Effect of listening to music with different tempo during moderate intensity pedaling exercise on the physiological responses

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Abstract

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Purpose The purpose of this study was to investigate the effect of listening to music with different tempo during moderate intensity pedaling exercise on the physiological responses. **Method** Twelve healthy participants performed moderate intensity pedaling exercise at constant exercise intensity at 7Mets for 5 minutes while three musical conditions: fast music (190 bpm), slow music (100 bpm), and no music. During the pedaling exercise, oxygen consumption (VO2), heart rate (HR), and cadence were measured. **Results** There were no significant differences in VO2, HR, and cadence among the three musical conditions ($p>0.05$). **Conclusion** Our data suggest that listening to music with different tempo during moderate intensity pedaling exercise, may not have different effects on the physiological response.

中強度ペダリング運動中のテンポの異なる音楽の聴取が生理学的応答に与える影響

目的　本研究の目的は、中強度のペダリング運動中に聴取する音楽のテンポの遅速が、生体にどのような影響を与えるのかを調べることである。**方法**　12 人の健康な男女が、7 メッツ相当の運動強度で自転車エルゴメーターによるペダリング運動を、早い音楽（190bpm）と遅い音楽（100bpm）、音楽なしの 3 条件で各 5 分間ずつ行った。その際の VO2、HR、回転数を計測した。**結果**　3 つの条件間の VO2、HR、回転数に、有意な差はみられなかった。（$p > 0.05$）**結論**　本研究の結果から、運動中の音楽のみならず、テンポの異なる音楽の聴取は、生体に異なる影響を与えない可能性があることを示唆する。

中等强度蹬踏运动中听快节奏音乐对生理反应的影响

这项研究的目的是调查听快节奏音乐的效果,在中等强度的自愿蹬踏运动中对生理反应。12 名健康大学生在三种音乐条件下以相当于 7 Mets 的运动强度进行中等强度的蹬踏运动 5 分钟：快音乐 (190 bpm)、慢音乐 (100 bpm) 和无音乐。那时，测量了摄氧量、心率和踏频。摄氧量、心率和踏频节奏在三种音乐条件之间没有显着影响（$p<0.05$）。我们的研究结果表明，在不同的节奏下听音乐以及在运动中听音乐可能不会影响对生理反应。

Abbreviations: ECG, Electrocardiogram; HR, Heart rate; HRmax, Maximal heart rate; MWSA, Mayer wave related sinus arrhythmia; RPE, rating of perceived exertion; RSA, respiratory sinus arrhythmia; VO2, Oxygen uptake; VO2max, Maximal oxygen uptake.

Introduction

Regular physical activity is a key protective factor for the prevention and management of noncommunicable diseases (NCDs) such as cardiovascular disease, type 2 diabetes, and cancers. Physical activity also benefits mental health, including prevention of cognitive decline and symptoms of depression and anxiety and can contribute to the maintenance of healthy weight and general well-being. The WHO guidelines on physical activity and sedentary behavior (2020) provide recommendations for children, adolescents, adults, and older adults on the amount of physical activity (frequency, intensity, and duration) required to offer significant health benefits and mitigate health risks (World Health Organization. (2020). Use of WHO guidelines on physical activity and sedentary behaviour: at a glance). That is all older adults should do at least 150– 300 minutes of moderate-intensity aerobic physical activity; or at least 75–150 minutes of vigorous-intensity aerobic physical activity; or an equivalent combination of moderate- and vigorous-intensity activity throughout a week, for substantial health benefits (World Health Organization. (2020). Use of WHO guidelines on physical activity and sedentary behaviour: at a glance). In addition, ACSM recommended to promote and maintain health, all healthy adults aged 18 to 65 need moderate-intensity aerobic physical activity for a minimum of 30 min on five days each week or vigorous-intensity aerobic physical activity for a minimum of 20 min on three days each week (American College of Sports Medicine (ACSM) and American Heart Association (AHA). (2007). Use of

Physical Activity Guidelines for American). Combinations of moderate- and vigorous-intensity activity can be performed to meet this recommendation. For example, a person can meet the recommendation by walking briskly for 30 min twice during the week and then jogging for 20 min on two other days. Furthermore, according to the report of exercise standards for health promotion (2006) by Ministry of Health, Labor, and Welfare of Japan, it is recommended that to promote and maintain health, all healthy adults aged 18 to 64 need physical activity of 23 Mets / hour / week with more than 3 Mets of exercise intensity. For example, a person can meet the recommendation by walking briskly (4Mets) for 6 hours a week or jogging (7Mets) for 3 hours a week. These recommendations are provided for not only healthy person but also subpopulations, such as pregnant and postpartum women, and people living with chronic conditions or disability (Ministry of Health, Labor, and Welfare of Japan. (2006). Use of the report of exercise standards for health promotion). It follows from what has been said that undertake moderate-intensity aerobic physical activity or more is important for most humans. However, global estimates indicate that 27.5% of adults and 81% of adolescents do not meet the WHO recommendations in 2010 for physical activity with almost no improvements during the past decade. Added to this, data from ACSM in 2005 indicate that less than half (49.1%) of U.S. adults met the CDC/ACSM physical activity recommendation. In Japan, according to the National Health and Nutrition Survey (2020), it is estimated that about 70% of people do not have exercise habits and do not meet the recommendations. Using IPAQ, Shibata et al.

(2009) estimated that 73.4% of adults do not meet the recommended standard of physical activity. All these things make it clear that there are few people who routinely carry out physical activity that exceeds the recommendations.

Various approaches have been taken to increase the amount of physical activity as much as possible. For example, extending duration, increasing intensity, increase the frequency, or changing the way are trying in order to increase total physical activity. Among various approaches, this study focused on workload for two reasons. First, there is need to exercise more efficiently in a situation there are not enough time. According to the National Health and Nutrition Survey (2020), it is clear that reason why exercise habits are hindered is that work, housework, and childcare is busy and there is no time (Ministry of Health, Labor, and Welfare of Japan. (2020). Use of the National Health and Nutrition Survey). Therefore, it can be imagined that it is practically difficult to extend the exercise time to increase the amount of physical activity. The second reason is that the importance of intensity has been gathering attention in the field of exercise physiology. High-intensity interval training (HIIT) has been attracting attention due to its effect that expected to improve cardiopulmonary function, increase muscle strength and to promote the fat burning effect in a short time (Ross et al. 2016). High-intensity exercise is also said to be effective in preventing and managing lifestyle disease such as sarcopenia and metabolic syndrome (Ross et al. 2016). As an example of an approach to increase the workload and increase the amount of physical activity, the Ministry of

Health, Labor and Welfare recommends adding to some extent workload in exercise that always do. For example, walking, if you a brisk walk you can expect 1.5 times more physical activity than normal walking, if you walk uphill, you can expect 1.7 times more physical activity, and if you slowly go up and down stairs, you can expect 1.3 times more physical activity (Ainsworth et al. 2000). Weight bearing during walking such as ankle brace could be also one of the classic ways to increase exercise intensity, have also attracted attention (Sooyong et al. 2016). However, Kutzner et al. (2010) reports that climbing stairs and hills puts a heavy burden on the knee joint, increasing the risk of injury and falls (Kutzner et al. 2010). Also, about ankle weights, Sooyong et al. (2016) may cause knee osteoarthritis disorder, increased body sway, increased risk of falls, and altered gait patterns if the ankle weights are not properly weighted (Sooyong et al. 2016). In this way, many approaches have been adopted to increase the amount of physical activity but there are always some risks in increasing the workload. These approach, which increase intensity using some tools, have been recommended and implemented in order to increase the amount of physical activity, but little attention has been given to approaches that affects the internal function of the body itself. This approach can be defined as to change the physiological responses by working on the internal parts of the body through the autonomic nerves even if the external factor does not change.

Caffeine provides an example. Effect of caffeine is many and different, for example, during exercise with caffeine, compared to not taking caffeine, research has shown that the caffeine

leads to increase energy consumption by improving promotion of fat burning effect and enhance muscular force development (Shabir et al. 2018; Timmins et al. 1995; Erica et al. 2010; Chesley et al. 1998). In addition to these, previous study suggested that caffeine makes you less likely to feel tired and has an analgesic effect, so caffeine leads to lower perceive exertion measures (RPE) and improved endurance exercise performance (Adrian et al. 2013; Pasman et al. 1995; Gregory et al. 2002). The background that causes these physiological responses is that caffeine promotes central nervous system excitement and arousal, and sympathetic nerve activity is increased. The point is that, even if the external factors do not change, some internal approach such as caffeine intake is possible to stimulate the inside of the body through the autonomic nervous system and promote changes in the physiological response. Music also appears to exert direct and indirect physiologic effects through the autonomic nervous system. There is considerable evidence to show that previous study presented various types of music and measured the subject's HR, emotions, Mayer wave related sinus arrhythmia (MWSA), and respiratory sinus arrhythmia (RSA) (Umemura et al. 1998). As a result, when listening to slow music such as classical music, emotions such as calmness and relaxation were induced, and parasympathetic nerve activity increased (Umemura et al. 1998). On the other hand, intense and bright music such as rock music made positive emotional states such as excitement and activity, and HR and sympathetic nerve activity were increased (Umemura et al. 1998). Kathi et al. (2005) also showed that music to enhances patient’s well-being, reduce stress, and

distract from unpleasant symptoms through the autonomic nerves. We may, therefore, reasonably conclude that the music holds the potential of causing physiological and psychological response by intervening autonomic nervous system.

In recent years, the number of people who use music during exercise has increased, and according to a previous study, it is estimated that 48% of people use that (Miyoshi.2014). One of the reasons is that music devices such as portable music players represented by the i-Pod have exploded and become widespread (Epstein 2010). It can be imagined that it has become possible to use it in all aspects of sports because these products can easily wear and with their hands and feet free. Considering the relationship between sports and music, music is widely used across sport and exercise for its reputed ergogenic and psychological properties for people of all generations regardless of a physical ability (Karageorghis. et al. 2018; Laukka & Quick 2013).

Many studies have been made on the relationship between the exercise and music of potential physiological and psychological feature, at the same time the beneficial effects of listening to music have been reported in a variety of applied settings. From an empirical point of view there are two main questions that need to be addressed. The first question is whether music has any effect on physiological and psychological measurements. The research evidence suggests that the use of music affects a range of dependent variables during exercise as below. Szmedra and Bacharach (1998) showed that exercising while listening to music differed on several measures

when compared to exercising in no music (Szmedra.1998). They found that hemodynamic and lactate measures were higher in the no music than in the music condition, although there was no difference in oxygen consumption (Szmedra.1998). Perceived exertion measures were also higher in the no music condition. They interpret their results as suggesting that music might allow participants to reduce muscle tension, thus increasing blood flow and consequently having a psychobiological impact on exercise (Szmedra.1998). Thornby et al. (1995) tested the effect of music and noise on participants. They found that the time spent exercising, the amount of work and HR were all significantly higher in the presence of music than in the other two conditions. By contrast, perceived exertion was lower in the music than in the other conditions. Perceived exertion was also greater in the no music than in the noise condition. Another study, where participants performed in a variety of conditions, found that perceived exertion while exercising in music was lower than for other attention distracters and for the no distraction condition in the previous study (Nethery et al. 1991). A more recent study by Edworthy et al (2006) showed that 10minuites of exercise while listening to music had a significant increase in HR of about 3% compared to the no music (Edworthy et al. 2006). The most consistent finding seems to be that perceived exertion appears to be lower when subject exercise to music, but its effect on actual performance and other physiological measures is perhaps less clear. The second question is whether the nature of the music has any effect on physiological and psychological measurements.

In this sphere, one of the key questions is that of whether fast music has different effects than slow music on either or both objective and subjective measures.

These physiological responses caused by listening to music have been found to be influenced by the components that make up the music. According to study by Karageorghis et al. (1999), music involves complex elements such as tempo, timbre, sound pressure, volume, and melody (Karageorghis et al. 1999). Therefore, when considering the influence of music, it is necessary to clearly distinguish which components affects the living body and how, and over the past few years a considerable number of studies have been made on the nature of the music itself. For example, Bernardi et al. (2006) presented various types of music and measured the HR, respiration, and cerebral blood flow of the participants (Bernardi et al. 2006). As a result, it was suggested that the music tempo is the main factor that affects the living body rather than the type and taste of music (Bernardi et al. 2006). In addition, Edworthy et al. (2006) focused on the loudness and tempo of music, and measured HR, RPE, treadmill running speed, and emotions under five conditions: fast/loud, fast/quiet, slow/loud, slow/quiet, or absent (Edworthy et al. 2006). As a result, HR, RPE, and running speed increased significantly under fast/loud musical conditions, but the results indicate that the effect of volume is dependent on the tempo of the music (Edworthy et al. 2006). As can be seen from the above studies, tempo is an important parameter that characterizes music and has the potential to great influence on physiological responses. Therefore, many studies focusing on tempo

of music. Avinash (2017) subjected their participants to three conditions, fast music, slow music and control. As a result, VO2 (5.5%), cardiac output (19%), stroke volume (17%), minute ventilation, and respiratory frequency significantly increased while listening to fast music compared to the slow music and no music. Systemic vascular resistance (SVR) significantly decreased while listening to fast music compared to slow music and no music. Brownley et al. (1995) also compared performance in fast and slow music conditions, as well as a no music condition. Their results showed an increased respiratory frequency during fast music compared to slow or no music. Becker et al. (1994) found that fast music produced a longer distance on an exercise bicycle, whereas a further study (Becker et al. 1995) found that slow music produced a decrement in walking distance. Copeland and Franks (1991) measured HR, rating of perceived exertion (RPE) and time to exhaustion on a group of exercising participants who ran on a treadmill in three different music conditions: slow easy-listening music; loud fast popular music; and no music. They found that HR, time to exhaustion and rated perceived exhaustion were all lower for the slow, soft music than for the loud, fast music. Edworthy et al. (2006) showed that fast music increases the running speed of the treadmill compared to slow music, and the heart rate increases accordingly. All these responses are possibly caused by music with different tempos. However, the effects of the nature of the music itself appear to be more ambiguous than the effects of the presence of music.

Focus on the tempo, for example, Edworthy et al. (2006) who conducted an experiment using three

music conditions; fast music, slow music, absent, they adopted [Viva La Van] as fast music stimulus, on the other hand, adopted [First Born's Lullaby] as a slow music stimulus. Birnbaum et al. (2009) introduced Miley Cyrus [See You Again] and Rihanna [Don't Stop the Music] as fast music stimuli, and as slow music stimuli. Five for Fighting [Superman] and Eve 6 [Here's to the Night] was adopted. However, these previous studies comparing slow and fast music might have issue; the tempo and harmony of the songs used in these previous studies are not constant, because it is famous songs that had already been fixed as original songs including various tempo and harmony. Therefore, we have the questions, whether the physiological response is influenced by the tempo itself, because except for elements of tempo are intricately intertwined with music.

The purpose of this study was to examine the effects of listening to music with different tempo during moderate-intensity pedaling exercise on the physiological responses. The present study used music that controlling the tempo constantly and a simple drum sound to exclude the influence of other parameters that make up the music, in order to investigate how music tempo affects the body. It was hypothesized that listening to fast music compared to listening to slow music and no music during exercise can give a greater load to the living body, such as an increase in VO2 and HR, even though the exercise intensity is the same. Because previous study reports that excitement of sympathetic nerve due to the influence of listening to fast music promotes physiological response (Birnbaum et al. 2009; Edworthy at al. 2006; Brownley et al. 1995).

Methods

1. Participants

Twelve healthy students volunteered as participants in this study (age 21.1 ± 0.5 years, height 162.4± 6.16 cm, body weight 53.4 ± 8.9 kg). No participants were taking any medication or had a smoking habit. And all subjects have not been involving vigorous exercising and drinking for 24hours before the study. They gave informed consent for the study after receiving a detailed explanation of the purposes, potential benefits, and risks associated with participation.

2. Study design

Figure 1 summarizes the design of the experiments. Subjects performed the pedaling exercise on an electrically braked cycle ergometer. Before the experiment began, subject is warm-up with 4 Mets which converted from body weight, on 5 minutes. After that subject carried out the exercise with 7Mets of exercise intensity on 5 minutes to each of the three experimental music conditions i.e., fast (190bpm), slow (100bpm), and no music. Order of three music conditions were randomized. During the pedaling exercise, VO2, HR, and pedaling cadence were measured.

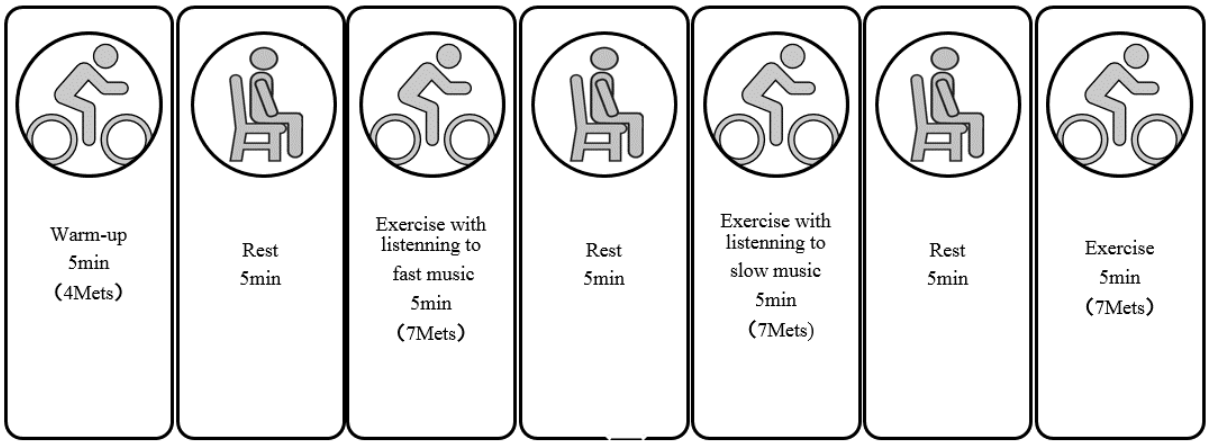

Figure1. Time schedule of the experiments.

3. Exercise

Participants performed the pedaling exercise on an electrically braked cycle ergometer (Aerobike 800; Combi Wellness, Tokyo, Japan). Saddle height was set at the trochanter height of individual. Consequently, the knee of the participants was slightly flexed (i.e., knee joint angle approximately 170 ° compared to full extension of 180 °) at the bottom of the crank cycle. Feet were fixed to the pedals by the pedal strap. The handlebar was in an upright position. The trunk of the participant was approximately vertical to horizontal line during exercise. During the pedaling exercise, participants remained seated on the saddle of the ergometer. During warm-up trial, participants were instructed to maintain pedaling cadence of 60rpm. For three music conditions, participants performed pedaling freely-chosen cadence.

Workload in the exercise was determined from the exercise intensity, which corresponds to adult medium-intensity exercise, i.e., 7Mets, with reference to the exercise standards for health promotion (2006) by Ministry of Health, Labor, and Welfare of Japan. Using ACSM's lower limb ergometer equation, workload for the exercises with three music condition were calculated from body weight of each participant. (ACSM metabolic calculation handbook .2008).

《 Lower limb ergometer equation 》

$$\text{V O2 (ml/kg/min)} = 1.8 \frac{\text{Power } (kg \cdot m / \text{min})}{\text{Body wight } (kg)} + 7$$

1 Mets = 3.5ml/kg/min

《 Conversion of watts 》

$$\text{Watts} = \frac{kg \cdot m / \text{min}}{6 \cdot 12}$$

The pedaling exercises for the three music conditions were set to 5 minutes for each, and the rest time between each exercise was set to 5 minutes.

4. Measurements

During exercise, participants wore the mask covering their nose and mouth for detecting the expired gas. VO2 was calculated from expired gas using the breath-by-breath method with an oxygen and carbon dioxide analyzer (Nippon photoelectric aero monitor AE310S, Minato Medical Science Co., Ltd., Osaka, Japan) and a flow transducer. VO2 was averaged for every 2-4 sec. Data from the gas analyzer and flow transducer were continuously recorded after conversion through the software (AT for Windows, Minato Medical Science Co., Ltd., Osaka, Japan).

Before the experiment, wipe off the sweat and sebum from the electrode-mounted area of the participants with alcohol cotton (Sanicot EQ AS ONE Co., Ltd. Osaka Japan), and then attached

an electrode (Magnerode TE-18, Fukuda Denshi Co., Ltd. Tokyo Japan) from the bipolar lead (CM5) electrocardiogram (ECG). The participants' ECG and HR were analyzed by a central monitor (DS-8600 system DS-8610) by way of ECG and respiratory transmitter (LX8100 Fukuda Denshi Co., Ltd. Tokyo Japan). The ECG signal was also collected after conversion through the software (AT for Windows, Minato Medical Science Co., Ltd., Osaka, Japan) from the gas analyzer and flow transducer. In case of failure to measure HR, subjects infrared radiation sensor at ear (ETC163 AEROBIKE 75XLⅢ, KONAMI sport & life Co., Ltd. Tokyo Japan) or finger (HPO-1601, OMRON Co., Ltd, Kyoto, Japan) were applied.

Cadences displayed on the monitor which had on an electrically braked cycle ergometer. It was recorded every 10 seconds, and the average every minute was used as the date. During exercise, participants were given discretion on the speed of the pedaling cadence.

During-the exercise trial, VO2, HR and cadences were measured at the end of the sample periods: 3-5 min.

5. Music

BPM is a unit that indicates the tempo of music and indicates how many beats are beaten in one minute. If you know the BPM value, you can grasp the approximate tempo of the song. The music was played garage band app through personal earphones (Ear Pods with Lightning Connector MMTN2JA,Apple Co.,Ltd California,America) in two of the experimental treatments, with the other

treatment being a no music condition where headphones were worn but nothing was played. One fast and one slow music were made referencing a modern analog sound which only comprises dram sound. For the music with fast and slow tempo, 190 and 100 bpm were used, respectively. These tempos were set with reference to previous studies (Fraisse 1982 &Trainer 2007). As a major premise, it is said that the tempo that is easy for humans to perceive, although there are individual differences, is in the range of 67-200 bpm, which makes it impossible to keep up with pace of the song from around 200 bpm. It is speculated that 200bpm is mistaken for 100bpm. (Fraisse 1982& Trainer 2007). First, regarding the setting of a fast tempo, after trying 200 bpm in a preliminary experiment, we rejected it and decided to set it to 190 bpm, which is estimated to be the fastest within the range that humans can perceive (Fraisse 1982 & Trainer 2007). Second, regarding the setting of the slow tempo, the tempo selected as slow music in the previous research varied, so it was decided mainly through preliminary experiments. The slow criterion used in previous studies was 70bpm, 80bpm, 117bpm, etc., and was determined to be 100bpm, based on the values of the preliminary experiment and the previous study (Edworthy et al. 2006 & Birnbaum et al. 2009). Both selections were played at approximately 60±dB at the ear. Volume was held constant for each. Right before the pedaling exercise, participants attached earphones, but during rest trial, earphone were removed.

6. Statistical Analysis

All data are provided as mean and SD. Since normal distributions of data were not found by Shapilo-Wilk test, non-parametric tests were used in this study. VO2, HR and cadence were compared between three music conditions by using Friedmann test. When significant effects of music condition, post-hoc test was applied to compare the values among the conditions. The level of statistical significance was set at $p < 0.05$. All statistical analyses were performed using SPSS software (SPSS version 15.0, Tokyo, Japan).

3. Results

There were no significant effects of music conditions on VO2 (Figure 2A), HR (Figure 2B) and cadence (Figure 2C) ($p > 0.05$ for all).

Discussion

The purpose of this study was to examine the effects of listening to music with different tempo during moderate-intensity pedaling exercise on the physiological responses. This study was hypothesized that listening to fast music compared to listening to slow music and no music during exercise can give a greater load to the living body, such as an increase in VO2 and HR, even though the exercise intensity is the same. Because previous study reports that excitement of sympathetic nerve due to the influence of listening to fast music promotes physiological response (Birnbaum et al. 2009; Edworthy at al. 2006; Brownley et al. 1995). However, in this study, significant differences

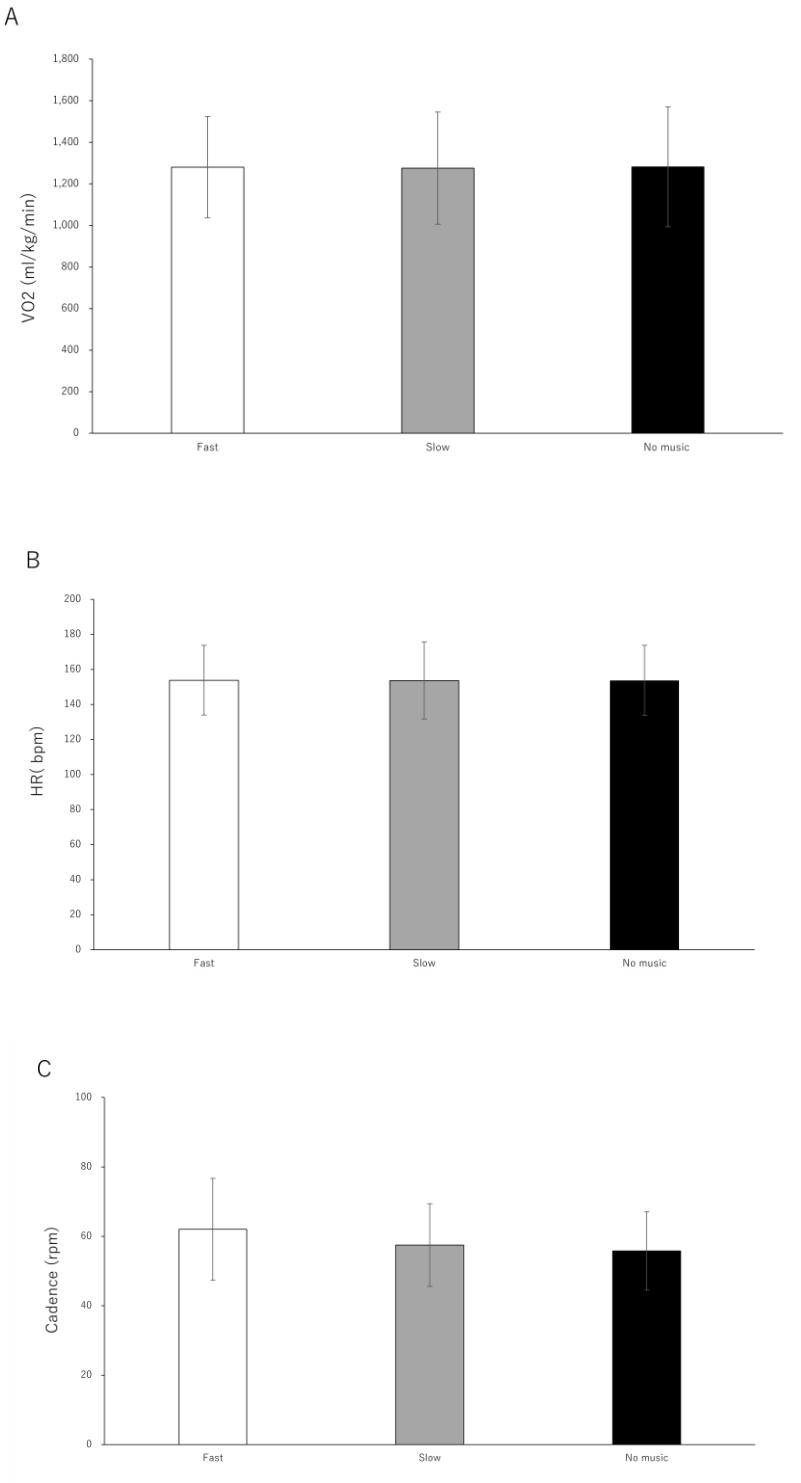

Figure 2 Mean data of oxygen consumption (VO2) (A), heart rate (HR)(B), and cadence (C) for the fast music and slow music and no music.

in Vo2, HR, and cadence under different three musical conditions could not be detected.

In this study, the workload was determined based on lower limb ergometer equation by converting the individual body weight. Its exercise intensity was 7 METs. The exercise intensity of this study based on the previous research, but incremental exercise test that used for standard way to determine the exercise intensity was not conducted, because Uchida et al. (2012) reported it is difficult to accurately obtain the data of unfamiliar non-exercise persons in the incremental exercise test (Uchida et al. 2012). Considering these reports, therefore, the load of 7 Mets was set to the wattage converted from the body weight individual. Since VO2max was not measured by performing an incremental exercise test in this study, an accurate exercise workload cannot be calculated. But %HRmax was calculated from the participant's HR based on the prospective maximal value [220-age (bpm)] (Machado et al. 2011). It can be estimated to average 76% HRmax. The load of 76%HRmax was estimated to be exercise of about 70% or less of the VO2max by referring to the report (Raven et al. 2013 & Garber et al. 2011). Both workload of 76%HRmax and 70%Vo2max seems reasonable to suppose that it is classified as medium-intensity exercise. The same observation applied to similar previous studies (Szmedra and Bacharach 1998; Edworthy et al. 2006; Birnbaum et al. 2009), it is also safe to say that compared the results of VO2, HR and cadence of our study with the previous studies (Szmedra and Bacharach 1998; Edworthy et al. 2006; Birnbaum et al. 2009). And it was predicted that the workload would not theoretically exceed

anaerobic threshold (AT). However, as you can see from Figure 3, both VO2, HR tended to increase as time proceeds, so workload used in this study may reach anaerobic threshold (AT).

Mostly the effects of music on exercise performance have been studied, previous study showed that music affects to reduce rating of perceived exertion, increase exercise enjoyment, and enhance exercise performance, mainly in low-moderate intensity exercises (Bucket et al. 2002; Crust et al. 2004; Potteiger et al. 2000; Schwartz et al. 1990). However surprisingly few studies have so far been made at supramaximal exercise, the effect of music on supramaximal exercise is not clear yet. Atan (2013) and Pujol et al. (1999) investigated the music effect on Wingate Anaerobic Power performance, and they found no significant differences between music and no music conditions (Atan 2013; Pujol et al. 1999). Schwartz et al. (1990) reported that in the case of anaerobic exercise, music and its rhythm cannot change physiological responses such as HR, blood lactate, and performance during exercise (Schwartz et al.1990). Some of the previous studies have shown that during anaerobic exercise listening to music with different tempo improves physical performance (Brownley et al. 1995; Copeland et al. 1991), but some studies have shown no improvement in performance (Coutts et al. 1961; Koç et al. 2009; Nelson et al. 1963; Schwartz 1990; Yamamoto et al. 2003). Like this, it has been reported that the influence of music is remarkable in the case of aerobic exercise, but the influence of music may be reduced in the case of anaerobic exercise. This study may support the results of these previous studies that investigated the effects of listening to

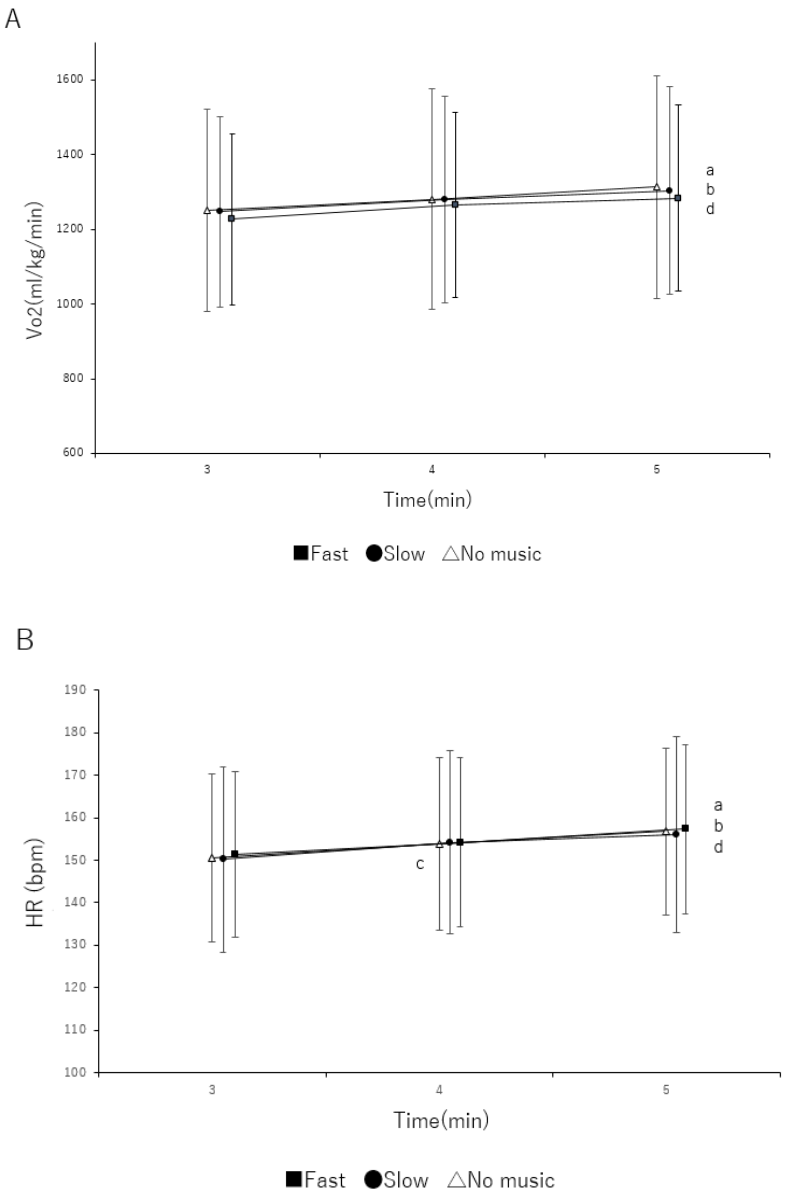

Figure 3 Time courses of oxygen consumption (VO2) (A) and heart rate (HR)(B)during exercises for the fast music and slow music and no music. a $p<0.05$ vs 3min for absent music; b $p<0.05$ vs 3min for 100bpm; c $p<0.05$ vs 3min for 100bpm; d $p<0.05$ vs 3min for 190bpm.

music under anaerobic exercise (Atan 2013; Pujol et al. 1999; Schwartz et al. 1990; Coutts et al. 1961; Koç et al. 2009; Nelson et al. 1963; Schwartz 1990; Yamamoto et al. 2003). Stuckey et al. (2012) reported that modulate autonomic nervous system inhibition and activation can depend on intensity and duration of exercise. First, regarding relationship between intensity and autonomic nervous system, studies by Daniela et al. (2014) and Shobo et al. (2010) have reported that high intensity exercise tends to suppress parasympathetic nerve activity and excite sympathetic nerve activity (Daniela et al. 2014; Shobo et al. 2010). These studies suggest that the higher the intensity, the higher the sympathetic nerve activity, while the lower the intensity, the higher the parasympathetic nerve activity. Previous studies using exercise intensity at 70％HR max has advocate these studies (Szmedra and Bacharach.1998; Birnbaum et al. 2009). However, in our study, despite the moderate or higher intensity exercise, we supported results different from those in previous studies using exercise intensity at 70％HR max. Regarding the relationship between duration of exercise and the autonomic nerve, according to the report by Shobo et al. (2010), among the exercise at 80%VO2max, the parasympathetic nerve showed a significant decrease after 2 minutes, and the sympathetic nerve showed a significant increase after 5 minutes. Because the exercise was performed for 5 minutes in this study, it is possible that the exchange nerve did not work predominantly within the experimental time. It can be considered that this may not have enhanced the effect of the music that should be supposed to obtained.

Effect of listening to music with different tempo on the physiological response in each study may be due to differences in music tempo. Music tempo used in this study was 190 bpm for fast music and 100 bpm for slow music. Regarding the fast tempo, considering the possibility that it will not be able to keep up with the beat and miscounted beat, the tempo is set to 5 % lower to maximum of perceptible tempo which was reported 200bpm (Fraisse, 1982; Trainer, 2007). Compared to similar previous studies (Atan.2013; Edworthy.2006), 190bpm is somewhat consistent with Atan (2013) and Edworthy (2006) with 200 bpm. Regarding the slow tempo, we also referred to previous studies (Atan.2013; Edworthy.2006). However, in this study, there was no difference in the physiological response under the three musical conditions, it is probable that setting the tempo in this study had some problems. Compared with Brohmer and Becker (2006) and Pujol (1999) studies which used 85-120 bpm as fast music, fast music in the present study was much faster (Brohmer and Becker 2006; Pujol 1999). On the other hand, compared with the studies of Atan (2013) and Edworthy et al. (2006) which used 70-80 bpm as slow music, slow music in the present study was much slower (Atan 2013; Edworthy et al. 2006). According to Umemura et al. (1998), the faster the music, the more significant the sympathetic nerve activity, on the other hands, the slower the music, the greater the parasympathetic nerve activity. In that case, the larger the difference between fast music and slow music, the larger the difference in stimulation to the autonomic nerves, which may have led to a large difference in physiological responses. In fact, in previous studies (Edworthy

2006), there were significant differences in HR, RPE, running speed, and emotions between 200bpm and 70bpm (difference of 130bpm). In this study, the contrast was 100bpm-190bpm (difference of 90), which was lesser than that of the Edworthy et al.'s study that supported the influence of music tempo, so it was possible that the results would be difficult to obtain (Edworthy et al. 2006). It may need to consider that individuals may feel differently because of their different responsiveness to music. The responsiveness of music may change depending on the feelings of the day, and the sensitivity and may differ depending on the habit of listening to music such as volume, frequency, and type of song (Kliuchko et al. 2015). Since the sensitivities differ from person to person, it is possible that the effects of music obtained between individuals were not maximized (Kliuchko et al. 2015; Hernandez et al. 2015; Ridder et al. 2013; Funahashi 2012).

The physiological responses evoked by listening to music have been found to be influenced by the components of the music (Edworthy et al. 2006). We used the music adopted a drum sound, and the tempo and volume were controlled to be constant in the three exercise tasks, aimed to consider how the influence of tempo on physiological responses. However, one issue that was not considered in this study was that of preference. As the music selection was made by the music speed, it is quite possible that some of the participants did not like the music. It is important as individual and preference factors are also known to affect in exercise performance (Dwyer et al. 1995; Karageorghis et al. 1999; North and Hargreaves. 2000), which in turn may have led to some of

the participants exercising less optimally than others. In addition, it has been reported that listening to subjectively preferred music and rhythms may affect changes in autonomic nervous function during exercise and promote psychological changes (Kornysheva 2010: Umemura et al. 1998). The data collected in this study do not allow any detailed investigation of the potential effects of preference on performance, but it is quite possible that preference would have had some effect, particularly if the findings presented here are to any extent aesthetically mediated, which they appear to be.

In conclusion, the purpose of this study was to examine the effects of listening to music with different tempo during moderate-intensity pedaling exercise on the physiological responses. However, there were no significant effects of music conditions on in VO2, HR, and cadence ($p>0.05$). Our data suggest that listening to fast or slow music during moderate-intensity voluntary pedaling exercise may not have different effects on the physiological responses.

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Relationship between understanding of food labeling and degree of awareness of eating habits in young people

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Abstract

Relationship between understanding of food labeling and degree of awareness of eating habits in young people

This study aimed to clarify whether the understanding of food labeling is proportional to degree of awareness of eating habits in young people. A questionnaire survey was conducted on 117 young people ranging from 20 to 29 years old. Two questionnaires were conducted a survey on the degree of understanding of food labeling among young people and a survey on the degree of awareness of eating habits. There are 7 questions about knowledge and 6 questions about eating habits. Specifically, it is the degree of understanding of the displayed contents of food labels, the presence or absence of recognition, and the degree of awareness in eating habits. The results showed that there was no correlation between the understanding of food labeling and degree of awareness of eating habits in young people ($p > 0.05$). These results suggest that understanding of food labeling is not related to degree of awareness of eating habits. Understanding of food labeling is not related to degree of awareness of eating habits in young people.

若者の食品表示の理解度と食生活の意識の高さの関係性

本研究の目的は、若者の食品表示の理解度が食生活の意識の高さに比例しているのかを明らかにすることであった。アンケート調査を２０歳から２９歳の若者１１７名（女性７６名、男性４１名、その他０名）を対象として行った。アンケートは若者の食品表示の理解度について調査と食生活への意識の高さについて調査の２種類を実施した。知識問題全７問、食生活の意識の高さを問うもの全６問となっている。具体的には食品ラベルの表示内容の理解度、認知の有無や食生活における意識の高さである。結果は、若者の食品表示の理解度と食生活への意識の高さは統計的に有意な相関関係は見られなかった（$p>0.05$）。これらの結果から、若者の食品表示の理解度と食生活への意識の高さの間に関係性がないことが示唆された。

Relación entre la comprensión de los jóvenes sobre el etiquetado de los alimentos y la alta conciencia de los hábitos alimentarios

El propósito de este estudio fue aclarar si el grado de comprensión del etiquetado de los alimentos entre los jóvenes es proporcional al grado de conciencia de los hábitos alimentarios. Se realizó una encuesta a 117 jóvenes de 20 a 29 años (76 mujeres, 41 hombres y otros 0). Se realizaron dos tipos de cuestionarios: una encuesta sobre el grado de comprensión del etiquetado de los alimentos entre los jóvenes y la otra sobre el alto nivel de conciencia en los hábitos alimentarios. Hay 7 preguntas acerca de los conocimientos alimentarios y 6 preguntas sobre la costumbre alimentaria. En concreto, es el grado de comprensión de los contenidos mostrados en las etiquetas de los alimentos, la presencia o ausencia de reconocimiento y el alto nivel de conciencia acerca de los hábitos alimentarios. El resultado fue que no hubo una significación estadística entre el grado de comprensión del etiquetado de los alimentos y su alta conciencia de los hábitos alimentarios entre los jóvenes (p> 0,05). Estos resultados sugieren que no existe relación entre la comprensión de los jóvenes sobre el etiquetado de los alimentos y su alta conciencia de los hábitos alimentarios.

Introduction

The appearance of adulthood is an important stage for health as it is often combined with the transition to unhealthy eating behavior and can adversely affect health（Stock, 2018). However, the rate of skipping breakfast is highest for both men and women in their twenties and tends to decrease with age (Ministry of Health, Labor and Welfare, 2014). Compared to other age groups, the number of people in their twenties are the lowest among those who answered, "I think I am careful my eating habits for my health (Ministry of Health, Labor and Welfare 2014). Breakfast skipping is associated with weight gain and then leads obesity (Smith et al,2017). Therefore, it is necessary to change the behavior of diets in young people in order to have a healthy life Smoking is also one of the causes of unhealthy life that causes illness (West, 2017). There is a TTM-like approach to quit smoking, no such approach is taken in the diet. In the case of smoking, there is established evidence that no smoking can be effectively promoted by using a behavior modification called TTM（Prochaska et al ,1997). In addition to TTM, behavioral transformation models include health belief models and pre-seed / pro-seed models. In the transtheoretical model, knowledge is acquired by collecting information in the first stage of the pre-contemplation period. And at a later stage, they are taking action（Rahimi et al,2019）. Also, I am conscious by imagining myself when I take action in the process of re-evaluating myself. In the health belief model, knowledge is acquired by weighing the advantages and disadvantages of good health behavior (Aldohaian et al, 2019).

Moreover, he is aware of the seriousness by feeling a sense of danger and recognizing the threat. (Aldohaian et al, 2019). In the pre-seed pro-seed model, knowledge is acquired by knowing what the target group thinks about their own needs and QOL in the first stage of social diagnosis (Cereda et al,2020). In the second stage of epidemiological diagnosis, we are conscious of clarifying health issues and their indicators and setting target values to be achieved (Cereda et al,2020). What these three behaviors modification models have in common is the acquisition of knowledge and awareness of behavior. Based on National Examination for Management Dietitians, knowledge about food includes food and health basic nutrition, applied nutrition, eternity education theory, clinical nutrition, public nutrition, and food management theory（Ministry of Health, Labor and Welfare, 4th year of Ordinance, National Examination for Management Dietitians) Food labeling is the only information that consumers can know when selecting food. "A food labeling system between white person in the United States and Latin Americans and Mexicans Previous studies on understanding and use" have shown that food labeling can guide consumers by allowing them to select informed foods (Nieto et al, 2019). Depending on the characteristics of foods, it is necessary to label items related to quality such as name, place of origin, name of raw material, allergens, expiration date, items related to ensuring safety such as storage method, and nutritional components （Ministry of Internal Affairs and Communications, 2016).Food labeling is an important source of information for consumers to correctly understand the content of food

when purchasing food, to ensure the selection of food and the safety of ingestion(Ministry of Internal Affairs and Communications, fact-finding survey on food labeling, 2016). However, young people tend to be less in aware of food labeling than older people, both men and women (Consumer Affairs Agency, 2018).

The aim of this study is to make clear the relationship between the degree of understanding of food labeling and the degree of awareness of eating habits. The present study set four hypotheses based on previous studies. First hypothesis is people with a high level of understanding of food labeling are also highly aware of their eating habits. Because it is recognized that it is necessary to acquire knowledge and be conscious in the process of behavioral transformation leading to behavior, I thought that people with more knowledge are also more conscious (Rahimi A et al,2019). Second hypothesis is women have a stronger correlation with food labeling comprehension and dietary consciousness than men. Women are more likely to eat in groups and stressful situations, with greater confidence in healthy nutrition, greater involvement in weight control, higher social pressure and attempts to reduce the joy associated with eating. Often experience frustration because of their reflected nutritional behavior. Men, on the other hand, prefer a fatty diet with a strong taste, dictated primarily by the joy of consumption. They eat sweet foods often, use more dietary supplements, and visit fast food restaurants more often while watching TV. Nutritional behavior, nutritional patterns, dietary profiles, approaches to nutrition, approaches to places

of dietary consumption, and sources of nutritional knowledge all indicate a relationship with gender (Małgorzata et al,2020). Third hypothesis a stronger correlation between the degree of understanding of food labeling and the degree of awareness of eating habits in people living alone than in people living together. It was found that the eating habits of students living at home and those living alone are different. Therefore, I thought that there would be a difference in this study as well (Silvia et al,2015). Fourth hypothesis is those who have received specialized education in nutrition and cooking have a stronger correlation between their understanding of food labeling and their awareness of eating habits than those who have not received specialized education in nutrition and cooking. A study examining the effects of nutritional counseling interventions on children's diets found that their diets improved more positively than those without counseling (Dike et al, 2021). From this study, it is considered that the dietary habits also change depending on the presence or absence of specialized knowledge about nutrition.

Materials and Methods

Participants

The target audience is young people in their twenties. The total number of survey respondents was one hundred seventeen (seventy-six women, forty-one men and zero other).

Experimental design

This study conducted a questionnaire survey. This questionnaire was conducted on an internet survey (Google form). There are two major categories in this questionnaire surveys. It takes about 15 minutes.

Questionnaire

The first is a survey of young people's understanding of food labeling. The present study asked gender from male, female, or others. Other questionnaires were also shown like this format. I asked about the attributes of other survey respondents, whether they live alone or at home, and whether they have received specialized nutrition education. Based on a survey by the Consumer Affairs Agency, we asked a total of 7 questions about the question of how much knowledge we have about food labeling (Consumer Affairs Agency,2019). Next, as a question of awareness of eating habits, a total of 6 questions were asked based on a survey by the Ministry of Agriculture, Forestry and Fisheries and the Cabinet Office (Ministry of Agriculture, Forestry and Fisheries 2015, Cabinet Office 2015). The contents of the questions are listed in Tables 1-5.

Statistics

The Shapiro-Wilk test was a nonparametric test for all factors. Therefore, I investigated Spearman's rank correlation coefficient.

Statistical analysis was performed using SPSS software (version 25.0, SPSS, Tokyo, Japan).

・male
・female
・others
・living alone
・living together
Have you ever been in a department of nutrition or cooking at a university, junior college, or vocational school and have received specialized education?
・Yes
・No
1Have you ever used "food labeling"?
・Yes
・No
2 Regarding the explanation of "additive labeling", please answer one that you think is correct.
・All the additives used are displayed on the display of additives.
・The labeling of additives is displayed in order from the one with the highest effect among the additives used.
・The labeling of additives is displayed in order from the one with the highest weight ratio to the additives used. Correct answer
・All additives are labeled with the substance name.
・I don't know

Table1 Questionnaires used in this study in English (1/5)

3 "Please answer the combination you think is correct for the amount of nutritional components and the amount of heat (nutritional component labeling) that are required to be labeled on processed foods for general consumers. (One answer)."
・Calorie, protein, fat, carbohydrate, sodium (salt equivalent)
・Calorie, protein, lipid, cholesterol, sugar, sodium (salt equivalent)
・Calorie, protein, fat, sugar, vitamin C, sodium (salt equivalent)
・Calorie, protein, fat, carbohydrate, calcium, sodium (salt equivalent)
・Calorie, protein, lipid, cholesterol, sugar, calcium, sodium (salt equivalent)
・I don't know
4 Please answer what you think is correct about the explanation of "Food for specified health use (Tokuho)".
・The national government is examining the displayed effects and safety.
・If it contains a certain standard　amount of nutritional components whose scientific basis has already been confirmed, it is not necessary to report it.
・If the nutritional components (vitamins, minerals, etc.) required for one day tend to be insufficient, this food can be used to supplement or supplement the nutritional components (vitamins, minerals, etc.).
・It is the responsibility of the business operator to display the functionality based on scientific evidence.
・I don't know

Table2 Questionnaires used in this study in English (2/5)

5 Please answer what you think is correct about the explanation of "nutritional functional foods". (One answer) "
・The national government is examining the displayed effects and safety.
・If it contains a certain standard amount of nutritional components whose scientific basis has already been confirmed, it is not necessary to report it.
・It is recognized based on scientific evidence that it is useful for maintaining and improving health, and expressions such as "conditioning the stomach" are permitted.
・Before the sale, information on the basis of safety and functionality was notified to the Commissioner of the Consumer Affairs Agency.
・ I don't know
6 Please answer what you think is correct about the explanation of "foods with functional claims". (One answer) "
・The national government is examining the displayed effects and safety.
・If it contains a certain standard amount of nutritional components whose scientific basis has already been confirmed, it is not necessary to report it.
・A mark (figure) is displayed on the product itself.
・It is the responsibility of the business operator to display the functionality based on scientific evidence.
・I don't know

Table3 Questionnaires used in this study in English (3/5)

7 Please answer all the labeling explanations for "genetically modified foods" that you think are correct. (Any number of answers) "
・Soybeans made from genetically modified soybeans are required to be labeled as "genetically modified" or "genetically modified unclassified".
・There is no obligation to label non-genetically modified agricultural products and processed foods made from them that have been separately produced and distributed.
・“Genetically modified unsorted” means that genetically modified crops and non-genetically modified crops are not separated and are distributed and managed.
・If the crop is not genetically modified, it can be optionally labeled as "not genetically modified" even if it is not the eight types of crops for which labeling is obligatory.
・I don't know
The second is a survey on the height of awareness of eating habits.
This is the actual questionnaire item.
1 "Are you trying to maintain a healthy diet on a daily basis?"
① I always keep in mind.
② I keep in mind
③ I don't keep much in mind
④ I haven't tried at all
2 "Do you feel that you can't wait for mealtime?"
・Applicable
・If anything, it applies
・If anything, it doesn't apply
・Not applicable

Table4 Questionnaires used in this study in English (4/5)

3 "What do you think of your current diet?"
・Very good and satisfied
・I think it's generally good
・There are some problems / improvements
・There are many problems and I think it is better to improve
4 "Are you conscious of paying attention to nutritional balance in your diet?"
・Very conscious
・I am a little conscious
・I'm not very conscious
・I'm not conscious at all
5 "Are you interested in dietary education?"
・There is so much
・Yes
・Not much
・No
6 "What kind of food do you eat so as not to adversely affect your health in the future?
Would you like to better understand what choices you should make and what kind of cooking you need? "
・I think very much
・I think to some extent
・I don't think so much
・I don't think at all

Table5 Questionnaires used in this study in English (5/5)

Results

A total of 117 young people, (seventy-six women, forty-one men and zero other), answered the questionnaire. Spearman's rank correlation coefficient did not show a significant correlation between young people's understanding of food labeling and their high awareness of dietary habits. ($r = 0.086$, $p > 0.05$) n.s.=not significant (Figure1.)76 women answered the questionnaire. Spearman's rank correlation coefficient did not show a significant correlation between young women understanding of food labeling and their high awareness of dietary habits. ($r = 0{,}087$ $p > 0.05$) n.s.=not significant (Figure2).41men answered the questionnaire. Spearman's rank correlation coefficient did not show a significant correlation between young women understanding of food labeling and their high awareness of dietary habits. ($r = 0{,}101$ $p > 0.05$) n.s.=not significant (Figure3). In this study, 37 people of participants living alone answered the questionnaire. Spearman's rank correlation coefficient did not show a significant correlation between participants living alone understanding of food labeling and their high awareness of dietary habits. ($r = 0{,}188$, $p > 0.05$) n.s.=not significant (Figure4). In this study, 80 people of participants living with others answered the questionnaire. Spearman's rank correlation coefficient did not show a significant correlation between participants living with others understanding of food labeling and their high awareness of dietary habits. ($r = 0{,}021$, $p > 0.05$) n.s.=not significant (Figure5).13 participants with specialized nutritional knowledge answered the questionnaire in this survey.

