et al., 2011) and also improving undernutrition leads to restraint of the cost of care.

We hypothesized that when eating with a spoon, food intake increases more than when using chopsticks

because when using a spoon, the percentage of chewing frequency and chewing time in a mouthful is less than using chopsticks results in inhibiting increase in postprandial blood glucose level, and hence inhibiting the stimulation of satiety center (AF, Debons., I, Krimsky., & A, From., 1970).

Materials and Methods

Participants

Ten healthy students in Chukyo University participated in this study (Age: 21.8±0.4, Weight: 56.7±10.1, BMI: 20.4 ± 2.4). The participants gave written informed consent for the study after receiving a detailed explanation of the purposes, potential benefits, and risks associated with participation in the study. All participants were fasted three hours before the experiment to match a condition among the participants.

Experimental design

Participants participated two experiments in separated days. First day, each participant ate rice (200 g) with chopsticks or spoons. During the eating, we used wearable device called Bitescan (Sharp corporation, Osaka, Japan) to record feature of chewing and video camera recorded participants, the meter and smartphone simultaneously. From rice on weighing scale between eating, amount of rice for each picked up was measured. Participants were not allowed to speak and to drink during the eating. After just the eating, participants were indicated satiety level with visual analogue scale between one and ten (One is hunger, ten is full). Second day, participants performed same procedure using remaining eating tools, i.e., chopsticks or spoons. The order to using chopsticks and spoons was decided at random. Spoons was 17 cm in length, 4 mm in depth and chopsticks was 22 cm in length (Figure1).

