Neuromuscular activation of masseter muscle during eating Japanese traditional foods and imported fast food

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Abstract

Neuromuscular activation of masseter muscle during eating Japanese traditional foods and imported fast food
Aim The purpose of the present study is to compare the change rate of neuromuscular activation of the masseter muscle between Japanese traditional foods and imported fast food. **Methods** Nine healthy men ate rice, salt-grilled mackerel, braised chicken and vegetable, spinach fried in butter and miso soup as Japanese traditional foods and hamburgers and French-fries were used as imported fast food. Using the surface electromyography (sEMG) and recorded video, on the basis of the first measurement using a gum, the Averaged rectified value (ARV) per chew of the first to eighth set was calculated and total number of chews was counted. **Results** The normalized ARV of each set and mean total number of chews in Japanese traditional foods were lower than imported fast food ($p < 0.05$). **Conclusion** From these results, we suggested that Japanese traditional foods require lower neuromuscular activation of the masseter muscle and number of chews than imported fast food.

和食とファストフードの食事中における咬筋活動
目的 本研究の目的は、和食とファストフードにおける一咀嚼当たりの咬筋における神経筋活動の変化率を同じカロリーの下で比較した。**方法** 9 人の健康な男性が、ご飯、鯖の塩焼き、筑前煮、ほうれん草のバター炒め、みそ汁を和食として摂取し、ハンバーガーとフライドポテトをファストフードとして摂取した。2 食分を 8 等分した食事を摂取し、1 食目の前後と 2 食目後に 1 秒に 1 回のペースで 1 分間ガムを噛ませた。2 種類の食事メニューとガムの摂取挙動は、左右の咬筋電位とビデオ観察を用いて解析した。1 食目の前のガムを基準にして、1 等分毎の 1 咀嚼あたりの平均 EMG と総咀嚼回数を求めた。**結果** 和食の変化率はファストフードと比べて低い結果が見られた ($p < 0.05$)。さらに、和食は平均総咀嚼回数が少ないことも確認された ($p < 0.05$)。**結論** これらの結果から、和食の食品はファストフードの食品と比べて、一咀嚼当たりの咬筋における神経筋活動が小さく、咀嚼回数が少ない可能性があるということが示唆された。

Neuromuskuläre Aktivierung der Muskelmasse während des Essens japanischer traditioneller Lebensmitteln und importierten Fast food
Ziel Ziel der vorliegenden Studie ist es, die Veränderungsrate der neuromuskulären Aktivierung des Massetermuskels zwischen traditionellen japanischen und importiertem Fast Food zu vergleichen. **Methoden** Neun gesunde Männer aßen Reis, Salzmakrele, geschmortes Hühnchen und Gemüse, gebratenen Spinat in Butter und Miso-Suppe als japanische traditionelle Essen und Hamburger und Pommes-Frites als importiertes Fast food. Unter Verwendung der Oberflächenelektromyographie (sEMG) und des Videos wurde auf der Basis der ersten Messung unter Verwendung eines Gummis der gemittelte gleichgerichtete Wert (ARV) des ersten bis achten Satzes berechnet und die Gesamtzahl der Kauen gezählt. **Ergebnisse** Die normalisierte ARV jedes Satzes und der mittleren Gesamtzahl an Kaugegenständen in traditionellen japanischen Essen war geringer ($p < 0,05$). **Schlussfolgerung** Aufgrund dieser Ergebnisse schlugen wir vor, dass japanische traditionelle Essen eine geringere neuromuskuläre Aktivierung des Massetermuskels und eine geringere Anzahl von Kauen erfordern.

Abbreviations:

SEMG: Surface electromyography.

ARV: Averaged rectified value.

Introduction

Mastication is a physiological process controlled by the central nervous system and modulated by inputs from the mouth. Mastication is also an important exercise to chew food, mix saliva and form a bolus suitable for swallowing. Peyron., et al., (2017) reported that some mastication parameters are slightly changed by age, but ageing itself does not impair mastication. Further, decreased chewing ability is related to eating habits and eating consciousness (Teraoka., et al., 1994). In addition, the maintenance or recovery of sufficient chewing ability for older adults is related to a longer total life expectancy and strongly related to a longer active life expectancy (Ikuo., & Saito. 2006). Moreover, mastication activates motor function and activities of daily living (ADL) (Nakata. 1998). Actually, low chewing ability was associated with lower ADL, lower cognitive functioning, depression and food insufficiency (Kimura., et al., 2013; Ono., et al., 2010). On the other hand, mastication is not only the direct action of digestion in an oral cavity, but has a vital role in the life and health.