Spearman's rank correlation coefficient did not show a significant correlation between expert knowledge participants' understanding of food labeling and their high awareness of their diet. (r= 0,259, p> 0.05) n.s. = Not significant (Figure6).104 participants without specialized nutritional knowledge answered the questionnaire in this survey. Spearman's rank correlation coefficient did not show a significant correlation between expert knowledge participants' understanding of food labeling and their high awareness of their diet. (r= 0,043, p> 0.05) n.s. = Not significant (Figure7). Comparing the correlation, significance probability and parameter, none proved a statistically significant hypothesis (Table 6).

Discussion

In this study, there was no significant correlation between high level of understanding and awareness of food labeling in young people. (r = 0.086, p> 0.05) In the first hypothesis, it is recognized that it is necessary to acquire and be aware of knowledge in the process of behavior change, so I thought that the more knowledgeable people are, the higher the awareness. (Rahimi A et al,2019). However, the reason why the hypothesis is not supported from the previous research is that not only knowledge, but also other factors have a great influence on the cause of raising awareness (Medina et al,2020). In the second hypothesis, all sources of nutritional knowledge indicate a relationship with gender (Małgorzataetal,2021), suggesting that females are more correlated than males. However, the reason why the hypothesis is not supported from the previous research is that even if the

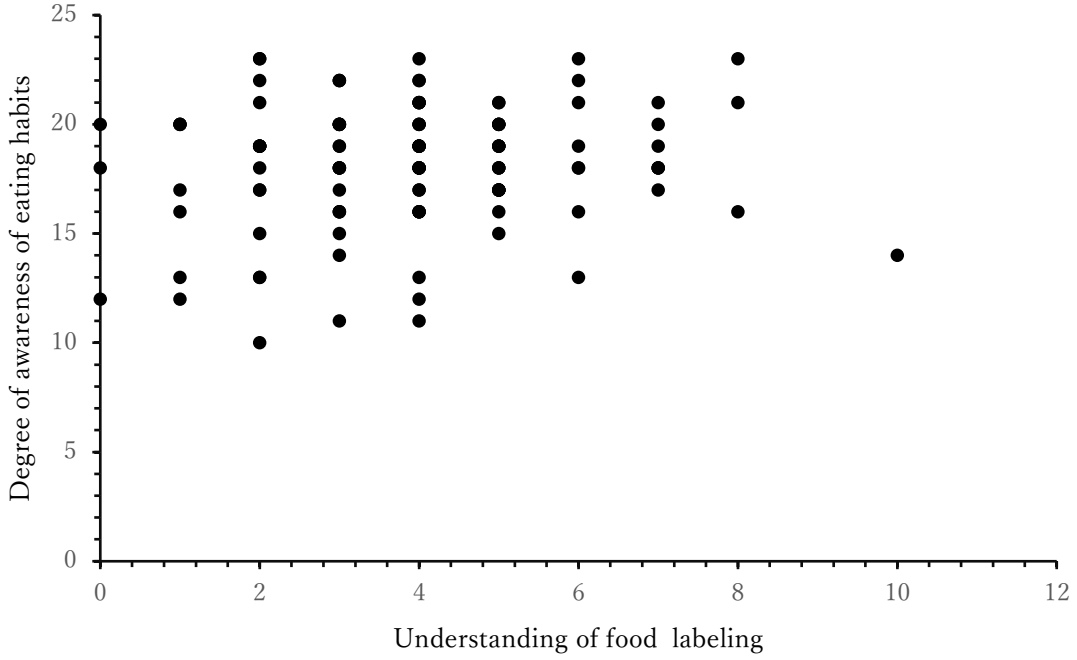

Figure1. Correlation between understanding of food labeling and high awareness of eating habits for all participants (n=117)

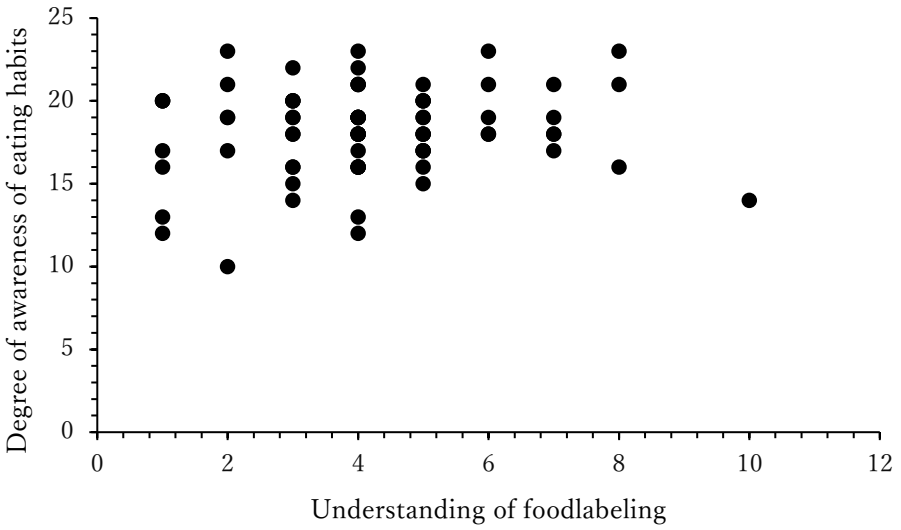

Figure2. Correlation between women's understanding of food labeling and high awareness of eating habits(n=76)

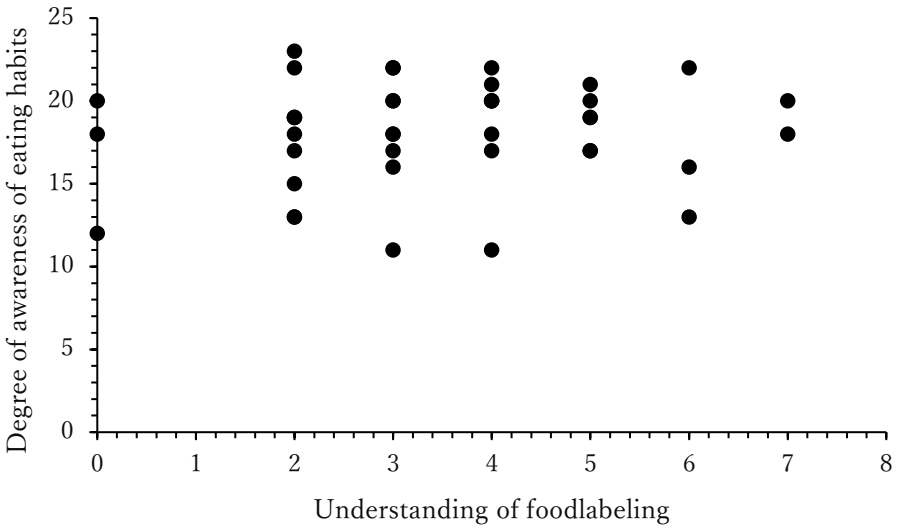

Figure3. Correlation between men's understanding of food labeling and high awareness of eating habits(n=41)

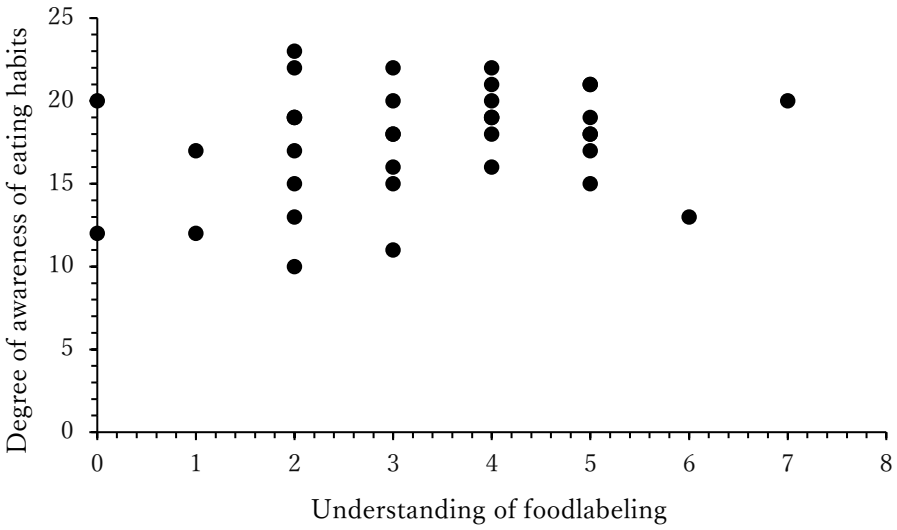

Figure4. Correlation between the understanding of food labeling and high awareness of eating habits in living alone(n=37)

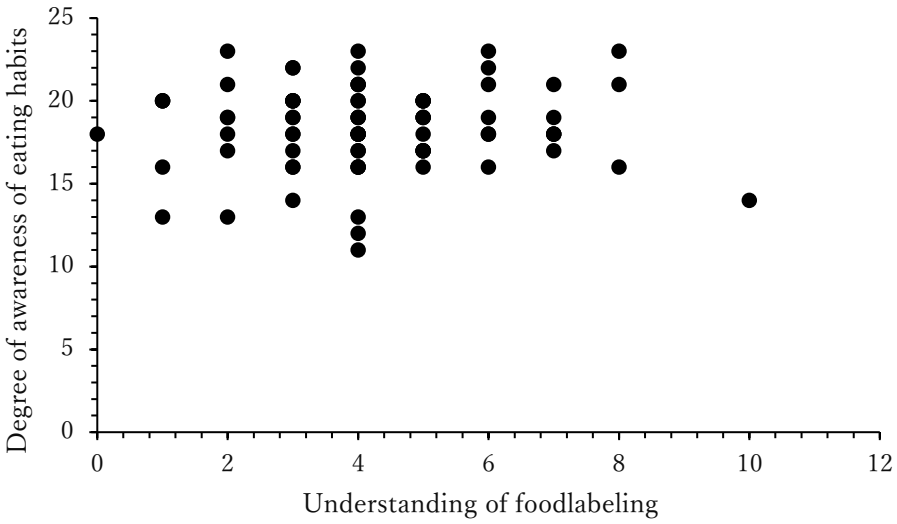

Figure5. Correlation between the understanding of food labeling and high awareness of eating habits participants living with others (n=80)

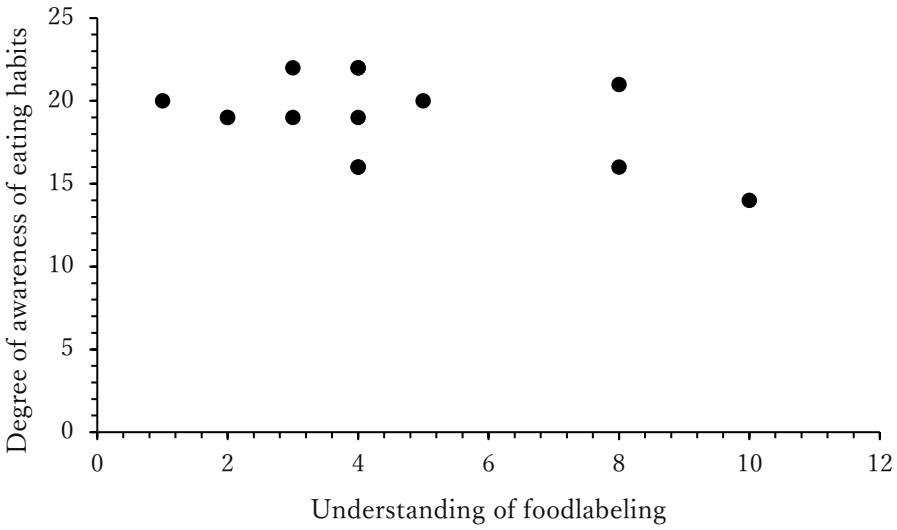

Figure6. Correlation between the understanding of food labeling and high awareness of eating habits participants with specialized nutrition education (n=13)

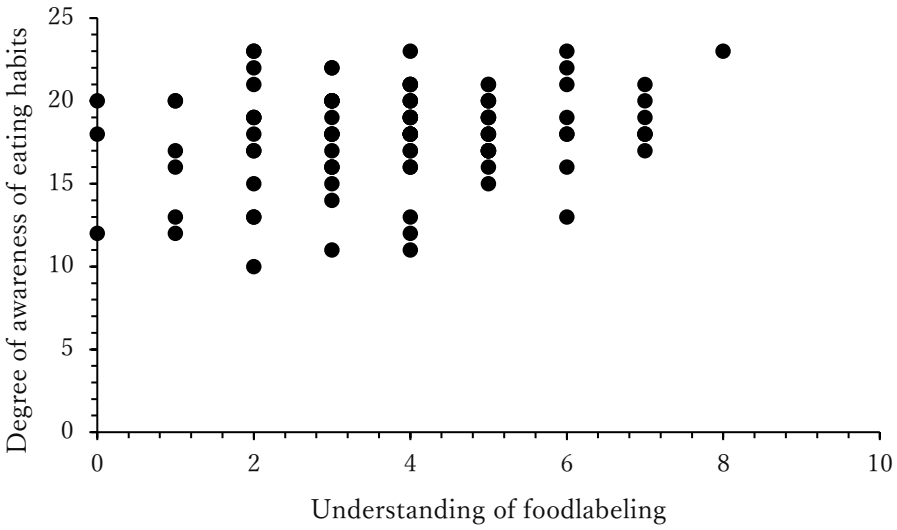

Figure7. Correlation between the understanding of food labeling and high awareness of eating habits participants without specialized nutrition education (n=104)

Table6 Comparison of correlation, significance probability, and population parameter

	Correlation	Significance probability	Population parameter
Entirety	r= 0,086	p=0,354	n=117
Women	r= 0,087	p=0,454	n=76
Men	r=0,101	p=0,529	n=41
Living alone	r=0,188	p=0,266	n=37
Living with others	r=0,021	p=0.857	n=80
With specialized nutrition education	r=0,259	p=0,371	n＝14
Without specialized nutrition education	r=0,043	p=0,665	n=103

eating habits differ between men and women, there is no gender difference within the limited range of knowledge of food labeling (Jovičić et al,2015).In the third hypothesis, the eating habits of home-based students and those living alone are different (Silvia et al,2015), so we thought that students living alone had a stronger correlation than students living at home. However, the reason why the hypothesis is not supported from the previous research is that the health consciousness of students living alone declines (Kobayashi et al,2017). In a study examining the effects of nutritional counseling interventions in the fourth hypothesis, their diet was more positively improved than a diet without counseling (Dike et al, 2021) and received specialized nutrition and cooking education. People believed that there was a stronger correlation between understanding food labeling and awareness of eating habits than those without specialized nutrition and cooking education. However, the reason why the hypothesis is not supported from the previous research is that not only knowledge, but also other factors have a great influence on the cause of raising awareness (Medina et al,2020).

In conclusion, the results of this study examined that a high level of understanding of food labeling does not necessarily mean a high level of dietary awareness, and that the first hypothesis of this study was not supported. This is study provided an opportunity to clarify that there was no relationship between food labeling comprehension and dietary awareness. It became clear that the recognition rate of correct knowledge was low as an issue for food

labeling in the future. We must reconsider the way food labeling should be. In the future, if the difference between healthy life expectancy (the period during which daily life is not restricted due to health problems) and life expectancy widens as the average life expectancy increases as in the past in Japan, medical expenses and long-term care will be required. It is expected that the burden of benefit costs will also increase. Especially in Japan, where the aging of the population is progressing rapidly, healthy life expectancy is achieved through the health promotion of each and every citizen, not only to prevent the deterioration of the quality of life of individuals, but also to improve the sustainability of the social security system. It is important to extend the life expectancy and reduce the difference from the average life expectancy. First of all, it is necessary to raise awareness of eating habits in order to lead healthy life for the people. It is necessary to consider what kind of efforts should be taken for that purpose.

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Appendix

若者の食品表示の理解度と食生活への意識の高さの関連性について

若者の食品表示の理解度が食生活への意識の高さに比例しているのかを明らかにすることを目的とする。アンケート調査を20代の若者を対象として行う。

所要時間は１５分程度です。

本調査の回答結果や回答を拒否することによって不利益を被ることはございません。

国際教養学部国際教養学科　4年　河合彩水

*必須

該当するものに○を付けてください。 *

- 男
- 女
- その他(答えたくない人も含む)

居住状況 *

- 独居(1人暮らし)
- 同居(実家暮らし)

大学や短大、専門学校において栄養や料理関する学科に属しており、専門教育を受けることがありますか。 *

- はい
- いいえ

1あなたは「食品表示」を活用したことがありますか。 *

- はい
- いいえ

2「添加物表示」の説明について、あなたが正しいと思うものを1つお答えください。 *

- 添加物の表示は、使用された添加物が全て表示されている。
- 添加物の表示は、使用した添加物に占める効果の高いものから順に表示されている。
- 添加物の表示は、使用した添加物に占める重量の割合の高いものから順に表示されている。
- 添加物の表示は、全て物質名で表示されている。
- 分からない

3一般消費者向けの加工食品への表示が義務付けられている栄養成分の量及び熱量(栄養成分表示)について、あなたが正しいと思う組み合わせをお答えください。(答えは1つ) *

- 熱量、たんぱく質、脂質、炭水化物、ナトリウム(食塩相当量)
- 熱量、たんぱく質、脂質、コレステロール、糖質、ナトリウム(食塩相当量)
- 熱量、たんぱく質、脂質、糖質、ビタミンC、ナトリウム(食塩相当量)
- 熱量、たんぱく質、脂質、炭水化物、カルシウム、ナトリウム(食塩相当量)
- 熱量、たんぱく質、脂質、コレステロール、糖質、カルシウム、ナトリウム(食塩相当量)
- 分からない

4「特定保健用食品(トクホ)」の説明について、あなたが正しいと思うものをお答えください。 *

- 表示されている効果や安全について国が審査を行っている。
- 既に科学的根拠が確認された栄養成分を一定の基準量含んでいれば、届け出しなくてもよい。
- 1日に必要な栄養成分(ビタミン、ミネラル等)が不足しがちな場合、その補給・補完のために利用出来る食品である。
- 事業者の責任において、科学的根拠に基づいた機能性を表示したものである。
- 分からない

5「栄養機能食品」の説明について、あなたが正しいと思うものをお答え下さい。(答えは1つ) *

- 表示されている効果や安全性について国が審査を行っている。
- 既に科学的根拠が確認された栄養成分を一定の基準量含んでいれば、届け出しなくてもよい。
- 健康の維持・増進に役立つことが科学的根拠に基づいて認められ、「お腹の調子を整える」等の表現が許可されている。
- 販売前に、安全性及び機能性の根拠に関する情報等が消費者庁長官に届け出されたものである。
- 分からない

Appendix1 Questionnaires used in this study in Japanese (1/2)

Appendix2 Questionnaires used in this study in Japanese (2/2)

Effect of using chopsticks and spoon on contact order of food and oral cavity and saltiness sensitivity

国際社会系(渡邊ゼミ)

S118039

北川茉実

Mami Kitagawa

Abstract

Effect of using chopsticks and spoon on contact order of food and oral cavity and saltiness sensitivity

Aim The purpose of this study is to reveal effect of contact order of food and oral cavity and saltiness sensitivity between chopsticks and a spoon. **Methods** Prior to main study, the contact order of food and oral cavity in the uses of chopsticks and a spoon was investigated using dental model with electrical touch sensors. Fifteen healthy students ate food with chopsticks and spoons, then saltiness threshold was measured before (PRE) and after (POST) food ingestions. **Results** When using chopsticks, the food contacted to the tongue and then to the palate. Meanwhile, when using a spoon, food contacted to the palate and then to the tongue. Saltiness thresholds increased from PRE to POST for both chopsticks and spoon ($p < 0.05$). Significant higher saltiness threshold than control at POST was found in chopsticks ($p < 0.05$), but not in spoon ($p > 0.05$). **Conclusion** From these results, we suggested that using chopsticks and a spoon changes the contact order of food and oral cavity, and use of chopsticks during eating decreases saltiness sensitivity.

箸とスプーンの使用が食品と口腔内の接触順序及び塩味感受性に与える影響

目的 本研究の目的は、箸とスプーンの使用が食品と口腔内の接触順序及び塩味感受性に及ぼす影響を明らかにすることである。**方法** 本研究に先立ち、電気式タッチセンサー付き口腔模型を用いて、箸とスプーン使用時の食品と口腔内の接触順序を調査した。若齢男女 15 名が箸とスプーンを使い塩味の食品を摂取し、食品の摂取前(PRE)と摂取後(POST)に塩味閾値が測定された。**結果** 箸を使用すると食品は舌に接触した後、口蓋に接触した。一方で、スプーンを使用すると食品は口蓋に接触した後、舌に接触した。塩味閾値は箸、スプーンともに PRE から POST にかけて上昇した（$p < 0.05$)。POST において箸はコントロールより有意に高い塩味閾値が見られたが（$p < 0.05$)、スプーンでは見られなかった（$p > 0.05$)。 **結論** これらの結果から、箸とスプーンの使用により食品と口腔内の接触順序が異なり、また箸の使用は塩味感受性を下げる事を示唆した。

筷子和勺子使用对食物-口腔接触顺序和咸味敏感性的影响

目的 本研究的目的是阐明筷子和勺子的使用对食物与口腔接触顺序以及对咸味的敏感性的影响。**方法** 在口腔模型的舌头和上颚安装传感器，研究使用筷子和勺子时食物与口腔接触的顺序。15 名青年男女使用筷子和勺子摄取咸味食物，并在进食前（PRE）和进食后（POST）测量咸味阈值。**结果** 使用筷子时，食物先接触舌头，然后接触上颚。当使用勺子时，食物先接触上颚，然后接触舌头。筷子和勺子的咸味阈值从 PRE 到 POST 增加（$p < 0.05$)。筷子在 POST 上显示出明显高于对照组的咸味阈值（$p < 0.05$)，但在勺子上没有（$p > 0.05$)。**结论** 这些结果表明，食物与口腔接触的顺序因筷子和勺子的使用而异，筷子会降低咸味敏感性。

Introduction

Salt intake has been reported to be high in the Japanese population (Ohta et al., 2005). While sodium is essential for normal human functioning, current sodium intakes far exceed recommendations for good health. WHO recommends that adult consume less than 5g of salt per day (WHO, 2020). However, according to National Health and Nutrition Survey in 2019 by Ministry of Health, Labor, and Welfare of Japan, most Japanese consume too much salt, on average 10g per day. The following points can give as reasons. First, the Japanese diet has high salt intake from seasonings, such as salt per se; soy sauce and miso; and salted foods, such as pickled vegetables and salted seafood (Tsugane & Sawada, 2014). Second, excessive exposure to high-salt foods may change the taste perception, which results in the overconsumption of sodium (Kim & Lee, 2009).

High sodium consumption contributes to high blood pressure and increase the risk of heart disease and stroke (WHO, 2020). Hence, salt reduction helps to reduce blood pressure and risk of cardiovascular disease, stroke, and coronary heart attack. As sodium reduction strategies, not adding salt during the preparation of food, and choosing products with lower sodium content have been applied. On the other hand, traditional methods of salt reduction are problematic because drastically reducing the salt content of processed meat products can lead to defects in food quality and safety (Xiong et al., 2020). Thus, there is a need for further methods that enable salt reduction by increasing the salt sensitivity of the receiver.

It is well known that saltiness sensitivity changes due to various factors. Previous studies indicated that oral temperature (Cruz & Green, 2000), contact order of food and oral cavity (De Wijk et al., 2011), food temperature (Green & Nachtigal, 2012), and umami taste (Fuke & Shimizu, 1993) affect the perception of saltiness. Changing contact order of food and oral cavity are particularly useful for incorporating into daily meals. Chopsticks and spoons are mainly used in many countries when eating (Dorota et al., 2016). Due to shapes of chopsticks and spoon, their delivering processes of food in oral cavity should be different between the uses of them.

The human taste system consists of taste buds, which are groups of 50-100 taste cells that are found throughout the oral cavity (Simon & Gutierrez, 2017). Simple taste reaction time is from 50ms to 2000ms durations. Taste bud cell communicate with sensory afferent fibers and may also exchange information with adjacent cells (Roper, 2006). Once a taste signal is generated in a taste cell, neurotransmitters including adenosine triphosphate (ATP) and serotonin are secreted. ATP secreted from receptor cells also acts on neighboring taste cells to stimulate their release of serotonin (Roper, 2007). Taste buds are located throughout the oral cavity including the tongue and the palate, but Earnest & John (1961) reported most of the taste buds are on the dorsal side of the tongue. It has been widely acknowledged that responses to tastes vary across the human tongue and other parts of the mouth such as soft palate depending on kind of taste (Julie et al., 2018). It is known that the tongue is more sensitive to saltiness than the palate (Virginia, 1974). Similarly to other physiological senses, the

sense of taste exhibits sensory adaptation – that is, a gradual loss of sensation during prolonged stimulation (McBurney, 1985). In the case of salt, taste intensity increases within a few hundred milliseconds and then rapidly falls (Henney et al., 2010).

The purpose of the present study is to reveal effect of using chopsticks and a spoon on contact order of food and oral cavity and saltiness sensitivity. The results from this study would be useful to propose further methods that enable salt reduction while increasing saltiness perception. We hypothesized that when eating with chopsticks, food contacts to tongue first and then contacts to palate, whereas when eating with a spoon, food contacts to palate first and then contacts to tongue. In addition, in previous study, prolonged stimulation of receptors often leads to a gradual loss of sensation, which is called adaptation. The time frame of the adaptation of sodium receptors is expected to be on the order of 100 ms to a few seconds (Busch et al., 2009). Furthermore, previous study has shown that the ingestion of salty food decreases the sensitivity of sodium receptors (Busch et al., 2009). Also, the tongue is more sensitive to saltiness than the palate due to the different distribution of taste buds (Gravina, 2009). In other words, when using a spoon, the time that the food contacts to the tongue is shorter and adaptation is less likely to occur. Moreover, it can be assumed that a spoon inhibits saltiness sensitivity of the tongue. Therefore, we also hypothesized that the decrease in saltiness sensitivity after eating with a spoon is smaller than the decrease in saltiness sensitivity after eating with chopsticks.

Materials and Methods

Experiment 1: Contact order of food and oral cavity between using chopsticks and a spoon

Experimental design

The contact order of food and oral cavity was measured with a sensor (a custom made measurement system). The aluminum foil was attached as electrical conductor to the tongue and the palate of the dental model (D216, ErlerZimmer GmbH&Co. KG., Germany) (Fig. 1) with adhesive tape. A 3.5 cm cube of simulated food was also made from aluminum foil, which is based on the shape of food used in experiment 2. The mouth of dental model was first open, and food was then put into the mouth of it using chopsticks (Maruki Co., Ltd., Osaka, Japan) and a spoon (Maruki Co., Ltd., Osaka, Japan), respectively (Fig. 2). Finally, the mouth of the dental model was closed, and chopsticks and a spoon were pulled out.

Sensor

Electrical signal from the sensor were sampled using an analog-to-digital convertor (PowerLab16/35, AD Instruments, Melbourne Australia) and synchronized with a personal computer using LabChart software (version 8.1.13; AD Instruments, Melbourne Australia). This sensor is energized when it comes in contact with aluminum foil.

Experiment 2: Saltiness sensitivity following food ingestion with chopsticks and a spoon

Participants

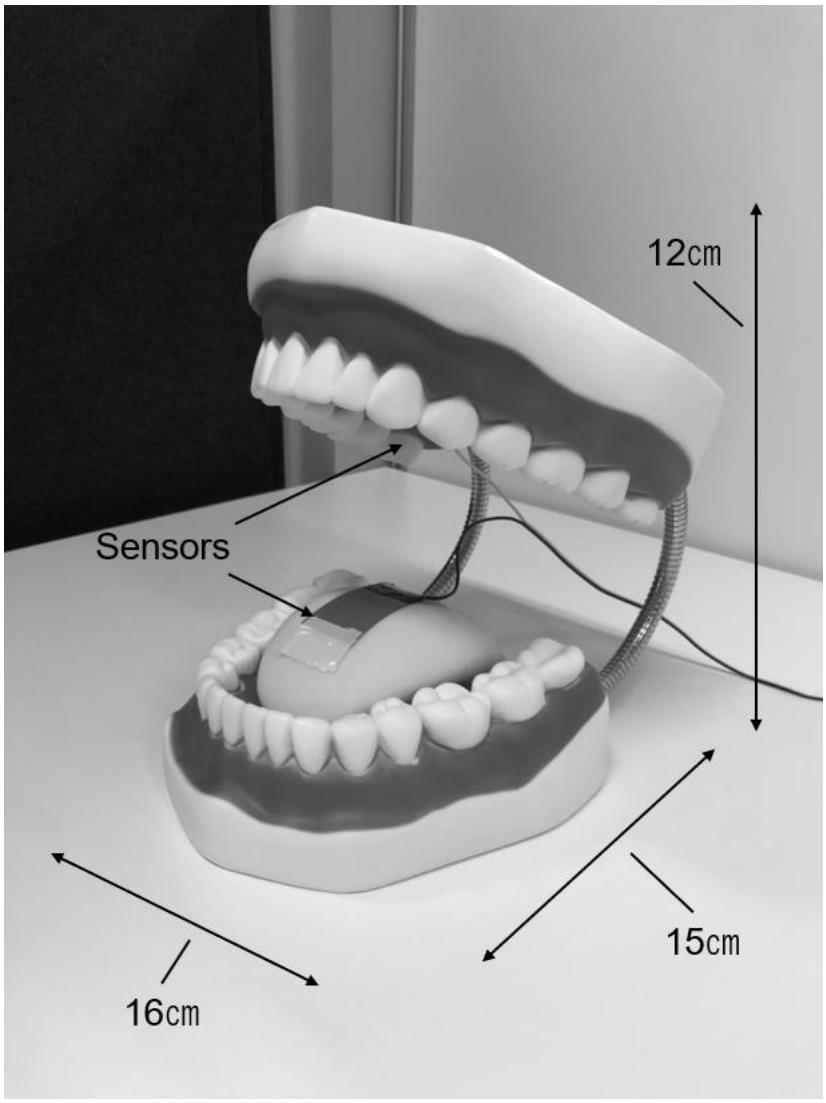

Fig. 1 A dental model and sensors.

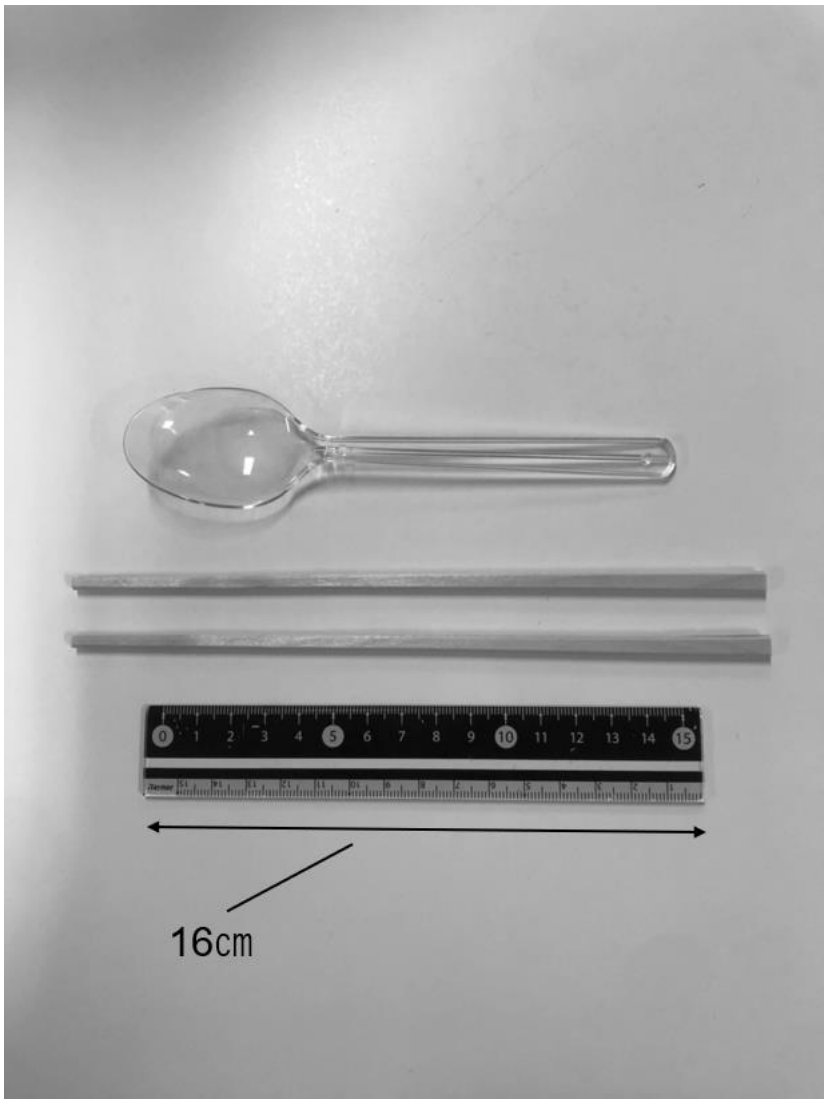

Fig. 2 Chopsticks and a spoon.

Fifteen healthy young adults (mean±SD: age: 21.1±0.8 years, height: 163.1±6.2 cm, weight: 53.9±9.7 kg) 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. All participants were instructed not to smoke or eat at least one hour before the experiment to avoid the effect of smoking and diet on the saltiness threshold.

Experimental design

First, participants performed taste test to measure their saltiness threshold. After this measurement (PRE), each participant ate test food (15g) with chopsticks or a spoon. Participants were first instructed to hold the food in their mouth without chewing, after 5 seconds the food was spat out, then participants were indicated the saltiness intensity of food with visual analogue scale between one and nine (One is not present at all, nine is extremely strong). Finally, participants performed taste test (POST) again to measure their saltiness threshold. In this study, the participants had been asked to conduct four trials; ①When eating food with chopsticks, the food contacts to the tongue first and when the mouth is closed and the chopsticks are pulled out, the food contacts to the palate. We used chopsticks to put the food into the participants' mouths (CHO: chopsticks), ②When eating food with a spoon, the food contacts to the palate first, then when the mouth is closed, the spoon contacts to the tongue, and finally when the spoon is pulled out, the food contacts to the palate. We used spoon to put the food into the participants' mouths (SPO: spoon), ③When food is placed on the tongue with

chopsticks, the food contacts to the tongue. We used chopsticks to put the food into the participants' mouths. (TON: tongue), ④no intervention (CON: control). In this experiment, two comparisons were made: salty food vs placebo food (Measurement A), chopsticks vs a spoon (Measurement B). In Measurement A, 5 people were targeted for each trial. In Measurement B, 15 people were targeted. The order of the trials was random. Participants were asked to gargle with water before and after each trial. Spoon was 16 cm in length, 8 mm in depth, and chopsticks was 20 cm in length (Fig. 2).

Taste tests

The quantitative clinical gustometry using filter paper discs and sodium chloride solution (Taste disc, Sanwa Chemical Laboratory Co., Ltd., Aichi, Japan) were performed. Thirteen kinds of sodium chloride solutions (0.1%, 0.3%, 0.5%, 0.7%, 0.9%, 1.1%, 1.8%, 2.3%, 2.8%, 3.3%, 3.8%, 4.3%, and 5%) were used in this study and the concentrations of sodium chloride solution were determined by preliminary experiment (Fig. 3). We measured saltiness sensitivity at the tip of the tongue because this region has a high density of taste buds and high sensitivities to taste stimuli. Taste test was performed as follows. First, a filter paper disc (8 mm diameter) soaked in salty solution was placed on the tip of the tongue with tweezers (M 025-121440-00, Kawamoto Co., Ltd., Osaka, Japan) for 3 seconds, ant then immediately we removed the disc and disinfect the tweezers with absorbent cotton (Sanicot EQ, AS ONE Co., Ltd., Osaka, Japan). The test was started from concentration number 1 and gradually increased. The lowest concentration for which the participant reported the existence

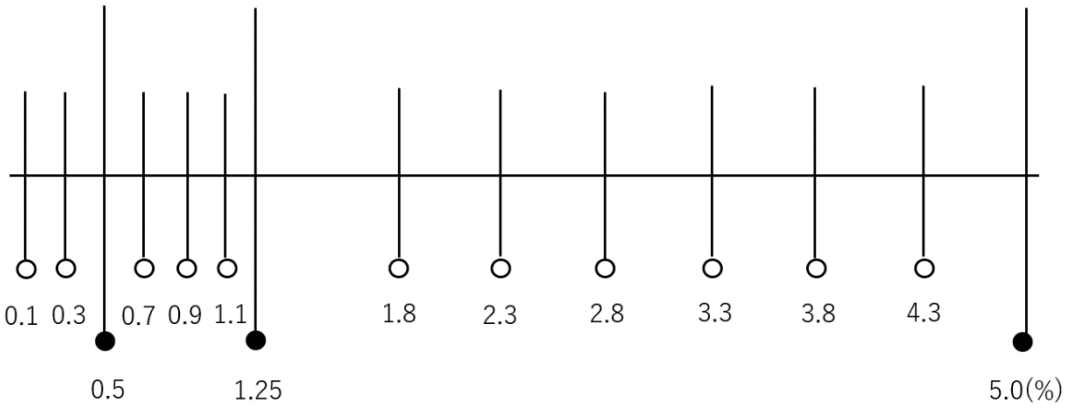

Fig. 3 Concentration of sodium chloride solution used in this study. ●original scale in taste disc. ○ modified scale in taste disc.

of saltiness stimuli was taken as the recognition threshold (Fukunaga et al., 2005). Taste tests were performed using the same method for PRE and POST.

Food

Gelatin gel of sodium chloride solution was used in this study. The concentration of sodium chloride solution was set to 1.8%. The salinity of food was determined based on a preliminary study to measure participants' saltiness threshold. This study used 15g for one bite (Zijlstra et al., 2009). Sodium chloride solution was heated at 50-60℃ in a pan, and gelatin powder (granule gelatin, JELEAF Co., Ltd., Shiga, Japan) was dissolved in water. The mixture was cooled at room temperature for 2 hours and then at 4-5℃ for 24 hours. Gelatin gel was cut into cubes with sides of 3 cm in length (Fig. 4).

Additional test for saltiness intensity of food

Five of the fifteen participants ingested placebo food. Water gelatin gel was used in this study. First, participants performed taste test to measure saltiness threshold, and then ate placebo food under TON, SPO, and CHO conditions. After 5 seconds the food was spat out, then participants were indicated the saltiness intensity of food on a scale of one and nine. Finally, participants performed taste test again to measure their saltiness threshold.

Statistics

All data are provided as mean and SD. Because we confirmed that data was not normally

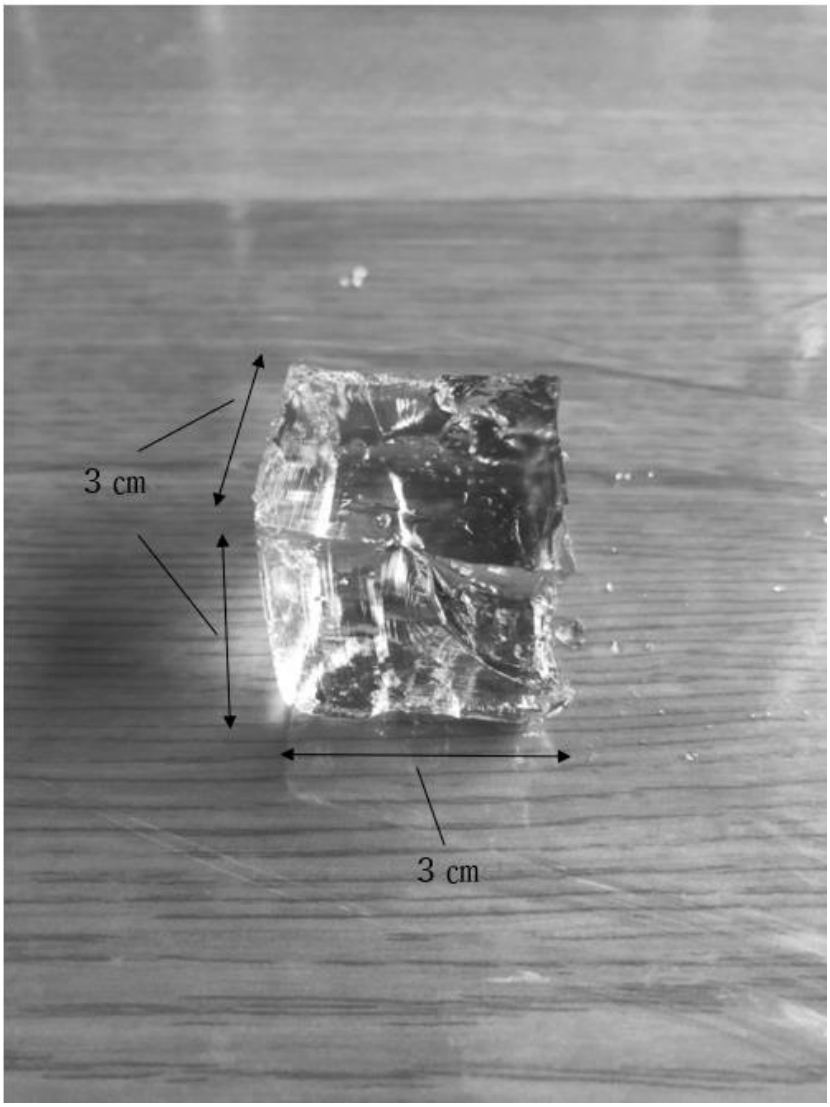

Fig. 4 Test food used in the present study.

distributed by Shapiro-Wilk test, the non-parametric analysis was used in this study. Subjective saltiness intensity of food, and saltiness threshold of PRE and POST were compared between salty food and placebo using Wilcoxon signed-rank test. Saltiness threshold of PRE and POST, and rate of changes of saltiness threshold were compared between the trials using Friedman test. When there was a significant effect in Friedman test, degree of change was compared between the trials by using post hoc 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

Experiment 1: Contact order of food and oral cavity between using chopsticks and a spoon

Fig. 5 shows the contact order of food and oral cavity in simulated delivering of food into mouth with chopsticks. When using chopsticks, food contacted to the tongue and then to the palate of the dental model. Also, Fig. 6 shows the contact order of food and oral cavity in simulated delivering of food into mouth with a spoon. When using a spoon, food contacted to the palate and then to the tongue of the dental model.

Experiment 2: Saltiness sensitivity following food ingestion with chopsticks and a spoon

Significant increases in saltiness threshold from PRE to POST were observed in TON, SPO, and CHO ($p < 0.05$) but not in CON ($p > 0.05$) (Fig. 7). There was no significant difference between

the groups in saltiness threshold at PRE ($p > 0.05$) (Fig. 7). A significant effect of trial in Friedman test was observed in saltiness threshold at POST ($p < 0.05$), and a significant difference was observed between CHO and CON at POST ($p < 0.05$) (Fig. 7). There were no significant difference between the groups in rate of changes of saltiness threshold ($p > 0.05$) (Fig. 8).

There were significant differences in subjective saltiness intensity between salty food and placebo in CHO and TON ($p < 0.05$), while there were no significant differences in subjective saltiness intensity between salty food and placebo in SPO ($p > 0.05$) (Fig. 9).

There were no significant differences in saltiness threshold between PRE and POST in placebo in TON, SPO, and CHO ($p > 0.05$) (Fig. 10).

Discussion

In the present study, we simulated contact order of food and oral cavity when ingesting food using chopsticks and a spoon. When using chopsticks, the food contacted to the tongue and then to the palate, and when using a spoon, food contacted to the palate and then to the tongue as expected. The present study thus confirmed that delivery process and contact of food in oral cavity is different between eating with chopsticks and spoon. Although there was no significant difference in saltiness threshold of POST between CHO and SPO ($p > 0.05$) (Fig. 7), a significant difference between CHO and CON was observed in saltiness sensitivity of POST ($p < 0.05$) (Fig. 7). These results support the

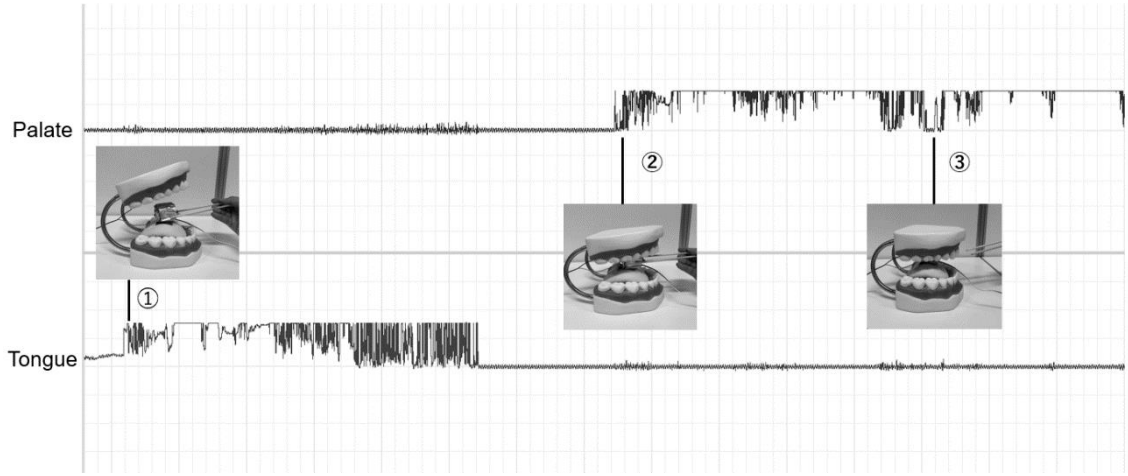

Fig. 5 The contact order of food and oral cavity when using chopsticks determined by electrical signal. ①When eating food with chopsticks, the food contacted to the tongue and a sensor attached to the tongue of the dental model reacted. ②When the mouth of dental model was closed, the food contacted to the palate and a sensor attached to the palate of the dental model reacted. ③The chopsticks were pulled out.

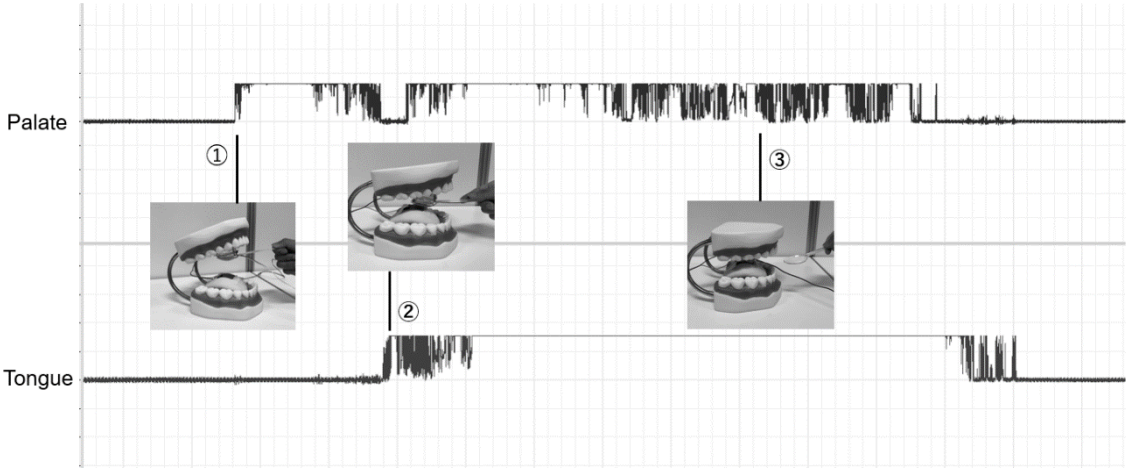

Fig. 6 The contact order of food and oral cavity when using a spoon determined by electrical signal. ①When eating food with a spoon, the food contacted to the palate and a sensor attached to the palate of the dental model reacted. ②When the mouth of dental model was closed, the spoon contacted to the tongue and a sensor attached to the tongue of the dental model reacted. ③When the spoon was pulled out, the food contacted to the palate.