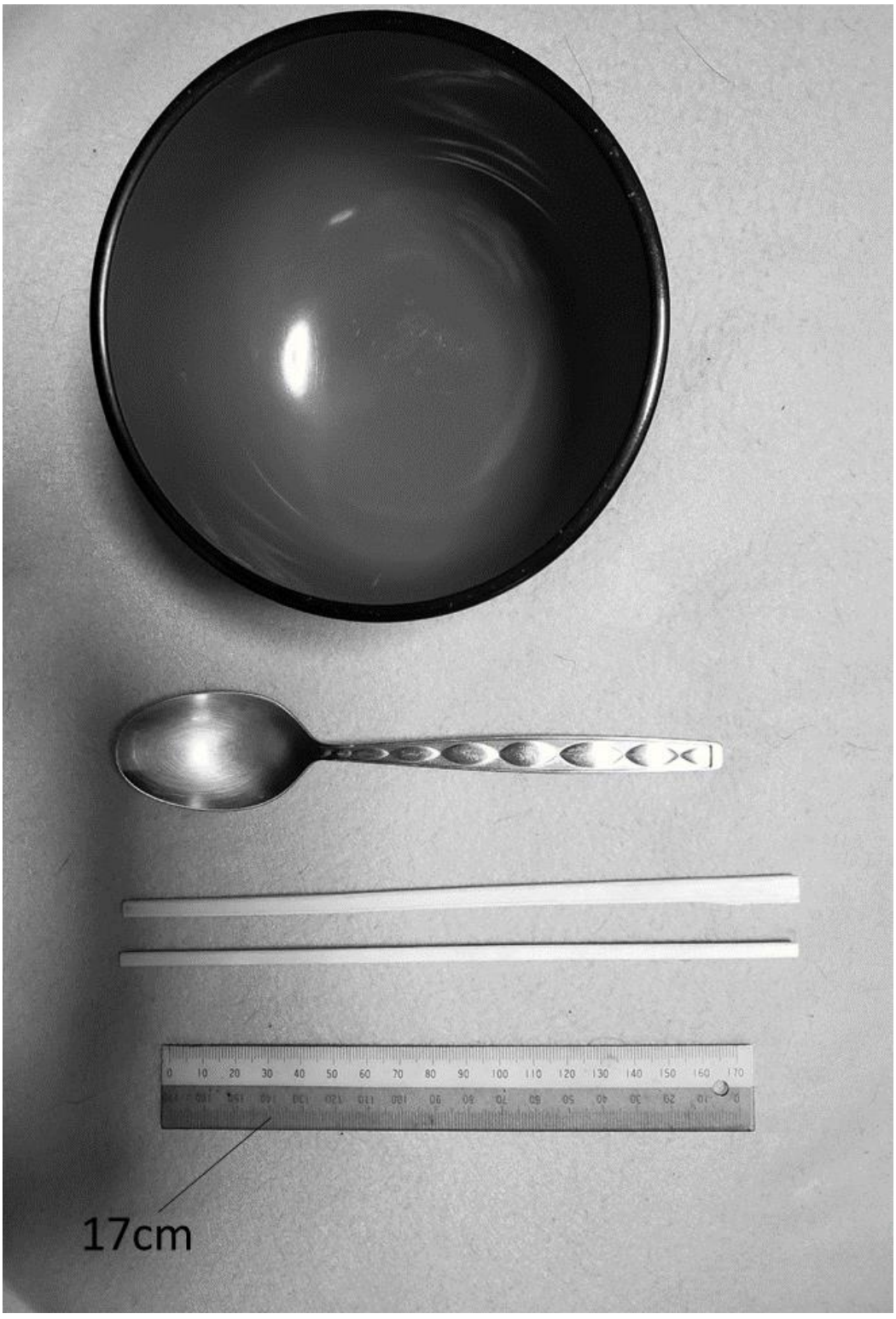

Fig.1 a bowl, chopsticks and a spoon

Measurements of bite features

Bitescan is a machine to record. Participants wore the device (Figure 2, 3). This device constructs the algorithm which identifies the amount of mastication by extraction difference between the features of wavelength and amplitude of mastication and other movements from the obtained waveform from an optical sensor and a triaxle acceleration sensor. Mastication that is recorded includes the following factor: Total time, total number of chewing, number of chewing for each picked up rice and speed of chewing. The device is connected to the smartphone via Bluetooth. Times of chewing is indicated immediately on smartphone. Total time, total number of chewing, number of chewing for each picked up rice and speed of chewing are checked on smartphone after measurement (Yoshio, Y., et al., 2018).

Food

Rice was used in this study because it is staple food in Japan and easy to eat with chopsticks and spoons (Ministry of Agriculture, Forestry and Fisheries, 2018). One of the microwave meals Sato-no-gohan which is Koshihikari from Niigata was used as rice. This study used one packs (200 g per pack). The amount of rice was referred to the meal balance guide issued by the Ministry of Health, Labor and Welfare. The standard for the amount of carbohydrates in one meal was equivalent to 200 g of rice. Pack of rice was warmed for two minutes with five hundred watts of power and the rice was kept for two minutes with the lid open to cool just before eating. All the rice was transferred from the pack to the bowl (Figure 1).

Fig. 2 Wearable device Bitescan

Fig. 3　Wearing Bitescan

Statistics

All data are provided as mean and SD. The non-parametric analysis was used for non-normally distributed data. Satiety level, total time, total number of chewing, speed of chewing, amount of rice for each picked up and number of chewing for each picked up rice were compared between when using chopsticks and a spoon using Wilcoxon signed-rank test. The level of statistical significance was set at $p < 0.05$. Statistical analyses were performed using SPSS software (version 25.0; SPSS, Tokyo, Japan).

Results

The average of satiety level were 6.2±1.7 and 6.3±1.9 for chopsticks and spoon, respectively. There was no significant difference in average of satiety level between chopsticks and spoon ($p > 0.05$) (Figure 4). The average of total number of chewing were 309.9 ± 133.9 and 319 ± 115.1 for chopsticks and spoon, respectively. There was no significant difference in average of total number of chewing between chopsticks and spoon ($p > 0.05$) (Figure 5). The average of number of chewing for each picked up were 23.8 ± 10.1 and 28 ± 10.7 for chopsticks and spoon, respectively. There was no significant difference in average of chewing for each picked up between chopsticks and spoon ($p > 0.05$) (Figure 6). The average of speed of chewing were 73.7 ± 8.8 and 76.7 ± 12.0 for chopsticks and spoon, respectively. There was no significant difference in average of speed of chewing between chopsticks and spoon ($p > 0.05$) (Figure 7). The average of total time were 5.8 ± 2.1 and 5.8 ± 1.7 for chopsticks and spoon, respectively. There was no significant difference in average of total time between chopsticks and spoon ($p > 0.05$) (Figure 8). The average of amount of rice for each picked up were 17.0 ± 7.4 and 18.9 ± 8.3 for chopsticks and