In recent years, Japanese food culture has changed, and as one of the changes, many types of processed foods have spread. As a result, it is assumed the decline in chewing ability due to the spread of processed foods such as fast food and it is reported various studies related to these problems. In many mastication studies, a bite of food was used to quantify mastication by surface electromyography (sEMG), mastication pressure, or mastication exercise (Brown., et al., 1998; Kohyama., et al., 1998, 2000; Mathoniere., et al., 2000). However, in an actual meal, various foods are put into the mouth at the same time and bitten the amount larger than a bite size. To take the significance of mastication in daily life into consideration, it is not enough to just discuss a bite size.

Fast food is sold in large quantities, especially for young people, but it has a serious negative impact on

health. In the US consumption of high-fat fast food may contribute to higher energy and fat intake, and lower intake of healthful nutrients. (Paeratakul., et al., 2003). In ages 20 years and older, grouped based on their fast food intake status, fast food consumption was also associated with a diet high in energy and energy density and frequent fast food consumption may contribute to weight gain. (Shanthy., et al., 2004). At the same time, among Japanese young people from schoolchildren to university students, especially male university students eat fast food and hamburgers are also the most commonly consumed in their use of fast food (Asano., et al., 2003). Although ample studies demonstrate that the fast food imposes a negative effect on health, few reports are available on the EMG activity of the masseter muscle. Moreover, there are no quantified studies that the masseter muscle activity in fast food has lower compared to other food cultures.

The purpose of the present study is to compare the change of neuromuscular activation of the masseter muscle between Japanese traditional foods and imported fast food under the same calorie. We hypothesized that change rate of sEMG in Japanese traditional foods was higher than imported fast food. The Japanese traditional foods contain the meals that require a large amount of mastication quantities (Shiono., et al., 1986). In addition, Japanese traditional foods are chewed in a balanced manner (Kohyama., et al., 2003). There are more types of dishes provided as one serving in Japanese traditional foods than fast food. Therefore, the masseter muscle requires more neuromuscular activities to Japanese traditional foods.

Materials and Methods

Participants

Nine healthy men participated in this study. The participants gave written informed consent for this study after receiving a detailed explanation of the purposes, potential benefits, and risks associated with participation in this study.

Experimental design

Rice, salt-grilled mackerel, braised chicken and vegetable, spinach fried in butter and miso soup were used as Japanese traditional foods. The Japanese traditional foods were based on the Japanese style diet called one soup, three side dishes. A hamburger and French-fries (Hamburger and French-fries, McDonald's Holdings Japan Co., Ltd.) were used as fast food (Table 1).

In this study, two meals divided into each of four equal set for each type of food were prepared and the participants ate a total of eight sets to observe the change of neuromuscular activation of the masseter muscle. In order to compare the change in sEMG for Japanese traditional foods with those for imported fast food, the participants bit a chewing gum (Masticatory Performance Evaluating Gum, XYLITOL_* LOTTE Co., Ltd, Saitama, Japan). The participants bit the gum once per second for one minute before first and fourth set and after eighth set using metronome. After the chewing sixty times, the chewing gum was spat out. The participants were allowed to eat freely and were not allowed to speak during the eating. During eating chewing gum and meals, eating behavior was recorded by a video. When the participant finished eating, he raised his own hand. Each of participants ate one menu a day at lunch or dinner and the order of eating the meals was random.

Tabale 1　Two meals used in this study.　In Braised chicken and vegetable were contained taros konjaks, bamboo shoots, carrots and shiitakes.　In Miso soup were contained tofus and brown seaweeds.

	Food	Weight (one meal : g)	Calorie (one meal : kcal)
Japanese traditional foods	Rice	200.0	294.0
	Salt-grilled mackerel	50.0	155.0
	Braised chicken and vegetable	200.0	115.0
	Spinach fried in butter	40.0	52.0
	Miso soup	24.5	51.0
	Total	514.5	667.0
Imported fast food	Hamburger	104.0	256.0
	French Fries	135.0	410.0
	Total	239.0	666.0