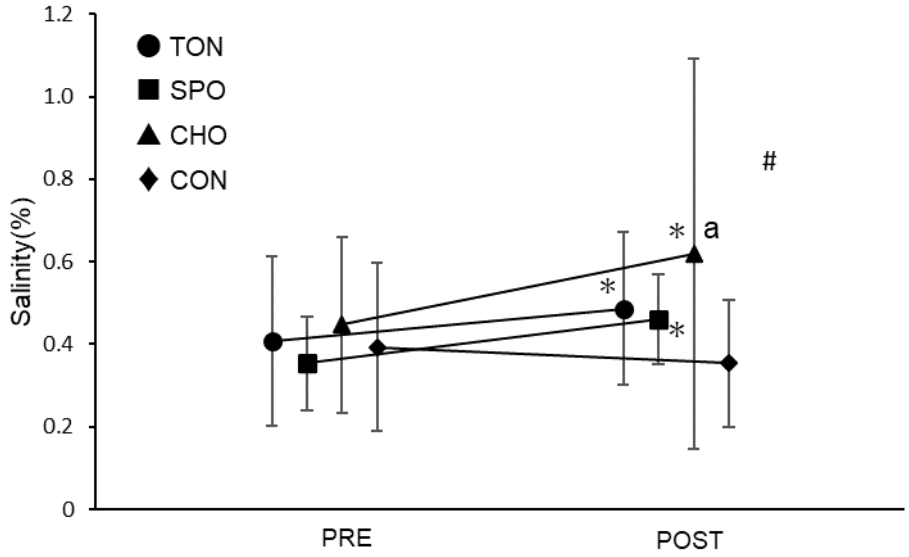

Fig. 7 Mean (±SD) of saltiness threshold in salty food between PRE and POST in tongue (TON), in spoon (SPO), in chopsticks (CHO), and in control (CON). * $p < 0.05$ between PRE and POST (Wilcoxon test). # $p < 0.05$ at POST (Friedman test). a $p < 0.05$ vs CON.

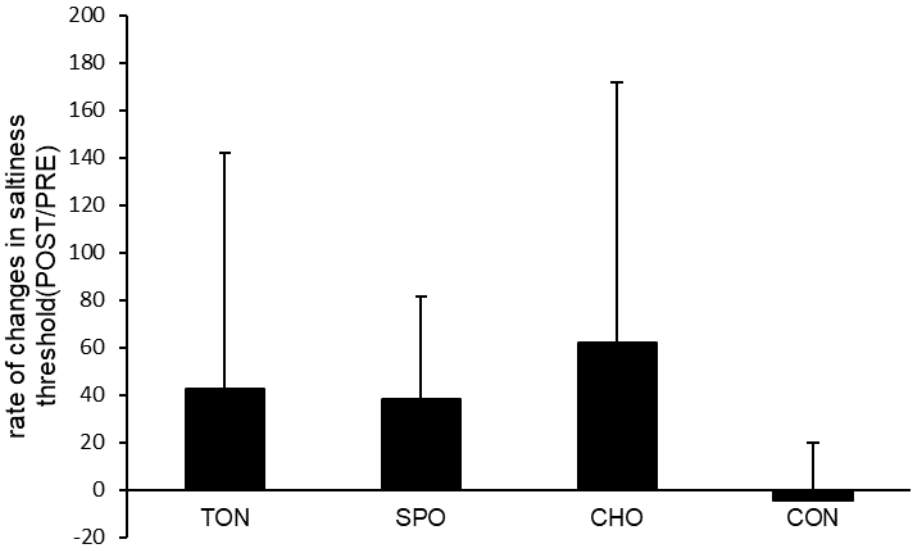

Fig. 8 Mean (±SD) of rate of changes in saltiness threshold between tongue (TON), spoon (SPO), chopsticks (CHO), and control (CON).

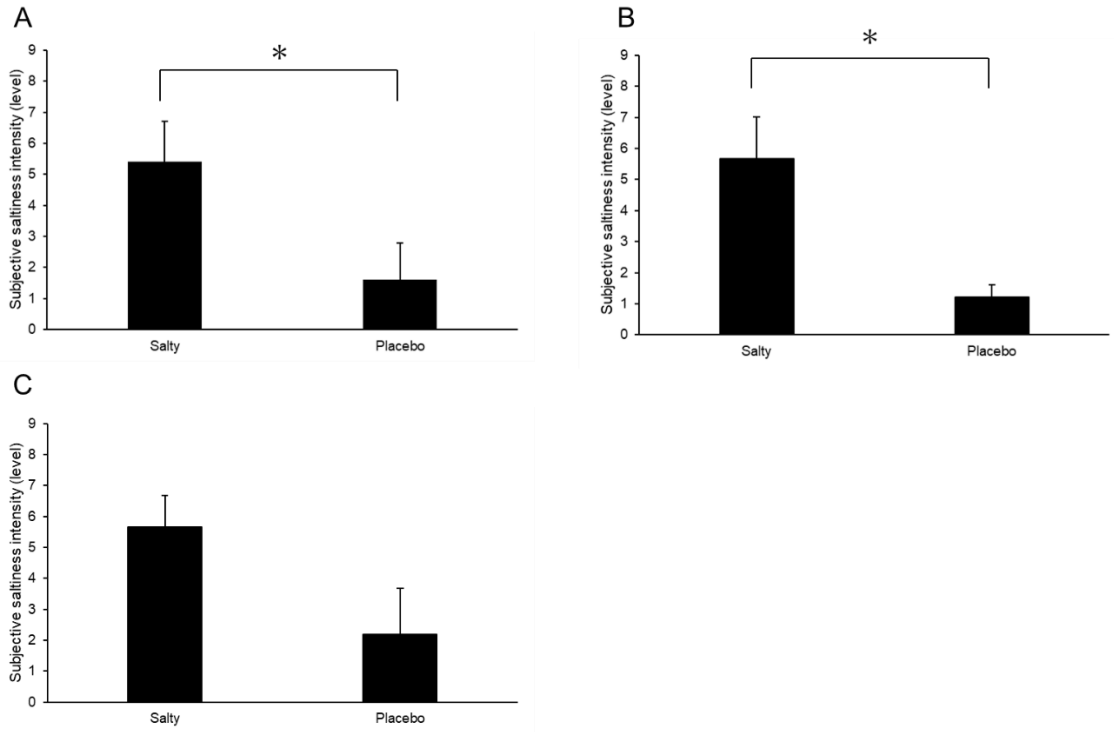

Fig. 9 Mean (±SD) of subjective saltiness intensity between salty food and placebo in tongue (TON) (A), Mean (±SD) of subjective saltiness intensity between salty food and placebo in chopsticks (CHO) (B), Mean (±SD) of subjective saltiness intensity between salty food and placebo in spoon (SPO) (C). *$p < 0.05$

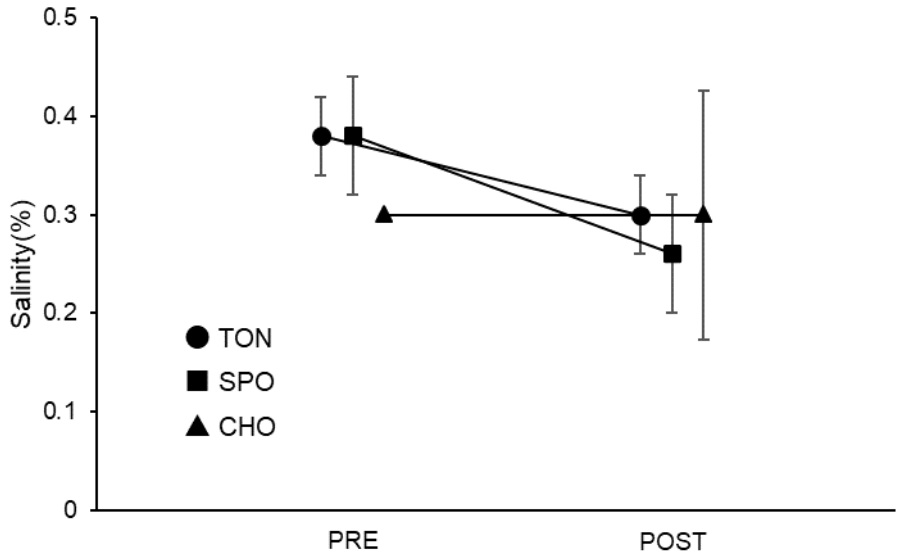

Fig. 10 Mean (±SD) of saltiness threshold in placebo between PRE and POST in tongue (TON), in spoon (SPO), and in chopsticks (CHO).

hypothesis that the decrease in saltiness sensitivity after eating with a spoon is smaller than the decrease in saltiness sensitivity after eating with chopsticks.

There was no significant difference in saltiness threshold between PRE and POST in CON. Due to high sensitivity of saltiness in taste sensors, it was assumed that saltiness threshold may be changed even by slight stimulus of taste such as the taste test (Funahashi, 2012). However, no significant differences in saltiness threshold between PRE and POST was found in CON ($p > 0.05$) (Fig. 7). This means that saltiness threshold could be unchanged following taste test used in the present study.

On the other hand, There were significant differences in saltiness threshold between PRE and POST in salty food in CHO, SPO, and TON ($p < 0.05$). These results show that sensitivity of saltiness becomes lesser following salty food. In addition, previous study has shown that the ingestion of salty food decreases the sensitivity of sodium receptors (Busch et al., 2009), and it was confirmed that salt sensitivity changes with food ingestion in this study.

Significant greater decrease in saltiness sensitivity comparing to CON was observed in CHO ($p < 0.05$), but not in SPO and TON ($p > 0.05$). There was no significant difference in saltiness threshold of POST between CHO and SPO. In previous studies, the saltiness sensitivity of the palate is significantly lower than that of the tongue (Virginia, 1974). In a preliminary experiment, we measured the saltiness threshold of the palate by filter paper method. However, all participants were

unable to recognize existence of saltiness stimuli at the highest concentration of sodium chloride solution (20%). These results indicate most of the salty perception can be from the tongue. The two main reasons for the difference between chopsticks and spoons were whether the food touched the tongue first, and whether the food touched the tongue directly or after a substance other than food touched the tongue. The former idea could be based on the difference between CHO and TON; the difference between CHO and TON is whether or not the mouth was closed after the food was placed on the tongue. This could mean that contact with taste receptors other than the tongue could have affected saltiness sensitivity. However, there was no significant difference in the saltiness threshold between CHO and TON. Therefore, it is possible that food contact with the palate is not as important for the perception of saltiness. The latter idea is considered from an additional experiment using placebo and salty food. There was no significant difference in subjective saltiness intensity between salty food and placebo in SPO ($p > 0.05$), while significant differences between salty food and placebo were found in TON and CHO ($p < 0.05$) (Fig. 9). Since most participants didn't feel salty in placebo food and felt salty in salty food, SPO inhibits saltiness sensitivity of the tongue. Frey (2008) reported that taste perception was evoked even when the control stimulus is an apparently tasteless one (e.g., water). Hence, it is possible that some intervening substance altered the sense of taste.

There was no significant difference in saltiness threshold between PRE and POST in placebo in CHO, SPO, and TON. Appelqvist et al. (2016) reported that residues of foods and beverages often

coat the oral mucosa after consumption, which may impact on the temporal perception during eating. Once a taste signal is generated in a taste cell, neurotransmitters including ATP and serotonin are secreted. ATP secreted from receptor cells also acts on neighboring taste cells to stimulate their release of serotonin, which spreads the taste in the oral cavity (Roper, 2007). In other words, prior contact of the food with the oral cavity other than the tongue when consuming the food with a spoon may have altered the taste of the food.

There was no significant difference in the rate of changes of saltiness threshold. This result can be explained by very large inter-individual differences as the rate of changes was very scattering data (Standard deviation, CHO: 109.7, SPO: 43.2, TON: 99.2 and CON: 24.1).

In conclusion, we compared the contact order of food and oral cavity and saltiness sensitivity between chopsticks and a spoon. When using chopsticks, food contacted to tongue and then to palate. Meanwhile, when using a spoon, food contacted to palate and then to tongue. In addition, significant increase in saltiness threshold than control was found after the use of chopsticks ($p < 0.05$), but not after the use of spoon ($p > 0.05$). Thus, we suggested that using chopsticks and a spoon change the contact order of food and oral cavity, and use of chopsticks during eating decreases saltiness sensitivity.

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Effect of neuromuscular electrical stimulation on word memory

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Abstract

The effect of neuromuscular electrical stimulation to word memory

Aim: The purpose of the present study is to investigate whether neuromuscular electrical stimulation (NMES) enhances memory function. Methods: Thirteen healthy university students performed 10min of NMES and voluntary isometric contraction for knee extensor muscles at 20% of maximal voluntary contraction on separated days. After each experiment, 10 Hungarian word memorizes was conducted immediately for 10 minutes. After 24 hours, word remember test and memory retention rate were measured. These procedures were also performed following 10min of rest as control trial. Result: The test score was significantly higher compared with the test score after Rest for NMES ($p<0.05$), but not for VOL ($p > 0.05$). Conclusion: From these results, we suggested that NMES activate cognitive function and enhanced word memory.

神経筋電気刺激が単語記憶に及ぼす影響

目的：本研究の目的は神経筋電気刺激（NMES）によって単語記憶力が向上するかどうか調査することであった。方法:13 人の健康な大学生が、最大随意収縮(MVC)の２０％でNMES、もしくは随意運動を各 10 分間実施した。各実験後すみやかに 10 分間で 10 問のハンガリー語記憶を行い、24 時間後を目安に単語記憶テストによって記憶力の定着度を測定しました。これらの記憶テストの手順は 10 分間の安静後でも同様に行われました。結果：NMES 後の単語テストスコアは安静時のスコアよりも有意に高かった（$p<0.05$）。結論：これらの結果から NMES は認知機能を活性化させ、単語記憶力を向上させることを示唆している。

El effecto de Estimulactión eléctrica neuromusclar a la memoria de palabras

Objectivo: El objectivo del presente estudio fue investigar si mejora la memoria palabras por estimulactión eléctrica neuromusclar (NMES). Métodos: Trece estudiante saludables hicienron NMES al 20% de MVC y extensión de rodilla isométrica (VOL) por 10 minutos cada uno en el dia diferente. Después de cada experimento, participantes recordaron 10 palabras Hungría inmediatamente por 10 minutos. 24 holas después, participantes hicieron la prueba de palabras y medimos la tasa de retención de memoria desde resultado dela prueba. Estos procedimientos también se realizaron después de 10min de descanso como control. Resultado: Los puntos de prueba después NMES fue alto significativamente comparado con los puntos de prueba despues descanso ($p<0.05$). Conclusión: Estos resultados sugieren que NMES actitivó la función cognitiva y mejoró la memoria de palabras.

Abbreviations:

NMES: neuromuscular electrical stimulation, VOL: voluntary exercise, QF: quadriceps femoris, STM: short term memory, LTM: long term memory, BDNF: brain derived neurotrophic factor, MVC: maximum voluntary contractions

Introduction

In recent years, the need for foreign language is increased with Globalization (Ministry of Education, Culture, Sports, Science and Technology (MEXT). 2018, British Council. 2018). Globalization is trendy word, and it seems that the development of information technology is one of the big factors progressing globalization. According to World Trade Organization (WTO) report in 2020, world merchandise trade in 2019 was slightly decreased compare with 2018. However, in the information businesses such as telecommunications, computer and information service grew 11% in 2019 from 2018 (WTO. 2020). Internet users and the volume of internet access have been increasing every year (International Telecommunication Union (ITU). 2020). International Organization for Migration (IOM) reported that human immigrations have been increasing and there are huge changes in immigrations between 2000 and 2020 (IOM. 2020). According to ministry of economy, trade, and industry in Japan (METI) show the changes in the number of foreign people coming in Japan (e-stat. 2006-2019). Also, many Japanese enterprises have been moving their company to foreign countries and Japanese people living in foreign countries have been increasing (METI. 1999, 2019).

Japanese Government defined three factor as global person and language ability is the one of those factors (MEXT. 2012). Government and enterprises are positive to recruit, cultivate such a global person (Ministry of internal affairs and communications. (MIC). 2017). Their policy with Globalization and the influx of diverse cultures into Japan may affect the number of Japanese

international students, it has been increased every year (MEXT. 2021). Also, other research says language business sales in 2019 make a more profit compared with 2015 (Yano Research Institute Ltd. 2016, 2020). Therefore, those human resources who can adapt to globalization has been required.

Rodrigo (2017), in his paper, investigated vocabulary knowledge in the production written in case of English as a Foreign Language (EFL) learner and he concluded vocabulary is essential process for learning language (Rodrigo. 2017). However, there is not much time for students or workers to study foreign language such as English because they have other fundamental curriculum or their work. But if they learn and memorize vocabulary more efficiently, they can save the time and use it for other things.

There are some ways to enhance human memory. Slow-wave-sleep enhance memory consolidation and transform memory for long-term memory afterwards, rapid-eye-movement sleep stabilize transformed memory (Rasch B et al. 2013). Hence, memory is kept for long time. Among them, many results of memory improvement caused by physical exercise have been reported. For instance, long-term aerobic exercises increased the size of hippocampus and induced memory improvement (Kirk et al. 2011). Marin (2021), reported moderate intensity exercise significantly enhance cognitive function compared with rest state and high intensity exercise (Marin. 2021). These studies reporting the enhancement of cognitive function following physical exercise would have another advantage such as countermeasures to sedentary lifestyle. According to Regina Guthold

(2018), in his report, current global estimates show one of four adults and 81% of adolescents don't do enough physical activity, especially the volume of not enough exercise people in high-income country is two times more than low-income country (Regina Guthold. 2018). Furthermore, COVID-19 pandemic in Japan would have further spurred a lack of exercise for Japanese people (Japan Sports Agency. 2021). On the other hand, exercises are recommended worldwide because it brings various benefits such as prevention of type 2 diabetes (Kirwan et al. 2017), depression (Brosse et al. 2002), and coronary heart disease (Cattadori et al. 2018).

Memory is divided into declarative memory and non-declarative memory, and declarative memory also divided into semantic-memory and episodic-memory (Tulving. 1972). Then, word memory classified to semantic memory which is the memory that meaning of things as in general knowledge. But human memory system is not still perfectly elucidated. In this study, we approved multi store model of memory, it is the theory that memory has two storage bank, short-term memory (STM) and long-term memory (LTM) (Atkinson and Shiffrin. 1968). On the first phase, memory is created in hippocampus as STM, but not all memories are retained as STM. The Hippocampus distinguish that those STM is needed to retain for LTM or no. Over the next few days, chosen STM gradually shifts to LTM in the cerebrum through nerve cells.

There are some factors to enhance word memory. In this experiment, we took attention to brain-derived neurotrophic factor (BDNF). Hofer (1990), in his report, BDNF promotes development,

growth, maintenance, regeneration of nerve cells and it is most scattered in hippocampus, followed by the cerebrum (Hofer. 1990). Also, previous reports revealed that BDNF has a great relationship with learning and memory function (Linnarsson. 1997, Mu JS. 1999). Recent study says voluntary exercise and neuromuscular electrical stimulation (NMES) enhance the BDNF volume, then BDNF are significantly enhanced in NMES than voluntary exercise (Kimura et al. 2019). In this study, we used NMES because it activates typeIIb fiber predominantly and promote glucose metabolism in the muscle (Clamann et al. 1974). In the case of voluntary exercise, it is difficult to use glucose metabolism because it is needed to exert high-intensity exercise. In addition, it occurs fatigue on the brain and decrease of brain function (Komiyama et al. 2017). On the other hand, NMES can induce glucose metabolism as low-intensity exercises (Malone. 2012). Therefore, NMES enhance BDNF easily than voluntary exercise. Using NMES is more effective and efficient on the way of learning language.

The purpose of the present study is to investigate whether neuromuscular electrical stimulation enhances memory function compared to voluntary exercise. We hypothesized that NMES enhances the word memory consolidation. NMES activate the volume of BDNF more than voluntary exercise. Therefore, increased BDNF positively enhance memory function (Kimura et al. 2019).

Materials and Methods

Participants

Thirteen healthy Japanese young male/female students in Chukyo University volunteered for the present study as participants (20-22ys). The participants gave written informed consent after receiving detailed explanation of this study's purpose, experimental benefit, and risk.

Experimental design

Participants visited laboratory three times and took three types of experiments per day. 10-minutes of word memorizes was done after 10-minutes-rest, voluntary exercise and NMES. Order of three conditions was randomized. We prepared three type of word test (Fig.1, 2, 3), each test has 10 words in Hungarian and Japanese. Hungarian is a suited language to this study because its language has 26 alphabets, accent sigh so that it was character that participants were familiar with, and all participants didn't have knowledge with Hungarian. After 24 hours from test memorizes, we sent the digital answer sheet by email in each experiment (Fig.4, 5, 6). In the answer sheet, the word meaning was list upped only in Japanese and participants answered the spells in Hungarian. The order of 5/10 words was changed. Asked words are same with memorized 10-words the day before. Participants answered memorized words as passible as they can remember and sent back to us. Answered sheets are scored as follows rule. [+1 point if 1 alphabet matches.], [+1 point if the position of accent sign matches.], [0 point if alphabet don't match although the position of accent sign matches and vice versa. This is preventing the score from being attached an accent sign to all alphabets.], [0 point if it is recognized that the answered word was clearly mistaken for other word.].

On present study, right side quadriceps femoris (QF) muscle was observed as the measurement site for voluntary exercise and NMES experiment. The participants were tested for maximum voluntary contractions (MVC) before starting voluntary exercise and NMES in order to determine 20% of MVC as target force. The participants were seated comfortably with the right leg fixed in a custom-made dynamometer (Takei Scientific Instruments CO., Ltd., Niigata Japan) with a force transducer (LU-100KSE; Kyowa electronic Instrument, Tokyo Japan) and both hip and knee joint angles flexed at 90° (180°corresponds to full extension) using previously reported procedure (Watanabe et al., 2016). The participants were asked to gradually increase their knee extension force from the baseline to maximum in 2-3 s and then sustain it maximally for 2 s.

Voluntary exercise

As mentioned above, MVC was measured. After sufficient rest period, participants were continuously seated and performed knee extension force at 20% of MVC on and off alternately for 10 minutes. On and off rate was 3 s/3 s except leg rise and fall down time. Lab chart 8 software observed the force of QF muscle during knee extension.

Neuromuscular electrical stimulation (NMES)

As mentioned above, MVC was measured. After sufficient rest period, participants were continuously seated and we put the NMES pads (20Hz) (Homer ION CO., Ltd., Tokyo Japan) on upper QF muscle and lower QF muscle. Before starting NMES experiment, we adjusted electric current

(mA) of NMES at 20% of MVC intensity for each participant because required NEMS intensity differs depend on the muscle mass of participants. After sufficient rest, QF muscle is stimulated on and off alternately with NMES for 10 minutes according to previous research (Kimura T et al. 2019). On and off rate was 3 s/3 s except leg rise and fall down time.

Word memorizes

After voluntary exercise or NMES over, participants immediately seated in a normal chair and began a 10-minutes word memorizes. Memorizing environment was that participants could hear a slight amount of life sounds. Nothing was allowed other than memorizing in the brain. After memorizing section over, Word memorizing sheet was promptly recovered.

Data analysis and statistics

All data are provided as mean and SD. Before the analysis, the normal distribution of the data was confirmed using Shapiro-Wilk test. The parametric analysis was used for normally distributed data and the non-parametric analysis was used for non-normally distributed data. Present study was normally distributed data, but there were few participants (13 participants) therefore, this experimental data was treated as a non-parametric data. Friedman test was performed for three type of test score to investigate the difference between each type of test score. Post-hoc test was used After Friedman's test. The level of statistical significance was set at $p < 0.05$. statistical analyses were performed using SPSS software (version 25; SPSS, Tokyo, Japan).

1	マンション	lakás
2	取る	vesz
3	柔らかい	puha
4	凍った	fagyott
5	鉛筆	ceruza
6	見る	látni
7	食べる	eszik
8	覚える	tanul
9	調べる	kitalál
10	お菓子	édesség

Fig.1 Word test (Rest).

1	紙	papír
2	持つ	van
3	音楽	zene
4	意地悪な	átlagos
5	湿った	nedves
6	行く	megy
7	投げる	dobás
8	蹴る	rúgás
9	掃除する	tiszta
10	筆箱	ecsetdoboz

Fig.2 Word test (Voluntary exercise).

1	落ちる	ledob
2	鉄	vas
3	走る	fuss
4	退屈な	unalmas
5	疲れた	fáradt
6	歩く	séta
7	洗う	mosas
8	遊ぶ	játék
9	木材	faipari
10	クリスマス	karácsony

Fig.3 Word test (NMES).

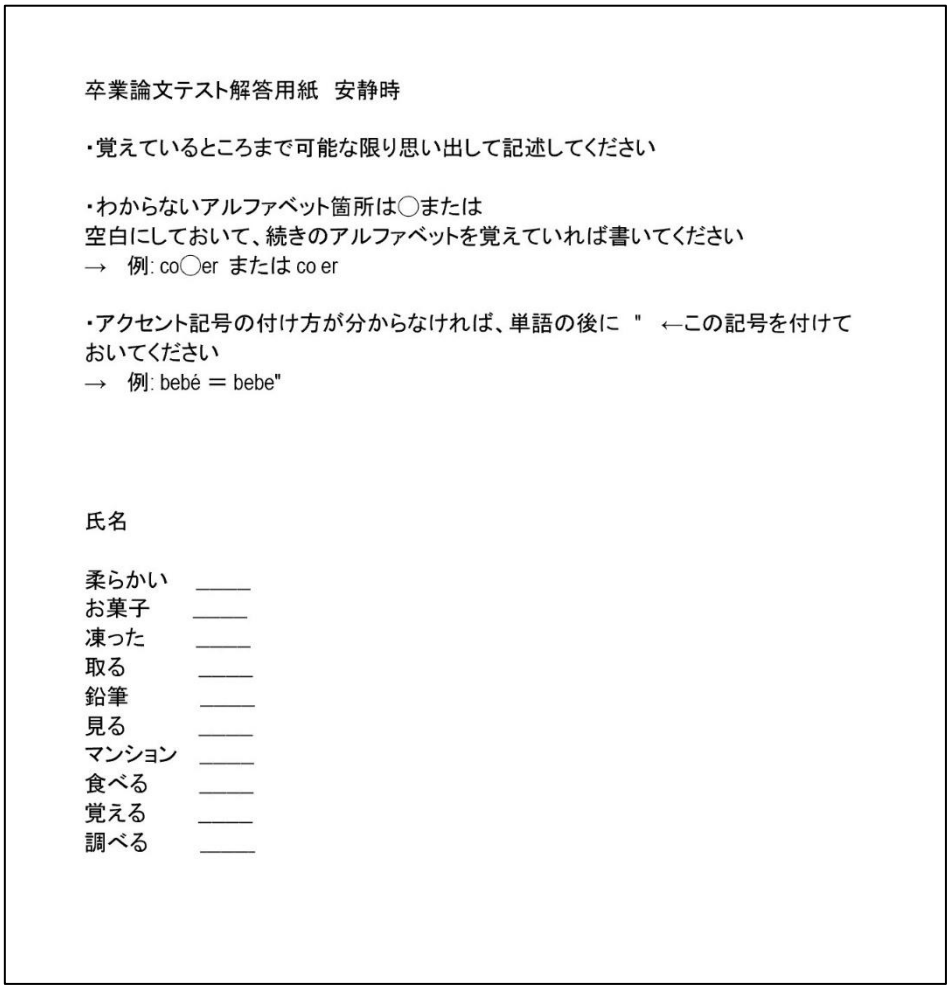

Fig.4 Answer sheet (Rest)

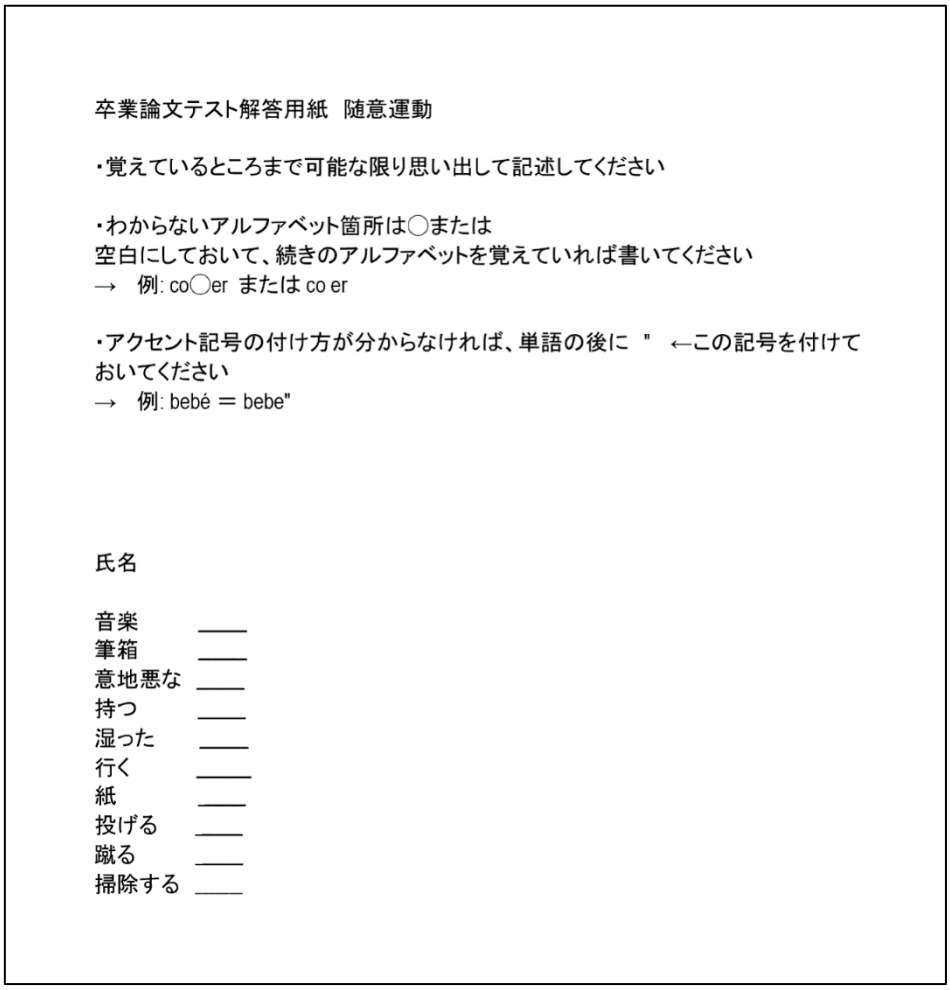

Fig.5 Answer sheet (Voluntary exercise)

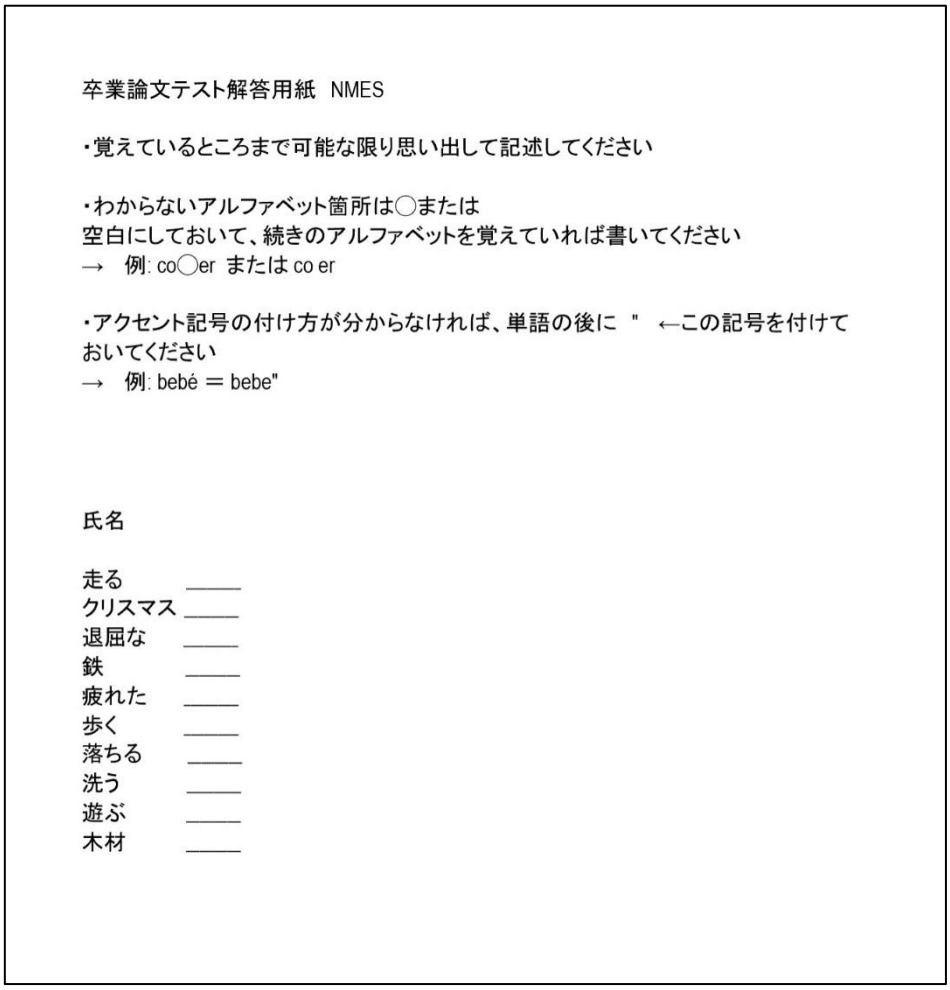

Fig.6 Answer sheet (NMES)

Results

Fig. 7 illustrated mean and SD of word test score after Rest, Voluntary exercise, NMES experiment, it was 35.0±13.6, 38.1±12.6, 43.1±9.0 respectably. There was significant difference in Friedman's test ($p<0.05$), and Significant difference was confirmed between Rest and NMES ($p<0.05$) but was not confirmed between Rest and Voluntary and between Voluntary and NMES in Post-hoc test ($p>0.05$). Thus, there was significant difference in word test score between Rest-NMES ($p<0.05$) (Fig.7). But no significant difference was observed in word test score between Rest and Voluntary ($p>0.05$) (Fig.7).

The mean of test scores was increased from Rest toward NMES, and SD areas narrowed. Fig. 8 and Fig. 9 explain the word test score graph of each participant. Table.1 is the detailed figure of word test score, it said that the rate of highest score test in each participant was NMES (69.23%), next one was Voluntary exercise (23.07%), and lowest was Rest (15.38%). Highest rate of test score in 2nd was Voluntary (46.15%), highest rate of test score in 3rd was Rest (61.53%). The percentage total was not 100% because Subject 7 got same score in Rest and Voluntary exercise.

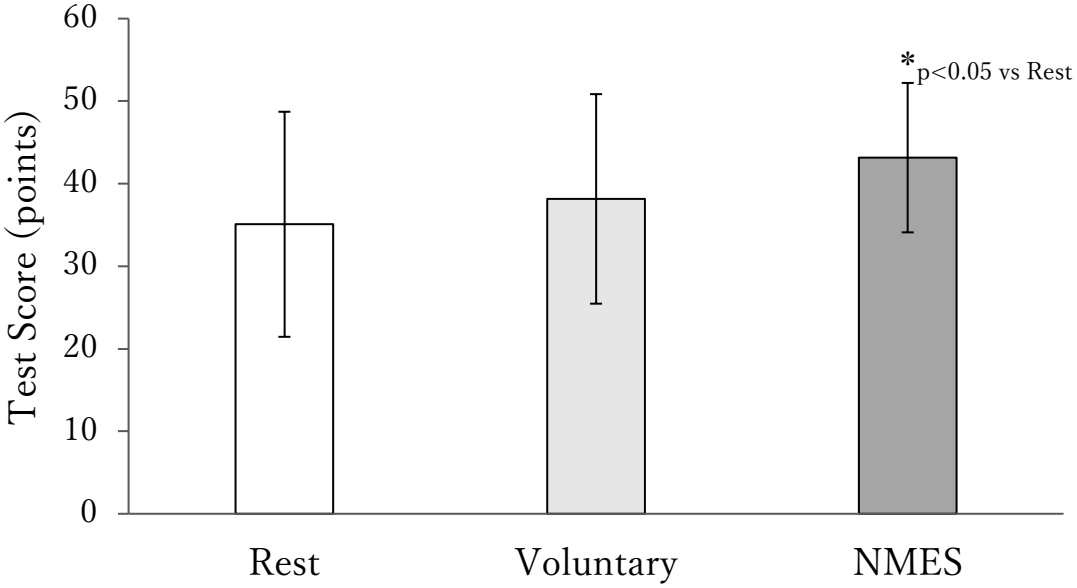

Fig. 7 Mean (±SD) of test score after Rest, Voluntary exercise, and NMES. * $p<0.05$ vs. Rest

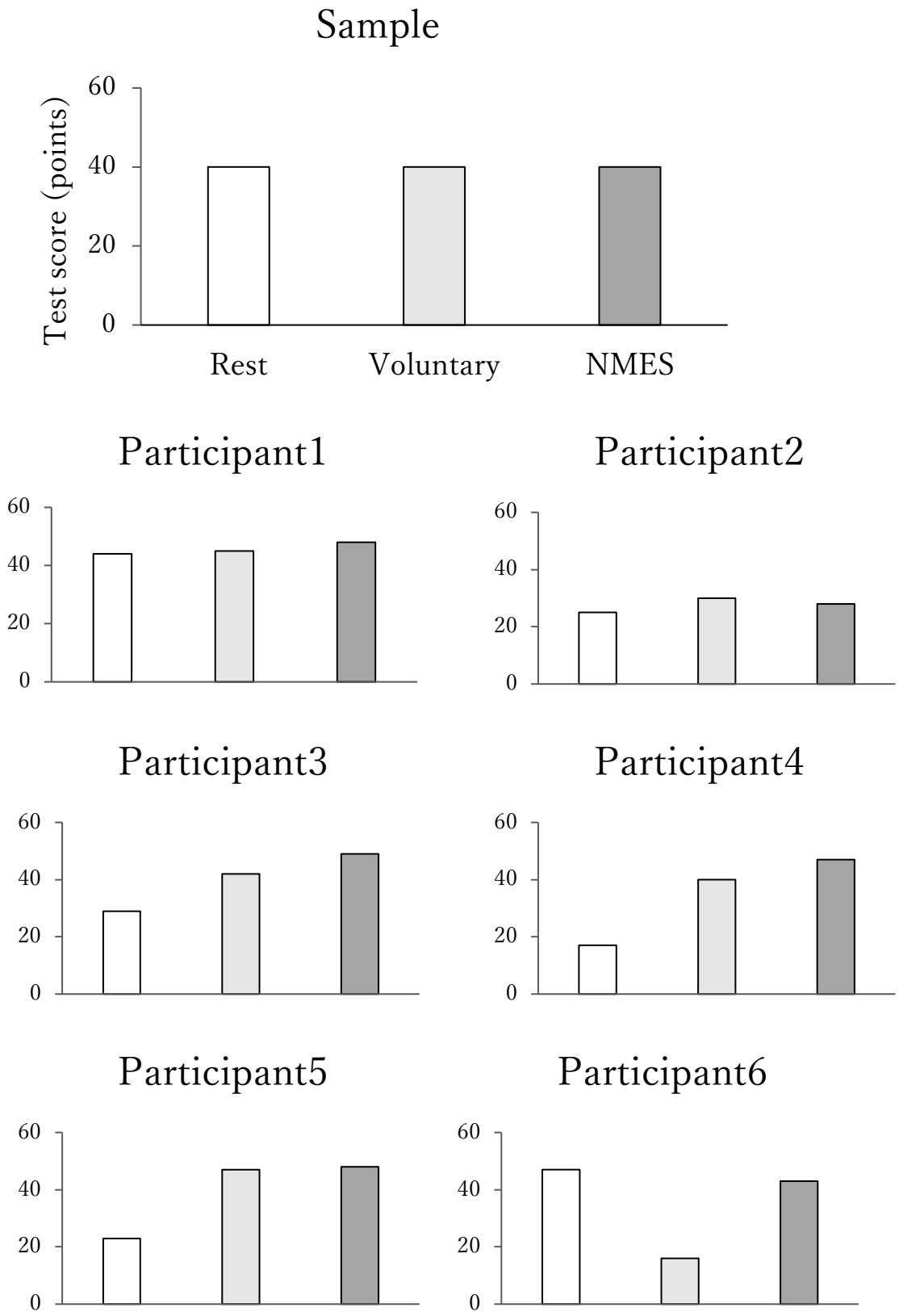

Fig. 8 Word test score graph in participants (participants 1～6) referred to table 1.

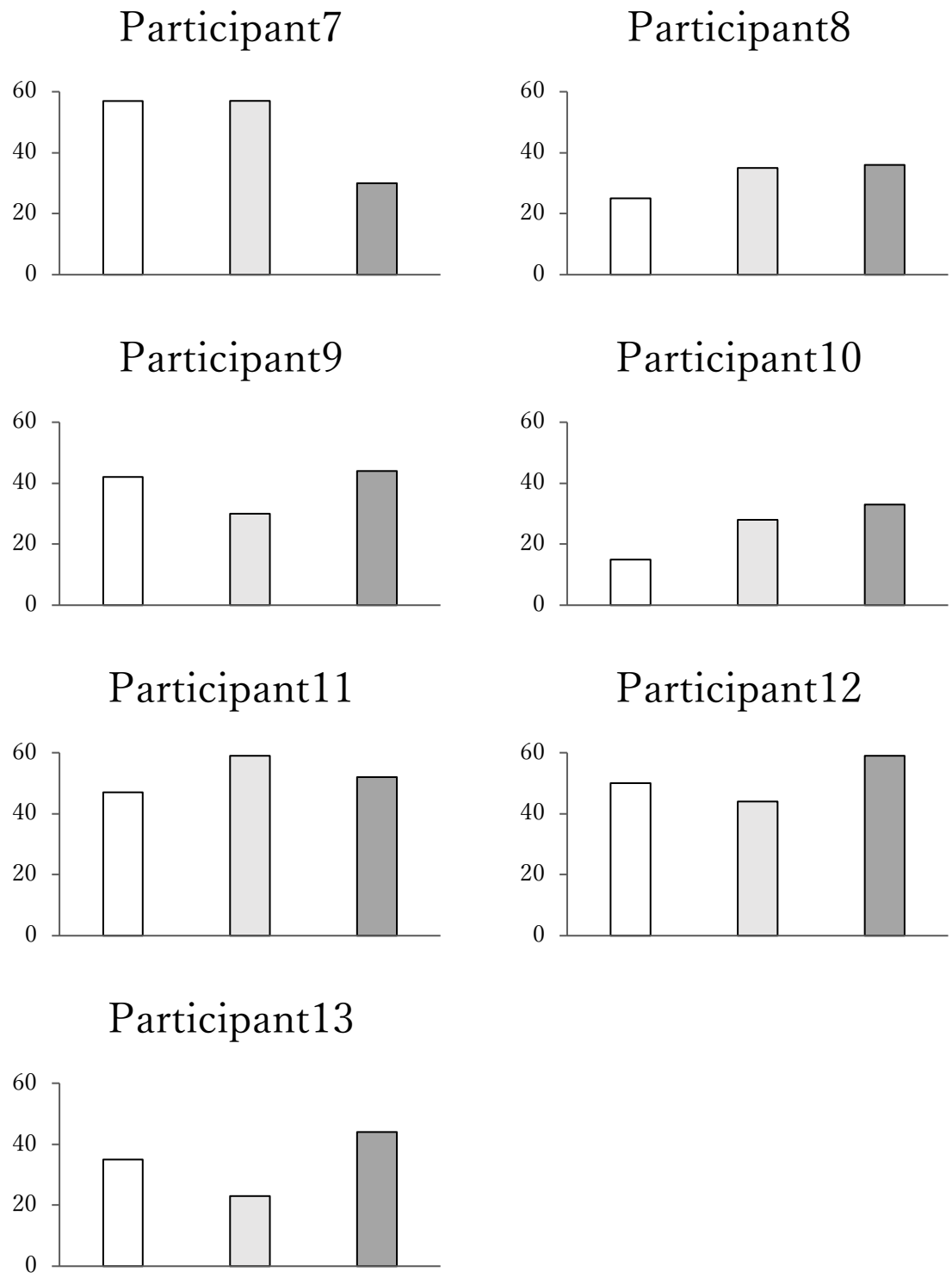

Fig. 9 Word test score graph in participants (participants 7～13) referred to table 1.

Subjects		Rest	Voluntary	NEMS		Rest	Voluntary	NEMS
1		44	45	48		○	●	●
2		25	30	28		○	●	●
3		29	42	49		○	●	●
4		17	40	47		○	●	●
5		23	47	48		○	●	●
6		47	16	43		●	○	●
7		57	57	30		●	●	○
8		25	35	36		○	●	●
9		42	30	44		●	○	●
10		15	28	33		○	●	●
11		47	59	52		○	●	●
12		50	44	59		●	○	●
13		35	23	44		●	○	●
					● 1st	15.38%	23.07%	69.23%
					● 2nd	23.07%	46.15%	23.07%
					○ 3rd	61.53%	30.76%	7.69%

Table. 1 Word test score and rank distribution of scores in each participant.

Discussion

In present study, there was significant difference in test score between Rest and NMES, suggesting that NMES could enhance memory function. This improvement of memory test following NMES could be explained by actions of BDNF (Linnarsson et al. 1997, Mu JS. 1999). Since a significant difference in memory function was observed between Rest and NMES, it seems that BDNF activity was increased and could enhance memory function in NMES experiment. NMES condition in the present study was different from previous study (Kimura et al. 2019), in terms of electric current (mA) and duration. Regarding of the intensity of electric current (mA), the present study was restricted adjusting 20% of MVC. Furthermore, NMES accumulates lactate on the muscle by promoting glucose metabolism. Lactate accumulation is an index of glycogen usage. As a result, exerted muscle force was decreased toward the end of experiment. Hence, we adjusted NMES output as much as possible aiming at 20% of MVC during NMES. However, stimulus intensity of previous study was progressively increased to the highest tolerated intensity during the experiment (31.3±7.6mA). It was difficult to compare electric current (mA) as index. But considering electric current (mA) on the present study was around 20～35mA, there was not big difference in electrical current from previous study (Kimura et al. 2019). Furthermore, the frequency of NMES devise and stimulated muscle site was same with the previous study (Kimura et al. 2019). The big difference was in stimulate duration. Present study's NMES duration (300s) was 4-fold times shorter than

previous study (Kimura et al. 2019) although, there was significant difference in test score between Rest and NMES. Thus, this result showed the possibility that BDNF had been activated and affect memory function even with short stimulate duration.

But there were no significant differences in test score between Rest and Voluntary and between Voluntary and NMES. This means secretions of BDNF were similar among them. In previous study (Kimura et al. 2019), there was significant difference between Rest and Voluntary and Voluntary and NMES. Voluntary exercise in previous study (Kimura et al. 2019) was performed as same with the conditions of NMES experiment, Participants did knee extension alternately left and right and on-off ratio of 4.5s-4.5s (leg rise time 1.0s, fall time 0.5s) for 20 minutes. Knee extension intensity was calculated based on NMES intensity data. Voluntary exercise intensity in the present study was also same with NMES. As mentioned above there was 4-fold times difference. It seems that the reason why there was no significant difference between Voluntary and NMES, was lactate concentrations. Ferris. 2007, reported that there was significant correlation between the change in blood lactate and the change in serum BDNF (Ferris et al. 2007). Motor unit induces from low-threshold motor units in voluntary exercise, but NMES induces preferential recruitment of high-threshold motor units or random-order recruitment of low- and high-threshold motor units (Bickel. 2011) and glucose metabolism (Hamada. 2003). Therefore, since sufficient Voluntary exercise and NMES to increase BDNF, was not performed in this experiment, there was no significant difference

between Voluntary and NMES and between Rest and Voluntary.

On the other hand, neurotransmitter would contribute to memory consolidation. Serotonin, dopamine, and noradrenaline are known for three major neurotransmitters, these are essential for communication between nerves. Noradrenaline is released from Locus coeruleus (LC), and it is a mainly noradrenaline supplier for brain, especially hippocampus and cerebrum, which are related to word memory (Tully and Bolshakov.2010). The frequency of firing in the locus coeruleus is increased with stimuli especially stress and pain (Borodovitsyna. 2018). So that NMES/Voluntary exercise gave stress to participants and noradrenaline would enhance memory consolidation. However, as the stimulus is repeated, the response is decreased as it gets used to the stimulus and nerve system excitement doesn't last long. It was considered that the noradrenaline concentration was increased during NMES/Voluntary exercise experiments, but noradrenaline wouldn't continue to affect until phase of word test. Therefore, neurotransmitters are unlikely to work significantly in 10min NMES/Voluntary experiments.

Regarding to difficulty of word test, Hungarian were adopted in present study because 26 alphabets are common in English and majority of European language, and accent sign is also common in European language. Recently, there are many people who speak or learn English and European languages. Furthermore, Hungarian is an unknown language for this study's participants, and knowledge-independent experimental results are expected. Therefore, Hungarian was selected as

test language in this experiment. We picked up words with the almost same number of alphabets (55 alphabets), vowels (21-22 vowels), consonants (33-34 consonants), accents (5 accents), and letter composition to make word test in a well-balanced manner so that there would be not much difference in difficulty in each word test. But test score was greatly difference among participants. This is because simply participants' innate memory function and possibly due to memorizing environment. Basically, the memorizing environment was quiet, but could be some surrounding noise. According to previous study (Smith A. 2010), music could reinforce cognitive function and Jeon and Oh (2019), reported that noise listening study method was positively influencing learning and concentration improvement (Jeon and Oh. 2019). In present study as well, surrounding noise may have had some effect on concentration. Like environment effect, memory contains fragility that is susceptible to all external stimuli. Loftus and Palmer (1974), reported memories can be reconstructed by subsequent events, questions, etc. (Loftus and Palmer. 1974). In the case of present study as well, participants behavior after NMES were not restricted. Thus, it is possible that something emotional affected memorized word.

Calculation of glucose consumption

There was also the possibility that glycogen consumption in the QF muscle by glucose metabolism causes decrease in brain function. However, a rough calculation shows that consumed glucose in the body by NMES was at most about 17.71g, and it was concluded that there was almost

no possibility of deterioration of brain function by glucose metabolism (the calculation was described below).