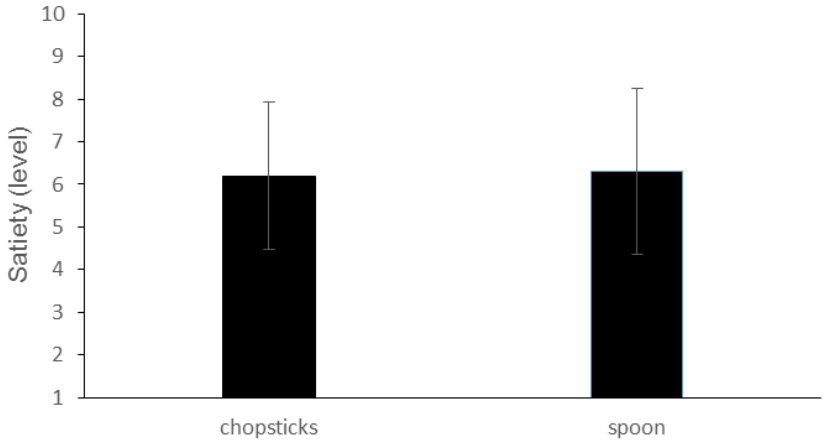

Fig. 4 The differences of satiety between chopsticks and a spoon. ($p > 0.05$)

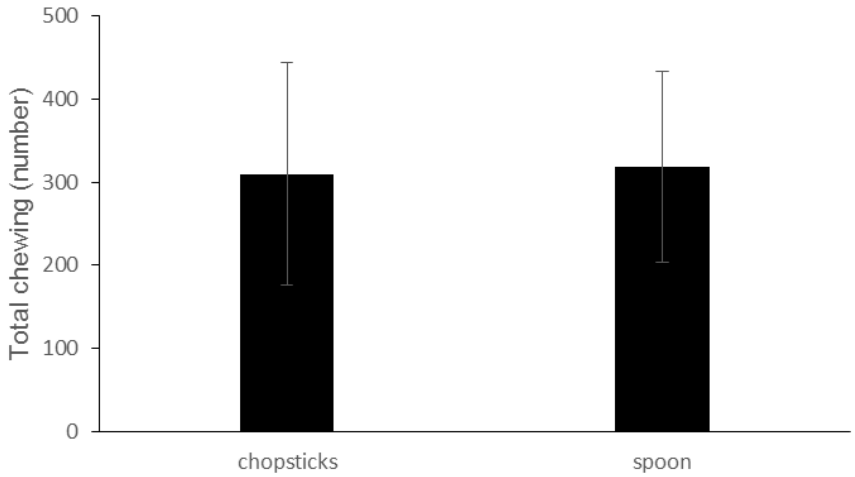

Fig. 5 The differences of total number of chewing between chopsticks and a spoon. ($p > 0.05$)

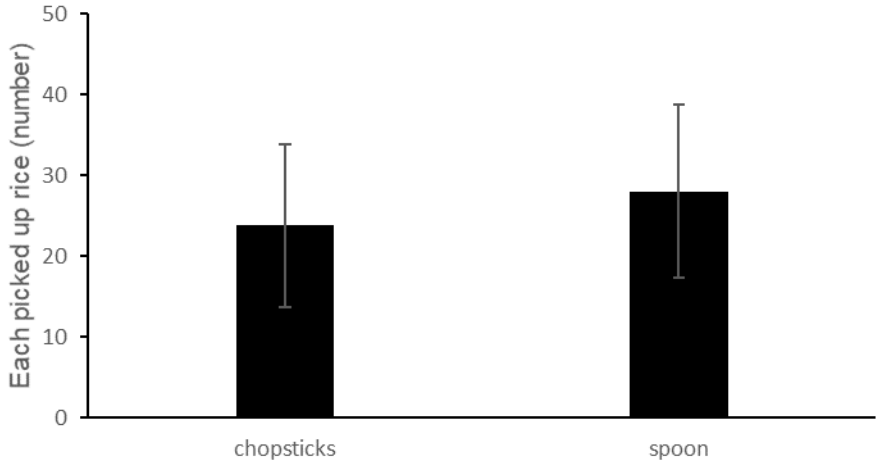

Fig. 6　The differences of number of chewing for each picked up rice between chopsticks and a spoon. ($p > 0.05$)