EMG recording

SEMG were measured to assume the neuromuscular activation level of the masseter muscle and was recorded from left and right masseter muscles using electrodes with two 0.1 × 1 cm silver bars (FA-DL-141, 4 assist, Tokyo, Japan). This muscle was the powerful muscles of mastication that plays an important role during occlusion. The electrodes were connected to a differential amplifier with bandwidths of 5-500 Hz and gain of 1000-fold. Signals from the EMG system were sampled at 1000 Hz using an analog-to-digital converter (PowerLab, ADInstruments, Melborne Australia) and synchronized with a personal computer using LabChart software (version 8.1.13; ADInstruments, Melborne Australia). The three-axis acceleration sensor (FA-DL-111A, 4 assist, Tokyo, Japan) was also placed under the mouth to clarify the eating start time and synchronized with. Prior to attaching the electrode, the skin was cleaned with alcohol. The location of the electrodes is based on the method using landmarks (Castroflorio., et al., 2008; Saifuddin., et al., 2001). One line was drawn from the inferior border of tragus of ear to the angle of the mouth. The masseter muscle width was measured by palpation and half of the width of the muscle was marked with a landmark on that line. The electrode was placed so that the half of its upper edge overlaps the landmark on the line (Figure 1).

SEMG during biting the chewing gum were recorded before first set, after fourth and eighth set and also recorded during eating each of sets. To calculate the average rectified value (ARV) of the masseter muscle, the both of the right and left amplitudes were rectified. The muscle onset time was clarified based on the recorded video and the amplitude detected in the acceleration sensor. In order to count the total number of chews, the total number for each set was counted referring the recorded video and the electromyogram waveform. The ARV per chew of the

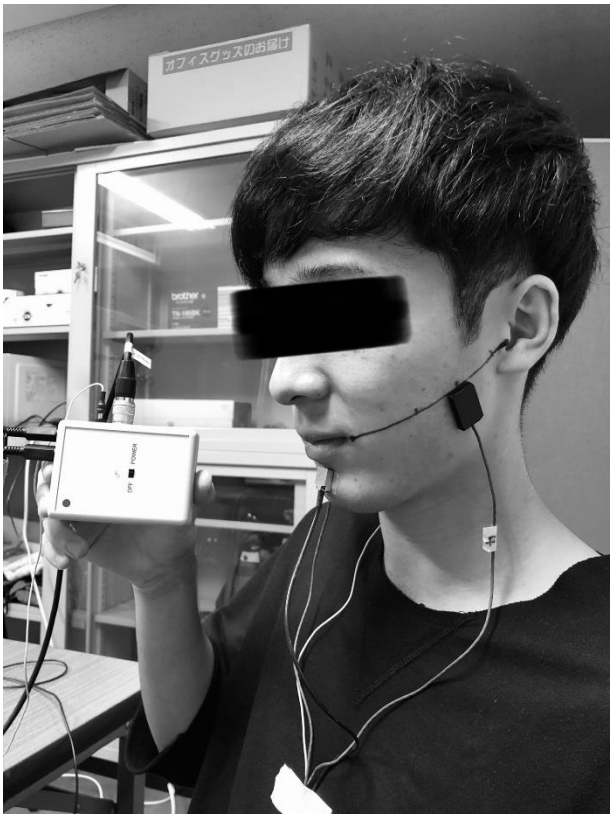


Fig. 1 Surface electromyography location of the masseter muscle using method of landmarks (Castroflorio., et al., 2008; Saifuddin., et al,. 2001) and a three-axis acceleration sensor was placed under the mouth.

first measurement using chewing gum was taken as one and compared to the second and third measurement using chewing gum. Moreover, the ARV of each set was normalized by the first measurement using chewing gum and the normalized ARV per chew of each set on the basis of first measurement using chewing gum was compared.

Statistics

All data are provided as mean and SD. Before the analysis, the non-parametric analysis was used in this study. Normalized ARV of first, second and third gum were compared between groups using Friedman test. Normalized ARV per chew of first to eighth set and the total number of chews were also compared to between the groups using Friedman test. In addition, each of the normalized ARV per chew and the total number of chews between same sets were compared between groups 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; SPSS, Tokyo, Japan).