Glucose consumption of brain at rest is [5.4 mg/100 g (brain weight) /minute] in the case of awakening adult man (Kety. 1962). The average of human brain weight is about 1321.61g (age 20.52±2.44). thus, glucose consumption is about 0.76g (1400g brain during 10min) (Parvin et al. 2012). Human glycogen storage amount is 90g～150g in the liver and 100g～400g in the skeletal muscle, and the total glucose storage is 190g～550g (Wasserman. 2009). In present study, 20% of MVC was induced. The amount of energy use is determined based on METs method, but since oxygen uptake doesn't change much during NMES, so that the energy use estimation is made based on the ergometer bicycle (160-200W, 11 METs) that would introduce typeIIb fibers (National Institute of Health and Nutrition. 2012). If a person (70kg) exercise 11 METs for 5 minutes, he consumes 67.375kcal. this, glucose consumption is 16.9 g (1 g=4 kcal). NMES experiment was 5-minutes NMES and 5-minutes rest (total 10 minutes). Hence, glucose metabolism for 10 minutes was 16.9 g +0.76 g =17.66g. Glucose metabolism by NMES doesn't exceed glucose storage in the body (17.71g<190g～550g), and adult man (70 kg) have 5.25g of glucose flowing in their blood. It was concluded that there was almost no possibility of brain dysfunction due to glucose metabolism by NMES. On the other hand, glucose consumption by voluntary exercise was lower than NMES because it works predominantly in lipid metabolism.

In conclusion, we tested the effect of NMES on word memory. This research confirmed that the word test score was significantly improved after NMES compared to Rest, but significant difference was not confirmed between Voluntary and NMES and between Voluntary and Rest. This result suggested that NEMS enhanced brain memory system in language territory, and this result support that NMES enhance memory function compared with voluntary exercise. In the future, word learning during NMES may be possible.

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Influence of cold footbath to appetite in morning

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Abstract

Influence of cold footbath to appetite in morning

The purpose of this experiment was to reveal the influence of cold footbath on autonomic nervous system, sensitivities of sugar and satiety in the morning. Seven male and female college students undertook footbath at 36℃ and 10℃ for 15 each on two separated days. We compared autonomic nervous activity based on heart rate variability. Also, we measured satiety with visual analogue scale (VAS) before and after the footbath and after eating rice. About Sensitivity of sugar was measured with Taste disc. There were no significant differences on autonomic nervous activity and sensitivities of sugar and satiety between footbath of 10℃ and 36℃. These results suggest that cold footbath is not effective on Autonomic nervous system and appetite of the morning.

朝食時の冷水による足浴の食欲に対する影響

本研究の目的は異なる水温を用いた水浴による食欲増進作用の有無を明らかにすることである。中京大学の学生 7 人対象とし別日に 2 回の測定を実施した。 1 日目は 10℃、２日目は 36°の水に足を 15 分間つけた。心拍変動をもとに自律神経の変化を比較した。また足の冷水浴の前後と白米実食後の空腹（満腹）度をＶＡＳ方式のアンケートを実施した。そして糖分の枯渇度を見るために甘味の味覚感受性のテストを行った。10 度と 36 度間の水に足をつける事による自律神経・甘味感受性・空腹（満腹）度に統計学的に有意な差は認められなかった。これらの結果から朝食時における水温 10 度の足水浴は自律神経活動の活発化やそれに伴う食欲の増進を引き起こさないことが明らかとなった。

El efecto del baño frío por la parte en pie para apetite por la mañana.

El objeto de este estudio es aclarar influencia del baño frío por la parte en pie para nervio autonómico, sensibilidad de azúcar y satisfecho en la mañana. Siete alumnos del Universidad del Chukyo metieron sus piernas en agua con la temperatura 36℃ y 10℃ por 15 minutos cada dos días. Comparamos la variabilidad del ritmo cardíaco (HRV) para ver el cambio de nervio autónomo. También, preguntamos el satisfecho a los participantes con la encuesta de escala visual analógica (VAS) antes, después del baño y después desayuno. La sensibilidad de azúcar fue midieron con Taste Disc. No había tanta diferencia en autonómico, sensibilidad de azúcar ni satisfecho entre baño frío por la parte en pie con la temperatura 10℃ y 36℃. Estos resultados significan q baño frío de pies no es efectivo para autonómico y apetite de la mañana.

Introduction

Recent years in Japan, energy shortage has become a social problem. According to survey by Ministry of Health, Labour and Welfar, the percentage of skinny level of BMI of women between 20 to 29 years is 21.5% and that is highest in all generations (Ministry of Health, Labour and Welfar, 2013). This is because they have a small appetite especially among young people (20 to 29 years old). The rate of skip breakfast is increasing (Ministry of Health, 2008). 13.2% of Japanese skip breakfast (Ministry of Health, 2008). Young people aged between 20 and 29 showed largest number of skipping breakfast (27.9%) comparing with other age groups (Ministry of Health, 2008).

Breakfast is essential opportunity for energy intake because it is first meal and became energy to active. If we skip breakfast, number of meals increases, and this leads the possibility of overeating. (John,2007). Also, children have low caloric intakes are significantly more likely to report hunger and have significantly worse grades in school, higher rates of absenteeism, and more psychological problems in comparison to children with more adequate dietary intakes. (Kleinman et al., 2002)

The studies of autonomic nervous have shown that heart rate of non-obese subjects was changed, and standard deviation (SD) raised after the cold exposure of 10℃. This result shows that the autonomic system was affected by cold exposure (Tamaki et al., 2001). The regulation of body temperature is one of the most critical functions of the nervous system (Chan & Zachary, 2018).

On the other hand, when temperature down, our body use glucose to preserve body temperature. (Zhichao et al., 2020). With these three previous studies, we can see the connection between temperature, autonomic nervous system and the regulation of body temperature. This means that when the temperature down, autonomic nervous system works to adjust the body temperature appropriate degree. And this brings up the consume of sugar as energy. Moreover, there is animal study reported that fall of air temperature induces increase of the amount of meal. In this report, they used seventeen male Sprague Dawley rats and put them to the room with temperature of 20℃, 33.5℃, 8℃, 30℃, and 20℃. As a result, the food intake increased during the week at low temperature (8℃) (Cormarèche-Leydier, 1984).

There is a study that it has been clarified that autonomic nervous system is also affected by water temperature. Footbath with 42℃ changes in the measured autonomic responses, indicating a shift to increased parasympathetic and decreased sympathetic activity. (Saeki, Nagai, & Hishinuma, 2006)

The purpose of this study was to reveal the influence of cold footbath on autonomic nervous system and sensitivities of sugar and satiety in the morning.

We hypothesized that cold footbath effect on autonomic nervous system and the HRV will show variance (Tamaki et al., 2001; Saeki, Nagai, & Hishinuma, 2006). Then the level of sensitivity of sweetness will improve because the sugar of one's body will consume to keep their body temperature

from cold stimulus (Zhichao et al., 2020). Consequently, we assumed that cold stimulus improves the level of hunger through VAS questionnaire.

Methods

Pre-experiment

We conducted a simple pre-experiment on 12 subjects. This is the experiment aiming to determine the detection place of sense of taste by using Taste Disc (Mikawa Chemical Laboratory company, Japan) on the tongue in experiment 2 (Fig.1). We used five level of sweetness solution and put on tip and center from weaker to stronger sweetness levels gradually (S-1 to S-5) and the filter paper with a diameter of 5mm. Then, put it on tip and center of the tongue. The participants tested from level1(S-1) to level5(S-5) gradually. The experiment was finished when the participants sense the sweetness. During each inspection, the participants rinse their mouth to wash their mouth and tongue in order to reset from the sweetness solution.

Experiment1: Pilot study

The participant is only one university student. This experiment was designed to investigate whether cold footbath has influence on autonomic nervous activity as much as cold exposure. The experiment started at 8 am following the previous study of cold exposure (Matsumoto, et al., 2001). First day, we reproduce with same environment (25° & 10°) to see the change of heart rate, SD. We used the

Fig.1 Taste Disc

thermometer to monitor the temperature of the room (Fig.2A).

Second day, we repeat the process with water (25° to 10°) and recorded the same as first day to confirm if there is same change on heart rate, SD as first day. To monitor the temperature, we used water thermometer (Fig.2B). In this case, we used outside temperature to reproduce the circumstances of chamber because it was difficult to use chamber. About 25°, we used heating and closed the door to keep the temperature.

Heart rate variability (HRV)

The participants dressed in T-shirts and shorts and instrumented with ECG electrodes. Then, rest for 20 minutes in order to keep stable heartrate. After this process, the subject entered the room that controlled the temperature at 25° by heater for 15 minutes. We took the room temperature by the remote control and thermometer (Fig.2A). In first process we recorded the heart rate during the participant was in the room with temperature 25°. During the test, the heart rate was continuously recorded by ECG for 5 minutes and subjects breathed in synchrony with a metronome at 15 beats ・ min^{-1} (0.25 Hz) (Smart Metronome & Tuner) (Fig.2C). We took rest for 2 hours as written in the preceding studies and repeated the first process with the room with temperature of 10° (Matsumoto, et al., 2001). Second day, we did the same process as first days only changed cold exposure, from room temperature to water temperature. First, heart rate was measured following 20 minutes of rest of period. Then, the participant take footbath with water temperature of 25° for 15 minutes. We monitor

Fig.2A Thermometer

Fig.2B Water thermometer

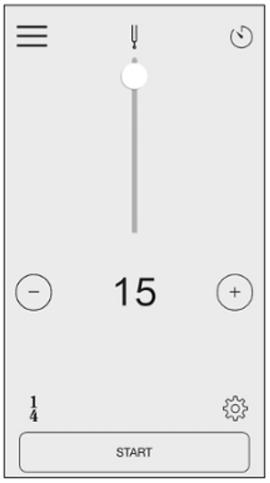

Fig.2C Metronome of application(Smart Metronome & Tuner)

the water temperature by water thermometer (Fig.2B). After the rest of 2 hours, the first process was repeated with water temperature of 10°.The participant wore a jacket so that the participant wouldn't be exposed to the cold. Through this consideration, the participant affected the influence of temperature only from her foot. The depth of water was set about 25cm to immerse the participant's ankle.

Experiment 2: Main study

Participants

Seven university students (BMI:19.1±1.1kg/m2) who are non-smokers participated in this experiment. All participants had been weight-stable for at least 1 year. Also, they hadn't had any disease of high blood pressure, diabetes, and cardiovascular diseases. They were instructed to avoid any food or beverage containing alcohol and caffeine after 21:00 of the day preceding the study. That is because these affect to autonomic nervous system（Matsumoto,2001）.All participants were fasted since 21:00 before experiment day to avoid the excessive fullness of the morning.

Procedure

The experiment were two consecutive days. Each day started at 8:00 or 7:00 and finished at 8:00 or 9:00. This study was conducted in the laboratory of Chukyo university. First, we recorded heart rate and sensitivities of sugar and level satiety before the foot bath. It is to know those basic lines of each participant. The volume of water is the same as pilot study. During the footbath, we recorded heart

rate. After that, the participants took a test of Taste disk and answered to the VAS of satiety. Finally, they ate rice and repeat the procedure that did after the footbath.

The effect of cold footbath on autonomic nervous system leads to sugar consumption to maintain body temperature from cold stimulation. Then we will prove that sugar was used for body temperature retention by the test before and after the experiment with the sweetened aqueous solution of the Taste disk. After of all, we will judge whether the increase in the food intake by the cold footbath by using hunger (satiety) VAS.

Heart rate variability (HRV)

The procedure of recording heart rate is same as pilot study. In this case, 25° and 10° of the temperature changed to 36° and 10° of water temperature. 36° is set as normal temperature of human as the water temperature that don't have an influence on the body temperature. This is because to remove the possibility that there is effect on the autonomic nervous system only by footbath.

Taste Disk

We used Taste Disk to examine the sensitivity of sweetness (Fig.1). The place to put filter paper was decided at the tip of the tongue according to pre-experiment and previous study (Xiaoke et al., 2012) (Fig.4).

VAS

We prepared VAS to measure the level of satiety（Fig.3）. The left end is level 0 of hunger. That

means “feel full”. On the other hand, the right is level 10 of hunger. That means “very hungry”. The VAS was measured at before, after of the footbath and at the end of all measurements. We referred “Japanese Food Guide Spinning Top” according to each participant’s active and divided the amount of food of one day by three to serve as an amount of the breakfast (Ministry of Agriculture, Forestry and Fisheries).

Statistics

All statistical analyses were performed using a commercial software package (SPSS version 7.5 for Windows, SPSS). The non-parametric analysis was used for non-normally distributed data. SD of HRV, sensitivity of sweetness and Satiety level were compared between footbath of 25° and 10° using Wilcoxon test. We compared the Percentage of change between pre and post of the footbath in SD of HRV and sensitivity of sweetness between day of 25° and 10° using Wilcoxon test. About sensitivity of fullness, we compared percentage of change between pre, post of the footbath and at the end of the experiment between day of 25° and 10°.

Result

Pre-experiment

From the graph of average of sensitivity of sweetness between center of tongue and tip, it can be said that the tip of the tongue is more sensitive to sweetness than the center (Fig.4).

Experiment 1

The SD of HR increased by the cold footbath as much as cold exposure (Fig. 7). SD of HRV with cold exposure changed 1.8 to 3.0 and the value with cold footbath changed 1.4 to 3.0.

Experiment 2

In main study, SD of heart rate changed from2.9±0.8 to 3.0±1.6 at footbath of 36° and from 2.6±1.0 to 3.1±0.8 at 10° respectively. There were no significant differences in HRV between 36° and 10° respectively ($p > 0.05$) (Figure 8). The level sensitivity of sweetness changed from 2.5±1.0 to 2.4±0.9 at footbath of 36° and from 2.0±1.9 to 1.8±0.7 at footbath of 10° respectively. There was no significant difference percentage of change in sensitivity of sweetness between pre and post of footbath in the day of 36° and 10° respectively ($p > 0.05$) (Fig.7). The average of level hunger (satiety) level VAS changed 6.9±1.2 to 6.8±1.5 at footbath of 36° and 6.6±1.9 to 6.4±1.2 at 10° respectively. About the final value of hunger were 2.1±1.1 to 2.7±1.7 for footbath of 36° and 10°. There was no significant difference in average of hunger level between 36° and 10° between pre and post ($p > 0.05$) (Fig. 8). Also, there was no significant difference in average of hunger level between 36° and 10° between pre and post ($p > 0.05$) (Fig. 8).

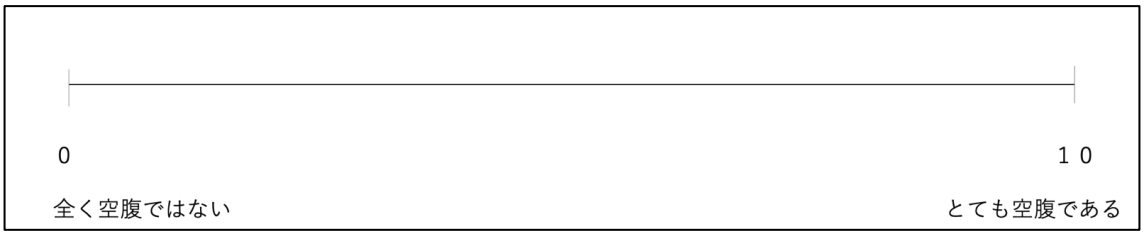

Fig.3 Questionnaire of VAS (A Visual Analogue Scale)

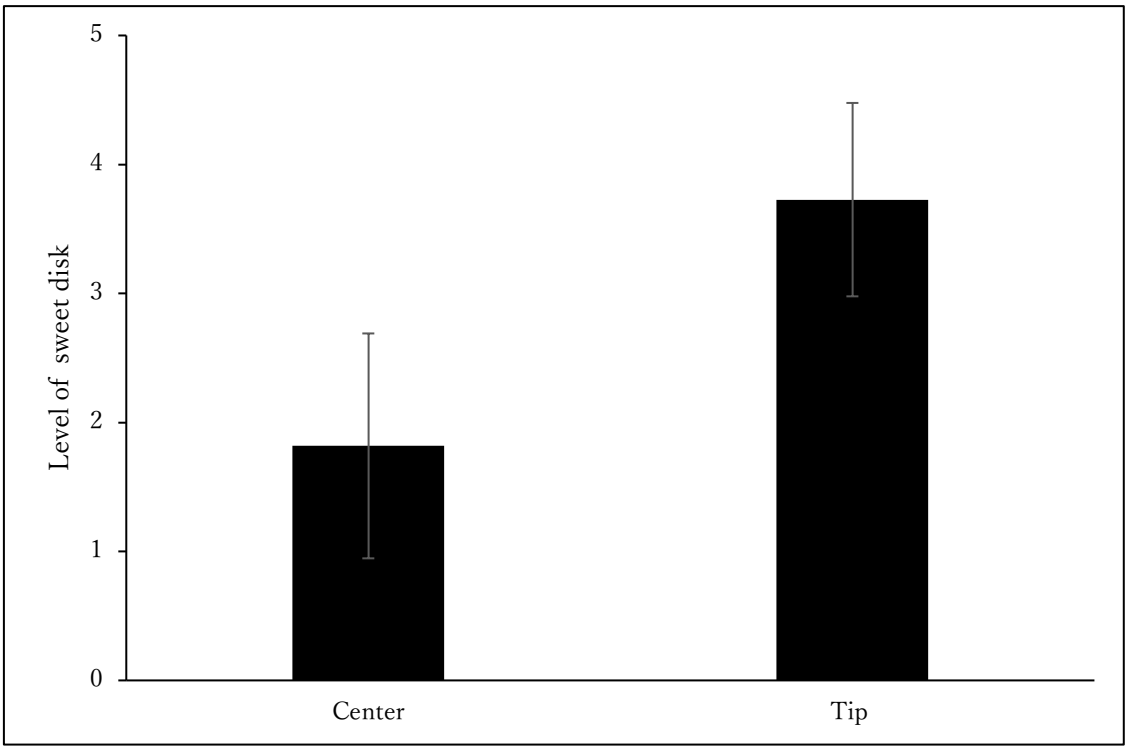

Fig.4 Average of sensitivity of sweetness between center of tongue and tip.

Discussion

In experiment 2, the influence by footbath of 10° on the autonomic nervous system wasn't observed. ($p < 0.05$) (Fig.5). That means the footbath of 10° is not sufficient to affect on the autonomic nerve system. However, in experiment 1, the SD of heart rate of 10°at footbath and cold exposure was same (3.0). We started experiment 1 at 8:00 and soaked at footbath of 10° at 10:40 following the previous study (Matsumoto, et al., 2001). On the other hand, experiment 2 was started 8:00 or 9:00 and the participants soaked their foots in footbath at 8:20 or 9:20. There is possibility of diurnal change between 8:20 and 9:20 because the autonomic nervous system changes a day (Raffaello, et al., 1990). In this previous study there is no reference about change of each hour. However, there was difference in average of SD of heart rate between the group of 8:20 and 9:20 (Fig. 11). The value of group 9:20 increased more than group 8:20. Moreover, the CV of 8:20 is 40.6 and 30.4 before cold footbath and after cold footbath. On the other hands, the CV of 9:20 is 18.6 and 9.2 before cold footbath and after cold footbath. This means that the group that soaked late, may have more influence. This makes sense because in previous study's result support that during early morning parasympathetic nerve system is active and sympathetic activity is passive (Raffaello, et al., 2009). As time go on, sympathetic activity becomes active and parasympathetic nerve system. Temperature is one of the environmental factors affecting the autonomic nervous system (Matsumoto, et al., 2001). Previous studies referred in experiment 1 have revealed that cold exposure of 25° to 10° affected the autonomic nervous

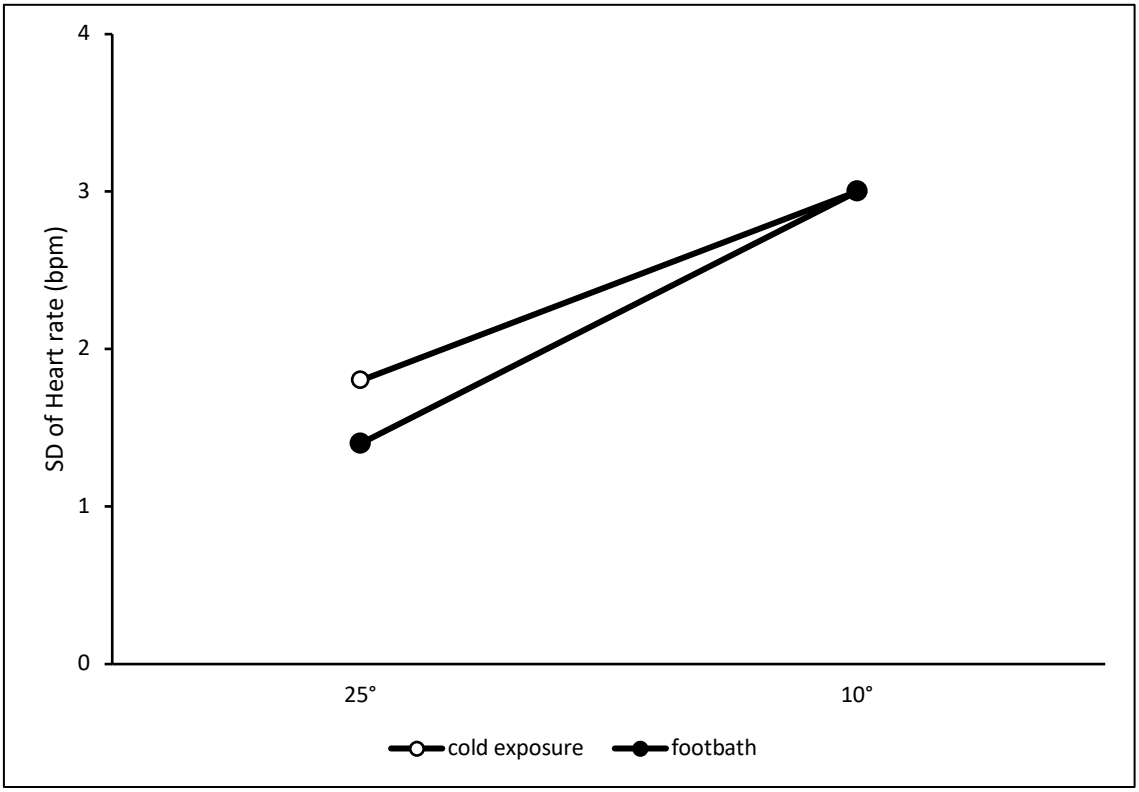

Fig.5 Standard variation (SD) of heart rate with cold exposure and footbath.

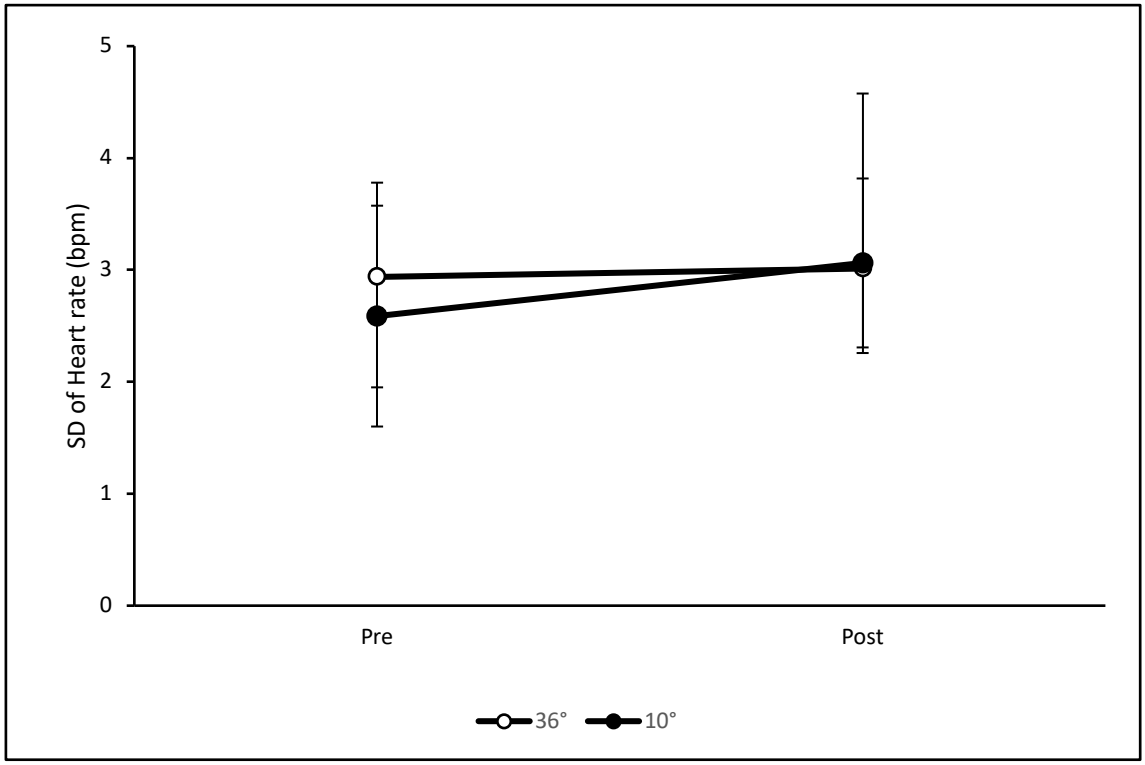

Fig.6 Standard deviation (SD) of heart rate before and after with footbath of 36° and 10°.

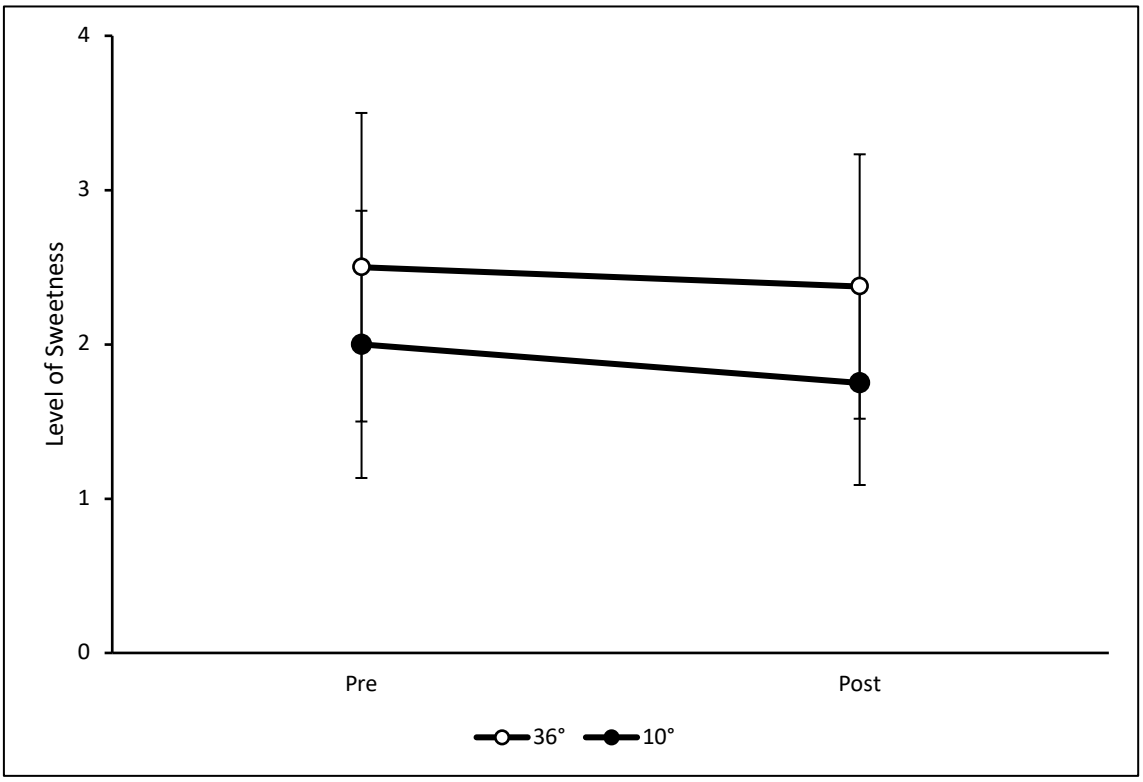

Fig.7 Average of sensitivity of sweetness before and after of footbath at 36° and 10°.

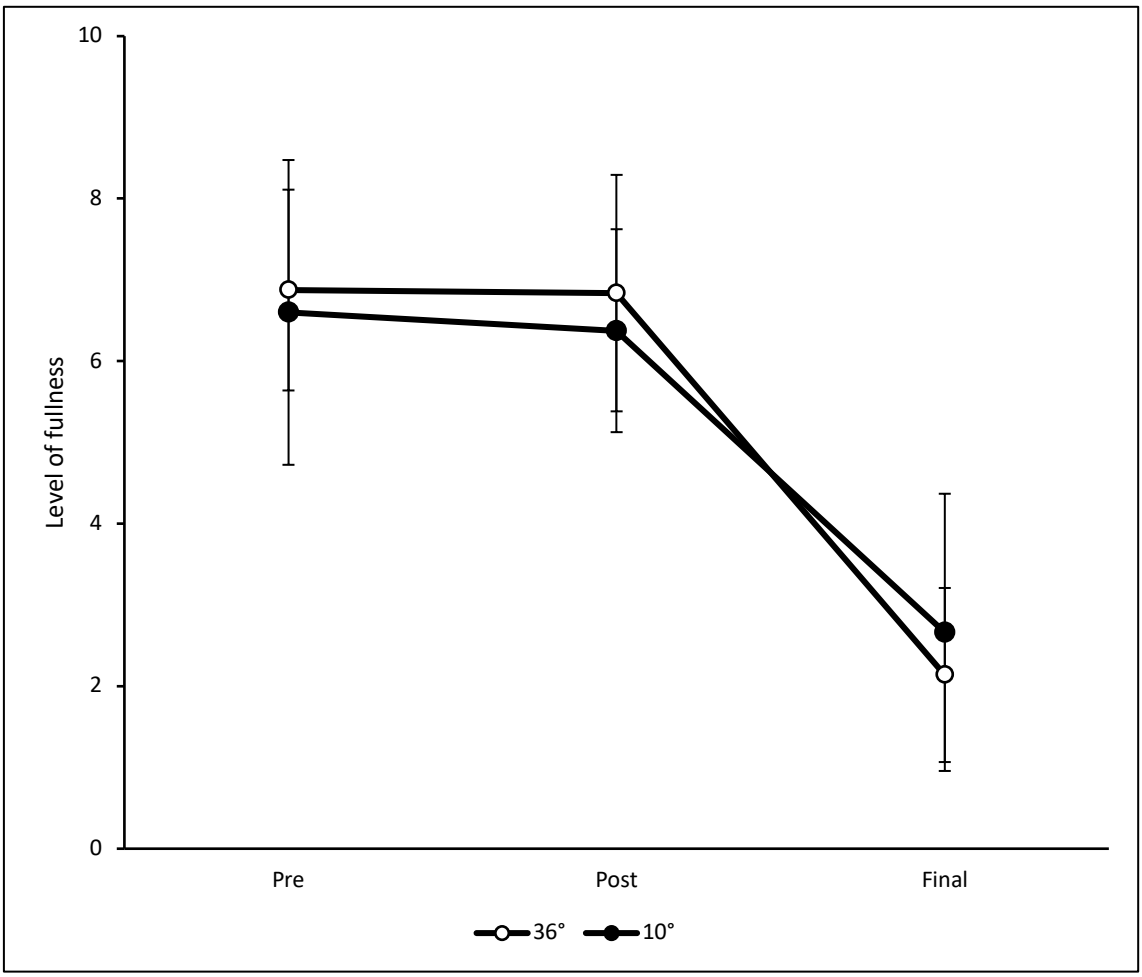

Fig.8 Average of hunger by VAS questionnaire.

system (Matsumoto, et al., 2001). Since the pre-experiment was carried out by one subject, the chamber room could be reproduced using heating in the closed room and the temperature could be kept constant. However, in this experiment, there were two or more people, and two windows were always opened because corona countermeasures were necessary. From this, the temperature change of about 2 degrees during the experiment was seen. According to previous studies, autonomic nervous system is affected even during comfortable temperature (Matsumoto, et al., 2001). However, there was not any previous study that reveal the effect on heart rate every degree. Therefore, we can declare about the influence of temperature change of few degrees.

The temperature of cold water was enough as a cold stimulus to effects on the autonomic nerve system and change HRV significantly (Fig.6). The temperature of the cold water was set same temperature as the preliminary experiment conducted based on the previous research on cold exposure (Matsumoto, et al., 2001). In other experiments using cold water to effect on the autonomic nerve system used water of 10°-12° or 12° (Geert, et al., 2016; Maxime et al., 2020). Previous studies have shown that cold stimulation produces dizziness and discomfort due to muscle tension caused by hypotension after peripheral vasoconstriction (Romain, et al., 2018). In other words, excessively low temperature or long-term inundation put a heavy load on the participants' bodies. There is a previous study that suggest the difference effect of HRV change of cold exposure between obese and non-obese young women (Matsumoto et al., 1999). However, the average of participants' BMI was 19.1±1.09.

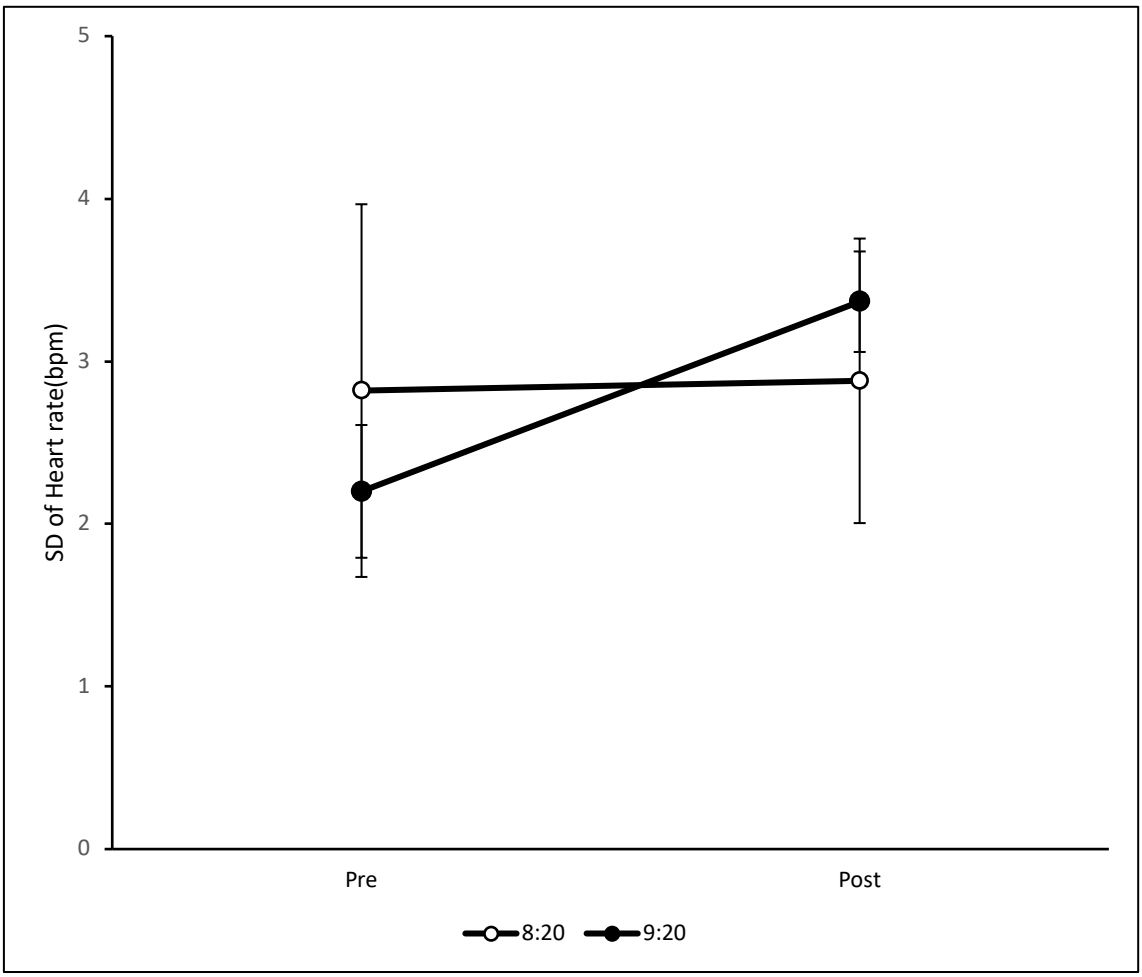

Fig.9 Standard deviation of heart rate of 8:20 and 9:20.

In the previous study, average of participants' BMI was 18.5±0.18 and 26.3±0.74 for non-obese and obese women (Matsumoto, et al., 2001). The average of participants' BMI of main study, was close to non-obese woman group's than obese ones. This means, it is extremely difficult that there was influence by variation of participants' BMI.

Next, about the fact that no significant change in sweetness sensitivity was observed ($P > 0.05$) (Fig.7).

During the experiment, there were several subjects who felt sweetness with the same level of solution but answered that they felt sweeter than before the water temperature was 10°. In other words, if we prepared a sweet aqueous solution with a concentration between 1 and 2, it might have been possible to record a slight difference in the sensitivity threshold as data. In hypothesis, we expected that the level of satiety will down by effect of cold-water irritation through autonomic nervous system. However, footbath of 10° of the experiment 2 was not sufficient to decrease the level of satiety.

In conclusion, we compared the change of SD of HR sensitivity of sweetness and satiety with footbath of 36° and 10°. In experiment 1, there is difference between the footbath of 10° and 25° as same as cold exposure in SD of heart rate as expected. However, there were no significant differences between footbath of 36° and 10°, SD of heart rate and sensitivities of sweetness and satiety. From these results, we suggested that the footbath with 10° was not effective on autonomic nervous system and appetite.

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Estimation of car accident risk from motor function

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Abstract

Estimation of car accident risk from motor function

The purpose of this study is to find out the ability to driving aptitude by simple physical fitness test. Seven healthy men and four women aged 20 to 23 took the driving aptitude test and performed physical fitness test. Attention distribution test, Timing test, running vehicle test and Cognitive test. Simple physical fitness test were carried out through the driving aptitude test and chair stand test (CST) and balance test（BT）. There was a significant correlation between driving aptitude test and the CST （r=0.8 1 ,p < 0.05) . Driving aptitude test and BT were slightly correlated (r=0.261 ,p > 0.05 ） Conclusion: These results suggest that there was a relationship between chair stand test and driving aptitude test. It was also suggested that the relationship between the balance test and driving aptitude is low. It is guessed that the driving aptitude can be understood by carrying out the physical fitness test which handles the muscle used in driving.

運動機能から交通事故リスクを推定

本研究の目的は、簡易的な体力測定で運転適性を割り出すことです。方法は 20〜23 歳の健康な男性 7 人と女性 4 人が運転適性検査を行い、体力測定を実施した。運転適性検査である注意配分検査､タイミング検査､走行検査と認知反応検査を経て体力測定である chair stand test (CST)と balance test (BT)それぞれ相関係数を算出した。運転適性検査と CST は相関関係が見られたが（r=0.8 1　p < 0.05)BT との間には統計的に有意な正相関関係が見られなかった(r=0.261 p > 0.05 ）。これらの結果から、運転時に使用される筋肉を使用する chair stand test と運転適性との間には関連性があることを示唆された。また Balance test と運転適性との関連性は低いと示唆された。運転時に使用する筋肉を扱う体力テストを行うことによって運転適性が推測できるのではないか。

从运动技能推定交通事故风险

本研究的目的是简单的体力测量来判断从运动功能估计交通事故的风险，本研究的目的是通过简单的体能测量来确定驾驶能力。 七名年龄在 20 至 23 岁之间的健康男性和四名女性接受了驾驶能力测试并测量了他们的身体素质。 通过注意力分布测试、计时测试、驾驶测试和认知反应测试，这些测试是驾驶能力测试，计算了每个椅子站立测试和平衡测试的相关系数，这些测试是体能测试。驾驶能力测试与 CST 之间存在相关性（r = 0.81 ,p <0.05），但与 BT 无统计学显着正相关（r = 0.261, p> 0.05）。这些结果表明椅子站立测试，它使用驾驶时使用的肌肉和驾驶能力。 也有人建议平衡测试和驾驶能力之间的关系是低的。

Abbreviations:

CST: Chair Stand Test, BT: Balance Test.

Introduction

From 2019 to 2021, traffic fatal accidents per year from 380,000 to 330,000. Since 1949 the death toll in traffic accidents has been the smallest (ITARDA,2019). Especially, when traffic accident statistics data according to age of the National Police Agency were seen, the death toll per 100,000 population aged 20 to 24 from 2009 to 2019 was 110,600, 30 to 39 was 88961, 40 to 49 was 79,237, 50 to 59 was 51,788. And growth rate of 20 to 29 was 15%, 30 to39 was 11%, 40 to49 was 12%, 50 to 59 was 11%（E-stat,2019）. Automatic braking and automatic sensing systems have been developed, why do traffic accidents occur when car continues improve (Ministry of Land, Infrastructure, Transport and Tourism,2021). As a cause of the traffic accident, the investigation of the traffic bureau of the National Police Agency in 1993 was classified as a human factor of the traffic accident. And it is classified into the operation unsuitable, the safety confirmation, the internal unprecedented carelessness, the external precaution, and the judgment error, among them, the most common cause of traffic accident is inappropriate operation（E-stat,2019）. As a result of comparing the lowering rate of the traffic accident in 2004 to 2013, it was proven that the lowering rate of the traffic accident except for the operation suitability was 28% for lowering rate with respect to 33% for lowering rate (Ministry of Land, Infrastructure, Transport and Tourism All right reserved,2021). Therefore, it can be said that it is difficult to carry out the inappropriate operation, to prevent the accident compared with the other

traffic accident factors.

In the previous study, driver 's discomfort has gained a lot of attention, especially among interested parties (Khamis et al.2018). There are many interacting factors involving both the driver and the interior components of the car that contribute to discomfort while driving. In this study, an investigation was carried out on the contraction of the lower leg muscle among drivers when operating the accelerator pedal. The main objective of this study was to determine the pattern of muscle contraction when operating the accelerator pedal with regard to three different actions; pressing, half-pressing and releasing. Eleven participants were involved in this investigation into the muscle pattern, whereby surface electromyography (SEMG) was used to measure the activity of the lower leg muscle, known as the tibialis anterior (TA). The data collection procedure on the selected muscle was in accordance with the SEMG recommendations for the Non-Invasive Assessment of Muscles. Based on the results, the TA depicted that the highest muscle contraction occurred during the releasing action. In addition, there were significant differences between each action in the T-test analysis with $p < 0.05$. It can be concluded that the TA muscle works differently based on the car pedal actions (Khamis et al.2018).

In other previous study, the effect of stroke on the steering of the car was examined. The hand paralyzed by the result of stroke was restricted to motor function due to the grip control defect, which failed to manipulate the operation ability ($r = 0.49$, $P < 0.05$). In addition, previous studies have

shown similar results in 11 patients with motor dysfunction and 11 diabetic patients (without neuropathy) in the previous study. The influence of the driving simulator on the control of the accelerator pedal by the driving simulator is as follows. The control of the accelerator pedal of 11 healthy persons was found to be affected by the muscle function of ankle joint strength and tibialis anterior , the intrinsic receptive sense and the control of the accelerator pedal(p=0.023)（Prrazzolo et al.2020）. Two experiments(Khamis et al.2018,Prrazzolo et al. 2020).showed the relationship between driving ability and motor function.

The purpose of this study is to find out the possibility of preventing a traffic accident by measuring motor function by simple physical fitness measurement and dividing the relationship between driving ability and motor function.

As a hypothesis, I think that it is possible to have the relation between driving aptitude test and simple physical fitness test. In the chair stand test of the item of the simple physical fitness test, the muscle of the thigh is used（Khamis et al.2018,Gao Z et al.2015). The gastrocnemius and tibialis anterior muscles, which are necessary for driving, are rarely used, but it seems that the relationship can be seen by using a little with the thigh muscles. Therefore, it is thought that there is the driving suitability as the result of the simple physical fitness test is good. And, since it is simple physical fitness test, it can be easily measured without using an instrument or time. In order to measure the strength of the lower body of the elderly and the stroke patient, the simple measurement can be

measured regardless of age (Johansen KL et al.2016, Jones CJ et al.1999). When CST and the four items of driving aptitude test are separated one by one, the accelerator pedal and brake pedal are used for CST and driving test. There is a relationship between the two because the thigh muscles used in CST and a few gastrocnemius and tibialis anterior muscles are used（Khamis et al.2018,Gao Z et al.2015). Since the timing inspection uses only the button for the investigation, the relationship between the two is low. Since the attention distribution test is mainly a handle investigation, it has a low relationship with CST, which is related to the muscles of the foot. The cognitive reaction test mainly investigates the steering wheel, but since it uses the brake pedal and the accelerator pedal, a relationship can be seen. Comprehensively, if the results of the same physical fitness test are high for some of the muscles used, the result of the driving aptitude test will be better, so a relationship can be seen. The relationship between BT and the running test is low because the muscles used in the balance test and the gastrocnemius and tibialis anterior muscles used in the running test are different. The relationship between BT and timing inspection is low because only buttons are used for timing inspection. Similarly, the gastrocnemius and tibialis anterior muscles are not used in the BT, attention distribution test, and cognitive response test, so the relationship is low. Since the relationship between the three items is low overall, the relationship between BT and the driving aptitude test is considered to be low.

Materials and Methods

Participants

The experiment participated in an experiment for 11 healthy student of 20-23 years old. All participants were instructed to stop the act of feeling intense exercise, drinking alcohol and fatigue 24 hours before the experiment. The chair stand test and the balance test were carried out as a simple physical fitness test. After that, participants took a driving aptitude test.

Experimental design

Driving aptitude test is consist of attention distribution, timing test, running vehicle test and cognitive reaction test. Attention was made in a quiet room for prevention of distraction.

The participants conducted a test using Simple Driving Simulator S (SiDS,TAKEI Equipment Industry Co) to test their driving aptitude. The trial time is 10 minutes for attention distribution test, 5 minutes for timing test, 8 minutes for running vehicle test, and 8 minutes for cognitive reaction test. In this test, handle and foot pedal which are used in car simulation games were used (logicool g steering controller lprc-15000d,logicool). After the completion of each inspection, the standard area, the obstacle area, the boundary area and the numerical value representing the degree of accuracy are determined following the previous study. Attention distribution test in order to examine the attentional distribution, the operator checks the pedal according to the color of the signal while

focusing on the handle. When the instruction of red comes out, the foot is pulled from the accelerator and the brake is stepped. When yellow instruction comes out, the foot is taken from the accelerator and waits. When there is a blue display, keep pressing the accelerator pedal. Timing inspection is only the button of the handle is used to inspect the running time of the car. It is estimated by the button length pushing that the car moving from left to right comes to the building. Running vehicle test is keep a safe inter vehicle distance and follow the blue car. When the color of the signal changes, it must stop in accordance with the rule. Cognitive response test in the case of red in the inspection to operate the pedal according to the signal, the foot is applied to the brake pedal from the accelerator. If it is yellow, take foot off the accelerator and wait. In the case of blue, the accelerator continues to tread. Driving aptitude test is Instruct to avoid intense exercise before the exam. Attention was made in a quiet room for prevention of distraction. For the simple fitness test, participants did chair stand test and balance test. Chair stand test records the number of times participants can stand up from chair in 30 seconds. Balance test that measures how many seconds can stand on one leg. Each test rating is not marked. In this experiment, participants were able to stand up for 30 seconds and observe the number of records that can be kept for many seconds. This test uses the thigh muscle. tibialis anterior muscle and gastrocnemius muscle are example of muscles used during driving. (Khamis NK, Deros BM & Nuawi MZ.2018) (Gao Z, Li C, Hu H, Chen C & Yu H.2015) These tests do not use exercise equipment and simple rules so it is not only by young people to old people.