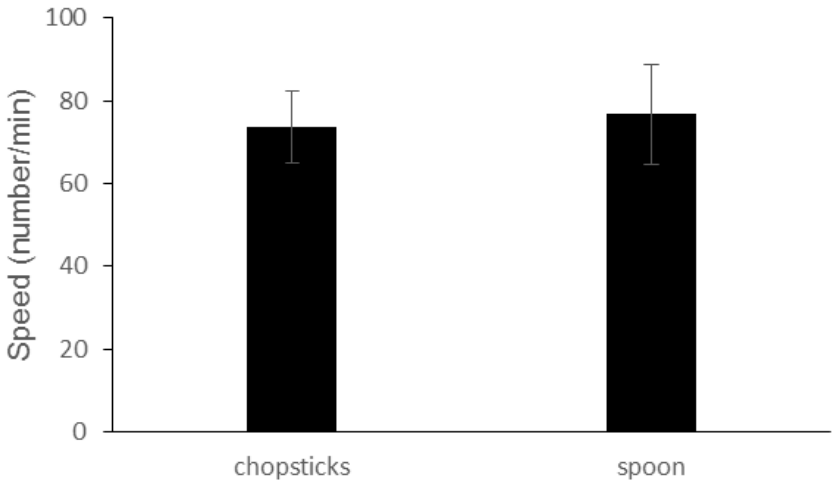

Fig. 7　The differences of speed of chewing between chopsticks and a spoon. ($p > 0.05$)

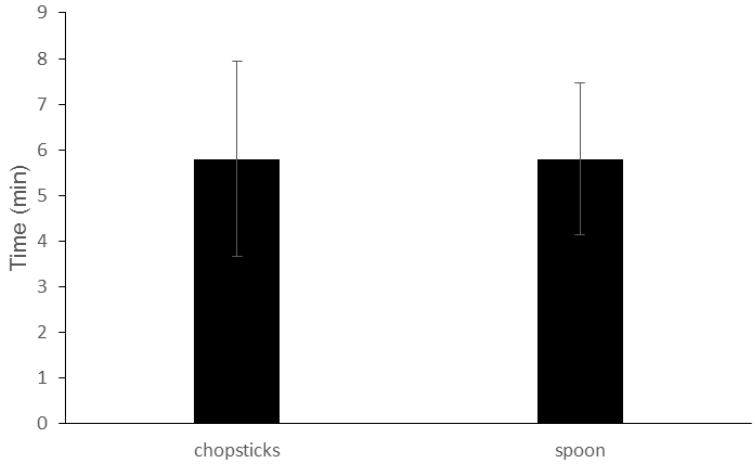

Fig. 8 The differences of total time between chopsticks and a spoon. ($p > 0.05$)

spoon, respectively. There was significant difference in average of amount of rice for each picked up between chopsticks and spoon ($p < 0.05$) (Figure 9).

Discussion

In the present study, a significant difference between chopsticks and a spoon was observed in amount of one bite as expected ($p < 0.05$). However, there were no significant differences in total time, total times of chewing, speed of chewing and number of chewing for each picked up rice between chopsticks and a spoon ($p > 0.05$). We consider that the reason why there was no significant difference in satiety is that there was no significant difference in the total number of chewing and total time because when chewing well, blood glucose level is increased then feel full (Fukuda, H., & Hirakawa, T., 2009; AF, Debons., I, Krimsky., & A, From., 1970). From previous studies, we predicted that there will be a difference in the number of chewing for each picked up rice when there is a difference in the amount of rice for each picked up (Kohyama, K., et al., 2014; Fukuda, H., & Hirakawa, T., 2009). However, this experiment suggests that there is no significant difference in number of chewing for each picked up rice when the difference in amount of rice for each picked up is small. This is because that the amount of food for each picked up is controlled to be doubled to tripled in previous studies (Kohyama, K., et al., 2014; Fukuda, H., & Hirakawa, T., 2009). When there is a significant difference in the amount of rice for each picked up and there is no significant difference in the total number of chewing, it is predicted that the number of chewing for each picked up rice is significantly higher with a spoon. The result of this study showed that there was no significant difference in the