Results

There were no significant differences between the groups in normalized ARV per chew of first, second and third gum in Japanese traditional foods and imported fast food ($p > 0.05$) (Figure 2). A significant difference between the groups was observed in the normalized ARV per chew of each set in each of the foods ($p < 0.05$) (Figure 3). Also, a significant difference between the groups was observed in the normalized ARV between two foods at first, second, third, seventh, and eighth ($p < 0.05$) and tendency of significant differences were observed at fourth, fifth, and sixth sets ($p = 0.051$) (Figure 4). There were significant differences between the groups in the total number

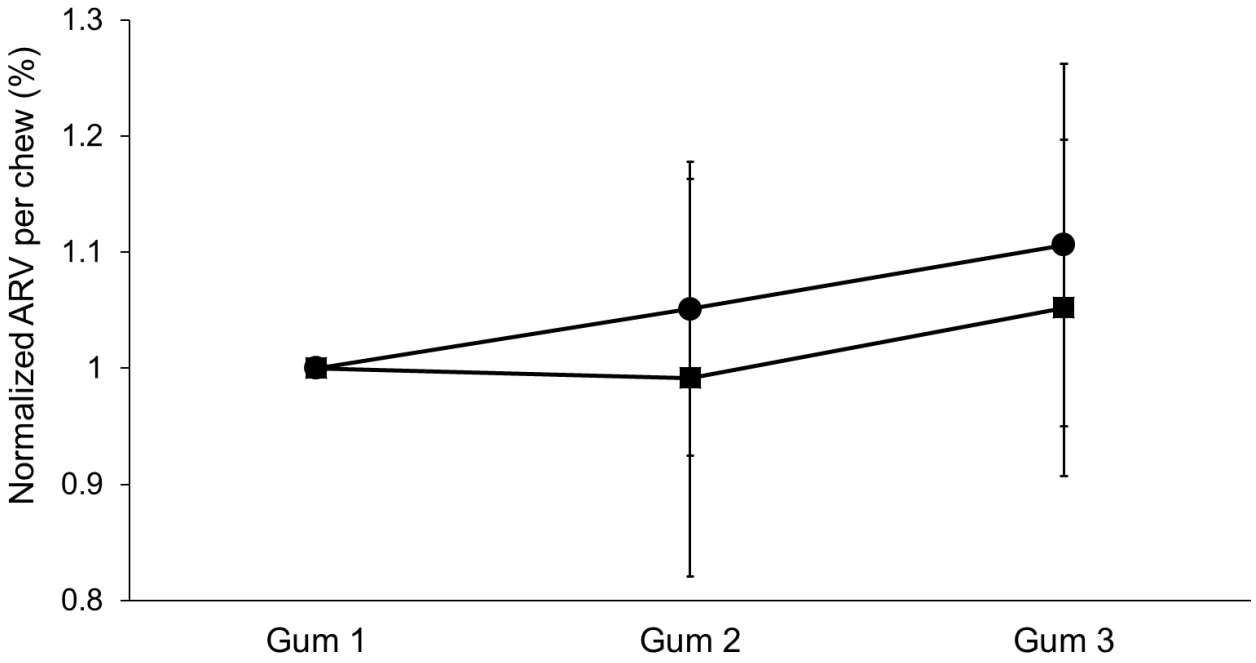


Fig. 2 Mean (SD ±) Normalized ARV per chew between first to third measurement using gum in Japanese traditional foods and imported fast food on the basis of the first measurement using chewing gum (● Japanese traditional foods ■ Imported fast food) ($p > 0.05$).