The Shapiro- Wilk test of SPSS was performed to determine the normality of Date distribution. And, the chair stand test of the physical fitness measurement and balance test were individually carried out on the Shapiro Wilk test of SPSS, and it was judged that the chair stand test had the normality, and the Spearman correlation coefficient was carried out. It was not possible to judge that there was normality in the balance test, and the correlation of the non parametric test was made. Degrees of correlation was judged as shown below; r＝1.0~0.7: Fairly correlated, r＝0.7~0.4, fairly correlated; r＝0.4~0.2, with a fairly strong correlation; r＝≦0.2, almost without correlation. (Mitchell H.2006)

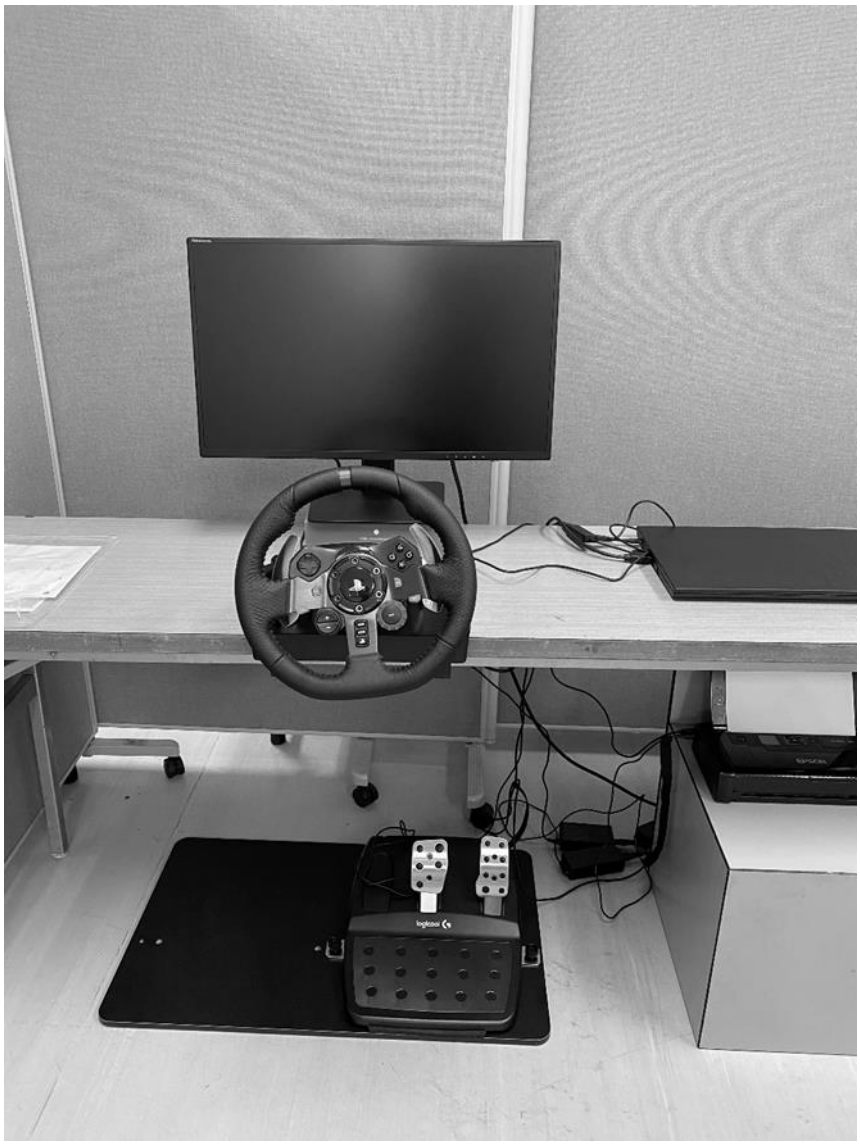

Fig. 1 Experimental set up for driving aptitude test

Fig. 2 Experimental set up for chair stand test

Fig3 Experimental set up for balance test

Results

Correlation analysis, driving aptitude test(r＝0.515 , P＞0.05） ,Chair stand test(r＝0.735, P＞0.05） ,balance test （r＝0.000 , P＜0.05） As a result of Spearman's correlation coefficient, the hypotheses of CST and driving inspection (r＝0.509, p<0.5)(Fig.4), and CST and driving aptitude test (r＝0.506, p<0.5） (Fig.8)were supported. The reason is that the gastrocnemius and tibialis anterior muscles used in CST are the same muscles used when using the accelerator pedal and brake pedal in the running test. CST and timing test (r = 0.237, p > 0.5)(Fig.5), CST and attention distribution (r = 0.321, p > 0.5)(Fig.6), CST and cognitive response test (r = 0.227, p >0.5)(Fig.7), BT and running test (r = 0.259, p > 0.5)(Fig.9), BT and timing test (r = 0.09, p > 0.5)(Fig.10), BT and attention distribution test (r = 0.107, p >0.5)(Fig.11), BT and cognitive response test (r = 0.166, p > 0.5)(Fig.12), BT and synthesis (r = 0.225, p> 0.5)(Fig.13) did not support the hypothesis. As mentioned in the hypothesis, the reason is that CST and timing test, and BT and timing test use only buttons, so the relationship is low. Since CST and attention distribution inspection are mainly for steering wheel investigation, they are different from the muscles used in CST, so there was no relationship. Although the CST and the cognitive response test are centered on the steering wheel investigation, it was hypothesized that there is a relationship because the brake pedal and the accelerator pedal are used, but the relationship was low because the steering wheel investigation was the main focus. As hypothesized, the relationship

between BT and the attention distribution test and cognitive response test was low because the relationship between BT and the muscles used in each test was low.

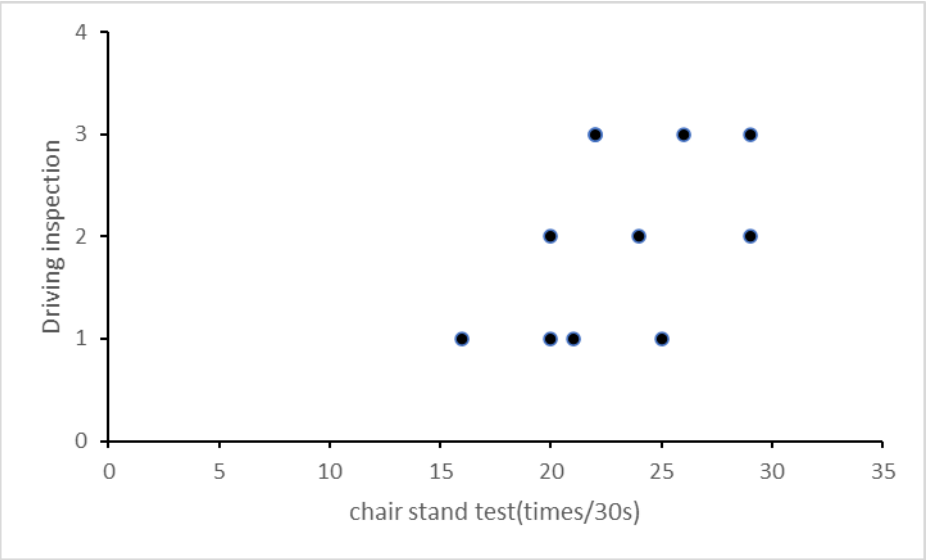

Fig.4 correlation between Driving inspection and chair stand test ($r=0.509$, $p<0.05$).

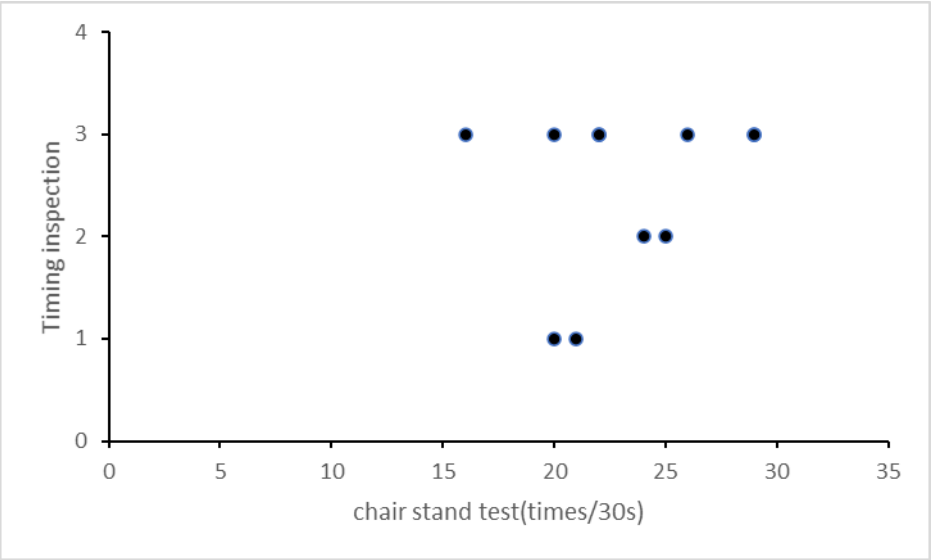

Fig.5 correlation between Timing inspection and chair stand test($r=0.237$, $p>0.05$).

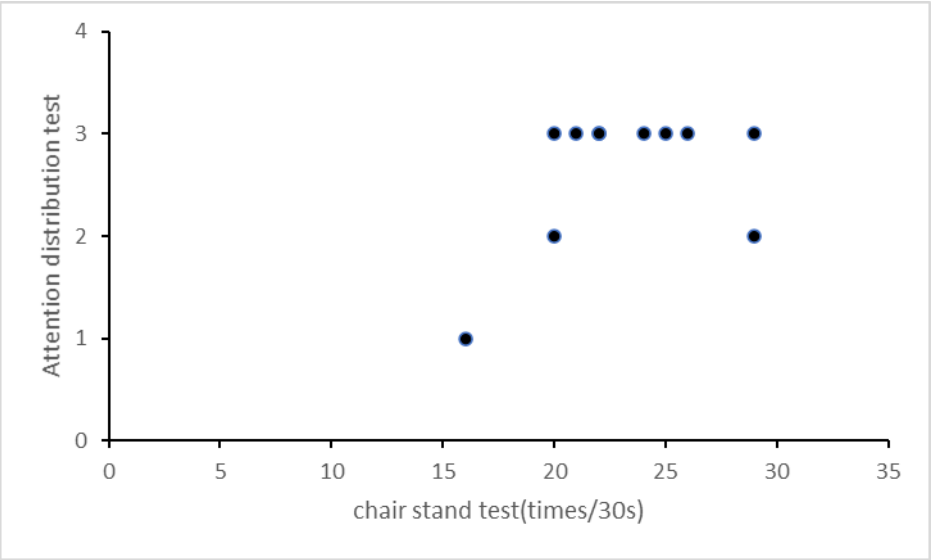

Fig.6 correlation between Attention distribution test and chair stand test ($r=0.321$, $p>0.05$).

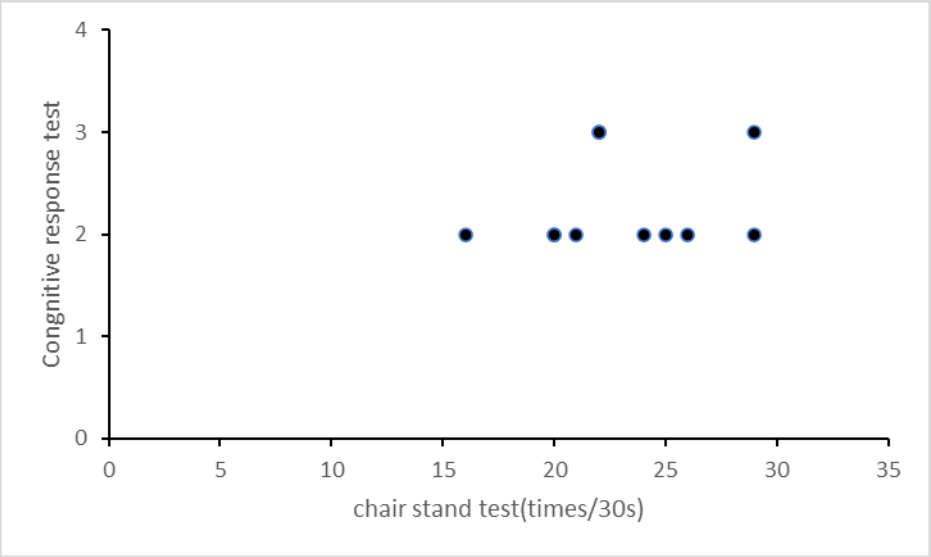

Fig.7 correlation between Cognitive response test and chair stand test($r=0.227$, $p>0.05$).

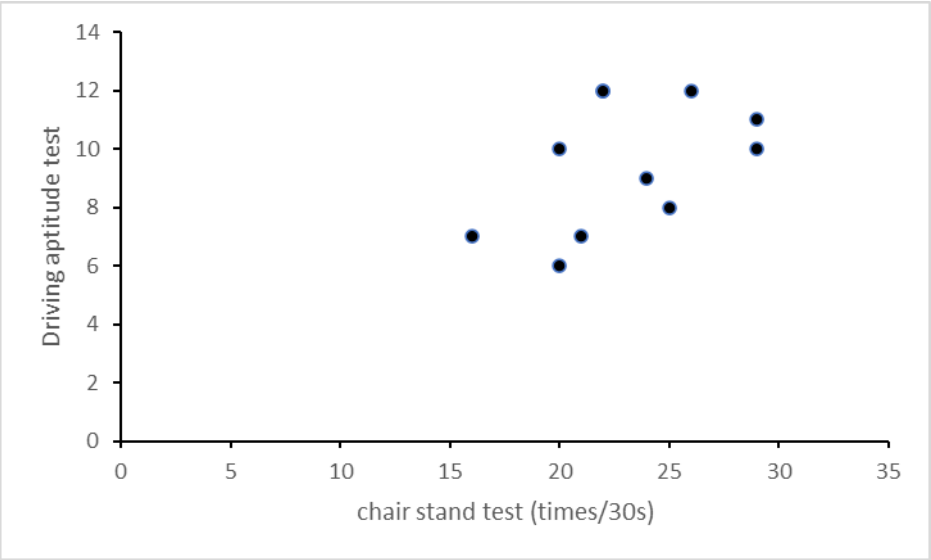

Fig.8 correlation between Driving aptitude test and chair stand test ($r=0.506$, $p<0.05$).

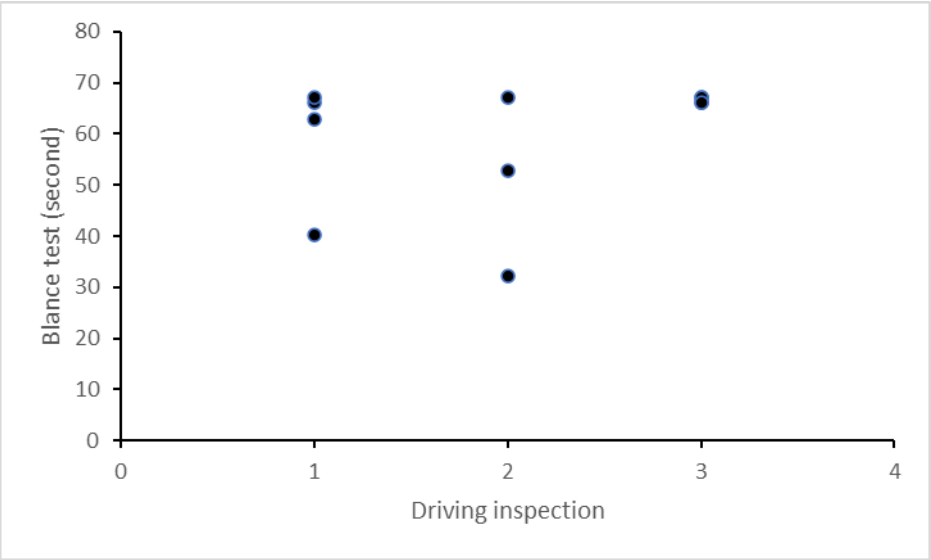

Fig.9 correlation between Driving inspection and Balance test ($r=0.259$, $p>0.05$).

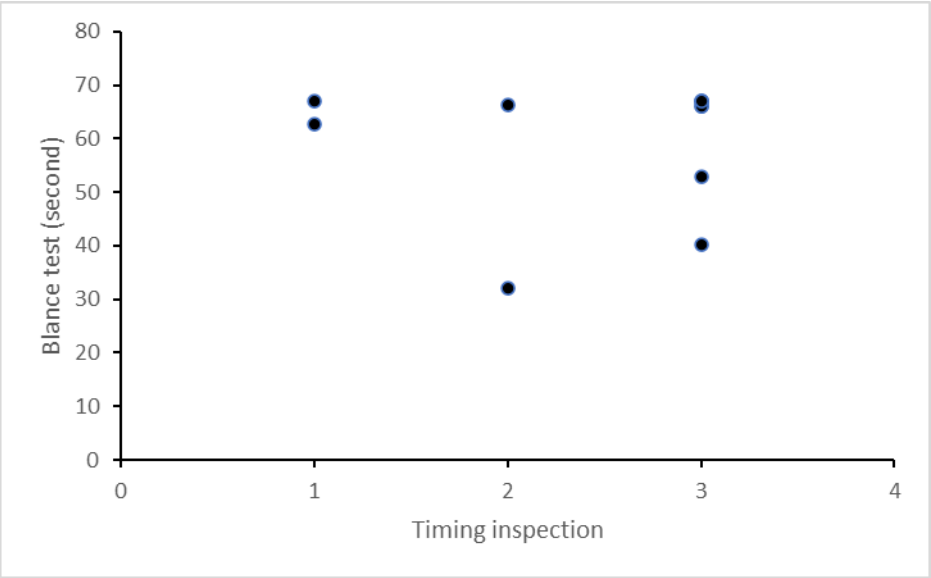

Fig.10 correlation between Timing inspection and Balance test($r=0.090$, $p>0.05$).

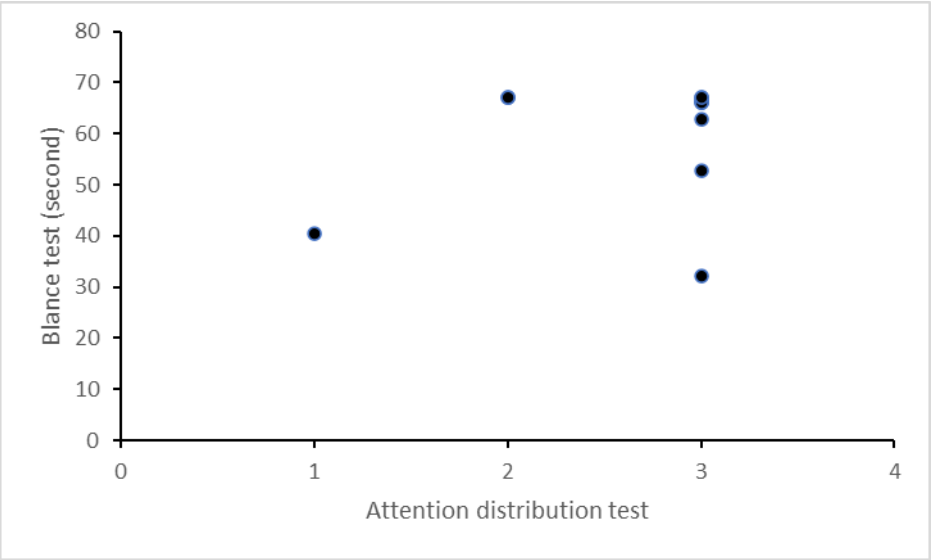

Fig.11 correlation between Attention distribution test and Balance test($r=0.107$, $p>0.05$).

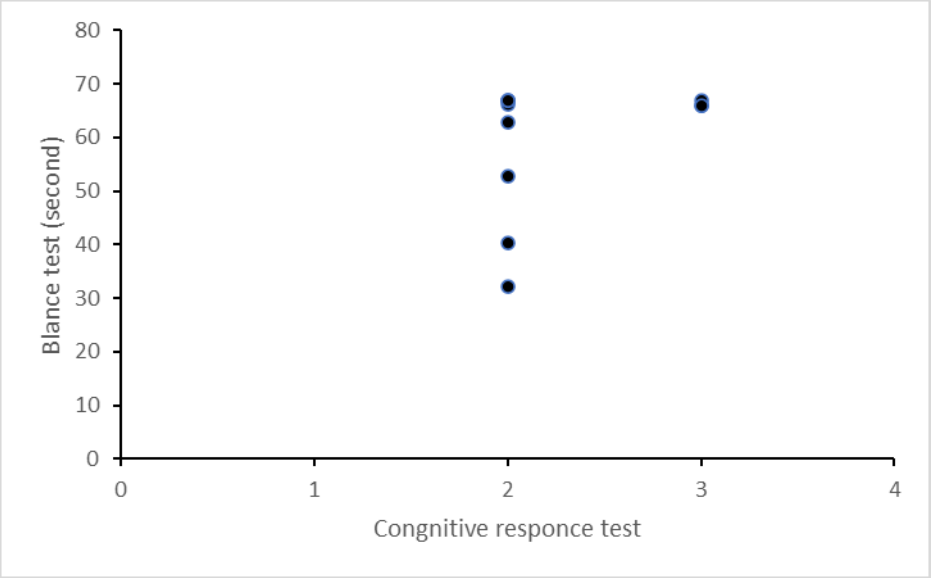

Fig.12 correlation between Cognitive response test and Balance test($r=0.166$, $p>0.05$).

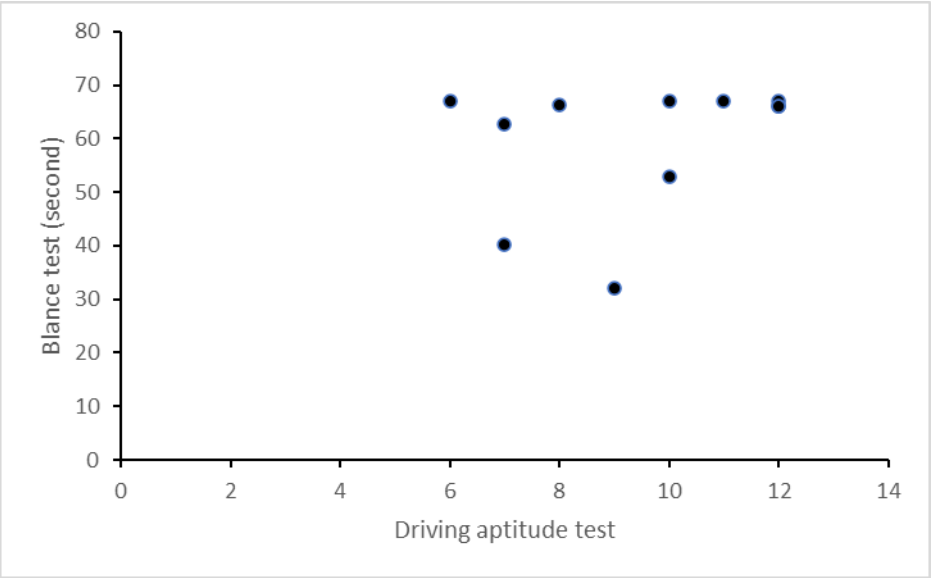

Fig.13 correlation between Driving aptitude test and Balance test($r=0.225$, $p<0.05$).

Discussion

In this study, the purpose of this study was to understand the usefulness of the measurement by simple physical fitness as a hypothesis, the muscles of thigh used for the chair stand test and the balance test for simple physical fitness test. As a result of Spearman's correlation coefficient, the hypotheses of CST and driving test(r＝0.509, p<0.5), and CST and driving aptitude test (r＝0.506, p<0.5） were supported. It seems that the thigh muscles used in CST are used in driving tests as the reason why the hypothesis was supported. So far, we have focused on the tibialis anterior muscle and the gastrocnemius muscle, but from the results of CST and running tests, it seems that the thigh muscle is also involved when using the accelerator pedal and brake pedal. CST and timing test (r = 0.237, p >0.5), CST and attention distribution (r = 0.321, p> 0.5), CST and cognitive response test (r = 0.227, p >0.5), BT and running test (r) = 0.259, p >0.5), BT and timing test (r = 0.09, p >0.5), BT and attention distribution test (r = 0.107, p >0.5), BT and cognitive response test (r = 0.166, p> 0.5), BT and synthesis (r = 0.225, p >0.5) did not support the hypothesis. As mentioned in the hypothesis, the reason is that CST and timing test, and BT and timing test use only buttons, so the relationship is low. Since CST and attention distribution inspection are mainly for steering wheel investigation, they are different from the muscles used in CST, so there was no relationship. Although the CST and the cognitive response test are centered on the steering wheel investigation, it was hypothesized that there is a

relationship because the brake pedal and the accelerator pedal are used, but the relationship was low because the steering wheel investigation was the main focus. As hypothesized, the relationship between BT and the attention distribution test and cognitive response test was low because the relationship between BT and the muscles used in each test was low. It is considered that this has a low relationship between the gastrocnemius muscle and the tibialis anterior muscle used during the BT and driving (Khamis NK et al.2018,Gao Z et al.2015).

This time, we conducted an experiment under the name of simple physical fitness measurement, but it seems that a more accurate relationship can be found when the measurement is performed focusing on the muscles used when operating the pedal and operating the steering wheel （Patel P et al.2019）.The reason for using the balance test, which is considered to be low correlation, is that it is easy to measure the simple physical fitness test of any place without using an instrument. The reason why the femur muscle will contribute strongly is because it is also simple physical fitness test. From this point of view, it was necessary to measure mainly the gastrocnemius and anterior tibialis muscle from the chair stand test using the thigh. In this study, it was clear that simple fitness test couldnot make clear operation suitability. This research was targeted young people, but as an experiment content, it can be practiced by people of all ages, and if it is possible to determine motor function anywhere, it is possible to take early measures to prevent the traffic accident that is occurring now. This time, we focused on motor function, but by clarifying the close relationship between

cognitive function and driving aptitude and conducting experiments, we may be able to find the possibility of reducing traffic accidents to zero. In conclusion, it can not say that even a simple physical fitness test has a relationship with driving aptitude, but there is room for improvement.

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Effect of acute mental stress on bitterness perception in matcha

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Abstract

Matcha taste experiment using changes in bitterness threshold due to stress response

Aim The purpose of the present study was to investigate the effect of acute mental stress on bitterness perception in matcha. **Method** Nine healthy men and women between the ages of 20 and 39 participated. Bitterness threshold in taste disc and bitterness perception in matcha and mental stress level in visual analogue scale (VAS) were measured before and after Kraepelin test as acute mental stress loading. **Results** While mental stress significantly increased following Kraepelin test ($p < 0.05$), bitterness threshold and bitterness perception in matcha were not changed following Kraepelin test ($p > 0.05$). **Conclusion** These results suggest that changes in bitterness perception in matcha was not detected following acute mental stress.

急性的な心理的ストレスが抹茶における苦味の感じ方に及ぼす影響

目的急性的な心理的ストレスが抹茶における苦味の感じ方に及ぼす影響を調べることであった。**方法** 9 人の 20〜39 歳の健康な男女に急性的な心理的なストレスを与えるためにクレペリン検査を実施し、その前後にテーストディスクの苦味閾値の検査と VAS による抹茶の苦味知覚、加えて精神的ストレスレベルを実施した。**結果**クレペリンテストによって心理的なストレスは有意に上昇したが（$p<0.05$）、苦味閾値や抹茶における苦味の感じ方はクレペリンテストの前後で変化しなかった（$p>0.05$）。**結論**これらの結果から急性的な心理的ストレスによって検出可能なほどの抹茶における苦味の変化は生じないことが示唆された。

Matcha-Geschmacksexperiment mit Veränderungen der Bitterkeitsschwelle aufgrund von Stressreaktionen

Ziel Ziel der vorliegenden Studie war es, den Einfluss von akutem psychischem Stress auf die Bitterkeitswahrnehmung bei Matcha zu untersuchen. **Methode** Neun gesunde Männer und Frauen im Alter zwischen 20 und 39 Jahren nahmen daran teil. Die Bitterkeitsschwelle in der Geschmacksscheibe und die Bitterkeitswahrnehmung in Matcha und der mentale Stresslevel in der visuellen Analogskala (VAS) wurden vor und nach dem Kraepelin-Test als akute psychische Stressbelastung gemessen. **Ergebnisse** Während der psychische Stress nach dem Kraepelin-Test signifikant zunahm ($p < 0,05$), waren die Bitterkeitsschwelle und die Bitterkeitswahrnehmung bei Matcha nach dem Kraepelin-Test nicht verändert ($p > 0,05$). **Schlussfolgerung** Diese Ergebnisse legen nahe, dass Veränderungen der Bitterkeitswahrnehmung bei Matcha nach akutem psychischem Stress nicht festgestellt wurden.

Abbreviations:

VAS; Visual Analogue Scale

Introduction

Exports of Japanese matcha have quadrupled in 10 years due to the impact of the Japanese food boom. About changes in consumption of the four major luxury item, such as Alcohol, Tea (Green tea, Black tea), coffee or cigarette. that have no age limit. For Coffee, Global total increased by 6.2% from 2016 to 2022. (581,340kg). Tea (Green tea, Black tea), Global total increased by 10% from 2005 to 2007 (419,419t). Yokomitsu et al. (2015) suggests that luxury items are of high importance to Japanese people. 542 Japanese (278 males ＆ 264 females) were questioned about their consumption of luxury items, and the results showed that more than 80% of males and females said they consume tea, and more than 70% said they consume coffee. This shows that Japanese people consume a high percentage of luxury items, and there is no gender difference in the percentage of tea and coffee consumption (Yokomitsu et al., 2015). Yokomitsu et al. (2015) said that, the benefits of tea include relaxation, communication, enjoyment of meals, mood swings, increased motivation, made rhythm in life, improved concentration, got positive mood, and time for problem solving. (Yokomitsu et al., 2015)

Among the effects of green tea, we focused on health. Matcha green tea (Scientific name, Camellia sinensis), which originates from Japan, is commonly considered as particularly beneficial to health. A large content of polyphenols, amino acids (mainly tannins) and caffeine potentially increase the antioxidant properties of the drink (Jakubczyk et al., 2020). Studies confirming the high antioxidant

potential of tea beverages claim that it originates from the considerable content of catechins, a type of phenolic compound with beneficial effects on human health. In addition, due to its potential for preventing many diseases and supporting cognitive function, regular consumption of matcha may have a positive effect on both physical and mental health (Joanna Kochman et al., 2021). Matcha is also effective in relieving stress. Taking 3 g of matcha daily, it has been shown that matcha with more than 17 mg / g of theanine may be effective in reducing stress (Unno et al., 2018). For a typical Japanese matcha, two cups of 2 g of matcha can be consumed (ITOEN, 2009).

Depression, one of the stressful illnesses according to the WHO, is a major cause of health and disability worldwide. With more than 300 million people ill and an increase of more than 18% between 2005 and 2015, stress-induced depression has become a serious problem (WHO, 2018). Humans suffer from depression by destroying the immune system due to long-term psychological stress. There is a stress check sheet recommended by the Ministry of Health, Labor and Welfare for disease prevention (Ministry of Health, Labour and Welfare. 2021). This stress check sheet includes 52 questions about work, health, people around you, and satisfaction. In Japan, stress checks are mandatory once a year in workplaces of 50 or more people. But the current stress check is not enough. Feedback of stress survey results and interviews with doctors may not be scientifically effective (Kawakami & Tsutsumi, 2016). Improvement can be expected by incorporating additional components. Besides depression, there are other responses caused by stress. Heath (2006) revealed

that as the level of anxiety increases, so does the bitterness threshold (Heath et al. 2006). There is a paper that uses Spielberger Trait and mentions the relationship between stress and bitterness threshold. Spielberger Trait is a psychological test that can measure a patient's anxiety. In this paper, the bitterness threshold differs with and without stress (Heath et al., 2006) (Figure 1, A). It was found that the bitterness threshold was different even under high / low stress, and the bitterness threshold was higher at higher stress (Figure 1, B) (Heath et al., 2006). Other perceived increased stress significantly increases average levels of prolactin and consumption of coffee, chocolate and cigarette (Tomei et al., 2012). From the above, we considered the possibility of using taste changes for stress management.

If caffeine and quinine have different bitterness intensities, we cannot track the change in bitterness threshold due to stress. Therefore, it is necessary to estimate the change in bitterness threshold due to stress before proceeding with this study. The bitterness of the taste test kit is quinine and the bitterness component contained in matcha is caffeine. The threshold for bitterness in quinine is 0.03 mM, which increases to 0.09 mM with stress (Heath et al., 2006). The bitterness threshold of caffeine is 1.2 mM (Keast & Roper, 2007), but the effect of stress addition is unknown. Therefore, taking advantage of the fact that the change in bitterness threshold due to stress in quinine is 3-fold, we multiplied 1.2 by 3 to calculate a threshold of 3.6 mM. The caffeine content of matcha was estimated to be 3.2 g (Ministry of education, 2015), and based on the molar concentration calculation,

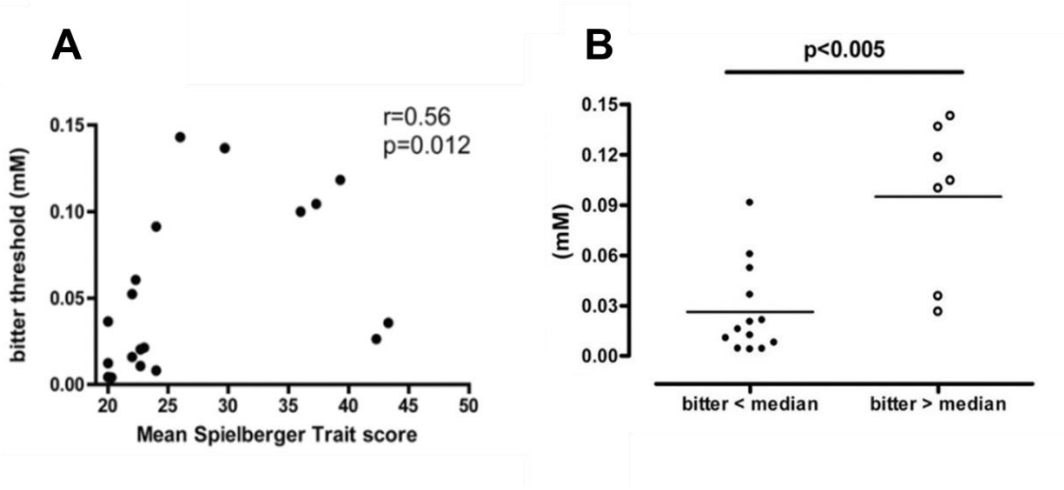

Figure 1, A; Results of correlation between anxiety score and bitterness threshold by Spielberger Trait. There is a significant difference, indicating that the bitterness threshold changes with stress (Heath et al., 2006)., B; Differences in bitterness thresholds when divided into high and low stress according to the intensity of the anxiety score of the Spielberger Trait. It can be seen that the higher the stress, the higher the bitterness threshold (Heath et al., 2006).

the caffeine concentration in matcha was estimated to be 2.3 mM. Since it is above the threshold before stress addition and below the threshold after stress addition, it is thought that the perceived bitterness of matcha changes with stress (Figure 2).

The aim of the present study was to investigate the effect of acute mental stress on bitterness perception in matcha. Since it is expected that the caffeine-related bitterness in matcha is higher than normal bitterness threshold and lower than the estimated bitterness threshold following mental stress (Figure 2), it is hypothesized that bitterness perception in matcha reflect the acute mental stress.

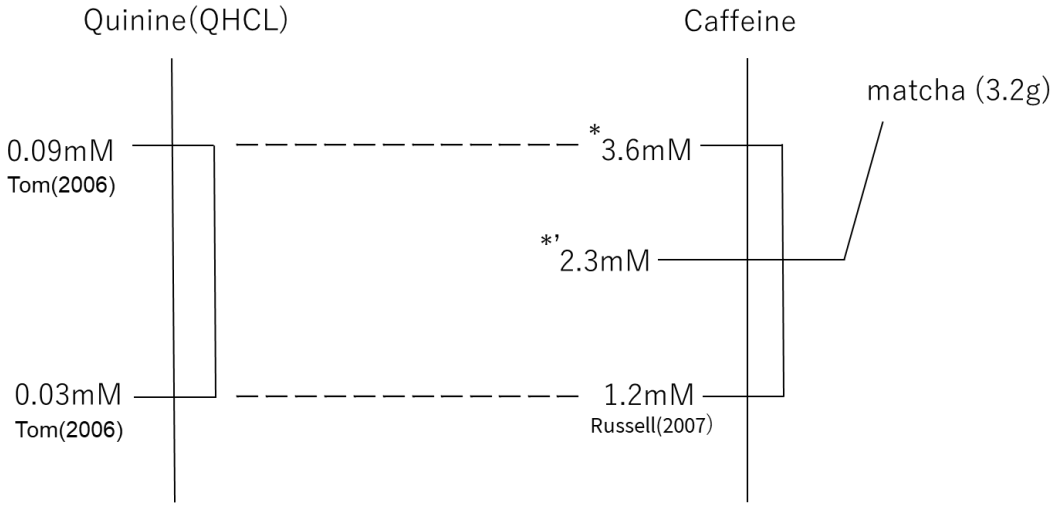

Figure 2, Bitterness thresholds of quinine and caffeine its changes with mental stress and bitterness threshold of matcha. *, Effect of mental stress on the Bitterness threshold in caffeine was calculated from changes in bitterness threshold in quinine following mental stress (Heath et al., 2006). *', The caffeine concentration of matcha was calculated from the caffeine content of matcha and molar concentration calculation. (Ministry of education, 2015)

Materials and methods

Participants

Nine healthy young man and women (age: 20 to 39 years) 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

The experimental protocol is shown in Figure 3. Participants came to the laboratory on 2 days separated by at least 24h and were randomly assigned the days for the trials. Following the preparation of the experiment, participants drank matcha and were asked bitterness perception by using visual analogue scale (VAS). Bitterness threshold were also measured from Taste disc. We used the Uchida-Kraepelin test (35min) sheet as way to give participants psychological stress. One of the two days was for control, so they were relaxed in the same posture for the same time as when they was undergoing the Kraepelin test. Before and after the Kraepelin test and rest, we asked them to answer a stress subjective questionnaire using the VAS evaluation to see how much they felt stress. After that, taste measurement (POST) was performed. The concentration of matcha used in the taste test is constant.

Measurement of the subjective bitterness of matcha

The ingredients for matcha are matcha powder (Hoshino Tea Garden Co., Ltd.) 2g with

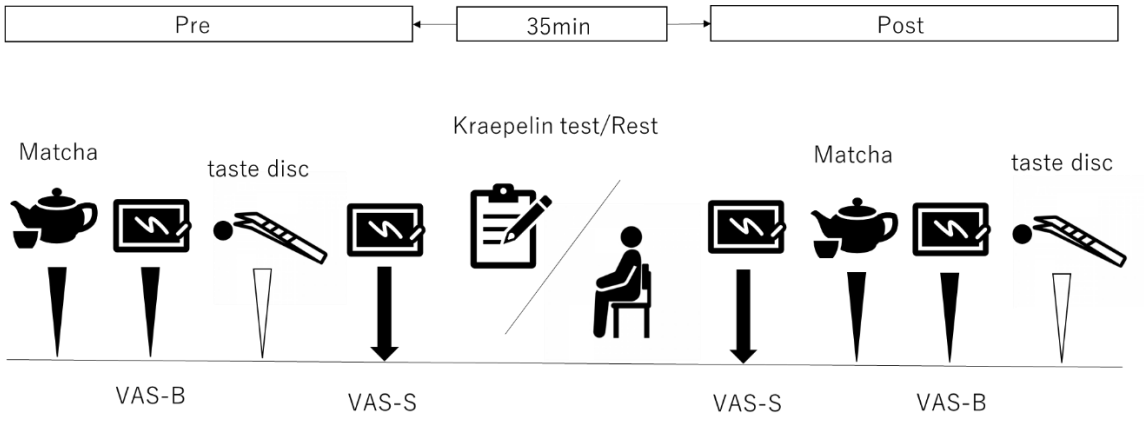

Figure 3, Schematic overview of the experimental protocol.; VAS-B, visual analogue scale for bitter taste.; VAS-S, visual analogue scale for stress.; Matcha, Matcha intake.

90 ℃ hot water 70ml. The reason for matcha intake before the taste disc test is to prevent the subjective taste of matcha from being influenced by the results of the bitterness threshold.Bitterness perception in matcha was measured by using VAS ranging from 0 to 10 which are corresponds to from don't feel bitterness to very bitter (Figure 4).

Measurements of bitterness threshold using taste disc

For measurements of bitterness threshold, traditional testing for taste thresholds, i.e., Taste Disc (Sanwa Kagaku Kenkyujyo Co., Ltd.), were applied with modification to increase sensitivity of the test. A 5 mm circular filter paper soaking the solution were placed on the measurement points in mouth with tweezers. After a few seconds with mouth open, remove the filter paper and ask if there is a bitterness reaction. Gradually increase the concentration until participants feel a bitterness reaction from the lowest concentration. There are 5 levels of solution concentration. (0.001%, 0.02%, 0.1%, 0.5%, 4%). However, this intensity is coarse, and if the change in the bitterness reaction is small, accurate results cannot be obtained. Therefore, it is necessary to narrow (dilute) the concentration interval of the aqueous solution. Preliminary experiments have shown that there are 23 levels of solution concentration. This is the minimum value at which changes in bitterness intensity can be recognized. The detailed solution concentrations are shown in Figure 5.

Measurement point,

The point connecting 1 cm from the retromolar trigone, which is behind the second molar

Figure 4, Visual analogue scale for measurement of bitterness perception in matcha.

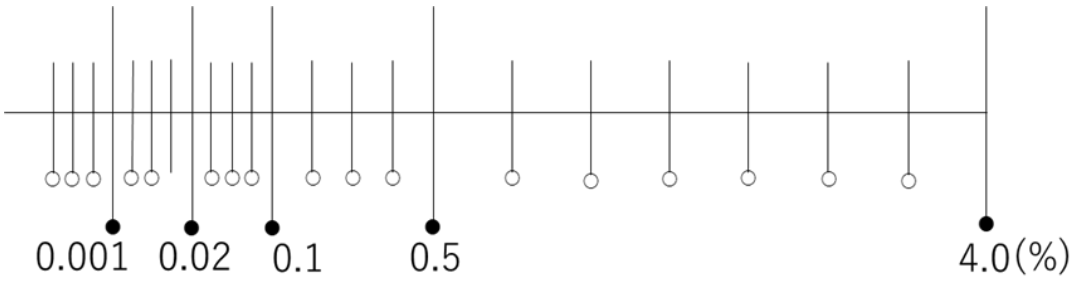

Figure 5, Concentration of quinine used in this study.; ●, Original scale in taste disc.; ○, Modified scale in taste disc.

alveolar, the sloping triangular bone surface that continues to the inner surface of the ramus of the mandible, to the front (End of the tongue). The measurement point was determined by preliminary experiments. In preliminary experiment, four measurement point were considered, i.e., 1) midpoints between right and left retromolar trigone on the center of the tongue, 2) midpoints between right and left retromolar trigone on the lateral edge of the tongue, 3) midpoints between right and left to the front from retromolar trigone on the tongue, and 4) midpoints between right and left to the front from retromolar trigone on the lateral edge of the tongue (Figure 6).

Kraepelin test

We used Uchida-Kraepelin for loading acute mental stress to the participants, which is consists of two sets of 15 min of calculation test with 5 min of break between them. Participants added two single-digit numbers, and repeated the task of entering the last digit of the calculation result. In the previous studies, this test was used for inducing mild acute mental stress (Li et al. 2004, Kanehira et al. 2011).

We used VAS evaluation to whether the stress changed due to Kraepelin test. One point is 1 mm, and 10 cm can be evaluated on a 100-point scale. There is evidence in favour of effective for stress assessment.

Statistics

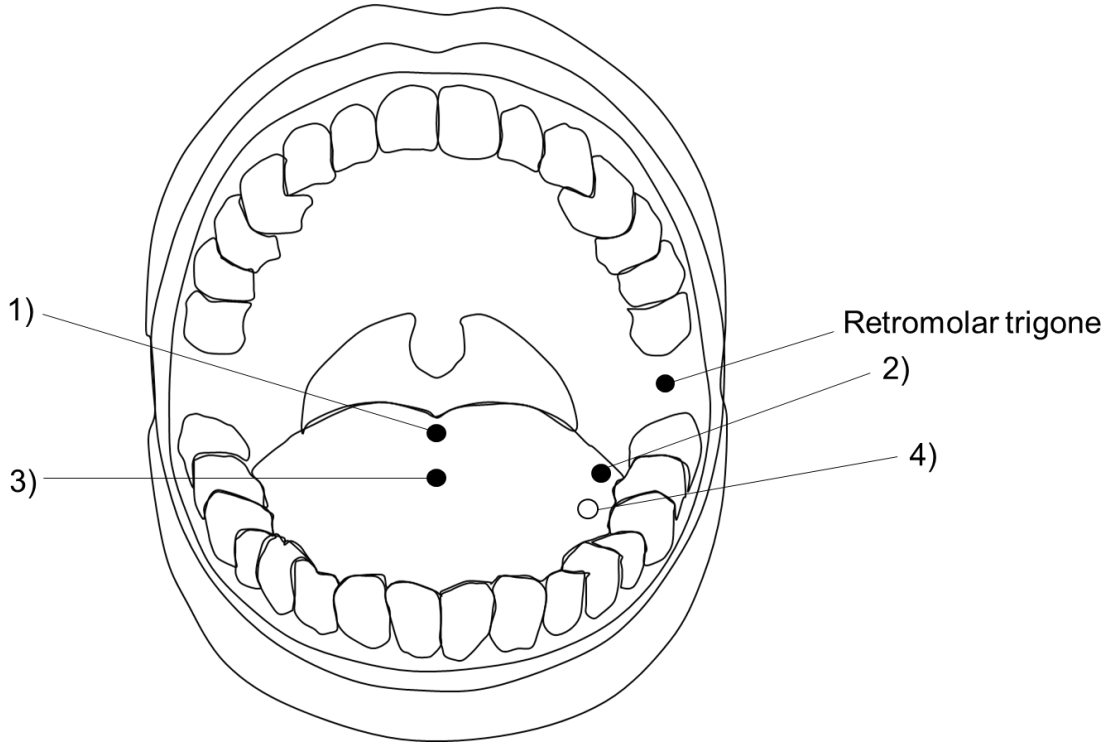

Figure 6, Retromolar trigone and preliminary experiment measurement position.; 1), Midpoints between right and left retromolar trigone on the center of the tongue.; 2), Midpoints between right and left retromolar trigone on the lateral edge of the tongue.; 3), Midpoints between right and left to the front from retromolar trigone on the tongue.; 4), Midpoints between right and left to the front from retromolar trigone on the lateral edge of the tongue.; ○, Measurement points determined by preliminary experiments.

ストレス主観アンケート

Figure 7, Visual analogue scale for measurement of subjective mental stress.

Each result is given as the mean and standard deviation. The non-parametric analysis was used in this study from the results of Shapiro-Wilk test. Bitterness perception in matcha, bitterness threshold, stress perception were compared between Pre and Post for Kraepelin test and rest and between Kraepelin test and rest at Pre and Post using Wilcoxon sum-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

Significant increase in stress was observed following Kraepelin test ($p < 0.05$), but not following rest ($p > 0.05$) (Figure 8). Bitterness perception in matcha and bitterness threshold were not significantly changed following both Kraepelin test and rest ($p > 0.05$) (Figure 9). There were no significant differences in bitterness perception in matcha and bitterness threshold between Kraepelin test and rest at Pre and Post ($p > 0.05$) (Figure 10).

Discussion

In this study, participants were subjected to acute psychological stress using the Kraeperin test. The results showed a significant increase in subjective stress level after the Kraeperin test, which means that the study was successful in creating an experimental acute stress state. It has also been used

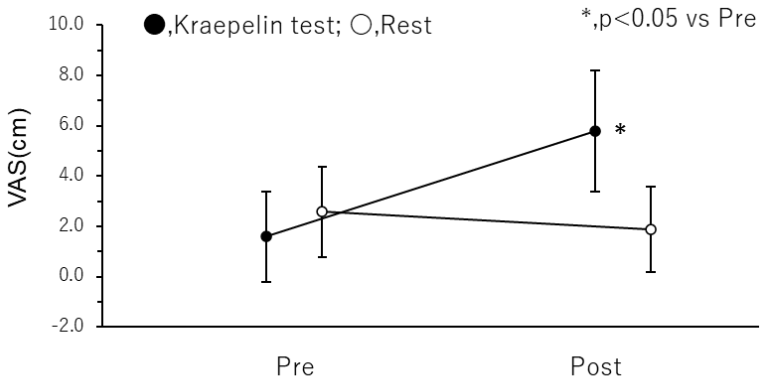

Figure 8, Subjective stress level following Kraepelin test and rest.; *, $p < 0.05$ vs Pre

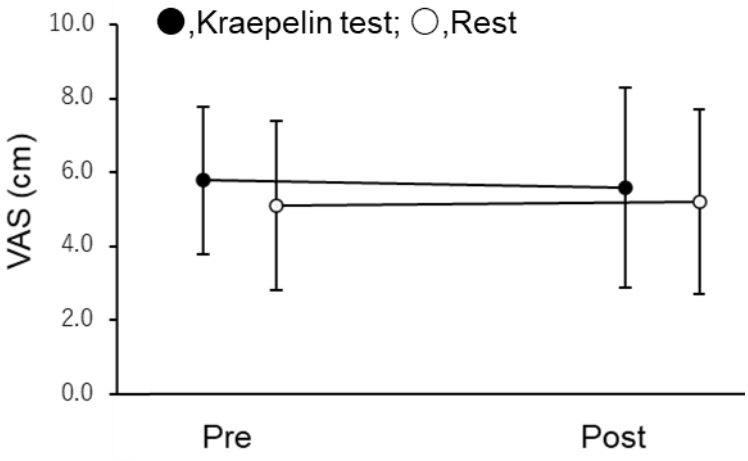

Figure 9, Bitterness perception in matcha following Kraepelin test and rest.

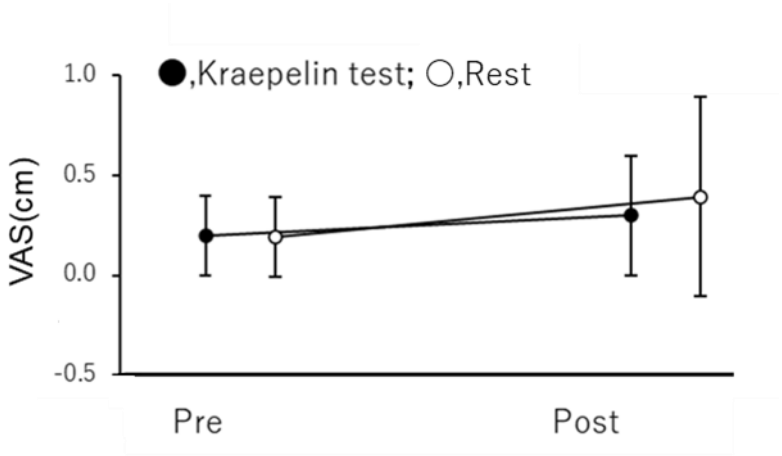

Figure 10, Bitterness threshold following Kraepelin test and rest.

in previous studies at 15-5-15 minutes. This test was able to provide mild acute psychological stress and may have lacked a little stress to affect how the bitter taste of matcha was perceived. It was necessary to revise the condition settings for long-term testing, changing the temperature of the matcha, and diluting the taste test kit (taste disc). Therefore, acute stress in this study is not sufficient to alter the perception of bitterness. Although subjective stress level was increased following Kraepelin test, changes in bitterness perception in matcha and bitterness threshold were not found following Kraepelin test. These results don't support the hypothesis that bitterness perception in matcha reflect the acute mental stress.

Amount of stress

Figure 8 shows that the Kraepelin test was effective in exerting stress load. Figures 9 and 10 shows that the stress load was not enough to change the taste. So how much stress did the taste change? Focused on the implementation time of the Kraepelin test. Which is more effective in giving more mental stress, the normal method (15 min-5 min-15 min) or the method performed continuously for 30 minutes. Sakamoto(2016) describes that if the change in the sAMY value during the test can be tracked, it may be a material for considering the implementation time of the test.

Relationship between Stress and Matcha Bitterness and Bitterness Threshold

As can be seen from the results, stress was applied to the test subjects, so why did no change in taste occur? In order to analyze the results in more detail, we examined whether there was a

correlation between the amount of stress on the Kraepelin test or rest and the amount of change in the VAS of matcha bitterness and bitterness threshold for each individual (Figure 11 & 12). It can be seen that the correlation results are not linear, indicating that there are individual differences in the perception of stress despite the same load of Kraepelin test. Therefore, it cannot be said that the stress load has a proportional effect on the change in bitterness threshold.