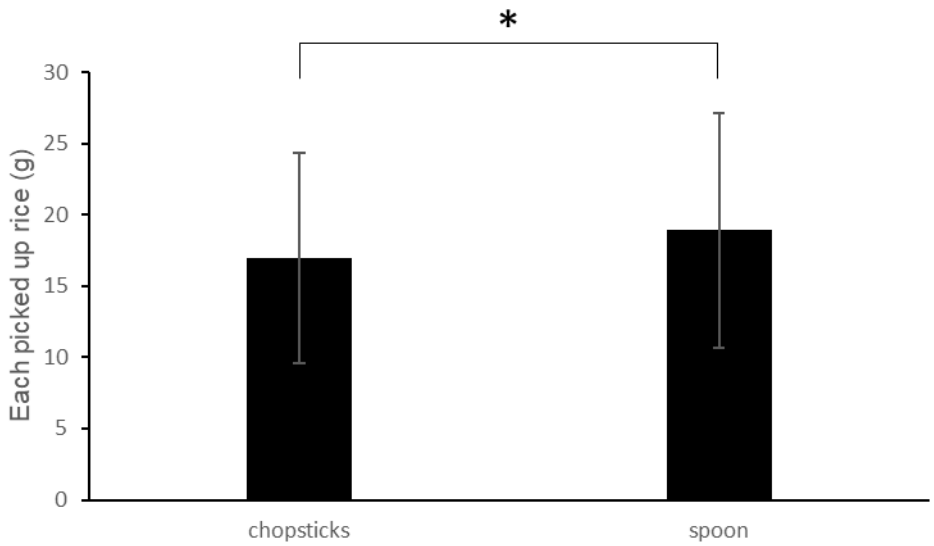

Fig. 9 The differences of amount of rice for each picked up between chopsticks and a spoon. (*$p < 0.05$)

number of chewing for each picked up rice as total number of chewing was very scattering data (Standard deviation, chopsticks: 309.9±133.9, spoons: 319±115.1).

In item of total number of chewing and number of chewing for each picked up, there was one participant who showed outlier. The average of total number of chewing when using a spoon was 1.1 times that when using chopsticks, whereas this participant showed 0.5 times. The average of number of chewing for each picked up when using a spoon was 1.2 times that when using chopsticks, whereas this participant showed 0.6 times. From these results, I determined that there was some abnormality in the measurement of this participant. Excepting one participant who showed outlier, total number of chewing, amount of rice for each picked up and number of chewing for each picked up were compared between when using chopsticks and a spoon by Wilcoxon signed-rank test as additional analysis. The average of total number of chewing were 289±124.7 and 324.3±120.1 for chopsticks and spoon, respectively. There was no significant difference in average of total number of chewing between chopsticks and spoon ($p > 0.05$). The average of amount of rice for each picked up were 17.3±7.7 and 19.3±8.6 for chopsticks and spoon, respectively. There was significant difference in average of amount of rice for each picked up between chopsticks and spoon ($p < 0.05$). The average of number of chewing for each picked up were 23.8±10.1 and 28±10.7 for chopsticks and spoon, respectively. There was significant difference in average of chewing per one between chopsticks and spoon ($p < 0.05$). These results suggest that the number of chewing for each picked up increases in direct proportion to the amount of rice for each picked up however, total number of chewing is unchanged. On other words, the difference in the amount of rice for each picked up between chopsticks and spoon is not enough to affect in satiety level and total number of chewing.

As mentioned above, the undernutrition for the elderly people is a problem, but the awareness of eating habits is high. Awareness about eating habits increases with age, and 77% (Men: 69%, Women: 85%) of elderly people over the 60's answers that they care the healthy meal (Ministry of Agriculture, Forestry and Fisheries, 2019). Hence, elderly people can expect to increase more the amount of food for each picked up by incorporating a spoon into their daily lives.

In conclusion, we compared the differences of the dietary intake between chopsticks and a spoon from the features of chewing. A significant difference between chopsticks and a spoon was observed in amount of one bite as expected. However, there were no significant differences between chopsticks and a spoon in total time, total number of chewing, speed of chewing and number of chewing per bite. From these results, we suggested that a spoon help increase amount of rice for each picked up.

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