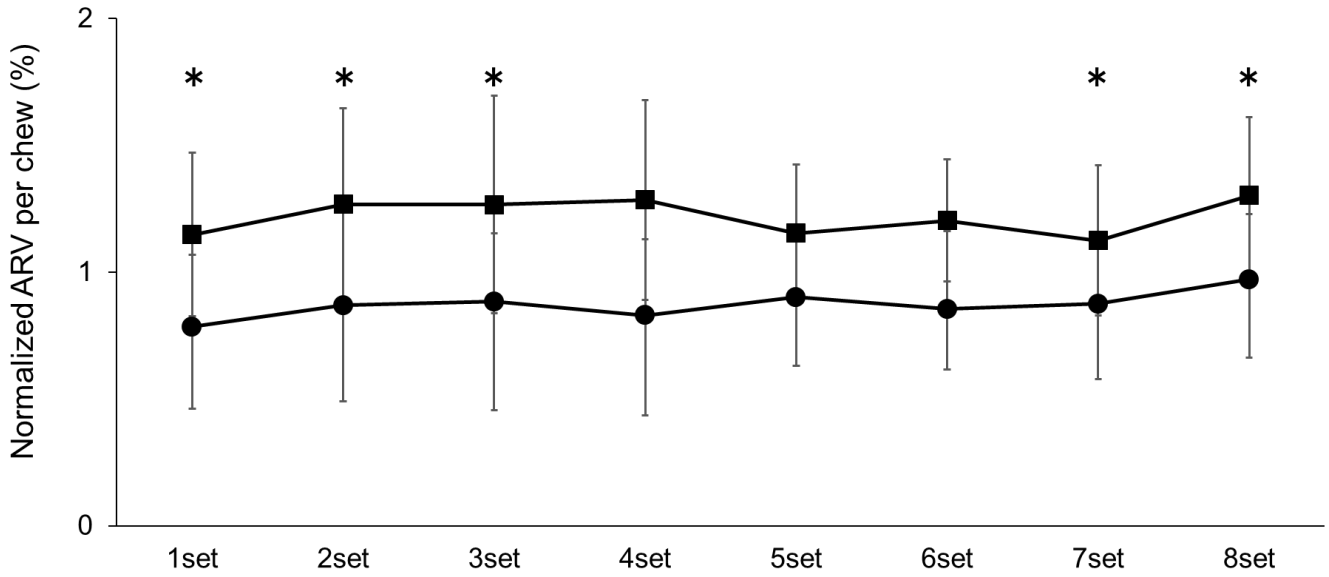
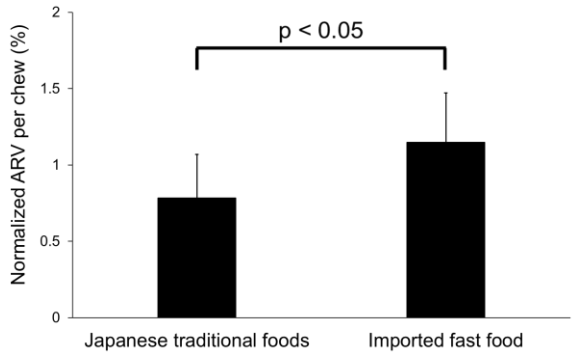
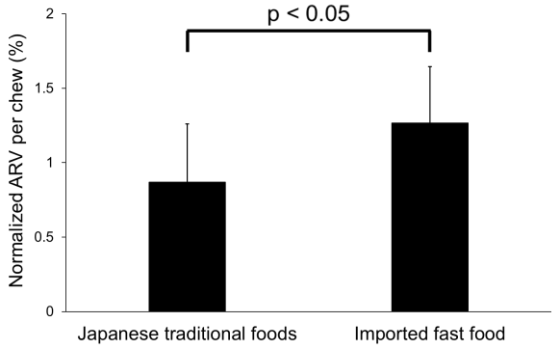


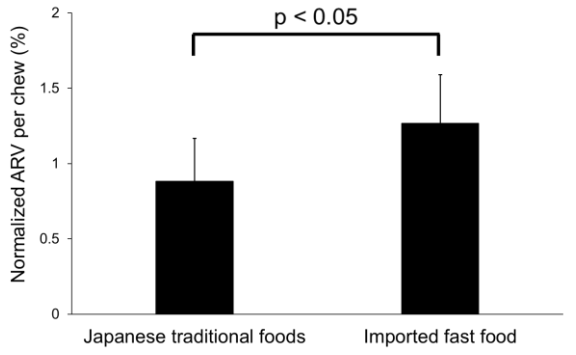
Fig. 3 Mean (SD ±) Normalized ARV per chew of each of sets in Japanese traditional foods and imported fast food on the basis of the first measurement using the gum (● Japanese traditional foods ■ Imported fast food). There were significant differences between the groups in normalized ARV per chew of each set in each of the foods (*$p < 0.05$ between two foods).



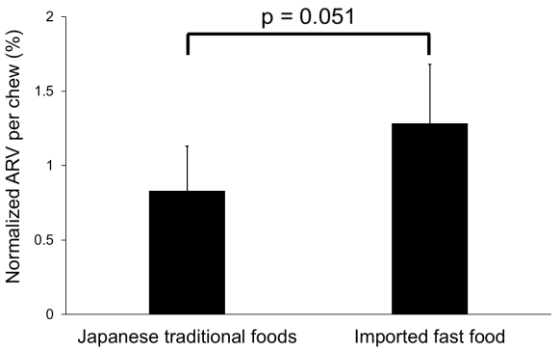
A The first set.