Proving a hypothesis

Calculate the quinine and caffeine thresholds and whether the hypothesis of change due to the effects of stress is correct using the 23 levels taste disc used. Multiply the taste disc thresholds by 3, just as we calculated the post-change values for the caffeine thresholds. The average of the 23 levels teste disc thresholds is 0.2%. 0.2 x 3 = 0.6 (%), so if the average of the 23 levels taste disc thresholds after the effects of stress is 0.6%, then the hypothesis is correct. However, since the result obtained in this study was 0.3%, the calculation of the hypothesis may be incorrect.

Matcha water temperature

Fujiyama (2017) revealed that a statistical comparison of taste recognition thresholds before and after cold stimulation showed increased taste sensitivity for all four basic tastes (Fujiyama & Toda, 2017). Decreased at bitterness threshold 1.9 ± 0.4. Fujiyama (2017) revealed that it was easier to feel the bitter taste if the drink was taken after cooling the mouth before drinking (Fujiyama & Toda, 2017). From the above, it is expected that the bitter taste of matcha will be easier to feel if you drink it after

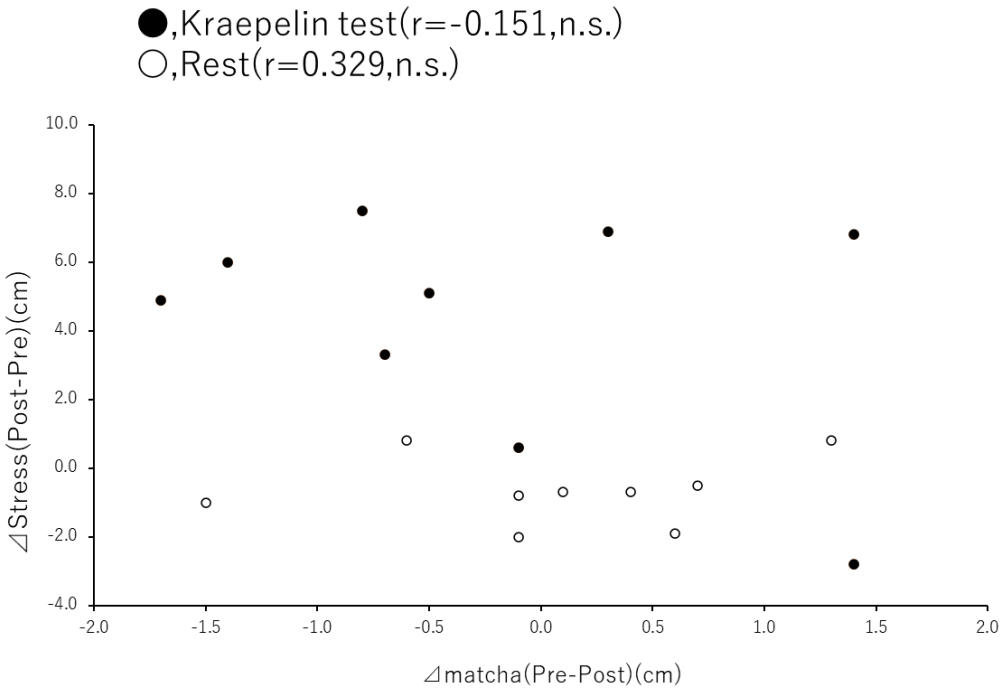

Figure 11, Correlation between changes following Kraeperin test and rest in bitterness perception in matcha and in subjective stress level.; ●, Kraepelin test.; ○, Rest.

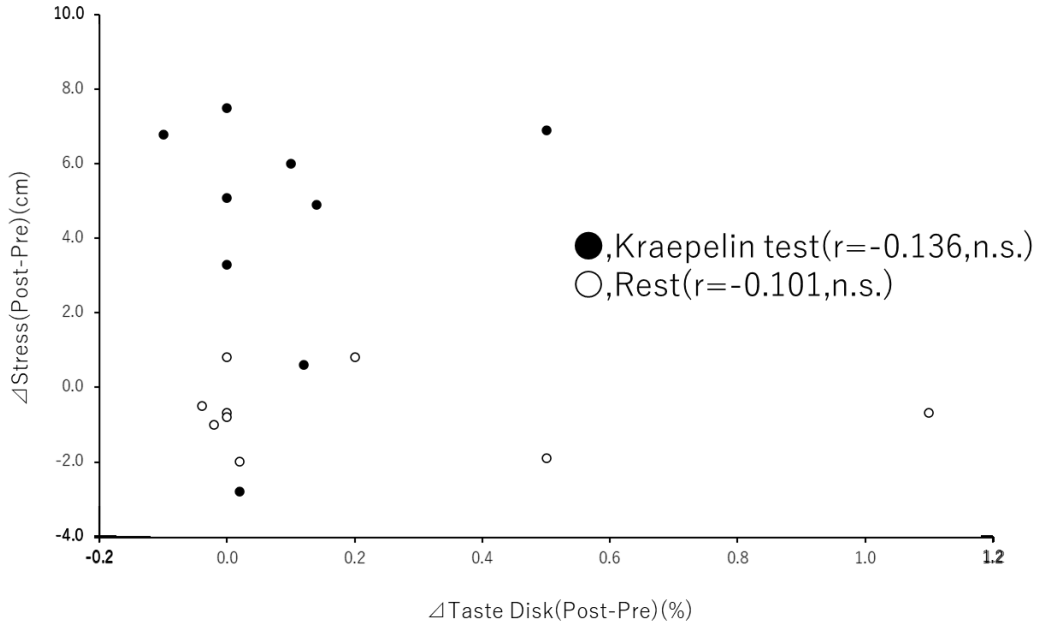

Figure 12, Correlation between changes following Kraeperin test and rest in bitterness threshold and in subjective stress level.; ●, Kraepelin test.; ○, Rest.

cooling your mouth.

Restrictions on participants

This expeimental did not limit the participants, but it may have been necessary to limit them. Mura (2018) revealed that a single exposure prolongs the taste until 120 minutes later (Mura, E et al. 2018). It is considered that the results were more remarkable when the subjects were restricted to refrain from ingesting bitterness for 2 hours before the experiment.

Conclusion

In conclusion, this study investigated the effect of acute psychological stress on the perception of bitterness in matcha. We were able to apply psychological stress, but we did not find any change in the perception of bitterness in matcha. This result suggests that more intense stress may have an effect on the taste buds to the extent that they change.

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Postprandial Glucose and Sense of Satiety following white rice and rice porridge

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Abstract

Postprandial Glucose and Sense of Satiety following of white rice and rice porridge

Aim The purpose of this study is to clarify the difference in the increase in blood glucose and satiety when white rice and porridge were ingested under the controlled conditions. **Methods** Nine healthy students ate glucose solution, white rice, and porridge on separate days. Blood glucose levels and satiety levels were measured every 30 minutes. The sugar content, total number of chews, and water content were controlled between white rice and porridge. Blood glucose levels were measured by a continuous blood glucose monitoring device. **Results** There was no significant difference in the increase in blood glucose among the three conditions ($p>0.05$), and satiety between white rice and porridge ($p>0.05$). Glucose was significantly less satiating than rice porridge at 30 minutes after consumption ($p<0.05$) **Conclusion** From these results, we suggested that the blood glucose level and satiety level are the same following eating of white rice and rice porridge when ingested under the sugar and water amounts and chews-controlled conditions.

白米と粥の食後血糖値変動と満腹度

目的 本研究の目的は、糖質量や咀嚼回数、水分量を統一した条件下で白米と粥の血糖値上昇と満腹度の差を明らかにすることである。**方法** 学生 9 名を対象とし、ブドウ糖溶液、白米、粥をそれぞれ別日に摂取させ、30 分ごとに血糖値および満腹度を計測した。白米と粥は糖質量と合計の咀嚼回数、水分量を統一し、ブドウ糖と白米、粥は糖質量と水分量を統一した。血糖値は、腕に装着された持続血糖測定装置によって測定した。**結果** ブドウ糖溶液と白米と粥の間で血糖値上昇に有意な差は無かった（$p>0.05$）。また、白米と粥の間で満腹度に有意な差は無かった（$p>0.05$）。一方、ブドウ糖は粥よりも摂取 30 分後で満腹度が有意に低かった（$p<0.05$）。**結論** これらの結果から、白米と粥は同じ条件下で摂取した場合、血糖値の上がりやすさや満腹度は同じであることが示唆された。

白米饭和粥的餐后血糖变化和饱腹感

目标 本研究的目的是研究在相同糖量，咀嚼次数和含水量下的白米和粥之间的血糖水平和饱腹感的差异。**方法** 参加这项研究的有 9 名健康的学生。他们在不同的日子里摄取葡萄糖溶液、白米饭和粥，每 30 分钟测量一次他们的血糖水平，并将饱腹感水平。白米和粥的含糖量、总咀嚼次数和含水量都是相同，而葡萄糖、白米和粥的含糖量和含水量都是相同。血糖水平是用戴在手臂上的连续血糖仪测量的。**结果** 葡萄糖溶液，白米和粥之间的血糖增加没有显着差异（$P>0.05$）。白米和粥之间的饱腹感也没有显着差异（$P>0.05$）。另一方面，在摄取 30 分钟后，葡萄糖的饱腹感明显低于粥（$P<0.05$）。**结论** 研究结果表明，在相同条件下摄取白米和粥，其血糖水平和饱腹感水平是相同的。

Abbreviations:

GI: Glycemic Index.

iAUC: incremental area under the curve.

Introduction

Recently, aging population has been remarkable in Japan. In 2019, the average life expectancy is 81.41years for men and 87.45years for women (Ministry of Health, Labor and Welfare, 2019). In the same year, the population over 65 years old accounted for 28.4% of the total population (Cabinet office, Government of Japan, 2020). In this super-aging society, increasing medical costs and low nutrition among the older adults are becoming broad social issues (Ministry of Health, Labor and Welfare, 2020). In particular, low BMI and low nutrition in older adults linked to sarcopenia due to muscle weakness and decreased muscle volume (Dhillon, & Hasni, 2017), and frail due to reduced motor and cognitive functions (María Elena Gómez-Gómez & Sara C.Zapico, 2019). Causes of care include dementia, stroke, weakness, and fractures and falls, which are due to muscle weakness, loss of cognitive and motor functions (Momose, et al., 2021). Therefore, both exercise and nutrition are necessary to prevent care due to sarcopenia and frail. However, the older adult experiences a decrease in appetite and food intake due to age-related anorexia (Wysokiński, et al., 2015). The percentage of people aged 65 and over who have an exercise habit in 2019 is 41,9 % for men and 33,9 % for women, which is higher than that of people in 20s to 50s (Ministry of Health, Labor and Welfare, 2020). However, in the same year, the energy intake of people aged 65-74 years was 2168 kcal for men and 1798 kcal for women (Ministry of Health, Labor and Welfare, 2020), which does not reach the energy requirement of 2400 kcal for men and 1850 kcal for women at a physical activity level of II (Ministry of Health, Labor and Welfare, 2019).

Of all the nutrients we get from our diet, carbohydrates account for the majority of the energy in the diet.

For example, the dietary reference intakes sets the carbohydrate target at 50-65% of energy (Ministry of Health, Labor and Welfare, 2014). Carbohydrates can be broadly divided into two categories: saccharinity which are absorbed by the body and become a source of energy, and dietary fiber, which is not digested and absorbed and does not provide energy. Of these, saccharinity produces about 4 kcal of energy, and plays an essential role in sustaining life (Ministry of Health, Labor and Welfare, 2014). In particular, the brain consumes 20% of the total basal metabolism, and carbohydrates provide glucose that is the brain's only source of energy (Ministry of Health, Labor and Welfare, 2014). Staple foods in Japan generally consist of rice, wheat, and buckwheat as the major source of carbohydrate (Zheng, et al., 2015). In particular, it is known that the masticatory function of older adults is declining (Ministry of Health, Labor and Welfare, 2020), and most older adults have eaten rice porridge; 76% of people over the age of 60 have eaten rice porridge and 93% of these people have eaten it as a staple food (Ministry of Health, Labor and Welfare, 2017).

However, rice porridge has the problem that it tends to raise blood glucose levels according to the glycemic index (GI), which is a measure of how easily a person's blood glucose level rises (Jenkins, et al., 1981). Rice porridge has a GI value of 92.5 or 78, compared to 69.9 or 73 for white rice (Kim, et al, 2019; Atkinson, et al., 2008). It has also been found that the older adults also have reduced glucose metabolic function (Kishimoto, et al., 2006), and porridge is a risk for the older adults. However, since the chewing and digestive functions have decreased in older adults, it is thought that rice porridge would be useful foods for older adults.

The GI value was first used in 1981 and represents the degree of increase in blood glucose level when

consuming 50g of carbohydrates contained in a certain food, with glucose being 100 (Jenkins, et al., 1981). However, this study did not take into account the number of chews, and there are other studies which do not know the number of chews or water content (Kim, et al., 2019; Atkinson., et al., 2008; Sugiyama, et. al., 2003). The difference in the number of chews also affects postprandial blood glucose levels. In one study, when white rice is chewed more often, the increase in blood sugar is greater (Ranawana, et al., 2014). On the other hand, in the experiment using nuts, blood glucose levels were lower when the number of chewing was increased (Madhu, et al., 2016). Furthermore, there is a study shows that differences in water intake and beverages also affect postprandial blood glucose levels (Torsdottir & Andersson, 1989). In addition, glucose is often used as a standard for GI and has a higher GI than white rice or porridge, but the difference in water content between the foods being compared is not taken into account (Kim, et al., 2019; Atkinson, et al., 2008). This chewing frequency and water content are not taken into account when the GI values are created, and the sugar content varies from study to study. Therefore, it can not be said that the GI value reflects the actual postprandial blood glucose variation between white rice and porridge. There are no studies that have examined blood glucose fluctuations under the control of conditions for sugar content, chewing frequency, and water content. In addition, studies have shown that a higher GI value results in a lower satiety level (Makris, et al., 2011; Niwano, et al., 2009; Holt, et al., 1992), and a higher number of chews results in a higher satiety level (Cassady, et al., Zhu, et al., 2009; 2013; Komai, et al., 2016). Rice porridge is considered less satiating than white rice because it has a higher GI value, but the GI value does not take into account the number of times it is chewed or the amount of water it contains, as discussed in the blood sugar section above. Therefore, the satiety of white rice and rice porridge cannot be measured by GI value. In addition, glucose has a high GI value, and glucose solution is more

satiating than water (Steinert, et al., 2011), but no studies have compared it to food.

The purpose of this study was to compare the variation and range of increase in blood glucose levels and satiety level when white rice and rice porridge were ingested with the same sugar content, number of chews, and water content, which are factors related to postprandial blood glucose levels. It is also to examine the fluctuation and rise in blood glucose levels and the satiety level when glucose, white rice and porridge are ingested with a same amount of water. Glucose solution has been used for testing blood glucose responses (Brouns, et al., 2005; Kim,et al., 2019; WHO, 1999). This is because glucose is digested quickly, and causes a faster rise in blood glucose levels (Clemens, et al., 2016). There is also a relationship between the rise in blood sugar and the level of satiety (Makris, et al., 2011; Niwano, et al., 2009; Holt, et al., 1992). Therefore, this study added glucose solution to compare the results provided from white rice or rice porridge as the widely-accepted test meal.

We hypothesized that there are no significant differences in the variation and increase in blood glucose levels, because it unifies the factors related to postprandial blood sugar levels: sugar content, number of chews, and water content (Jenkins, et al., 1981; Izumi, et al., 2012; Madhu, et.,al., 2016; Torsdottir & Andersson, 1989). Furthermore, the number of chews, which is related to satiety (Cassady, et al., Zhu, et al., 2009; 2013; Komai, et al., 2016), was controlled, and blood glucose was assumed to be the same in this study, so there is also no difference in satiety between white rice and rice porridge. When focusing on glucose solution, white rice, and porridge, we assumed that glucose would cause a faster rise in blood glucose levels than white rice or porridge, and that satiety would be higher at earlier points. This is because glucose is a monosaccharide and is digested quickly, unlike rice

which is a polysaccharide (Clemens, et al., 2016), and because there is a relationship between the rise in blood sugar and the level of satiety (Makris, et al., 2011; Niwano, et al., 2009; Holt, et al., 1992).

Materials and Methods

Participants

The participants are 6 healthy females and 3 healthy males (Age: 21.3±0.5 ys, Weight: 51.6±5.1 kg, BMI: 20.0±1.4 kg/m^2). All participants did not smoke and had no abnormalities in glucose metabolism function. The participants were received a detail explanation of the purposes and risks associated with participation in this study.

Experimental design

Participants performed three experiments on the days at least 24h. All experiments were conducted in the morning. The experimental protocol is shown in Fig.1. First day, the participants ingested a glucose solution. The specified amount of glucose was dissolved in water. On the second or third days, the participants ate white rice or rice porridge. Order of white rice or rice porridge was randomized. In the case of white rice, water was ingested to match the water content with the rice porridge. Blood glucose levels were measured before consumption (0 minute) and 30, 60, 90, 120 minutes thereafter. Satiety levels were measured before consumption (0 minute) and postprandial, and 30, 60, 90, 120 minutes thereafter. Participants did not consume any additional food or liquids other than water for 12 hours prior to the experiment and until finish the day's experiment. They were instructed to rest during the

experiment. They also had prohibited from alcohol intake, intense exercise, medication intake the day before the experiment, and instructed to lead a regular life.

The amount of carbohydrates used in the oral glucose tolerance test, and in the calculation of GI is 50 g. However, the amount when converted to porridge was so large that it was expected that the participants would not be able to finish the meal. In addition, since there was a difference in the energy requirements of the participants (1675-2160 kcal) calculated from basal metabolic rate and physical activity level (Ministry of Health, Labor and Welfare, 2014), they were divided into groups that ingested approximately 30g and 40g of carbohydrates. Then, the amount of glucose, white rice, and rice porridge corresponding to the amount of carbohydrates in each group was calculated. Furthermore, the amounts were determined by taking into account that the total number of chews of white rice and rice porridge should be the same (Table 1).

White rice and rice porridge were divided into cups, with each cup containing 10 grams (Fig. 2). Participants were asked to consume one cup per mouthful. In previous study, the average number of times when white rice was chewed per 10g bite was 35 times (Yanagisawa & Wakabayashi, 1991), and when thin rice porridge was chewed per 5 or 10 g bite was approximately 8 times and 16 times, respectively (Nakayama & Kohyama 2004; Takahashi, at el., 2013). In preliminary experiments, the average number of chews for 10g of white rice was 35 times, and for rice porridge was 25 times. In order to controll the total number of chews, the number of chews per mouthful of rice porridge was set to 15, which is the number of times it is possible to swallow in preliminary experiments. Therefore, each mouthful of white rice was chewed 35 times, and for rice porridge was chewed 15 times. The total number of chews was 315

times in Group 1, and 420 times in Group 2. The total number of chews of white rice and rice porridge was same in the group. We measured the chewing speed of white rice and porridge beforehand, and found no difference. Therefore, the participants chewed food at a rate of 75 bpm in time with a metronome. In order to unify the water content of white rice and rice porridge, Group 1 and Group 2 were asked to drink 120 ml and 160 ml of water, respectively after consuming white rice.

Measuring methods

Blood glucose

The participants' blood glucose levels were measured using self-glucose monitoring system (Abbott Japan LLC, The FreeStyle Libre Flash glucose monitoring system, Tokyo, Japan). It is consist of two parts: a reading device and a disposable sensor (Fig. 3). The participants wore the censor on the back of upper arm until all the experiments were completed. The sensor measures glucose levels in the subcutaneous interstitial fluid, which is a reliable indicator of blood glucose levels. When the reader scans the sensor, the glucose level recorded on the sensor is wirelessly transmitted to the reader, and the glucose level is displayed on the screen. Blood glucose levels were measured before consumption (0 minute) and 30, 60, 90, 120 minutes thereafter.

Satiety level

The satiating capacity following eating of the test meals was assessed by interview. The participants were asked to number their satiety on a scale of 1 to 9 as shown below (Fig 4). These scores were recorded before each meal, immediately after having it and at 30, 60, 90, 120 minutes after having it.

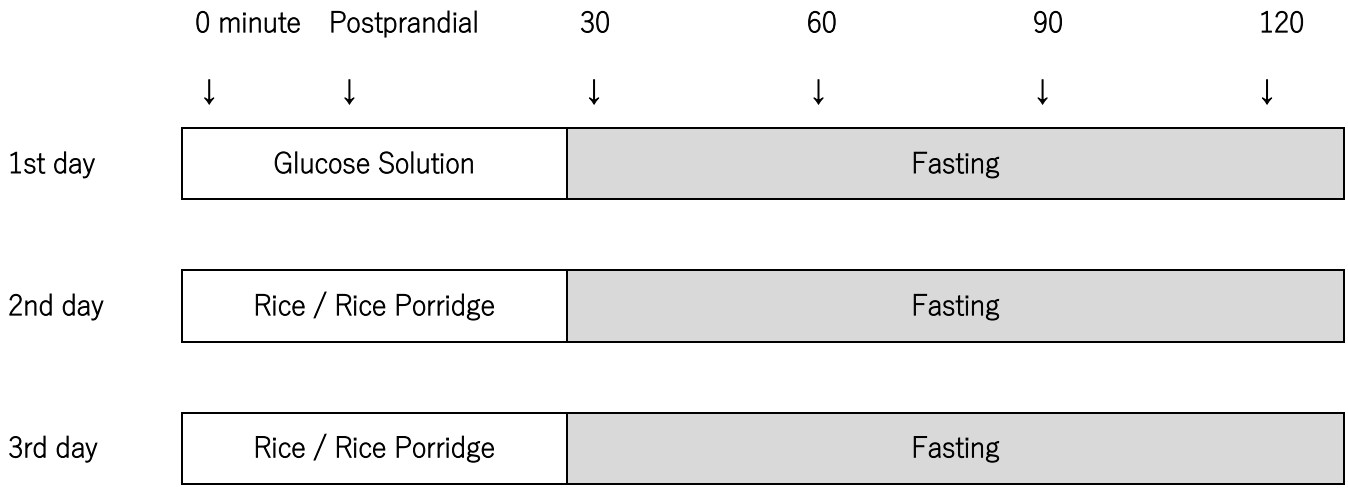

Fig. 1 The experimental protocol. Blood glucose levels were measured before consumption (0 minute) and 30, 60, 90, 120 minutes thereafter. Satiety levels were measured before consumption (0 minute) and postprandial, and 30, 60, 90, 120 minutes thereafter.

Table.1 Nutrient components of the test meals for each group (Group 1: n=6, Energy requirements=1675-1855 kcal; Group 2: n=3, Energy requirements=2099-2160 kcal). We used glucose (Marugo Corporation), and polished white rice (Aichi no kaori). White rice and rice porridge were cooked in a rice cooker.

Group		Weight (g)	Energy (kcal)	Water content (g)	Water intake (g)	Sugar (g)
1	Glucose solution	36.0	124.0	3.2	170.0	32.8
	White rice	90.0	140.0	54.0	120.0	33.1
	Rice porridge	210.0	136.0	174.3	0.0	32.8
2	Glucose solution	48.0	165.0	4.3	230.0	43.7
	White rice	120.0	187.0	72.0	160.0	44.2
	Rice porridge	280.0	182.0	232.4	0.0	43.7

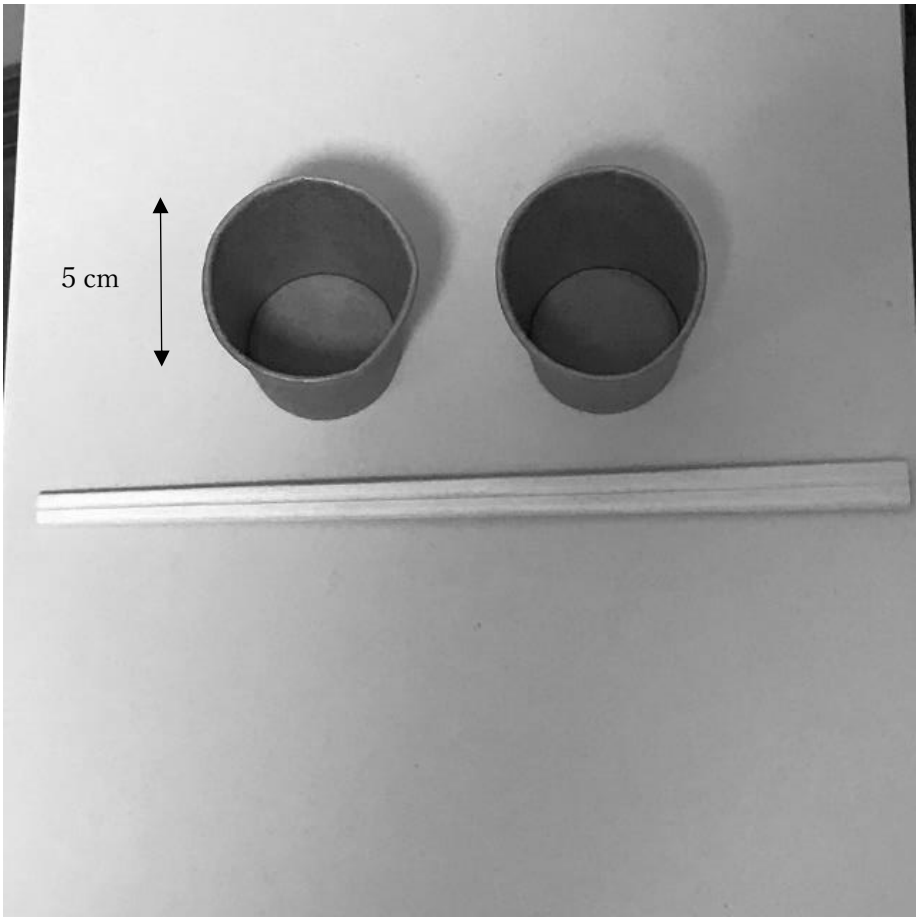

Fig.2 Cups and chopsticks for eating.

Fig. 3 A reading device and a disposable sensor of the FreeStyle Libre Flash glucose monitoring system.

Number	Satiety level
1	Painfully hungry
2	Very hungry
3	Hungry want to eat
4	Not hungry, but ready to eat
5	No particular feeling
6	Partly satisfied
7	Pleasantly full
8	Unpleasantly full
9	Full to nausea

Fig. 4 Satiety scale.

Statistics

All data are provided as mean and SD. The non-parametric analysis was used in this study since the sample size was small. The incremental areas under the curve (iAUC) were calculated for the blood glucose concentrations during tests. The area was calculated using the trapezoidal method. The iAUCs of glucose solution, white rice, and rice porridge were compared using Friedman test. Blood glucose levels at 0 minute and other times (30, 60, 90, 120 minutes) and satiety levels at 0 minute and other times (postprandial, 30, 60, 90, 120 minutes) among glucose solution, white rice, and rice porridge were compared using the Friedman test. Wilcoxon with Bonferroni collection was performed as a post hoc test for the pairs between 0 minute and other times of blood glucose and satiety. 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

There were no significant differences between the iAUCs for blood glucose of glucose solution, white rice and rice porridge ($p > 0.05$) (Figure 5). The changes of the blood glucose levels are shown in Fig. 6. There was a significant differences between 3 groups at 90 minutes ($p < 0.05$), and were no differences between 3 groups at 0, 30, 60, and 120 minutes. However, there were no significant differences between glucose solution and white rice, glucose solution and rice porridge, white rice and rice porridge at 90 minutes ($p > 0.05$). The blood glucose level of glucose solution at 60 minutes after taking was significantly higher than at 0 minute ($p < 0.05$). The blood glucose levels of

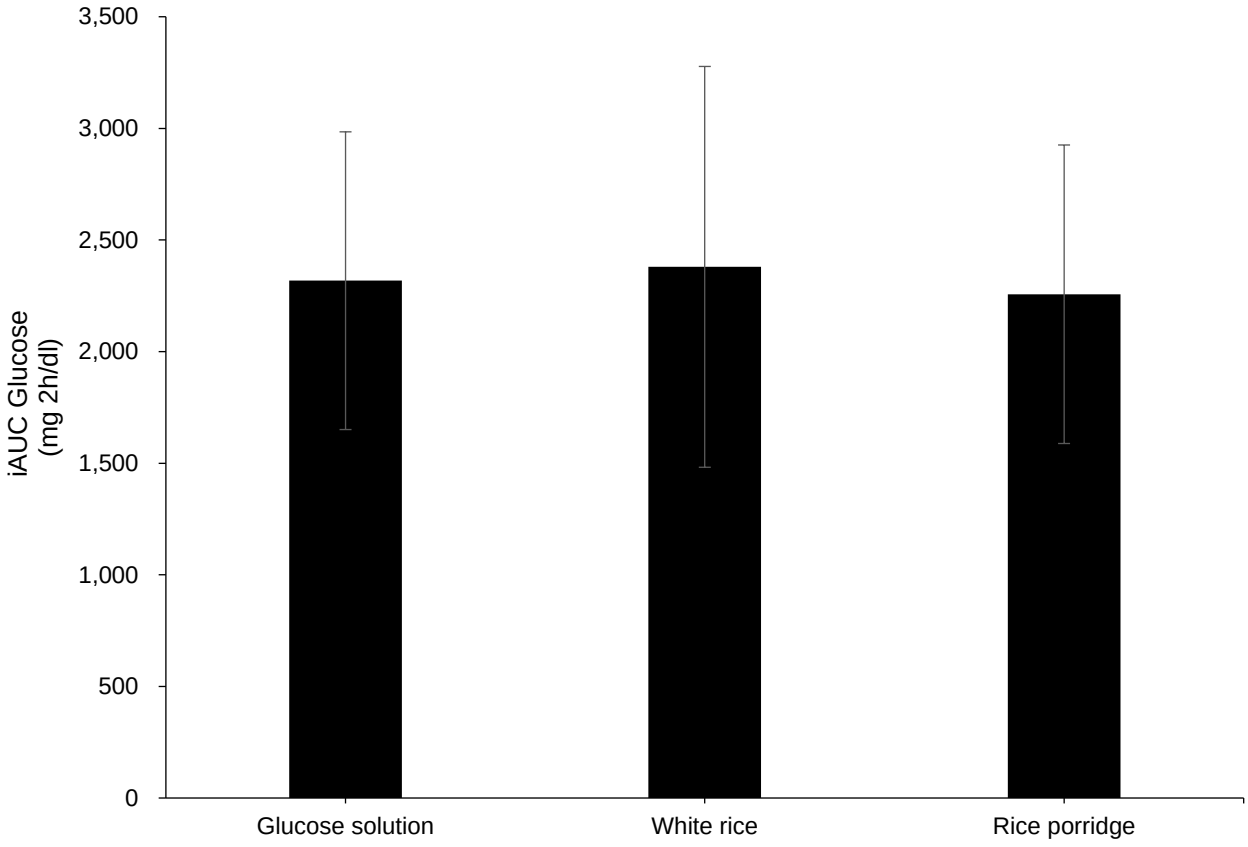

Fig.5 The iAUC for Glucose solution, white rice, and rice porridge.

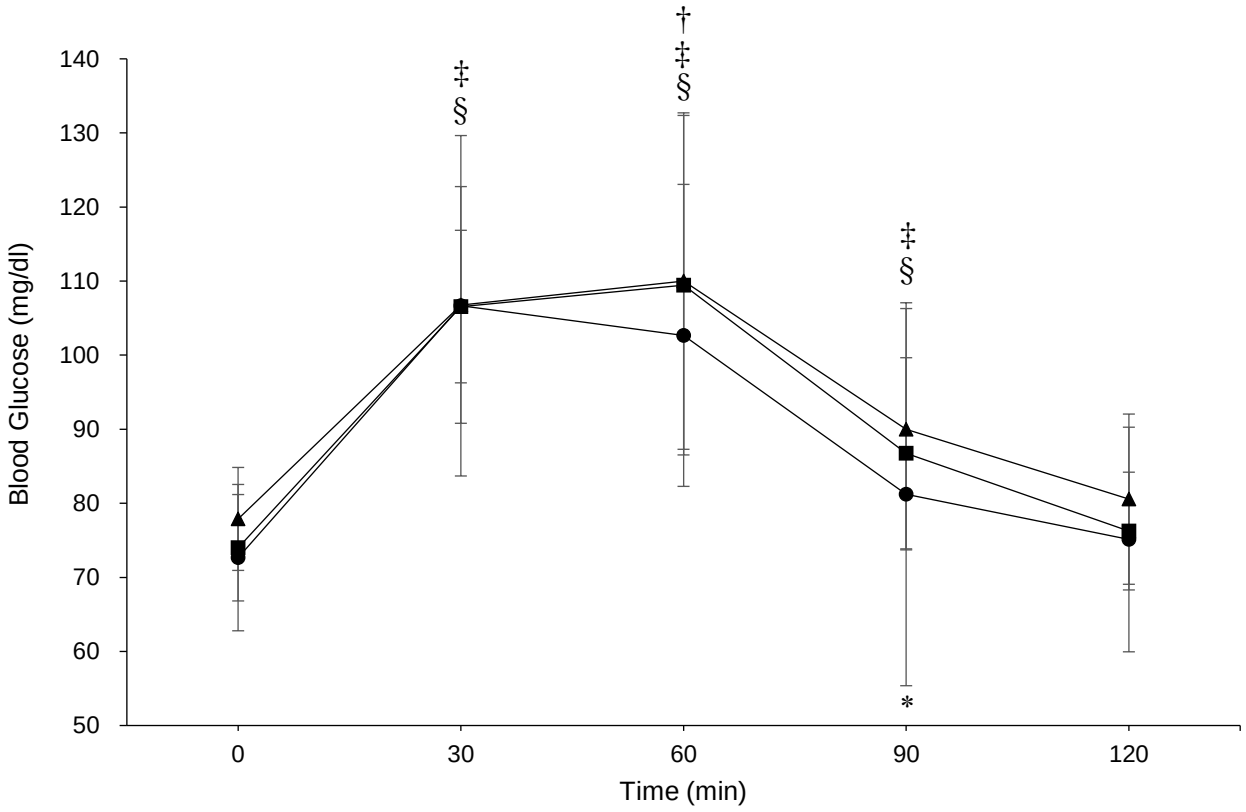

Fig.6 Mean(±SD) Blood glucose levels after taking glucose solution (-●-), white rice (-▲-), and rice porridge (-■-). (*$p < 0.05$ among the three meals analyzed using Friedman test. †$p < 0.05$ vs 0min in glucose solution, ‡$p < 0.05$ vs 0min in white rice, §$p < 0.05$ vs 0min in rice porridge analyzed using Wilcoxon with post hoc Bonferroni correction.)

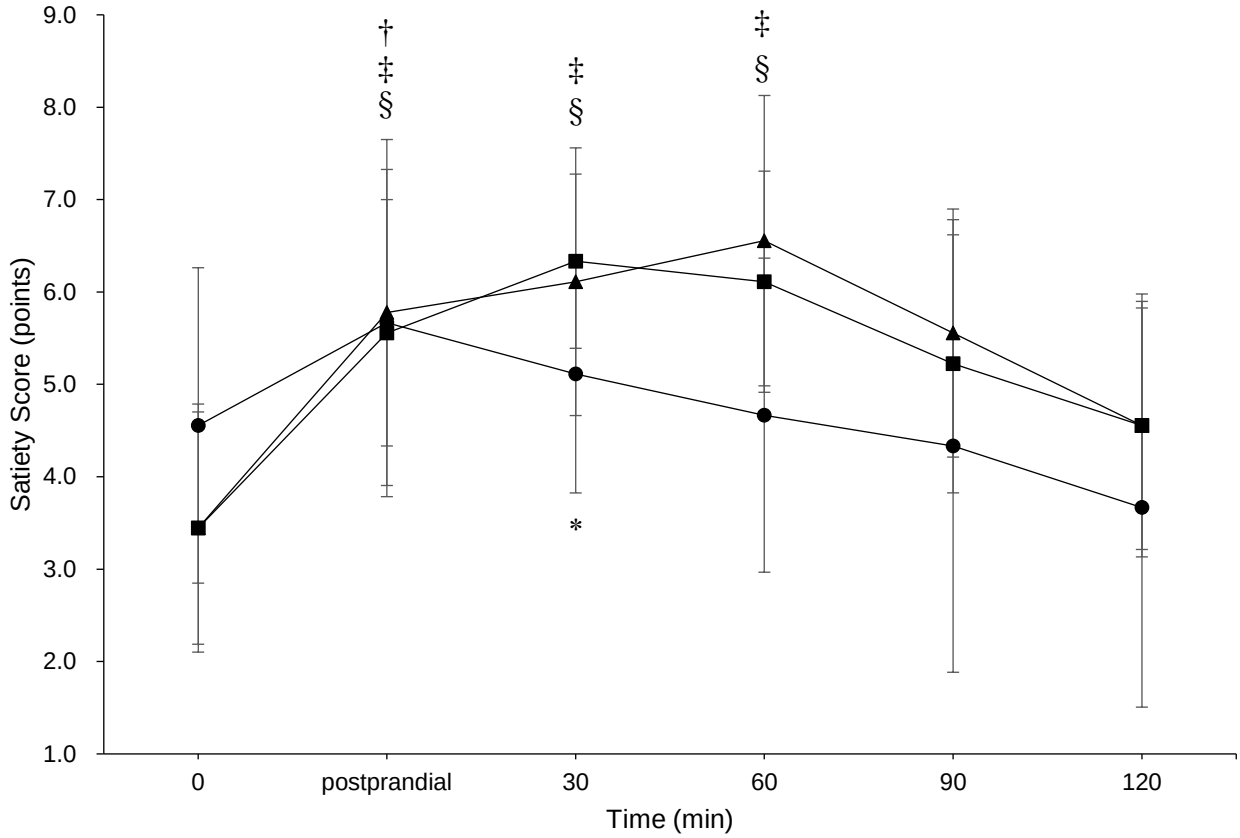

Fig.7 Mean(±SD) Satiety levels after taking glucose solution(-●-), white rice(-▲-), and rice porridge(-■-) (*$p < 0.05$ between glucose solution and rice porridge. †$p < 0.05$ vs 0min in glucose solution, ‡$p < 0.05$ vs 0min in white rice, §$p < 0.05$ vs 0min in rice porridge analyzed using Wilcoxon with post hoc Bonferroni correction.)

white rice and rice porridge 30, 60, 90 minutes after taking were significantly higher than at 0 minute ($p < 0.05$).

The changes of the satiety levels are shown in Fig. 7. There was a significant differences between 3 groups at 30 minutes ($p < 0.05$), and were no differences between 3 groups at 0, postprandial, 60, 90, and 120 minutes. The satiety level of glucose solution was significantly lower than rice porridge at 30 minutes ($p < 0.05$). The satiety level of glucose solution was significantly higher at immediately after taking than at 0 minute ($p < 0.05$). The satiety levels of white rice and rice porridge were significantly higher at immediately, 30, 60 minutes after taking than 0 minute. ($p < 0.05$).

Discussion

In this study, there were no significant differences between glucose solution, white rice and rice porridge before and after 30, 60, 90, and 120 minutes of consumption in the blood glucose levels and the iAUC of glucose ($p>0.05$). Time courses in blood glucose levels following eating of white rice and rice porridge were similar. These results support the hypothesis. This could be explained by following six factors.

The first is amount of sugar content. The amount of sugar is related to blood glucose level. For example, a cake with one-fourth the sugar content had one-fourth the maximum blood glucose level compared to a regular cake, partly due to the effect of dietary fiber (Izumi, et al., 2012). The amount of sugar in white rice and rice porridge was controlled in this study (30g in group 1, 40g in group 2). Therefore, the sugar content in this study did not affect the blood glucose levels and the iAUC of glucose. The second is number of chews. In a previous study, when white rice is chewed 30 times, the blood glucose response is greater than when it is chewed 15 times (Ranawana, et.,al., 2014).

The total number of chews for white rice and rice porridge was controlled in this study (315 times in group 1, 420 times in group 2). Therefore, the total number of chews in this study did not affect the blood glucose level and the iAUC of glucose. The third is the amount of water. In a previous study, when potatoes, a high carbohydrate food, are ingested with or without 300 ml of water, the blood glucose level rises rapidly and the glycemic response is greater when water is ingested due to rapid gastric emptying (Torsdottir & Andersson, 1989). The amount of water ingested was controlled in this study (170g in group 1, 230g in group 2). Therefore, the amount of water in this study did not affect the blood glucose level and the iAUC of glucose. The fourth is the types of sugar and varieties of rice. The absorption rate of monosaccharides and polysaccharides is supposed to be different (Clemens, et al., 2016), and monosaccharides are considered to increase blood glucose levels. In addition, high amylose rice has a lower increase in blood glucose levels than white rice because amylose reduces enzyme accessibility and results in a greater proportion of slowly digestible and resistant starch (Yamaguchi, et al., 2019). The sugars in the white rice and rice porridge were polysaccharide starch, and the rice varieties used were same in this study. Therefore, the types of sugar and varieties of rice in this study did not affect the blood glucose level and the iAUC of glucose. The fifth is the difference in temperature. In a previous study, when white rice is cooled, the range of increase in blood sugar is smaller than that before cooling due to the function of resistant starch (Sonia, et al., 2015). The Heat retention temperature of the rice cooker used in this study was 70 ± 3 degrees Celsius (Sharp, 2021), and the temperature of both white rice and porridge at the time of consumption was considered to be the same. Therefore, the temperature of both white rice and porridge did not affect the blood glucose level and the iAUC of glucose. The sixth is chewing speed. Although there are no studies showing that chewing speed or rhythm affects blood glucose levels, fast eating

is associated with higher glycemic excursion (Saito, et al., 2020). In previous study, the chewing cycle of white rice was 87.9 bpm while that of porridge was 84.8 bpm (Nakayama & Kohyama, 2004). In the preliminary experiment of this study, the chewing cycle of white rice was 74.0 bpm and that of porridge was 78.9 bpm, and there was no difference between the two conditions. They were combined at 75.0 bpm, the speed of mastication and mastication rhythm were controlled in this study. Therefore, it is thought that the speed of mastication did not affect the blood glucose level and the iAUC of glucose.

There was no difference in satiety between glucose solution, white rice and rice porridge before, postprandial, 60, 90, and 120 minutes after consumption ($p>0.05$). Time courses in satiety levels following eating of white rice and rice porridge were similar. These results support the hypothesis. This result may be related to blood glucose levels, number of chews, and stomach fullness. Factors related to satiety include gastric fullness and hormones released from the small intestine (Maljaars, et al., 2007). Some of the peptides released from the small intestine act on the hypothalamus, and are involved in regulating eating. Among them, GLP-1 is associated with elevated blood glucose levels. GLP-1 suppresses elevated blood glucose levels by secreting insulin from islet of Langerhans b cells in the pancreas when the concentration of glucose in the blood rises (Baggio & Drucker 2007), and it also acts on the nucleus of the solitary tract to suppress food intake (Williams, 2009). Although elevated blood glucose is a factor that stimulates the satiety center, there is no difference in blood glucose fluctuations between the white rice and rice porridge in this study. Therefore, there is no difference in GLP-1, which secretes insulin in response to elevated glucose levels, and suppresses eating, resulting in no change in satiety. In addition, chewing has also been shown to increase cholecystokinin, which is considered to be related to satiety and appetite regulation

(Beglinger & Degen, 2004; Beinfeld, 2013). In a previous study, 40 chews resulted in higher plasma cholecystokinin concentration and lower hunger than 15 chews (Li, et al., 2011; Zhu, et al., 2013). Thus, the difference in the number of chews affects the level of satiety, but since the total number of chews was same in this study, we consider that it did not affect the level of satiety. Furthermore, gastric fullness is related to volume, and a study has shown that gastric dilation with a balloon decreases food intake and satiety (Oesch, et al., 2006). However, in this study, water was added after the intake of white rice to unify the water content, taking into account the inherently high water content of porridge. This suggests that the volume of white rice and porridge in the stomach was the same. Therefore, we consider that there was no difference in the level of satiety between white rice and rice porridge.

In this study, there were no significant differences between glucose solution, white rice and rice porridge before and after 30, 60, 90, and 120 minutes of consumption in the blood glucose levels and the iAUC of glucose ($p>0.05$). When focusing on glucose solution, this result does not support the hypothesis. This result suggests the influence of chewing. A study showed that when rice or potatoes were chewed for 15 seconds and ingested, or swallowed without chewing, blood glucose levels rose rapidly in both cases of chewing (Read, et al., 1986). This is considered because chewing makes the grains smaller, which facilitates the transport of food from the stomach to the small intestine, and chewing also increases the surface area of the food, making it easier for enzymes to work (Zhu, et al., 2013). For these reasons, we consider that chewed white rice and rice porridge accelerated the rise in blood glucose levels, and at the end of 30 minutes, they were equivalent to glucose solutions that had not been chewed.

The satiety level of glucose solution was significantly lower than that of rice porridge at 30 minutes after consumption ($p<0.05$). We hypothesized that the glucose solution would raise blood glucose levels more, and thus

satiety would be higher earlier than rice. However, since there was no difference in blood glucose fluctuation between the two groups, we considered that the presence or absence of chewing was related to the level of satiety. Since chewing increases satiety (Cassady, et al., Zhu, et al., 2009; 2013; Komai, et al., 2016), it is thought that chewing rice porridge increases cholecystokinin, which increases satiety, while they are not released without chewing, resulting in lower satiety in glucose solution. In addition, glucose is a monosaccharide and is digested and absorbed faster than the polysaccharide starch (M, Wee & C, Henry, 2109), which may have resulted in a faster decrease in satiety.

This study was conducted as an experiment on healthy young people. In the case of older adults, if the amount of water and the number of chewing is the same, there would be no difference in blood sugar fluctuation and satiety between white rice and rice porridge. However, insulin secretion decreases due to aging, and the ability to metabolize sugar declines. Therefore, it can be expected that the elevated blood glucose level will be difficult to lower and hyperglycemia will continue. There is a data showing that hyperglycemia two hours after a meal is associated with a higher mortality rate from cardiovascular diseases (DECODE Study Group, 2001), thus blood glucose control is necessary in the older adults. Although rice porridge without ‘omoyu’ which is the clear liquid in top of rice porridge was used in this study, thin rice porridge has a higher water content (Ministry of Education, Culture, Sports, Science and Technology. 2015). Since blood glucose levels rise when water intake is increased (Torsdottir & Andersson 1989), blood glucose levels must be controlled when older people with reduced masticatory function consume rice porridge with high water content. When eating rice porridge as part of a meal, rather than as a stand-alone food, it is necessary to change the foods they eat together and the order in which they are eaten.

In conclusion, we compared the difference of the increase in blood glucose and satiety level between white

rice and rice porridge, and between glucose solution and white rice, rice porridge with the same conditions. There are no significant difference in the increase in blood glucose among the three. However, glucose solution reduces satiety more quickly than rice porridge. From these results, we suggested that rice porridge does not necessarily raise blood glucose levels and satiety levels than white rice, and chewing may increase satiety.

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Effect of conversation on rate of perceived exertion and physiological responses during exercise

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Abstract

Effect of conversation on rate of perceived exertion and physiological responses during exercise

Aim The purpose of this study was to investigate the effect of exercising with conversation on rate of perceived exertion (RPE) and physiological responses. **Methods** Ten healthy college students performed pedaling exercise on bicycle ergometer with and without conversation. At this time, oxygen consumption (VO2), heart rate (HR), and RPE were measured during these exercises and were compared between the exercises with and without conversation. **Results** Resting VO2 was significantly higher with conversation than without conversation ($p = 0.037$). There was no significant difference in resting HR, exercise VO2, HR, and RPE between with and without conversation. **Conclusion** These results suggest that conversation induces feeling of shorter exercise time while RPE and physical responses were not influenced by conversation.

会話が運動時の主観的運動強度と生理学的応答に及ぼす影響

本研究の目的は、会話を伴う運動が主観的運動強度(RPE)と生理学的応答へ与える影響を調査することであった。健康な大学生１０名が自転車エルゴメーターによる運動を行った。この時会話ありと会話なしの場合の酸素摂取量（VO2）や、心拍数（HR)、および RPE を比較した。安静時の VO2 は会話なしよりも、会話ありの方が有意に増加した（ｐ＝０．０３７)。安静時の HR、運動時の VO2 と HR、RPE において、会話ありと会話なしの場合の間に有意差はなかった（ｐ>0.05)。これらの結果から、運動時の会話は RPE や生理学的応答は変化させないが、運動時間を短く感じさせることが示唆された。

El efecto de la conversación sobre el RPE y las respuestas fisiológicas durante el ejercicio

El objetivo de este estudio ha sido investigar el efecto de hacer ejercicio con conversación sobre la tasa de esfuerzo percibido (RPE) y las respuestas fisiológicas. Diez estudiantes universitarios sanos realizaron ejercicios de pedaleo en bicicleta ergómetro con y sin conversación. El consumo de oxígeno (VO2), la frecuencia cardíaca (HR) y el RPE se midieron durante estos ejercicos y se compararon entre los ejercicos con y sin conversación. El VO2 en reposo fue significativamente mayor con la conversación que sin la conversación ($p = 0,037$). No hubo diferencias significativas en el HR en reposo, el VO2, el HR y el RPE del ejercicio entre los casos con y sin conversación ($p> 0,05$). Estos resultados sugieren que la conversación durante el ejercico induce la sensación de un tiempo de ejercico más corto, mientras que el RPE y las respuestas físicas no se vieron influenciadas por la conversación.

Abbreviations:

VO2: oxygen consumption, HR: heart rate, RPE: rate of perceived exertion.

Introduction

In recent years, the world is aging rapidly (Cabinet Office. 2018). According to the Ministry of Foreign Affairs (MOFA), there are 611.9 million older people around the world, and Japan has the highest average life expectancy in the world, and the population is aging internationally (MOFA. 2021). As of October 1, 2018, the total population of Japan is 126.44 million, and the population aged 65 and over is 35.58 million, so the ratio to the total population (aging rate) is also 28.1% (CAO. 2018). According to the Cabinet Office (CAO), it is important for people to live long and healthy because the aging of Japan causes social problems such as economic growth and social security system (CAO. 2018).

Therefore, according to Raven et al. (2013), exercise is effective for a healthy and long life (Raven et al., 2013). In general, the positive effects on mental health, cognition and brain activity as a result of exercise programs are very clear (Rimes et al., 2015). Many exercise physiologists are beginning to apply the concept of facilitating exercise training programs, which improve an individual's physical activity and athletic performance, help prevent illness, and improve physical fitness and athletic performance (Raven et al., 2013). It is said to improve and recover from injuries and illnesses (Raven et al., 2013). Consequently, all adults, including older people, need to having exercise habits. For substantial health benefits, adults need to perform at least 150 minutes of moderate or 75 minutes of intense aerobic exercise per week, or a combination of equivalent moderate and intense aerobic activity (Department of Health

and Human Services. 2008). According to a survey by the Japan Sports Agency (JSA), 62% of both men and women having habits of walking in one year, while 20% of men and 7% of women having habits of running. The study shows that running is not preferred, as the number of people running marathons is overwhelmingly less than those walking (JSA. 2019).

Moreover, high-intensity exercise increases subjective exercise intensity. According to Raven et al. (2013), the Borg ratings of perceived exertion scales, developed by Dr. Gunnar Borg, was developed to estimate intensity based on overall perception of physical cues such as breathing difficulty, heart rate, and muscle discomfort (Raven et al., 2013). Accordingly, since the Borg scale indicates how hard you are moving during exercise, it can be said that the higher the intensity of exercise, the higher the subjective exercise intensity.

Then in order to reduce the subjective exercise intensity, it is effective to distract. In a previous study of the interactive cycling games, which is a game whose contents change according to the player's operation, interactive cycling games have higher exercise intensity and energy consumption rate than conventional cycling (Monedero et al., 2015). The user of interactive cycling games has increased significantly (Monedero et al., 2015). On the other hand, heart rate and subjective exercise intensity did not change much. Therefore, it is possible to reduce the subjective exercise intensity by distracting. In another previous study, Virtual Reality (VR) was used during medical procedures to distract and reduce pain and anxiety (Arane et al., 2017). Distraction is a

common non-pharmacological technique used by healthcare professionals to manage and relieve anxiety and, in some cases, pain during painful procedures in pediatric patients (Koller et al., 2012). The theory behind VR's role in reducing pain as well as anxiety is related to the limited attention that humans have. Pain requires attention, and if some of that attention can be distracted, patients are slow to respond to incoming pain signals (Hoffman et al., 2011). Virtual reality also does not interrupt pain signals, but acts directly and indirectly on pain perceptions and signals through attention, emotion, concentration, memory, and other sensations (Gold et al., 2007). By distracting in this way, discomfort such as pain and anxiety is reduced, so it is possible to reduce discomfort during exercise, that is, fatigue. Previous studies have shown that distractions during exercise have a positive effect, as watching television makes you feel more comfortable while exercising (Privitera et al., 2014). Distractions during exercise can enhance a comfortable mood and lead to continued training routines (Rocheleau et al., 2004). Consequently, distraction during exercise leads to habituation of exercise. Loneliness and depression are also particularly associated with the elderly (Abella et al., 2017). Rosenquist et al. (2011) suggested that individuals with fewer contacts had higher levels of depression (Rosenquist et al., 2011). It was also found that loneliness is a major risk factor for increasing mortality in older men (Holwerda et al., 2012). In addition, those suffering from both depression and loneliness had a 2.1-fold higher risk of death (Stek et al., 2005). In summary, emotional and social isolation have a clear impact on depression. Therefore, loneliness must be avoided in order for the elderly to

live a healthy and long life. Thus, I thought that exercising while talking with people might have a positive effect on the health of the elderly. However, no studies have investigated the effects of conversation on psychological and physiological responses during exercise.

The purpose of this study is to clarify the effect of conversation on RPE and physiological responses during exercise. It was hypothesized that exercise with conversation reduced RPE and felt shorter than the actual exercise time. This hypothesis is based on studies using VR in the medical field and studies of time judgment (Arane et al., 2017, Wittmann, 2009). Studies have shown that the use of VR as a method of distraction during procedures such as vaccination and blood sampling reduces pain and anxiety in children, so distraction may reduce discomfort (Arane et al., 2017). In addition, we speculated that distraction can make time feel short because time judgment is emotional in nature, feeling slower in unpleasant situations and faster in fun situations (Wittmann, 2009). As a result, I think that participants will be able to continue exercising.

Materials and Methods / Measuring methods

Participants

Ten university students with no abnormalities in the lower limbs participated in this study. Participants gave informed consent for the study after receiving a detailed

explanation of the purpose, potential benefits, and risk associated with participation in the study.

Experimental design

In the experiment, we compared oxygen intake (VO2), heart rate (HR), and rate of perceived exertion (RPE) between the exercises with and without conversation. An incremental workload test was performed on the first day to determine the exercise intensity for the main experiment. On the second day, the participants performed pedaling exercise at the slight tightness exercise intensity. First, we took data for 5 minutes without conversation at rest. Next, we took date for 5 minutes with conversation at rest. Then, after warming up for 5 minutes and taking a 10-minute break, we took data of the participants performed pedaling exercise while having a conversation for 5 minutes. After a 10-minute break, we put a screen between the two and took data of the participants performed pedaling exercise without conversation for 5 minutes. As for how to instruct the conversation at this time, I prepared 19 questions on the paper and asked the two people to talk freely while looking at the paper. The content of the question was a topic that was easy to talk about. Contents of conversation are about hobby, favorite food, favorite movie, recently watched movie, hometown, club activities, part time job, a fun travel destination, a cat person or a dog person, favorite sport, the country which participants want to visit the most, favorite entertainer, favorite song, brothers, what want to do if participants win the lottery, favorite season, favorite oden ingredient, favorite YouTuber, and what want to do when COVID-19

pandemic ends (TOWNWORK. 2017). Immediately after the experiment, we asked the subjects which one felt shorter, with or without conversation. As a caveat, the ratio of the case of rowing an exercise bike while having a conversation with two people first and the case of rowing an exercise bike with one person first is planned to be the same, so the order of the experiment is different from the current explanation.

Exercise

The workload at first stage of incremental workload test was set at an intensity of 5METs based on the body weight of the subject. The following formula was used. The formula used to determine the power.

5METs×3.5ml/kg/min = 17.5ml//kg/min

$$17.5\text{ml/kg/min}=1.8\frac{\text{Power(kg·m/min)}}{\text{Weight(kg)}}+7$$

$$\text{Watts}=\frac{\text{kg·m/min}}{6.12}$$

Then, a gradual load test was performed from the determined workload, and the workload at which the subjective exercise intensity was 13 indicating a little tightness was determined as the slight tightness exercise intensity for each participant. We increased workload of bicycle ergometer by 10W in 1 minute and cadence of pedaling was 60bpm. The main experiments with and without conversation were performed at the slight tightness exercise intensity. In this experiment, two bicycle ergometers （ETC163, AEROBIKE 75XLⅢ, CONAMI SPORTS & LIFE Co., Ltd. Tokyo, Japan, Lode Excalibur Sport; Lode Medical Technology, Groningen, The Netherlands） were

used. They were placed next to each other so that participants could perform pedaling exercise in the same direction. Each exercise time was 5 minutes. This exercise time was determined from the fact that VO2 became steady 3 minutes after exercise (Robert, 2014).

Measurement of VO2

VO2 was measured using a breath gas analyzer (AE310S, AEROMONITOR, Minato Medical Science Co., Ltd. Osaka, Japan) covering the mouth and nose with a mask. VO2 at each exercise was determined by the average value obtained during the last 1 min. The data obtained at the time of measurement was synchronized with a personal computer using Lab Chart 8 software (ADInstruments, Melbourne, Australia). The stored data of VO2 were downloaded to a personal computer (PC) and used for analysis.

Measurement of Heart rate

HR was measured using an electrocardiogram (Central Monitor with Analysis Function DS-8600, Fukuda Denshi Co., Ltd. Tokyo, Japan), an electrocardiographic / respiratory transmitter (ECG & Respiration Transmitters, LX-8100, Fukuda Denshi Co., Ltd. Tokyo, Japan), and a magnerode (MAGNERODE, TE-18, Fukuda Denshi Co., Ltd. Tokyo, Japan). Before mounting the electrodes, the participant's electrode mounting site was wiped with alcohol disinfectant cotton (Sanicot EQ, Marusan Sangyo Co., Ltd., Ehime, Japan) to remove skin stains such as sweat and oil. The positions of the ECG electrodes were fitted according to the CC5 Holter ECG guidance method

(Guiteras et al., 1982). After that, an electrocardiographic / respiratory transmitter was attached to the electrodes. HR at each exercise was determined by the average value obtained during the last 1 min. The stored data were downloaded to a personal computer (PC) and used for analysis.

Measurement of RPE

RPE was measured using a Borg scale at 19 levels of subjective exercise intensity. We asked the participants for RPE in 4 minutes after the start of the experiment. At that time, we showed participants the Borg scale paper and asked him/ her to point his/ her finger at the current RPE.

Data analysis and Statistical analysis

We compared VO2 and HR during rest, exercise, with and without conversation. We used a delta analysis to determine the net difference between with and without conversation and the net difference between during exercise and during rest. In order to compare the effect of conversation on net VO2 and HR, the difference of VO2 and HR between with and without conversation at rest and exercise were calculated. Furthermore, similar to the method that analyzed the effects of conversation on net VO2 and HR, we analyzed the effects of exercise on net VO2 and HR.

Due to the small number of subjects, a nonparametric method was used for statistical analysis. VO2, HR, RPE, net VO2, net HR, and how to feel time compared variables between with and without conversation and between during exercise and during rest using Wilcoxon test. The level of statistical significance was set at $p < 0.05$.

All statistical analyzes were performed using SPSS software (SPSS version 25.0; SPSS, Tokyo, Japan).

Result

Resting VO2 was significantly higher during with conversation than without conversation ($p = 0.037$) (Fig. 1). There were no significant differences between with and without conversation in HR during rest ($p = 0.799$) (Fig. 2), VO2 during exercise ($p = 0.074$) (Fig. 3), HR during exercise ($p = 0.059$) (Fig. 4), and RPE during exercise ($p = 0.0751$) (Fig. 5). No significant differences were not observed in the value obtained by subtracting VO2 and HR at rest from VO2 and HR during exercise with and without conversation ($p = 0.074$) (Fig. 6) ($p = 0.092$) (Fig. 7). Significant difference was not detected in the value obtained by subtracting VO2 and HR without conversation from VO2 and HR with conversation during exercise and at rest ($p = 0.074$) (Fig. 8) ($p = 0.092$) (Fig. 9). Subjects felt that the time was shorter with conversation than without conversation (There is a significant difference, $p = 0.002$).

Discussion

In this study, we investigated the effects of conversation on VO2, HR, and RPE. Resting VO2 was significantly higher with conversation than with silence during rest and exercise ($p <0.05$) (Fig. 1). There were no significant differences in resting HR, exercise VO2 and HR, and RPE between silent and conversational cases ($p> 0.05$) (Fig.

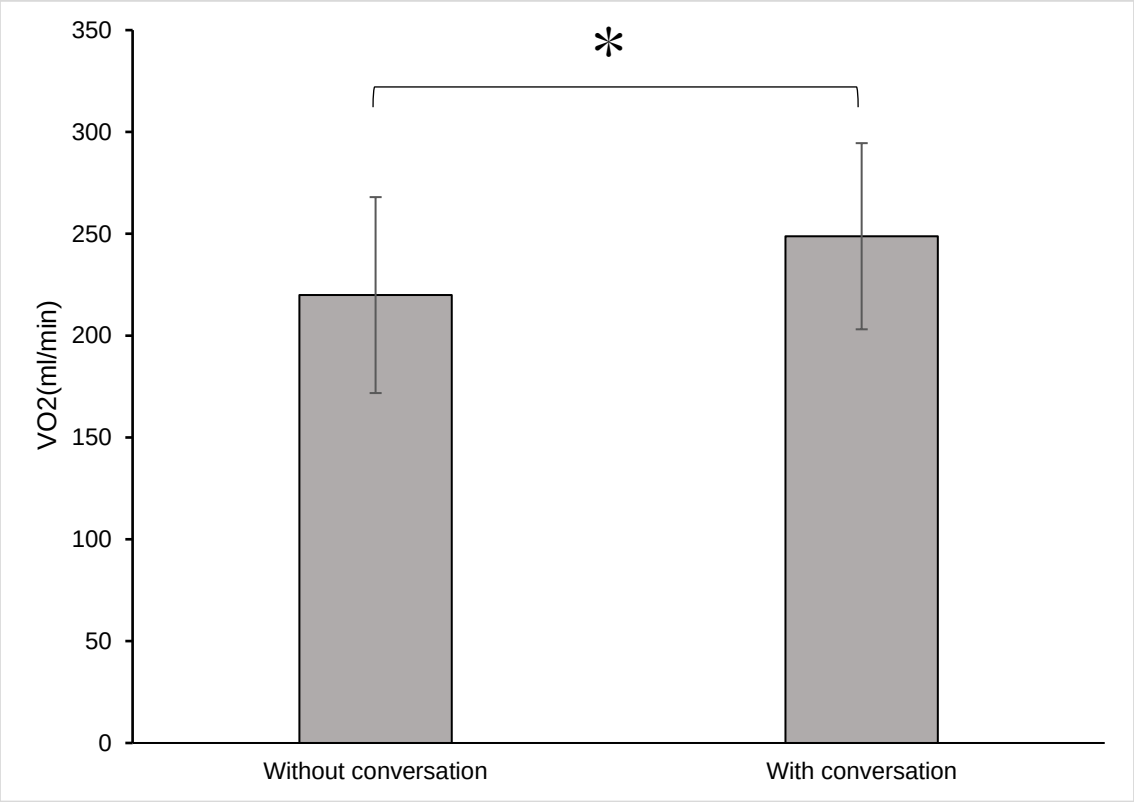

Fig. 1 Mean VO2 between with and without conversation during rest (*$p < 0.05$ between with and without conversation).

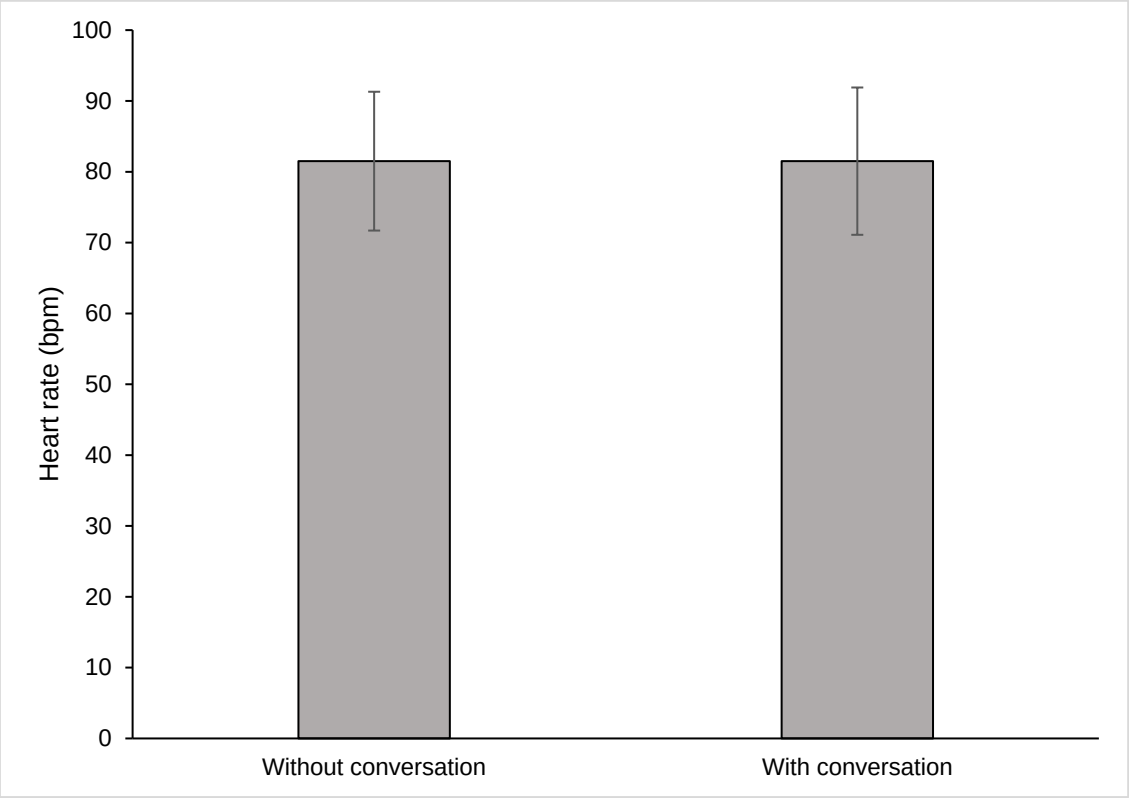

Fig. 2 Mean HR between with and without conversation during rest.

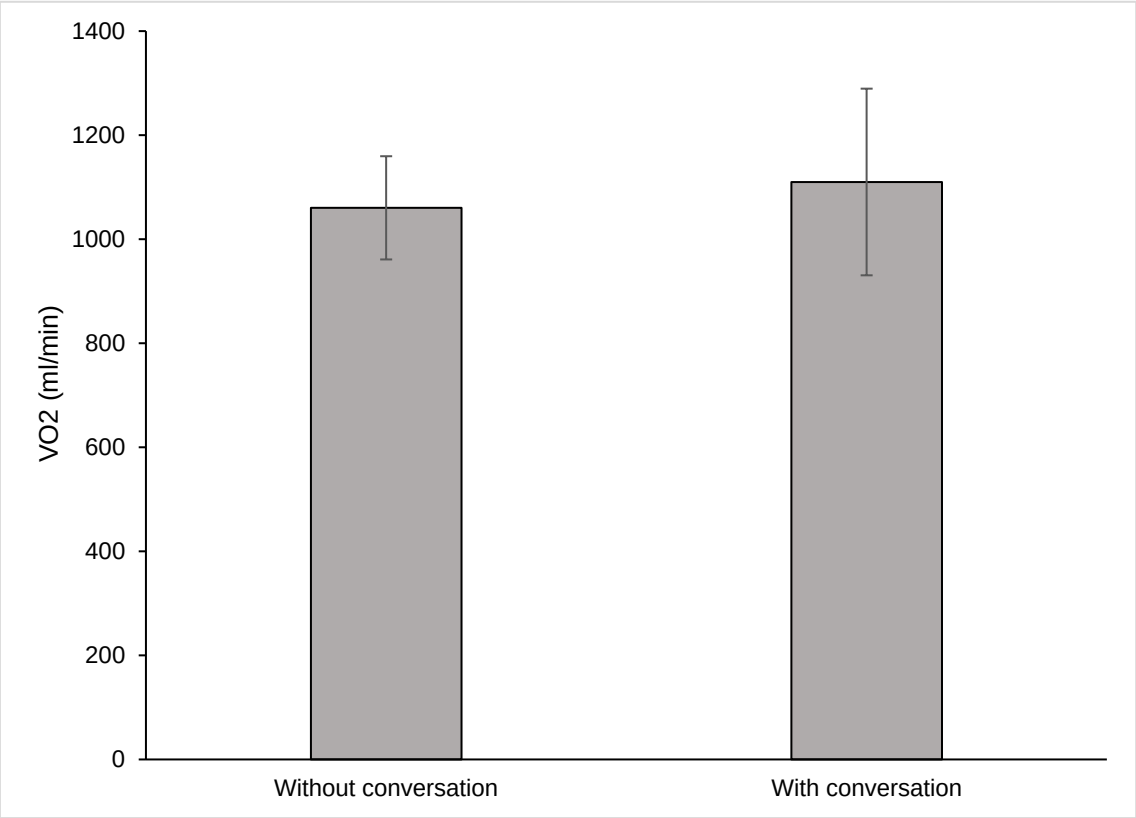

Fig. 3 Mean VO2 between with and without conversation during exercise.

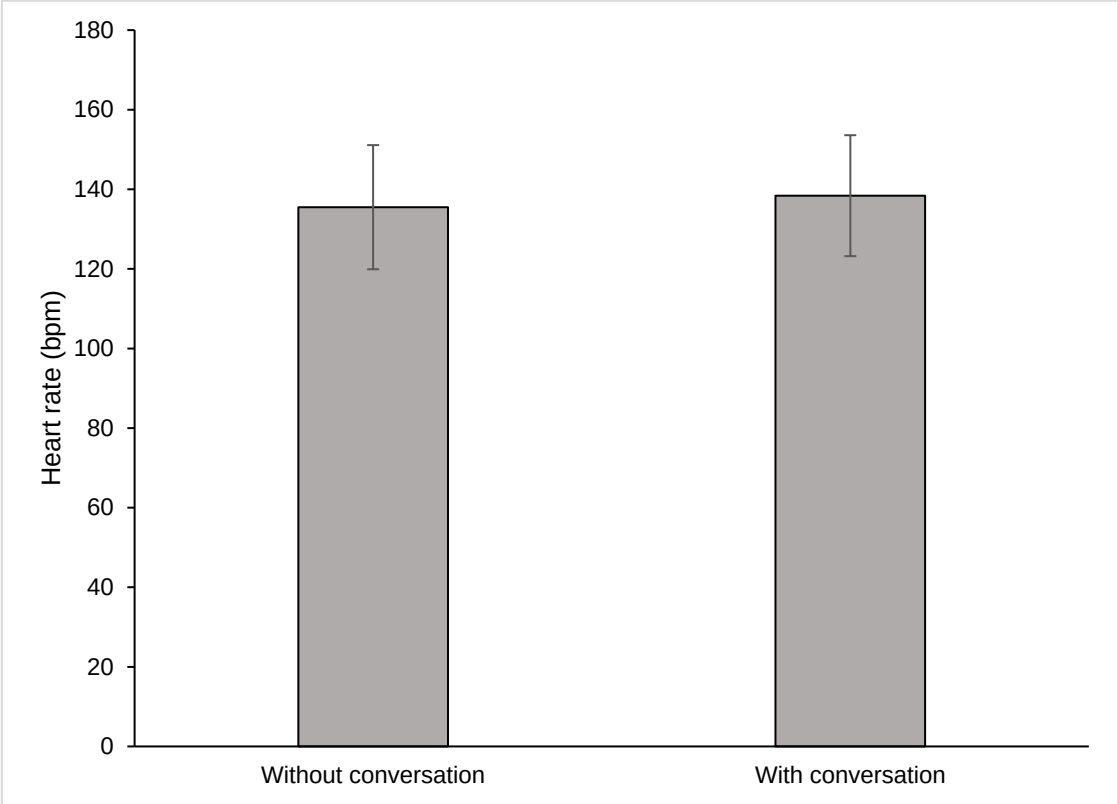

Fig. 4 Mean HR between with and without conversation during exercise.

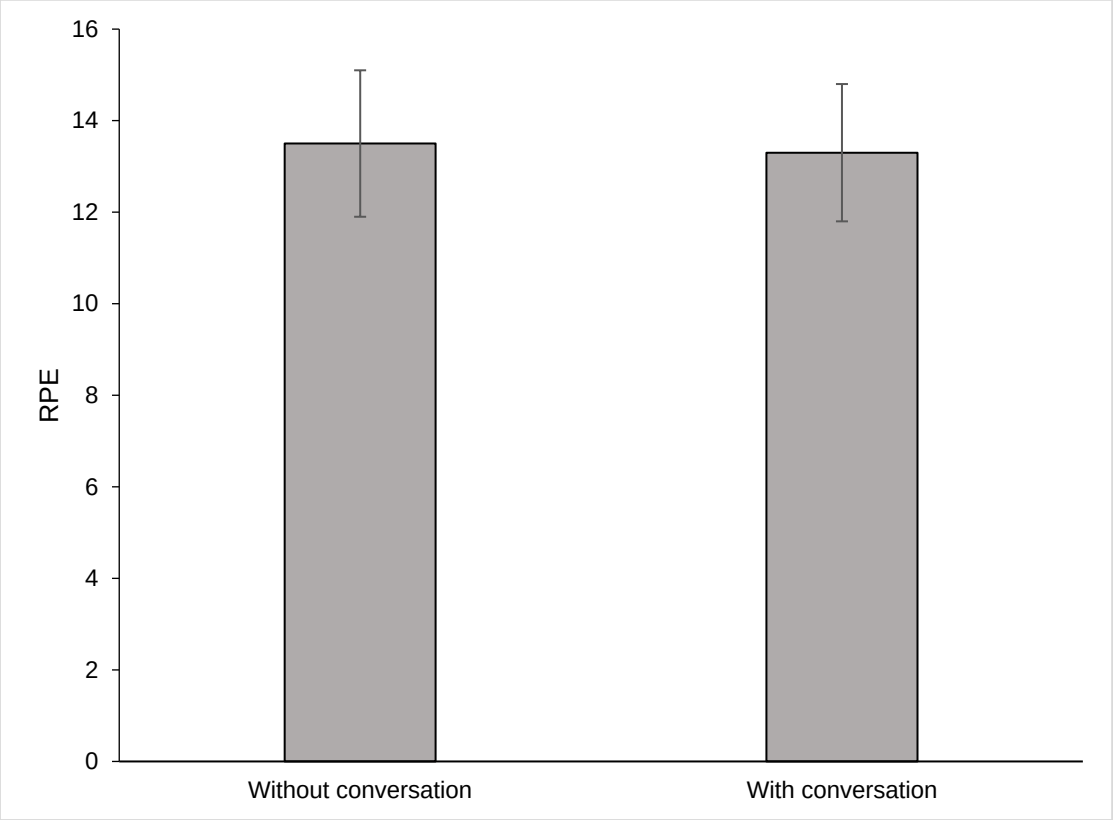

Fig. 5 Mean RPE between with and without conversation during exercise.

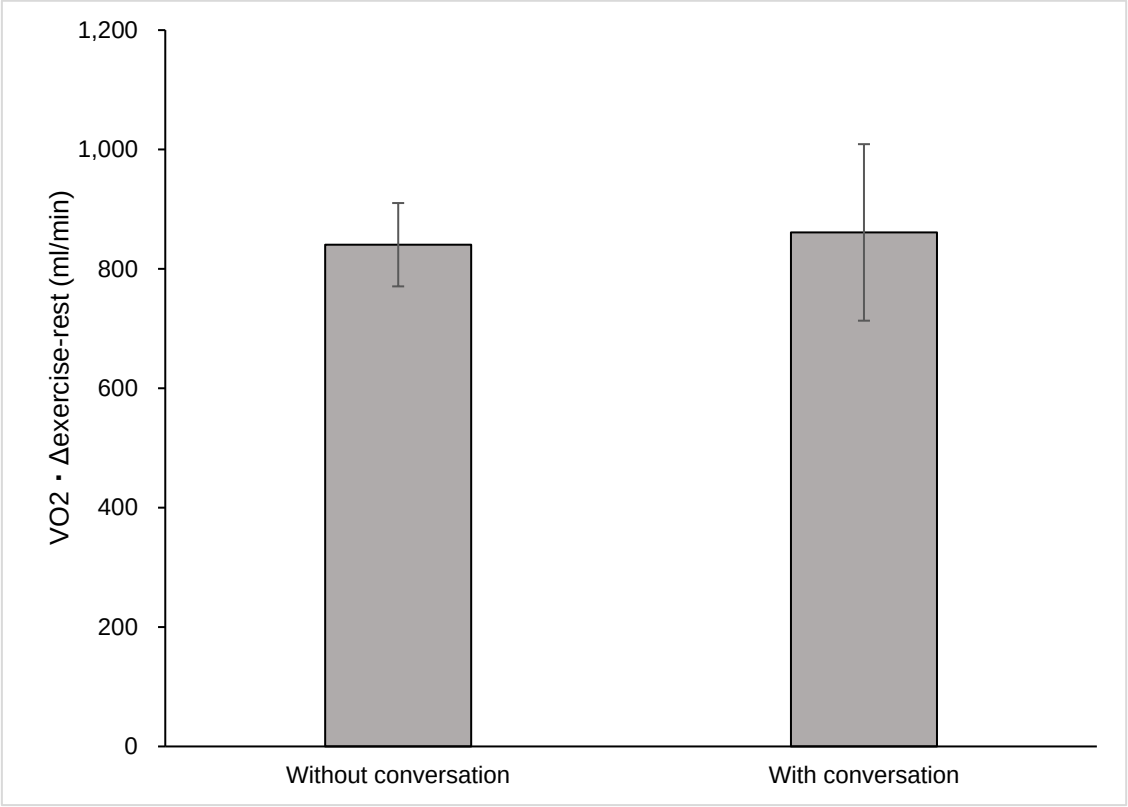

Fig. 6 Mean data obtained by subtracting VO2 at rest from during exercise for the exercises with and without conversation.

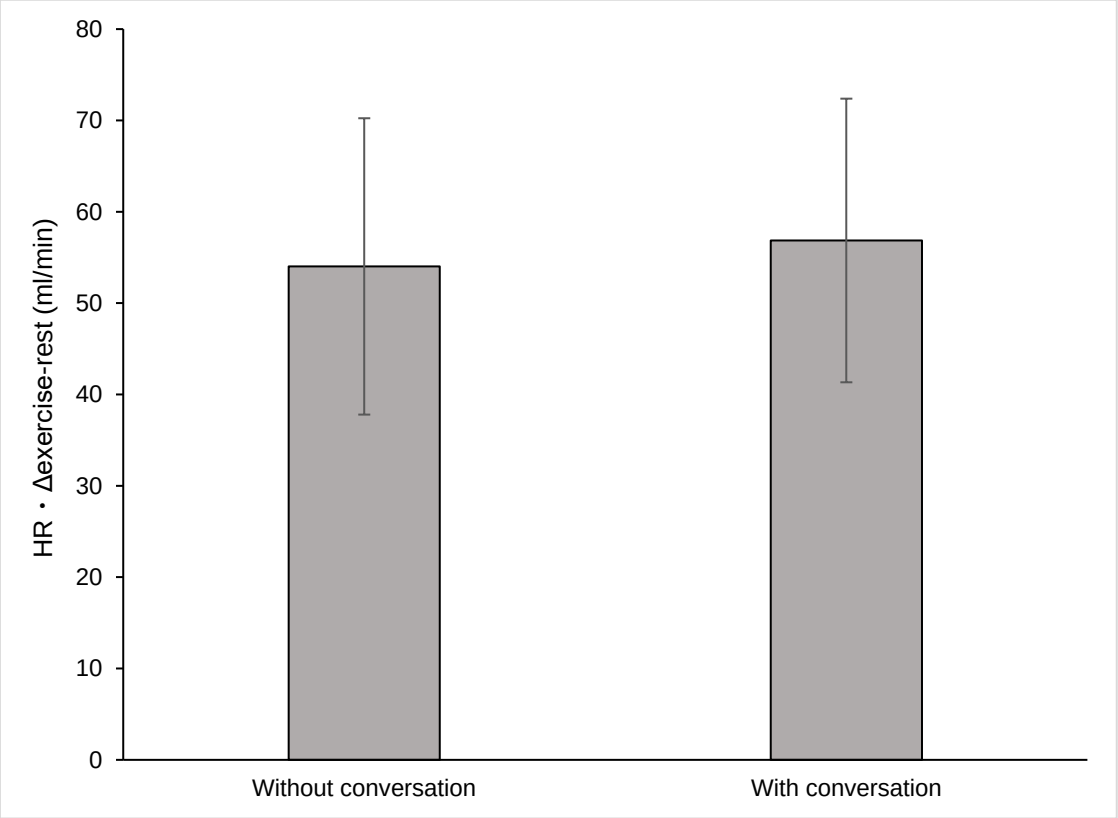

Fig. 7 Mean data obtained by subtracting HR during rest from during exercise for the exercises with and without conversation.

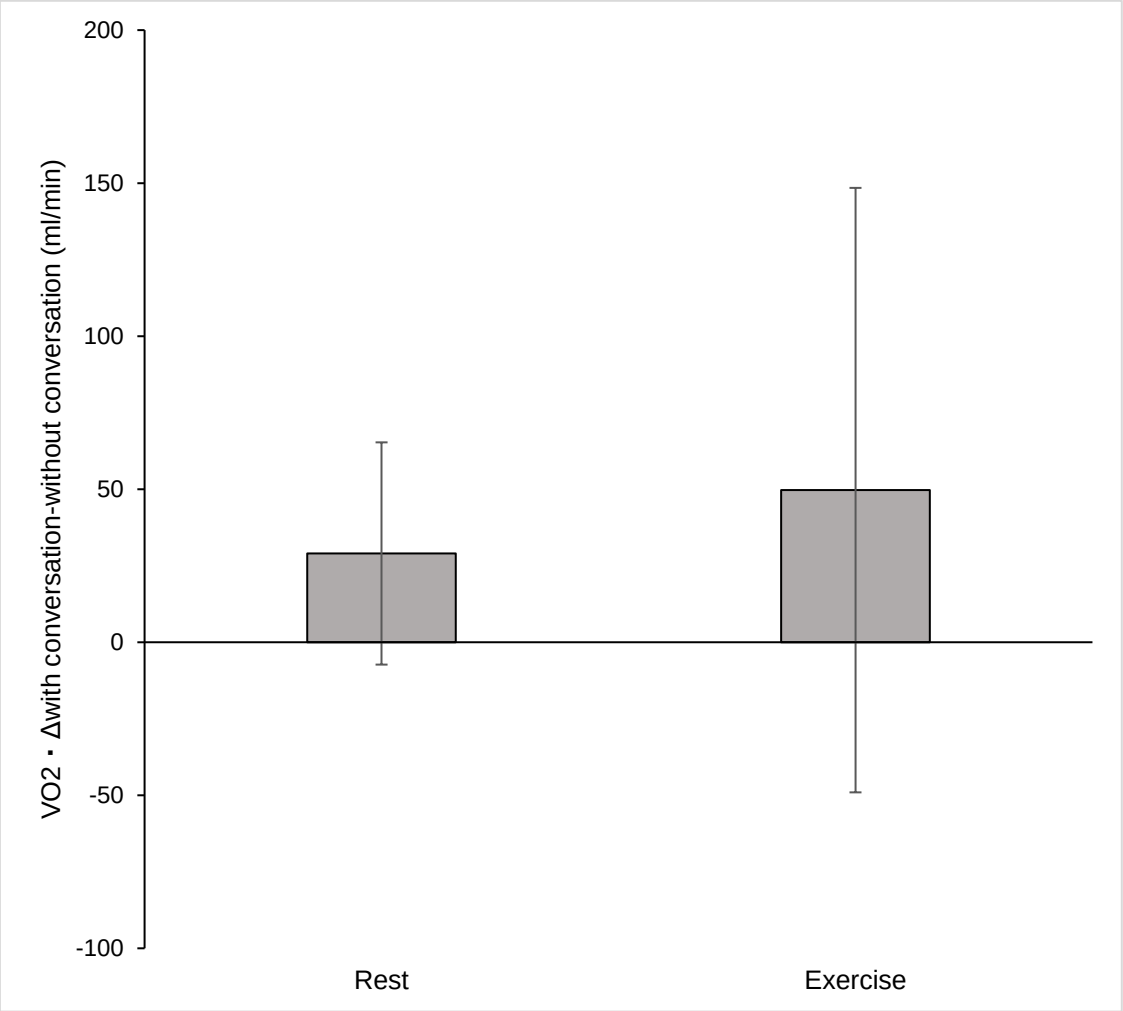

Fig. 8 Mean data obtained by subtracting VO2 without conversation from with conversation during rest and exercise.

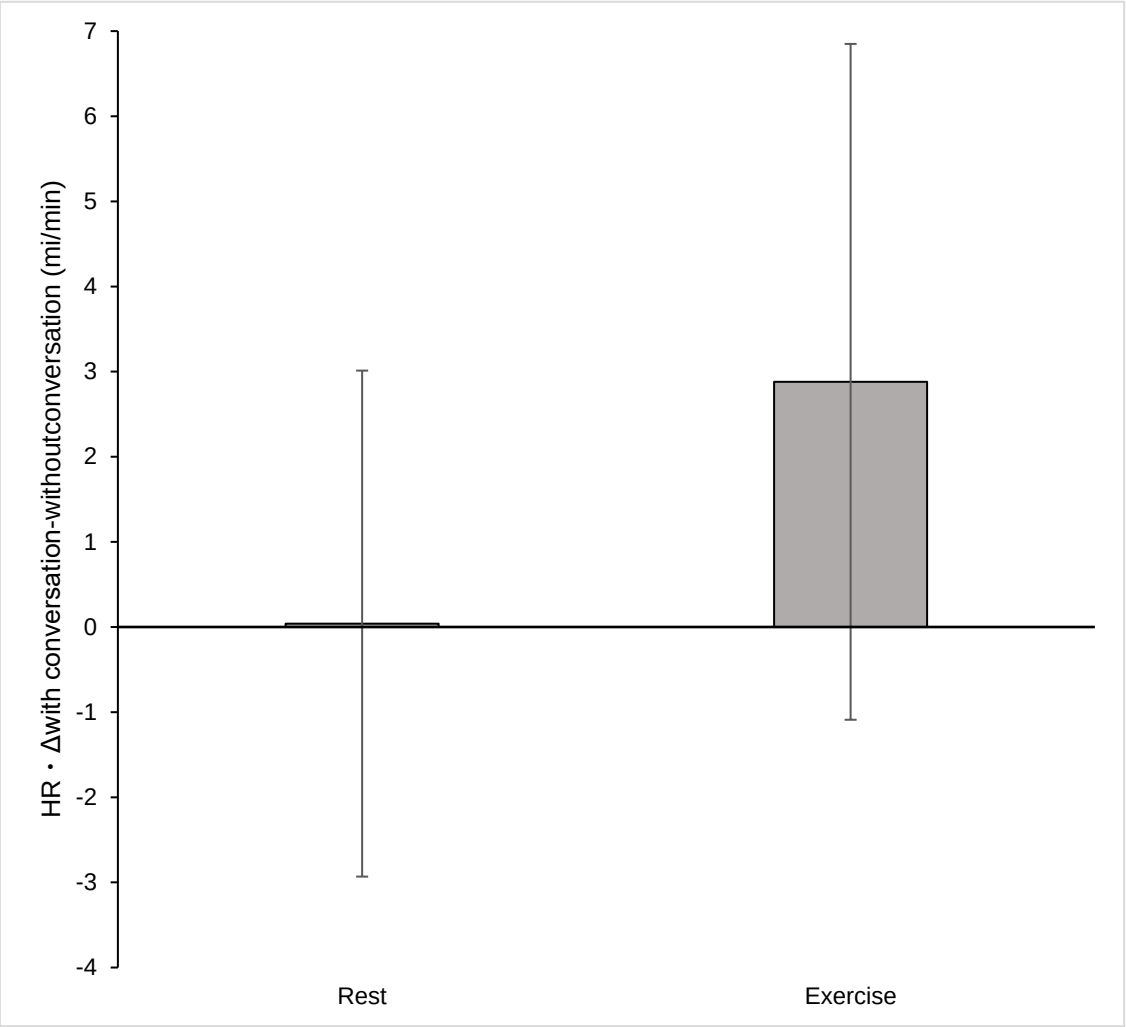

Fig. 9 Mean data obtained by subtracting HR without conversation from with conversation during rest and exercise.

2, 3, 4, 5). The subjects felt that the time was significantly shorter with conversation than without conversation ($p < 0.05$). These results support the hypothesis. Previous studies showed a significant increase in VO2 and no significant difference in RPE and HR (Monedero et al., 2015).

Although there were significant differences in VO2 changes due to resting conversation, there was no significant difference in VO2 changes due to exercise conversation (Fig.1, 2). Therefore, although the change in VO2 due to conversation at rest is large, I supposed that the effect of conversation on VO2 might be small in an environment where VO2 increases to some extent, such as during exercise. Therefore, we compared the values obtained by subtracting VO2 at rest from VO2 during the exercises with and without conversation using delta analysis. I assumed that VO2 would increase more without conversation than with conversation. However, there was no significant difference between VO2・Δexercise-rest without conversation and VO2・Δexercise-rest with conversation ($P > 0.05$) (Fig. 6). In order to confirm inter-individual differences in the subtracted VO2 between exercise and rest, the coefficient of variation (CV) was calculated. CV of VO2・Δexercise-rest without conversation was 8.3 and CV with conversation was 17.2. Meaning that VO2 during conversation varies greatly among individuals (Fig. 10). In other words, some people had VO2 up during conversation. Using delta analysis, we compared the values obtained by subtracting VO2 without conversation from VO2 with conversation during exercise and during resting. There was no significant difference between them ($p > 0.05$) (Fig. 8). As same as

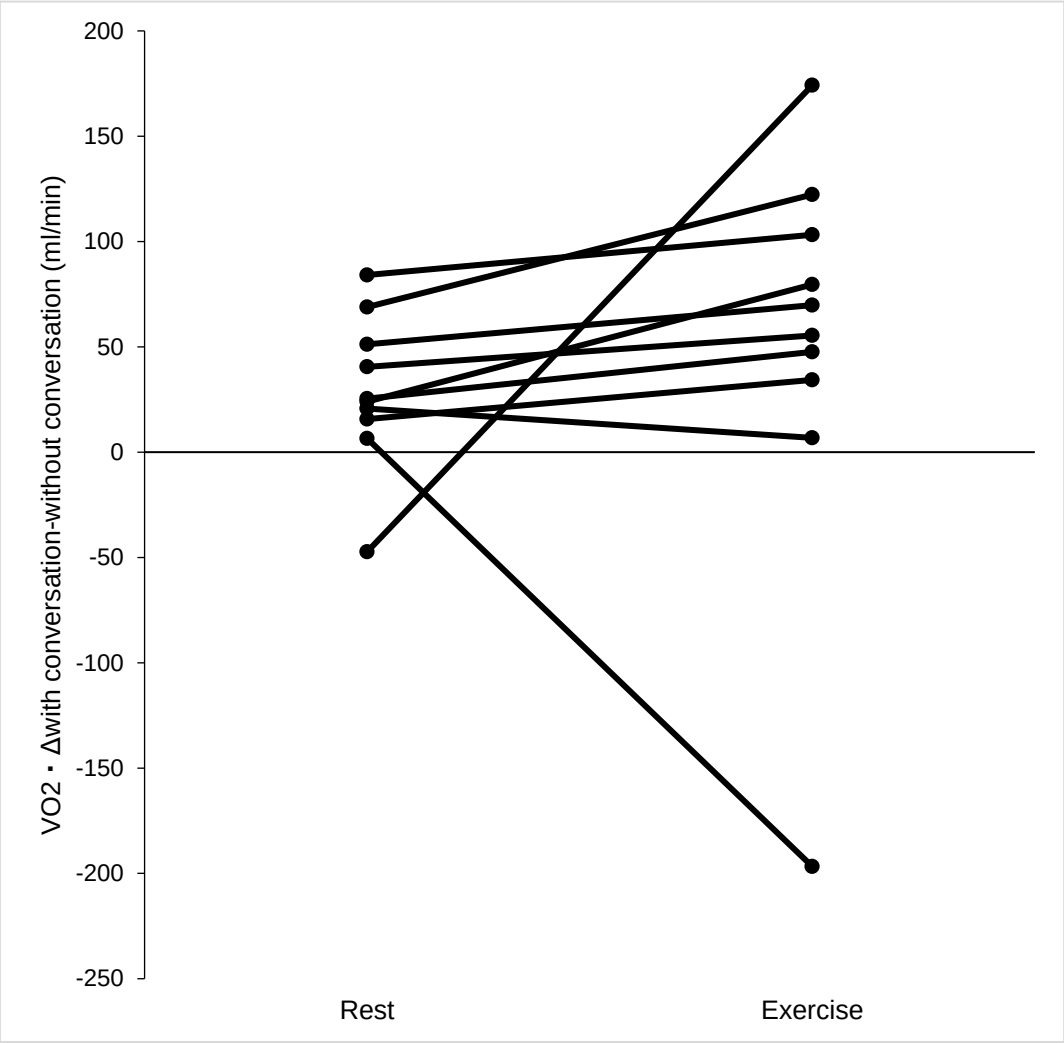

Fig. 10 Individual data during rest and exercise when VO2 with conversation minus VO2 without conversation.

CV of VO2・Δexercise-rest, CV of VO2・Δwith conversation-without conversation was also calculated, CV of VO2・Δwith conversation-without conversation during rest was 125.3 and CV during exercise was 198.9. In other words, since the CV was larger during exercise than at rest, it was found that VO2 during exercise varies greatly among individuals (Fig. 11). I suppose that the reason why there are individual differences in VO2 changes is that there are various breathing methods and the effects of each breathing method are different. For example, according to Jeniffery et al.(2017), pranayama of yoga breathing methods has the effect of lowering blood pressure (Brandani et al., 2017). Also, according to Burtch et al. (2017), Controlled frequency breathing (CFB) is a common form of swimming training that reduces inspiratory muscle fatigue (Burtch et al., 2017). In this way, because there are various breathing methods, it is considered that the way of breathing differs depending on the individual, and the change in VO2 may also differ among individuals.

Significant difference was not found between the change in HR due to conversation at rest and the change in HR due to conversation during exercise ($p > 0.05$). Therefore, using delta analysis, we compared the values obtained by subtracting HR at rest from HR during the exercises with and without conversation. Since HR increases as exercise intensity increases, I thought that HR would be higher with conversation (Raven et al., 2013). However, significant difference was not seen in HR ($p > 0.05$) (Fig. 7). The changes in HR varied greatly among individuals (Fig. 12). Using delta analysis, we also compared the values obtained by subtracting the HR during silence from the HR during

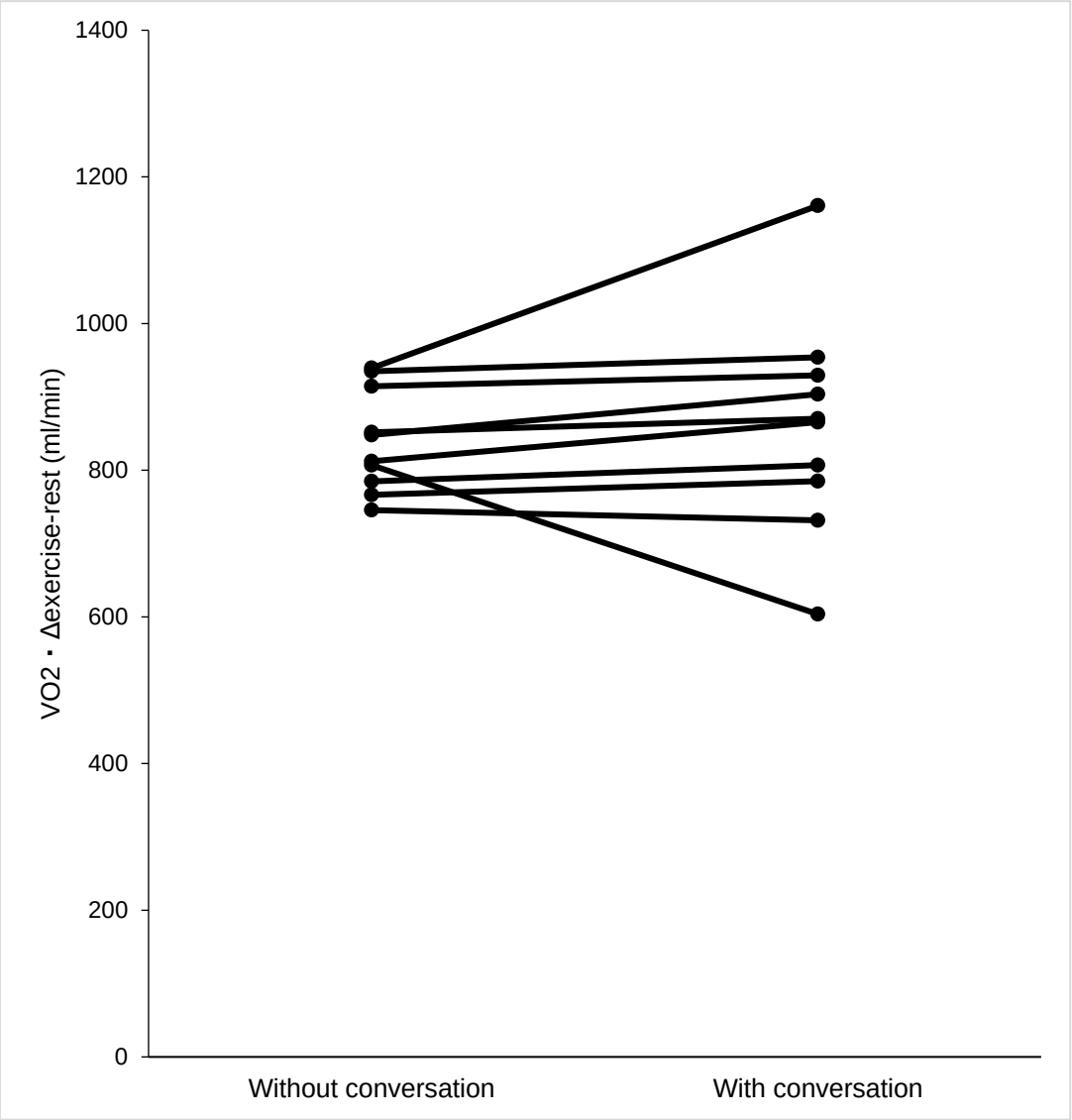

Fig. 11 Individual data without and with conversation when VO2 during exercise minus VO2 at rest.