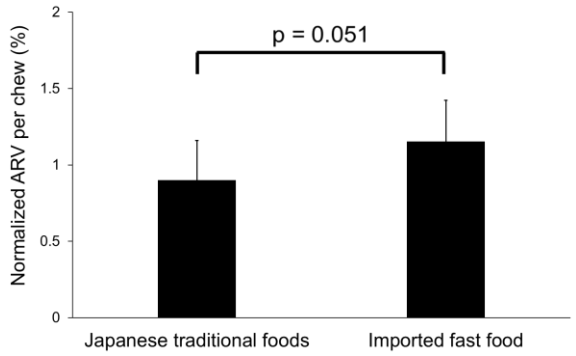
B The second set.



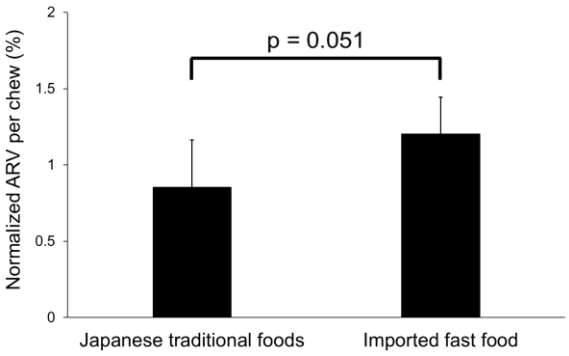
C The third set.



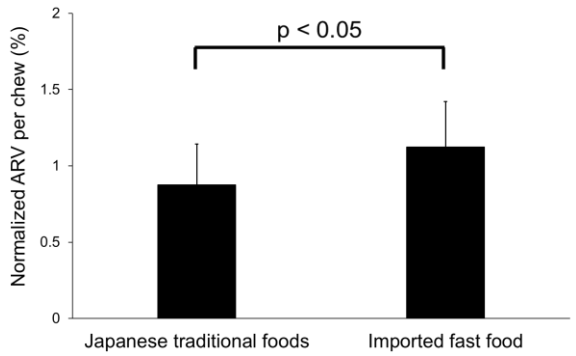
D The fourth set.



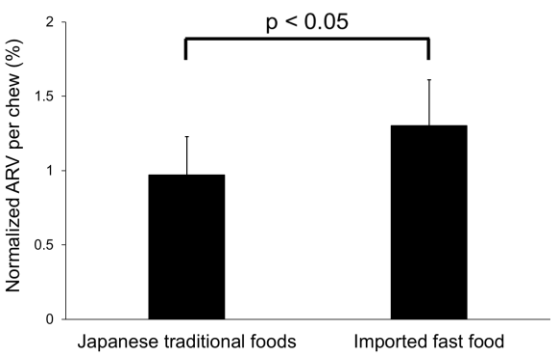
E The fifth set.



F The sixth set.



G The seventh set.



H The eighth set.

Fig. 4 The figures from A to H showed that mean (SD ±) each of Normalized ARV per chew between same sets in Japanese traditional foods and imported fast food on the basis of the first measurement using the chewing gum.

of chews of each food ($p < 0.05$) (Figure 5).

Discussion

In this study, there were no significant differences between the groups in normalized ARV per chew of first, second and third gum in Japanese traditional foods and imported fast food ($p > 0.05$) (Fig. 2). It is assumed that change was not occurred because the measurement time from end of meal to gum was not set. The time was left to the preparation of the participants. Also, the masseter muscle is almost restored motoneurone firing rates to normal within 3 minutes (Bigland., et al., 1986). Therefore, it is assumed that the masseter muscle has been restored motoneurone firing rates from the end of the meal to the next measurement using gum.

Normalized ARV per chew of the first to eighth set on the basis of the first measurement using gum was compared (Fig. 3). Also, each of normalized ARV per chew between same sets was compared (Fig. 4). The first measurement using gum is set at a fixed number of times and meal times, and chewing gum is a food with little change in toughness and elasticity. It is appeared that the normalized ARV per chew on the basis of the first measurement using gum tend to increase in each food, but the rate of fast food was higher than of Japanese food. The breakdown of food in mastication depends on the food the toughness and modulus of elasticity (Agrawal., et al., 1997). Horio & Kawamura (1988) reported that the duration of muscle discharge in the masseter muscle increased with hard food. Rice, salt-grilled mackerel, braised chicken and vegetable, spinach fried in butter and miso soup were used as Japanese traditional foods and hamburger and French-fries were used as fast food (Table 1). In Braised chicken and vegetable were contained taros, konjaks, bamboo shoots, carrots and shiitakes. In Miso soup were

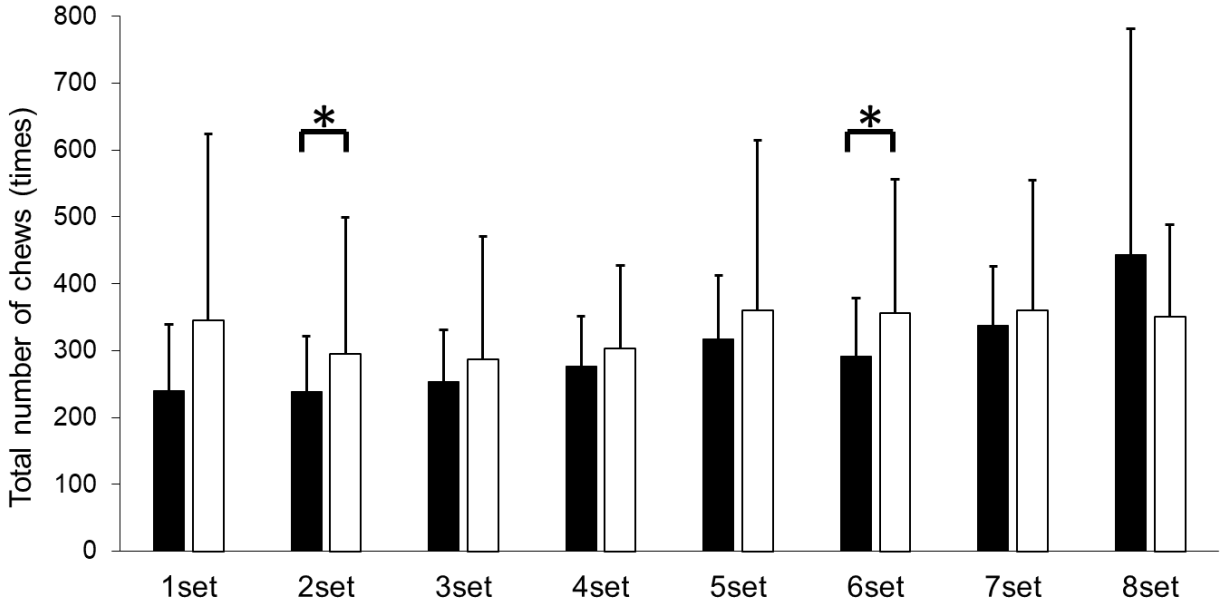


Fig. 5 Mean (± SD) Total number of chews each set in Japanese traditional foods and imported fast food (■ Japanese traditional foods, □ Imported fast food) (*$p < 0.05$ between two foods).

contained tofus and brown seaweeds. In Hamburgers were contained bread and hamburger steak. A study using the tactile sensor for detecting hardness showed that the hardness of the Japanese traditional foods used in this experiment is included in the first rank (≥ 0 Hz), second rank (≥ 500 Hz), and third rank (≥ 1000 Hz) excluding rice (Sekiguchi et al., 1996). Rice is included in the fourth rank (≥ 1500 Hz). Also, in imported fast food, French fries are included in the fourth rank (≥ 1500 Hz). Hamburger steak and breads included in hamburgers are ranked the fourth (≥ 1500 Hz). On the other hand, there is a possibility that imported fast food contains more food with higher hardness rank than Japanese traditional foods. From these results, it is considered that normalized ARV per chew increased during eating fast food.

Furthermore, in the total number of chews fast food was higher than Japanese traditional foods (Fig. 5). As mentioned above, in the foods used in this experiment, there is a possibility that imported fast food contains more food with higher hardness rank than Japanese traditional foods. In addition, hard foods require a greater number of chewing to swallow them (Nakamura 1987; Horio & Kawamura 1988). As a result, it is assumed that the number of chewing of imported fast food is greater than Japanese traditional foods.

In conclusion, using left and right masseter 1-channel surface electromyograms, the change rate of neuromuscular activation of the masseter muscle between Japanese traditional foods and imported fast food was compared under same calorie. Change rates of the sEMG per chew of each set in Japanese traditional foods were lower than imported fast food. In addition, mean total number of chews in Japanese traditional foods was also lower than imported fast food. Thus, we suggested that Japanese traditional foods require lower neuromuscular activation of the masseter muscle and number of chews than imported fast food.

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