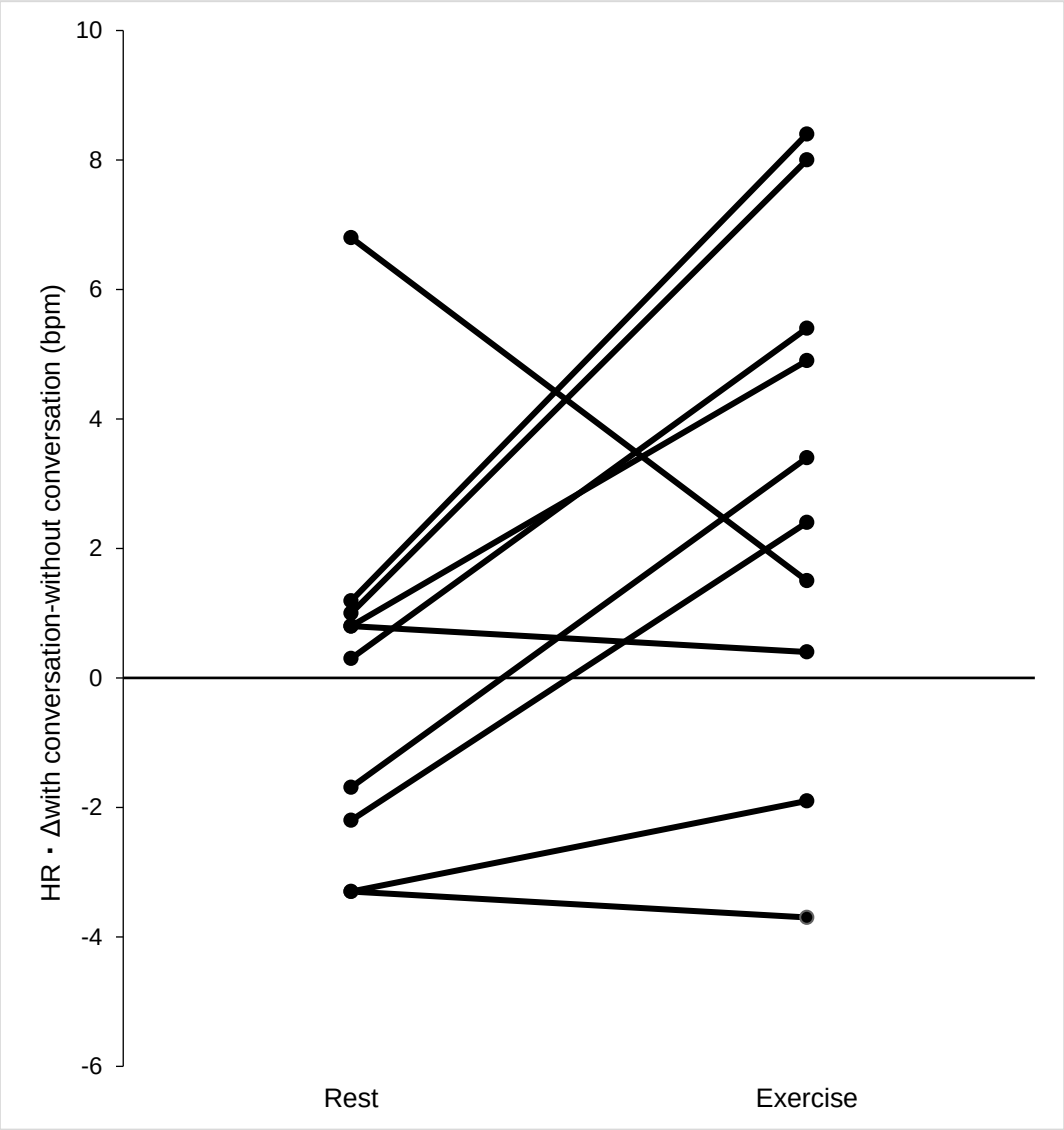

Fig. 12 Individual data during rest and exercise when HR with conversation minus HR without conversation.

conversation during rest and exercise. There was no significant difference ($p > 0.05$) (Fig. 9). The change in HR varied greatly among individuals (Fig. 13).

According to Raven et al. (2013), VO2 and HR are proportional to RPE and both of them should had increased (Raven et al., 2013). Similar to our experimental results, Monedero et al. (2015) found no significant difference in HR and RPE, despite a significant increase in VO2 (Monedero et al., 2015, Haddock et al., 2009). I think the reason why the reactions of VO2 and HR are different is that HR has a mental effect. Decreased heart rate variability (HRV) is caused by increased sympathetic nervous system activity (Wentzel et al., 2020). In other words, HR increases when the sympathetic nervous system becomes dominant (Wentzel et al., 2020). It is possible that relaxing when talking with a person and making the parasympathetic nerves significant suppresses the increase in HR (Gaffney et al., 2019, Song et al., 2019).

According to Raven et al. (2013), VO2 is proportional to exercise intensity, so an increase in VO2 means an increase in exercise intensity (Raven et al., 2013). Originally, RPE increase as exercise intensity increased, but no significant difference was found in RPE in this experiment (Fig. 5). This result supports the hypothesis that RPE decreases by exercising while talking with people. These results are based on previous studies in which VR is effective in distracting by directly and indirectly acting on pain perception and signals through sensations such as attention, emotion, concentration, and memory (Arane et al., 2017). Also, according to Takaishi et al. (1998), Pedaling skills that reduce muscle stress contribute to fatigue resistance despite increased VO2. That is, exercise

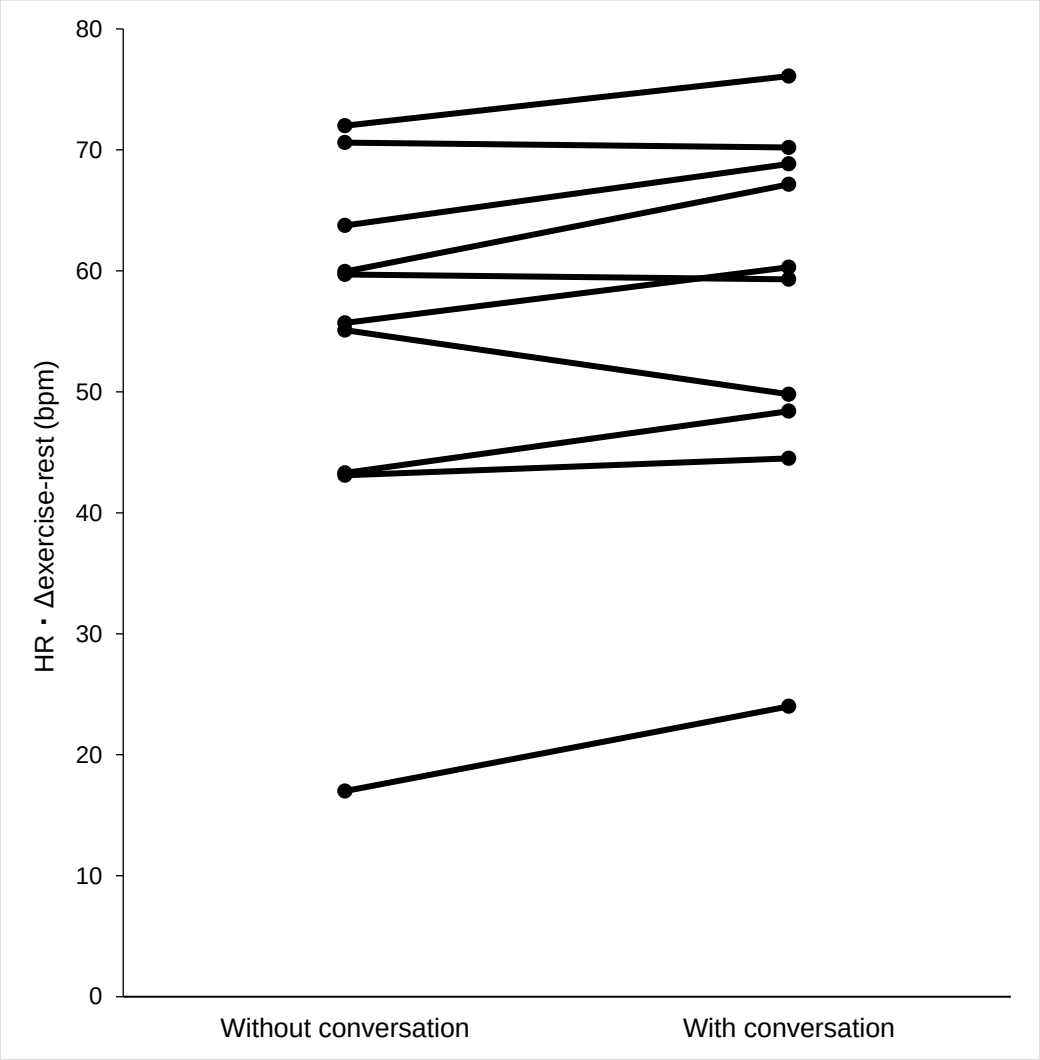

Fig. 13 Individual data without and with conversation when HR during exercise minus HR at rest.

intensity and RPE may not be matched (Takaishi et al., 1998). Also, according to Ekblom et al., RPE is associated with tension (Ekblom et al., 1971). These suggest that relaxing when talking with a person and increasing parasympathetic nerves may have suppressed the rise in RPE.

According to the post-experiment question, it can be said that the participants were distracted by the conversation because they felt that the time was significantly shorter with conversation than without conversation. This result supports the hypothesis that exercising while talking with people feels shorter than the actual exercise time. According to Wittmann, the perceived time represents a person's state of mind (Wittmann, 2009). Psychological research has shown that cognitive functions such as attention, working memory as well as long-term memory determines our temporal judgements (Brown, 1997, Zakay et al, 2004). Time judgements are inherently emotional. In unpleasant situations, such as when nervously waiting for something to happen, we experience a slower passage of time and overestimate its duration. By contrast, if we are entertained and focus on rewarding activities, time seems to pass more quickly and duration is more likely to be underestimated（Wittmann, 2009).

In conclusion, this study confirmed that conversation during exercise induces feeling of shorter exercise time while RPE and physical responses were not influenced by conversation. I suppose that it will be possible to continue exercising at medium intensity. This suggests that exercising with people has a positive effect on the health of the elderly.

Acknowledgement

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日本の外国人労働者政策の展望―共生を目指して―

所属演習：国際社会系

学籍番号：ｓ１１７００９

石井 志那

目次

1　はじめに

外国人問題は日本の社会問題の中で早急に解決すべき問題の一つである。その中でも外国人労働者問題は人権侵害や労働基準法違反の巣窟となり、「特定技能」が追加され門戸がより広がってからはメディアでも頻繁に取り上げられ、その内情について度々批判されてきた。しかし、そのような状態であっても外国人の流入は年々増加している。本研究では、日本の外国人政策に焦点を当てて振り返りながら、他国の外国人政策にも触れ、違いや見直すべき部分を模索していく。その上で、現在のように外国人労働者を受け入れる日本社会に足りないものを指摘し、外国人労働者問題の解決のみならず将来的な外国人との共生を視野に入れた方法を提案する。

2　日本の外国人労働者政策の歴史

現在に至るまで日本は外国人労働者に対し様々な政策を施してきた。その最たるものが現在メディアでも頻繁に目にするようになった「技能実習制度」や「特定技能制度」であるが、当然外国人労働者政策はこれだけではない。この章では過去に実施されてきた政策を外国人の入国状況やその背景と絡めて分析していく。

正式に外国人労働者の受け入れに着手したのは 1980 年代のバブル景気からである。しかし、外国人という存在は戦前より日本国内に存在する。1920、30 年代では総人口に占める割合では 1%に満たず特筆すべき点はないが、国籍別でみると 1940 年にかけて韓国・朝鮮の人口が大きく増加しているのがわかる（表 1, 表 2）[1]。これには日本と韓国の歴史的背景が関係している。1920 年代、日本国内では好景気が終わり、失業率が上昇しつつあった。しかし朝鮮でも人々の生活は苦しく、職を求め日本へと脱出する人々が続出した。日本国内の企業が低賃金で雇うことができる朝鮮人を欲していたというのも朝鮮人が日本へと移動する後押しとなった（外村，2007）。1930 年代では、韓国・朝鮮人の数は 10 倍以上に膨れ上がっている。

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[1] 総務省統計局（2010）『平成 22 年国勢調査報告書「日本の人口・世帯」』
https://www.stat.go.jp/data/kokusei/2010/final/pdf/01-16.pdf（2021 年 12 月 10 日取得）

表 1

表 16－１　総人口，男女別外国人人口，外国人の人口性比及び外国人人口の割合の推移

－全国（大正９年～平成 22 年）

年次	総人口（千人）	外国人人口（千人） 総数	男	女	外国人の人口性比	総人口に占める外国人人口の割合（%）
大正 9年 (1920)	55,963	78	63	15	425.1	0.1
昭和 5年 (1930)	64,450	478	341	137	249.2	0.7
15年 (1940)	73,114	1,304	788	516	152.6	1.8
25年 (1950)	84,115	529	299	230	129.6	0.6
30年 (1955)	90,077	598	328	270	121.7	0.7
35年 (1960)	94,302	579	312	266	117.4	0.6
40年 (1965)	99,209	596	317	279	113.7	0.6
45年 (1970)	104,665	604	319	285	112.1	0.6
50年 (1975)	1) 111,940	642	335	307	109.2	0.6
55年 (1980)	1) 117,060	669	344	325	105.8	0.6
60年 (1985)	1) 121,049	720	364	356	102.3	0.6
平成 2年 (1990)	1) 123,611	886	445	441	101.0	0.7
7年 (1995)	1) 125,570	1,140	567	574	98.8	0.9
12年 (2000)	1) 126,926	1,311	621	689	90.1	1.0
17年 (2005)	1) 127,768	1,556	727	829	87.7	1.2
22年 (2010)	1) 128,057	1,648	742	906	82.0	1.3

1）日本人・外国人の別「不詳」を含む。

表 2

表 16－２　国籍別外国人人口及び割合の推移－全国（大正９年～平成 22 年）

年次	総数	韓国，朝鮮	中国	アメリカ	その他 総数	ブラジル	フィリピン	ペルー	その他
実数（人）									
大正 9年 (1920)	78,061	40,755	24,130	3,966	9,210	－	－	－	－
昭和 5年 (1930)	477,980	419,009	44,051	3,640	11,280	－	－	－	－
15年 (1940)	1,304,286	1,241,315	45,825	4,755	12,391	－	－	－	－
25年 (1950)	528,923	464,306	39,965	4,995	19,657	－	－	－	－
30年 (1955) 1)	4) 597,438	539,635	40,500	7,858	9,443	－	－	－	－
35年 (1960)	578,519	1) 516,211	40,505	10,688	4)5) 11,115	－	－	－	－
40年 (1965) 2)	593,030	1) 520,465	43,945	13,550	5) 15,075	－	－	－	－
45年 (1970)	604,253	519,997	44,765	17,548	21,943	－	－	－	－
50年 (1975)	641,931	558,833	39,521	18,755	24,822	－	－	－	－
55年 (1980)	4) 668,675	557,672	43,748	18,590	29,521	－	－	－	－
60年 (1985)	4) 720,093	571,234	60,549	25,170	49,084	－	－	－	－
平成 2年 (1990) 3)	886,397	567,598	109,229	33,317	176,253	42,273	36,079	6,181	4) 91,720
7年 (1995) 3)	1,140,326	560,414	175,640	38,954	365,318	133,609	68,496	27,112	4) 136,101
12年 (2000) 3)	1,310,545	529,408	253,096	38,804	489,237	188,355	93,662	33,608	4) 173,612
17年 (2005) 3)	1,555,505	472,711	353,437	38,581	690,776	215,487	126,486	40,444	4) 308,359
22年 (2010)	1,648,037	423,273	460,459	38,327	725,978	153,166	145,950	36,776	4) 390,086
割合（%）									
大正 9年 (1920)	100.0	52.2	30.9	5.1	11.8	－	－	－	－
昭和 5年 (1930)	100.0	87.7	9.2	0.8	2.4	－	－	－	－
15年 (1940)	100.0	95.2	3.5	0.4	1.0	－	－	－	－
25年 (1950)	100.0	87.8	7.6	0.9	3.7	－	－	－	－
30年 (1955) 1)	4) 100.0	90.3	6.8	1.3	1.6	－	－	－	－
35年 (1960)	100.0	1) 89.2	7.0	1.8	4)5) 1.9	－	－	－	－
40年 (1965) 2)	100.0	1) 87.8	7.4	2.3	5) 2.5	－	－	－	－
45年 (1970)	100.0	86.1	7.4	2.9	3.6	－	－	－	－
50年 (1975)	100.0	87.1	6.2	2.9	3.9	－	－	－	－
55年 (1980)	4) 100.0	83.4	6.5	2.8	4.4	－	－	－	－
60年 (1985)	4) 100.0	79.3	8.4	3.5	6.8	－	－	－	－
平成 2年 (1990)	100.0	64.0	12.3	3.8	19.9	4.8	4.1	0.7	4) 10.3
7年 (1995)	4) 100.0	49.1	15.4	3.4	31.4	11.7	6.0	2.4	11.3
12年 (2000) 3)	100.0	40.4	19.3	3.0	37.3	14.4	7.1	2.6	4) 13.2
17年 (2005) 3)	100.0	30.4	22.7	2.5	44.4	13.9	8.1	2.6	4) 19.8
22年 (2010)	100.0	25.7	27.9	2.3	44.1	9.3	8.9	2.2	4) 23.7

1）沖縄県を除く。 2）20%抽出集計結果による。 3）外国人に関する特別集計結果による。
4）無国籍及び国籍「不詳」を含む。 5）沖縄県に住む韓国人，朝鮮人を含む。

〔前略〕雇用機会は増加し労働者の実質賃金も上昇していた。だが、朝鮮農村経済に著しい改善は見られず、朝鮮内の労働者の賃金は日本内地と比べて低かったから、日本内地での就労を望む朝鮮人は減少していなかったのである。そのため、「密航」は増加の傾向を示し、「密航詐欺」などの犯罪の多発が社会問題となっていた。（外村, 2007. 5, p. 95）

つまり、1930 年代の韓国・朝鮮人の日本国内での人口増加は朝鮮国内の情勢悪化と日本の景気回復に原因があった。次に、1940 年代であるが、これは日中戦争、並びに第二次世界大戦により起こった労働市場のひっ迫によるものである。戦時中の物資の増産と兵力の動員を同時に行う必要があり、日本国内の朝鮮人の需要が急激に高まった。朝鮮国内の労働市場とのバランスを取るために朝鮮人の斡旋は、企画院と朝鮮総督府の主導のもとに行われた。徴兵により不足した労働市場の補充を主に目的としていたそれは、しだいに軍事労務にもかかわるようになり、最終的に徴用目的での受け入れとなっていった（木村, 2005)。これが 1940 年代における韓国・朝鮮人増加の理由である。

第二次世界大戦後、外国人の出入国に関しては連合国軍最高司令官の管理下に置かれた。そのため日本の出入国管理制度は米国の手法が色濃く残している。終戦後、多くの外国人が帰国した。結果、戦時中の 1940 年代と比べると国内の外国人数は半分以下になった。しかし、祖国の情勢が不安定であることや、生活基盤が整っていないなどの理由により日本に残留せざるを得なかった人々も少なくなく、また、長期に渡る滞在により日本に定着した人々もいた。そういった旧日本植民地出身の韓国・朝鮮人らをオールドカマーと呼び、在日外国人の多数を占めていた。当時、外国人政策といっても戦後間もない日本においてその対象は専ら中国人、朝鮮人や韓国人であった。GHQ は在日朝鮮人に対して日本の司法に従うようにとし、日本政府は 1947 年に「外国人登録令」を公布・施行した。この法令は当時日本国民として扱われていた在日韓国人、朝鮮人を外国人とみなすものであった。また、戦後初の外国人管理法であり、現在の入管法の原点となった。そして 1950 年、外務省に入国管理庁が設置された。

戦後から GHQ の管理下で政治を進めてきた日本であったが、転換期となったのが 1951 年に締結されたサンフランシスコ講和条約である。それにより翌年日本は、主権国家としての地位を回復することに成功した。ここから日本は日本国民と外国人の枠組みを再編し、国民

の範囲を再定義する方向に進んでいく。同年、法務府民事局長からの通達により在日韓国人、朝鮮人の日本国籍の喪失が決定し、外国人として出入国管理令の対象となった。

1972 年 9 月、日中共同声明を発表し中国との国交が回復した。これに伴い台湾出身者や中国大陸出身者の日本への帰化が増加した。これを機に、韓国人、朝鮮人を対象にした外国人政策の範囲が広がることとなった。

ここで、外国人労働者の焦点を当ててみる。高度経済成長期では何度か外国人労働者受け入れが検討されたものの国内の就業率を上げることを理由に外国人労働者の受け入れは実現することはなかった。しかし、「1960 年代後半、経済の国際化に伴い海外進出した日本企業は、現地法人や関連企業の外国人社員を受け入れて技術研修を行うようになりました」（宮島;鈴木, 2019, p.12）とあるように、国際貢献を名目にあくまで「研修生」として外国人を受け入れ始めていた。1985 年のプラザ合意を皮切りに迎えたバブル経済の好景気により人手不足が深刻化し、正式に外国人労働者受け入れに踏み切りだすこととなる。これに伴い、在日外国人の人口も急増し，国籍の多様化も進んだ。1990 年代では韓国・朝鮮、中国、アメリカに加え、ブラジル、フィリピン、ペルーの国内人口が増加した（表 2)。当時のブラジルは軍事政権から民主化されたばかりで経済基盤が弱く、加えて日本は現在と違い、日系移民を多く受け入れていたため、ブラジル人にとって出稼ぎにぴったりの国であった（独立行政法人労働政策研究・研修機構,2020)。

日本政府は人手不足を解消するために出入国管理及び難民認定法（以下、「入管法」）を頻繁に改正し、受け入れ範囲を拡大してきた。1960 年後半より始まった研修生制度は、1989 年に入管法改正に伴い新たに在留資格「研修」が創設され、多くの研修生を呼び込んだ。しかしその実態は権利侵害の巣窟であった。研修生が労働者ではなく、あくまで学ぶ者という立場であったことが原因の一端を担っていた。労働者でない研修生らは労働法の適用条件から除外されていたため、法で守られることなく低賃金、長時間労働、残業代未払いなどの劣悪な環境に置かれていた。1990 年の法改定では日本企業の現地法人や合弁会社などに限られていた研修生の受け入れを中小企業団体まで拡大し、研修生は日本の労働市場を支える存在となった（宮島;鈴木,2019;落合,2010)。

1991 年、財団法人として JITCO が設立され、1993 年には国内での研修を終えた外国人研修生を対象に、発展途上国等の経済発展を担う「人づくり」に協力することを目的とした技能実習制度が導入された。同制度は「JITCO に対する予算措置及び法務省告示により運営することとし、法令に基づく制度となされなかった」（相, 2013, p.71）ものの、これに伴い

在留資格も「研修」から「特定活動」に変更された。1997 年には労働省の「技能実習制度推進事業運営基本方針」の改正により技能実習生の滞在期間は 3 年に延長された。

2000 年に入り、より増加する研修生、技能実習生の存在は日本社会で目立ち始め、メディアでも取り上げられるようになる。ここで賃金未払いや違法な残業、パスポート取り上げなどの研修生、技能実習生の労働環境・条件の劣悪さが世間に露見し、制度見直しの声が上がった（宮島;鈴木, 2019)。この結果、2010 年の法改正では在留資格「技能実習」が創設された。これにより、研修生と技能実習生との差別化がされた。技能実習生は労働者として扱われるため、労働基準法の対象に入り最低賃金や社会保険が適用されるようになった。しかし、研修生、技能実習生への待遇に大きな改善が見られず、2017 年に「外国人の技能実習の適正な実施および技能実習生の保護に関する法律（技能実習法）」が施行された。また 2019 年に、国内人材確保の取り組みを行っても尚、人手不足が深刻な中・小規模事業者に向けて、即戦力となる外国人を受け入れるために新たに在留資格「特定技能」が新設された。非専門的、非技術的な分野の職に属する外国人に与えられる「技能実習」とは違い、特定産業分野に属する専門的知識、技術や経験を有する外国人に与えられるのが「特定技能」である。この特定技能は「特定技能 1 号」と「特定技能 2 号」に分けられる。特定技能 1 号では、在留期間は最長 5 年まで、技能と日本語能力の水準は共に試験等で確認、家族の帯同は基本的に不可、受け入れ機関又は登録支援機関による支援の対象とされている。また特定技能 2 号では、在留期間は最長 3 年、技能水準は試験等で確認するが、日本語能力に関しては試験等で確認は不要、家族の帯同は要件を満たせば配偶者と子に限り可能、受け入れ機関又は登録支援機関による支援は対象外とされている。この在留資格「特定技能」の新設は単純労働者受け入れと取り上げられることもある。しかし依然、政府は単純労働者の受け入れはしないスタンスで、あくまでも専門的知識と技術を持つ労働者とみなしている。特定技能の取得には技能レベルと日本語能力を測る試験に合格することが条件である。日本語レベルに関しては、「ある程度日常会話ができ、生活に支障がない程度の能力を有することを基本としつつ、特定産業分野ごとに業務上必要な日本語能力水準が求められる」（出入国在留管理庁, 2018, p. 2）[2]とされ、「日本語能力試験」で N4 以上、または、「国際交流基金日本語基礎テスト」のどちらかに合格する必要がある。これに加えて各々の技能評価試験にも合格して

[2] 出入国在留管理庁（2018,12）『特定技能の在留資格に係る制度の運用に関する基本方針』https://www.moj.go.jp/isa/content/930003796.pdf （2021 年 12 月 10 日取得）

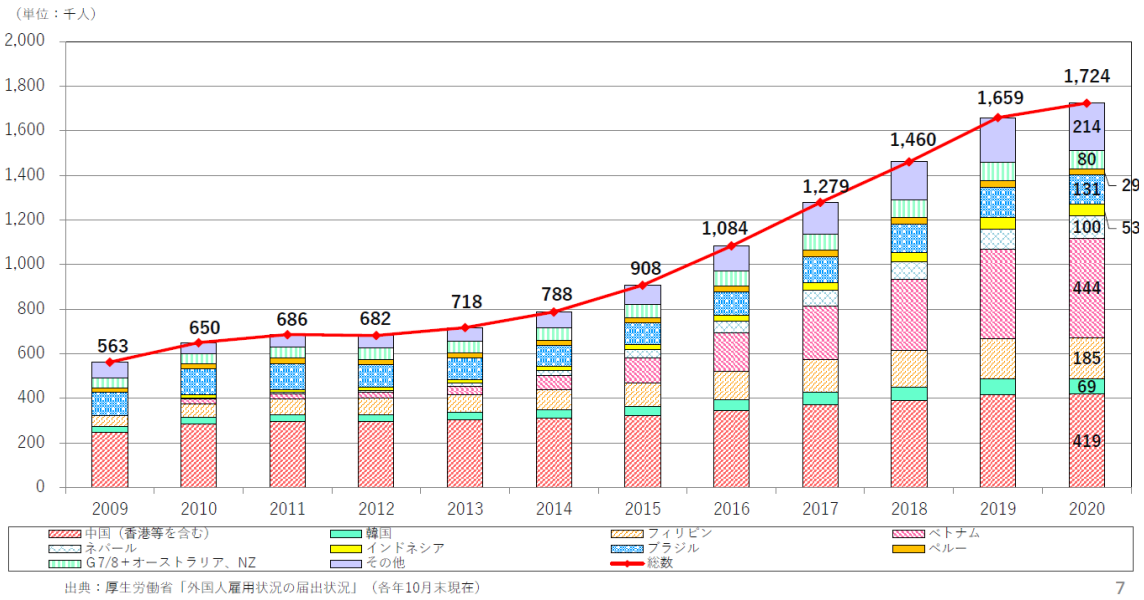
ようやく特定技能取得の要件を満たすのである。ここで着目したいのが、特定技能と技能実習の曖昧性である。実習生は実習実施者により実習内容を十分に達成したと評価をされることで、上で述べた試験なしに特定技能 1 号への変更が可能となる（澤田, 2020）。このように技能実習と特定技能との線引きが不十分なことで、特定技能は技能実習の延長的位置付けとなり技能実習法などの外国人労働者に関する法律が正しく機能しない恐れがある。また、外国人労働者のほとんどの目的が出稼ぎである。そんな彼らがわざわざ試験が必須の特定技能制度を利用するだろうか。答えは当然、否だ。また、なるべく多くの人を最低限の労力で送り出したい斡旋業者としても、試験が必要な特定技能制度よりも技能実習制度の方が手間がかからず利用しやすい。一刻も早く稼ぎたい労働者と、手間をかけず送り出したい斡旋業者にとって技能実習制度は特定技能制度よりも魅力的に映る。特定技能制度は移民政策を否定しつつ、人手が不足している業界への一時的な外国人労働者をし、彼らを雇用の調整弁として扱うことを正当化する要素が強いと言える。さらに、特定技能の創設に伴い、永住条件の改定がなされたことも留意すべき点である。技能実習と特定技能 1 号の最大在留期間はともに 5 年であり、最長で 10 年在留することが可能である。しかし、改定に際して、技能実習と特定技能 1 号の労働期間は永住要件に含まれないとした（宮島；鈴木, 2019）。つまり、外国人労働者から定住の機会を極限まで奪っているのである。

外国人労働者を正しく受け入れる環境にないことは研修生制度時代より明白であるが、日本にやって来る外国人労働者は後を絶たない。これには日本と労働者送り出し国の間の経済格差によるものが大きい。例えば研修生受け入れが中小企業まで拡大した 1990 年の場合、世界銀行によると、日本の一人当たりの所得（GNI）は 27,820 ドルであった。これに対し韓国は 6,450 ドル、ブラジルは 2,730 ドル、ペルーは 840 ドル、フィリピンは 720 ドル、そして中国は 330 ドルであった。10 年ごとに見ていくと 2000 年では日本 36,210 ドル、韓国 11,030 ドル、ブラジル 3,930 ドル、ペルー1,970 ドル、フィリピン 1,150 ドル、中国 940 ドルで、2010 年では日本 43,430 ドル、韓国 22,290 ドル、ブラジル 9,650 ドル、ペルー4,410 ドル、中国 4,340 ドル、フィリピン 2,370 ドルである。加えて 2014 年より増加傾向にあるベトナム人（グラフ 1[3]）であるが 2014 年時点での一人当たりの所得は 1,880 ドルであった。このように送り出し国と受け入れ国の間には所得の面で大きな差があり、この隔たりこそ

[3] 厚生労働省 https://www.mhlw.go.jp/content/12401000/000755657.pdf （2021 年 12 月 15 日取得）

が日本の技能実習制度を利用し一発逆転を狙おうとする人が後を絶たない理由である。

グラフ 1



出典：厚生労働省「外国人雇用状況の届出状況」（各年10月末現在）

3　他国の外国人政策　－ドイツと韓国を例に－

外国人に対する対応で試行錯誤をしているのは日本だけではない。世界中のあらゆる国が移民、労働者の受け入れや逆に送り出す側として各々の最適解を模索している。移民、難民、出稼ぎ労働者など、外国人を取り巻く問題は一筋縄ではいかない。地理、歴史、文化、経済状況、政治に深く複雑に絡み合っており、それらを考慮した対応を求められる。また、国民との共生という部分でも配慮と十分なサポートが必要である。

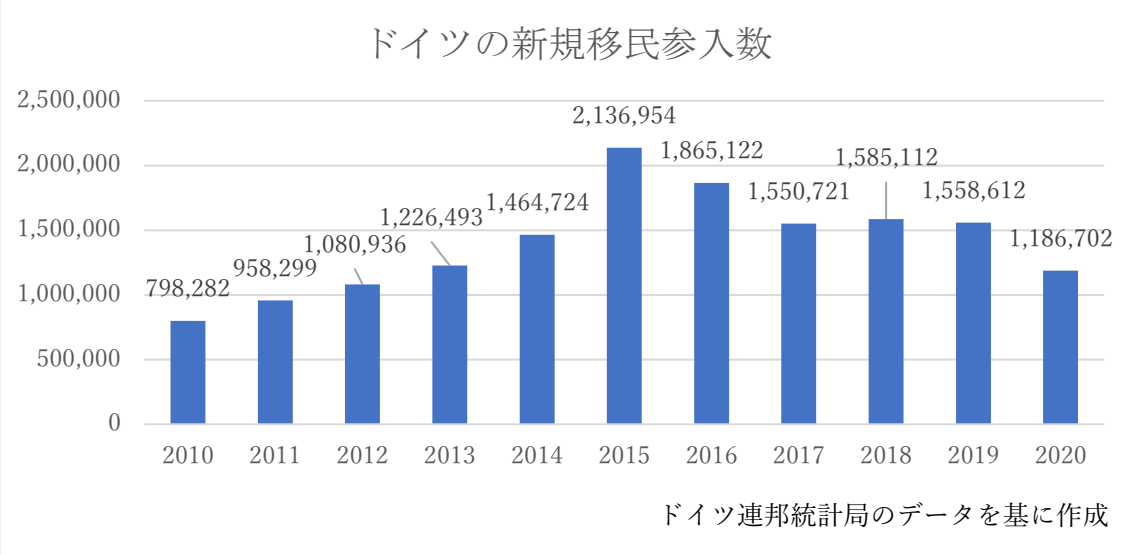
各国それぞれ自国の状況に合わせた対応をしているが、今回はその中で「ドイツ」と「韓国」に焦点を当てる。

3.1　ドイツの外国人政策

ドイツは世界でも有数な移民受け入れ国の一つである。何故そのドイツを選択したのかというと、かつてのドイツも日本と同様に「血統主義」を掲げていたからである。近年のドイツの移民の受け入れ数は世界でもトップレベルであり、ドイツ連邦統計局によると 2015

年には 200 万人を超える移民を受け入れた（グラフ 2）[4]。日本国内の移民の数はおよそ 150 万から 250 万人と推計されている（竹内，2021）ことを考えるとドイツがどれだけ移民を受け入れているのかが理解できる。血統主義であったドイツがどのような経緯で移民を受け入れるようになったのか、西ドイツに注目して論じる。

グラフ 2



ドイツ連邦統計局のデータを基に作成

ドイツが外国人労働者受け入れはじめたのは 1950 年代後半のことであった。当時、経済力を回復しつつあったものの、第二次世界大戦の影響で若者の人口が減っていたことにより労働力が不足する事態に陥っていた。ドイツ政府は外国から労働力を仕入れることを決定し、1955 年に外国人労働者に関する二国間協定をイタリアと結んだことを皮切りにスペイン、トルコ、モロッコ、ポルトガル、ギリシア、チュニジア、ユーゴスラビア、韓国、フィリピンと、1973 年に募集を停止するまで次々に同様の協定を締結していった。1961 年にベルリンの壁が築かれ、東ドイツ経由の労働力が期待できなくなったことも労働力不足に拍車をかける要因となった。1973 年までに 260 万人を超える労働者を受け入れた（㈶自治体国際化協会, 1997）が、外国人労働者がガストアルバイター（客人労働者）と呼ばれていたことからもわかる通り、ドイツ政府はあくまで労働力の補充のための一時的な労働者だと考えていた。1969 年に成立した「就労促進法」でも、外国人がドイツで働くためには労

[4] ドイツ連邦統計局 https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Wanderungen/Tabellen/wanderungen-alle.html;jsessionid=7FD1C38A0EA51473F0AA99DAA6A425F1.live741#fussnote-1-115678 （2021 年 12 月 12 日取得）

働許可の取得が必要であることや、就労期間を制限する内容が織り込まれていた（天瀬,2014)。しかし、就労促進法自体はもとよりドイツ全体に向けて制定されたものであったため、外国人労働者のための法律であるというよりはドイツ人の雇用促進におまけで添えられたような意味合いが強いことがうかがえる。

ガストアルバイターの多くが鉄・金属製造業、鉱業、化学産業など、ドイツ人が避ける傾向にあった職に従事（独立行政法人労働政策研究・研修機構,2014）し、資格やスキルは、自国で元々就いていた職などは考慮されなかった。非熟練、単純労働といった面が、ガストアルバイターを労働の最下層へと位置付ける原因となった。ガストアルバイターはドイツ人と比べて低賃金であったが、平均収入に関して言えばドイツ人と大差はなかった。本来ガストアルバイターは稼ぐことを最大の目的として入国している。そのため、長時間労働や残業、ハイリスクな仕事を嫌うどころか、むしろ進んで行う傾向にあった。ガストアルバイターらは、低賃金をそういった特別手当で補っていた。

ガストアルバイターは受け入れ期間を限定されていたため滞在期間が終了すると帰国しなければならない。企業は定期的に新たなガストアルバイターを雇う必要があり、その都度教育を施さなければならなかった。この非効率な仕組みに難色を示した企業側が政府に訴え、1971 年労働許可法の改正へと至った。ガストアルバイターの労働許可証には「一般労働許可」と「特別労働許可」があり、前者は労働市場の要件により、時間や場所に制限を受けるもので、後者はそういった条件のないものであった。同法の改正ではその期間が延長され、一般では 1 年から 2 年に、特別では 3 年から 5 年に変更された。このような、可能な限り長期的に雇いたい企業とドイツに腰を据えて働きたいと望むガストアルバイターの利害が一致し、その結果、家族の呼び寄せに拍車がかかったことによる外国人の人口増加、ドイツ人との結婚などによる外国人の長期滞在、定着に繋がった。

増加する外国人にストップがかかったのは 1973 年のことであった。オイルショックの影響による経済状況の悪化を理由にドイツ政府は 1973 年 11 月 23 日に外国人労働者の募集を原則停止とした。この募集停止の理由には諸説あり、

> 同年の 1 月にブラント首相（社会民主党：以下 SPD）が「ドイツの受け入れ能力は限界に達した」と言明して」いるように、西ドイツは、オイルショック以前にすでに外国人労働者の流入をせきとめようとする方向に向かっていた。〔中略〕外国人労働者がストライキを指導したケースが目立ったのが 1973 年であったことから、

企業側から政府に圧力がかかった可能性を示唆する見解がある。また、1970 年ごろに生じた外国人雇用に関する世論の盛り上がりを鎮静化するための政府の方策とする場合もある。さらに、外国人労働者の長期在留に対する労組側の不安感（ドイツ人労働者との競合によってドイツ人労働者の賃金水準と労働条件が悪化する）と、政府側の不安（社会不安の増幅）が、政策の転換に繋がったとする見解もある。（杉町, 2000, p. 17）

つまり経済成長が低迷したことによる社会不安が長期滞在化する外国人へと矛先を向けたということである。外国人労働者の募集停止は外国人の流入をある程度コントロールできるという面では成功したと言えるが、看護、介護など一部のではガストアルバイターの受け入れを継続していた上に、当時の EC の協定内では EC 市民であれば加盟国の中では自由に就労可能と決まっていたため、完全に停止とまではいかなかった。グラフ 3[5]で 1973 年以降トルコだけ他国と比べて比較的横ばいになっているのはトルコが EC 加盟国でないこと、逆にギリシア、スペイン、ポルトガルは比較的国の経済状況が安定していたこともあり、帰国しやすい状態であった。

グラフ 3

1980 年代に入ると、外国人の立場はより一層厳しいものとなった。第二次オイルショッ

[5] Klaus F. Zimmermann, Circular migration, 05.2014, https://wol.iza.org/articles/circular-migration/long （2021 年 12 月 13 日取得）

クによる失業率の上昇に加えて、シュミット政権[6]では外国人の立場を安定化する動きがあったために国民の不満が高まっていた。特に外見、文化、宗教面でドイツ人との違いが明白であったトルコ人への風当たりが強かった。トルコはEC加盟国でなく、ドイツ国内に滞在する外国人の大多数を占めていたことも原因の一つである。ドイツ国内では外国人労働者の在り方について様々な意見が飛び交っていた。外国人労働者の雇用に反対する運動が起こされたり、実際に外国人労働者の雇用を規制した市もあったりした一方で、ある程度熟練した技術を持つ外国人の有用性を主張する意見もあった。こういった世論に対し、政府は1981年に「家族呼び寄せの制限措置法」、1982年に「不法就労対策法」を施行、そしてコール政権[7]に交代して間もなく、1983年に外国人政策委員会より「外国人労働者政策に関する報告書」が提出された。これは「外国人の長期的な滞在、特定地域への集住減少、そして家族呼び寄せが将来外国人の増加を招き、結果的に社会的緊張を生み出すであろうと予測」（杉町, 2000, p. 21）する内容であった。そして同年、「外国人帰国支援法」が施行された。同法はその名の通りドイツに滞在する外国人に帰国を奨励する法律であり、永久帰国を条件に、帰国後の職業斡旋、「年金における被用者負担の速やかな返還、職業年金受給権の補償」（厚生労働省, 2010, p. 72）を約束された。しかし、帰国に応じたのはやはりポルトガル、スペイン、ギリシア、イタリア、ユーゴスラビアのような政治的、経済的に安定した国出身の外国人ばかりであった。トルコ人労働者らは長期的滞在や定住を見込み家族を呼び寄せ、ドイツ内のトルコ人の人口はグラフ 4[8]を見てわかるように外国人労働者の募集停止以降も増え続けた。

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[6] シュミット政権：1974年から1982年、自由民主党

[7] コール政権：1982年から1998年

[8] Klaus F. Zimmermann, Circular migration, 05.2014, https://wol.iza.org/articles/circular-migration/long （2021年12月13日取得）

グラフ 4

与党のこのような排斥志向の政策は野党だけでなく与党内からも難色を示される結果となり、政府内でも外国人の対応について対立し始めることとなった。

ここまでドイツ政府は一貫して「ドイツは移民国家ではない」という姿勢を崩さなかった。そんな強固な姿勢が変わり始めたのは 1990 年代に入ってからであった。戦後よりドイツは政治難民を受け入れてきていたが、ベルリンの壁の崩壊後東欧や旧ソ連からも難民がやって来るようになった。1990 年代ドイツ国内の外国人の人口は総人口の 9 %の 700 万人を突破した（佐藤, 2019）。1990 年、初めて帰化に関する内容が明文化された「外国人法」が制定された。要件として原則二重国籍は認められず、経済的自立、ドイツ憲法の民主主義原則への忠誠、また市民権を得るための条件は他国に比べて厳しいものであったが、移民に対する法的な保障が強化された（山田, 2019）。市民権を得るための道は開かれたものの、これは移民をドイツ国民と認めようとする意図は含まれていない。移民に対する世論は賛否両論で、移民の統合には慎重にならざるを得なかった。外国人の中には 10 年以上ドイツで暮らす人や、ドイツで生まれドイツ育ちの外国人も存在したが、ドイツの国籍法は血統主義に基づいていたため、ドイツ人と同様の文化や教育を受けていながら国民の権利は与えられない「二級市民」が多く存在した（佐藤, 2019）。

転換期となったのは 1998 年に成立したシュレーダー政権からである。ここで 1980 年代末より長らく検討されてきた出生地主義が導入されることとなった。しかし、完全に出生地主義に切り替わったというわけではなく、従来の血統主義に基づいた国籍法の中に出生地主義的内容を織り込んだものとなった。

> 親が八年間以上ドイツに滞在し、無期限の滞在資格をもっていれば、その子どもはドイツ国内で出生したことによりドイツ国籍が付与されることになった。また、ドイツ国外で生まれたドイツ国民の子どもは、あえて申請しない限りドイツ国籍を自動的に喪失することになった。これによりドイツ国籍と「血統」とのつながりが弱められ、「出生地」との結びつきが強化されたのである。（佐藤, 2019, p. 196）

重国籍の容認は野党の反対によってこの時点では実現しなかったが出生地主義への第一歩を踏み出したのだった。

この出生地主義の導入は外国人労働者、移民の受け入れに関する新たな議論を展開させるきっかけとなり、2000 年 9 月には「移民に関する独立委員会」が設置されることとなった。2001 年同委員会により提出された最終報告を受けて、ドイツ連邦内務省により「移民法」草案が提出され、2004 年に移民法が成立した（厚生労働省, 2010）。これに伴い外国人法は廃止された。移民法では全国に「統合コース」が設けられ、ドイツ語習得のための講習から、歴史、文化、社会制度を学ぶ講習、ドイツで暮らすために必要な基本的な知識を身に付けるための講習などを受講することができる（佐藤, 2019）。受講料のほとんどを連邦政府が負担し受講者の負担額は一時間につき 1 ユーロのみであり、最終的に修了試験を合格することが帰化の条件であった。外国人の孤立を防ぐ面でも有効であると言える。さらに 2005 年に成立したメルケル政権も統合政策の推進を後押しした。毎年多くの移民、難民を受け入れるドイツでは多様な文化を前に統合政策を完璧に機能させるのは困難を極める。しかし、かつて、「移民国家ではない」と主張していた国が現在では世界でもトップレベルの移民国家と変貌を遂げた歴史には示唆を得ることができる。

3.2　韓国の外国人政策

現代社会で韓国はアジアでも有数の外国人労働者受け入れ国である。しかし、戦後の韓国は労働者を送り出す側であった。

1960～1970 年半ば、西ドイツに炭鉱労働者と看護婦、そしてベトナム戦争への軍隊の派遣を行っており、1970 年代～80 年ごろまで中東、サウジアラビアにも約 7 万人の建設労働者を送り出していた。世界銀行によると、当時の韓国の GNI は 1960 年では 120 ドル、1970 年では 280 ドルであり、1967 年での失業率はおよそ 30％であった（三浦, 2020）。韓国政府

が行った西ドイツ炭鉱労働者募集には、募集人数を大幅に超えた人数の応募があり、高卒以上の条件であったが、大卒者の応募も目立っていた。「第一次として、1966 年まで 7 陣に分けて 2,521 人の韓国人炭鉱労働者が派遣された。さらに、1970 年からは第二次として、47 陣に分けて第一次の倍以上の 5,415 人が派遣された」（三浦,2020,p.8）が、1973 年、西ドイツが外国人労働者の募集停止をしたため派遣は終了した。しかし、西ドイツにおける看護師は依然人手不足であったため募集停止には含まれず、引き続き派遣がされた。

1980 年代後半、韓国国内の外国人労働者が増加した。1984 年に韓国政府が国外の朝鮮族を対象としたビザを新設したこと、また海外旅行自由化に伴い相互ビザ免除協定の締結国が拡大したことで韓国への入国が容易になったのが要因である。これにより、韓国国内の不法滞在者や不法就労者が増加した。当時、製造業を中心とした中小企業で人手不足が発生しており、加えて同時期に国内で起こった労働者大闘争により韓国人の賃金が上昇したことで、安価な外国人労働者の需要が高まっていたことも不法就労者を増加させた原因である。次に「漢江の奇跡」と呼ばれる急速な経済発展と、1988 年に行われたソウルオリンピックの影響で韓国が新たな労働市場として発見されたことも外国人労働者をさらに呼び込むこととなった。「1988 年に 7,410 人にすぎなかった外国人労働者が、次の年の 1989 年には 14,610 人に倍増した」（宣,2002,p.4）ことからもわかるように、韓国は新たな出稼ぎの国となりつつあった。また 1990 年の GNI は韓国が 6,450 ドルに対してタイ 1,490 ドル、フィリピン 720 ドル、中国 330 ドル、ベトナム 130 ドル（世界銀行）であった。不法滞在者が増加したことに対し韓国政府は新設したビザを停止し、中国からの朝鮮族の入国を制限するなどの対応を行った。

1990 年に入ると人手不足が深刻化したことにより、1911 年「産業技術研修生制度」を導入し、海外の現地法人がある企業でその現地で採用した労働者に限り、最長 12 か月韓国内への滞在を認めた。しかし、海外に投資できるような企業は中堅や大企業ばかりであったため、肝心の中小企業の人手不足の解消には至らなかった。そこで政府は 1993 年に、海外投資をしていない企業も対象範囲とした「産業研修制度」を導入し、その翌年には制限していた中国からの朝鮮族の入国を解除した。ここで韓国は本格的に送り出し国から受け入れ国へと転換した。

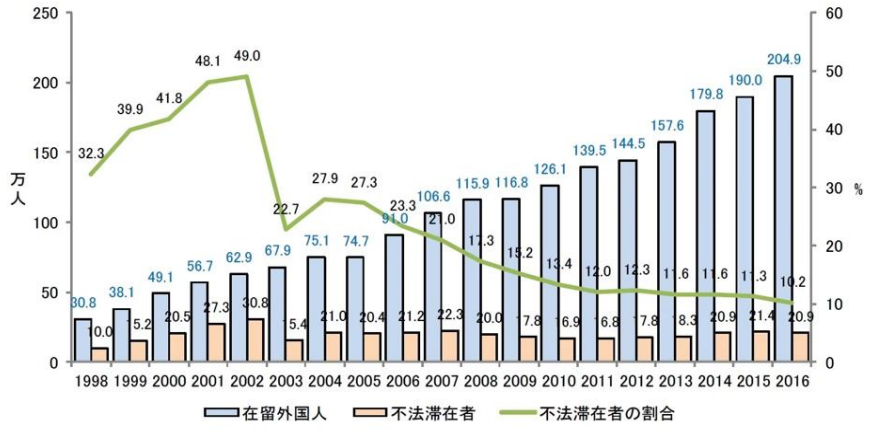
ここで導入された「産業研修制度」であるが、多くの問題点があった。まず、この制度を利用して入国した労働者の扱いは「労働者」ではなく「研修生」であった。つまり、正式な労働者でないために労働法は一部しか適用されず、他の労働関連法の保護を受けることが

できなかった。そのため、受け入れ機関の不正や暴言、暴行にさらされた労働者の多くが失踪し、特に朝鮮族は言語の壁がなく他国の外国人労働者に比べて転職しやすかったため、不法就労が増加した。1994 年から 97 年までに多くの支援団体が設立し、外国人労働者の人権保護や制度の見直しを求めたが改善はされなかった。

転換期となったのは 2003 年に成立した盧武鉉政権からである。政権を執って間もなく「外国人労働者の雇用等に関する法律」を制定し、翌年「外国人労働者雇用許可制（以下、雇用許可制）」をし、外国人を政府の管理下で正規労働者として受け入れる仕組みを整えた。労働者の受け入れを透明化することでブローカーの排除や不法滞在者を減らすことが可能になった。その後、「不法就労外国人合法化措置」が発表された。「これは、外国人労働者雇用法の附則において、雇用許可制の施行前に不法就労者を合法化するよう規定されていたことから執られた措置である。これにより、2003 年 11 月 15 日までに、18 万 4 千人の不法

グラフ 5

図表 1　韓国における在留外国人などの推移



出所）法務部『出入国・外国人政策統計年報』各年より筆者作成。

就労外国人が「合法化」され、期間付きで正式に就業することを認められた」（白井, 2007, p. 35）とされ、グラフ 5[9]のように不法就労者の減少の一端を担った。

2004 年に雇用許可制が導入される以前、1995 年にも既に導入が検討されていたものの、産業界の猛反発により頓挫していた。また、1998 年に「研修生が 2 年間の研修終了後受け入

[9] 金 明中（2010.03）「韓国でも外国人労働者が増加傾向―外国人労働者増加のきっかけとなった雇用許可制の現状と課題を探る―」https://www.nli-research.co.jp/report/detail/id=61191?pno=2&site=nli （2021 年 12 月 15 日取得）

れ企業の推薦を受け所定の試験に合格した場合、その企業に 1 年間就業できる資格を与える」（宣, 2002, p. 15)、「研修就業制度」を研修制度の補完として導入した。研修終了後の就業では労働法が適用されるといった制度であったが、当時は通貨危機により外国人労働者を制限する傾向にあったため、1997 年以前の入国者は対象外となった。2000 年に入ると通貨危機による不景気が回復し、それに伴い不法就労者も増加した。2001 年には独立機関として「国家人権委員会」が設置され、労働者の権利保障を訴えた。結局、2002 年には不法者数が外国人労働者数の 80%に近づくほどとなり、ようやく 2004 年の雇用許可制に繋がった（白井, 2007)。

雇用許可制の導入により、外国人労働者の権利が保障され、人権保護、社会保障が大幅に改善された。しかし、「3 年以上の在留延長不可、就業期間中の家族の同伴・呼び寄せの禁止、就業可能な業種の制限など」（春木, 2011, p. 98）があった。つまり、あくまでも短期労働者としての受け入れで、移民の受け入れではないという意味合いであった。2006 年に韓国政府は外国人の人権保護と統合の議論を目的とした組織、「外国人政策委員会」を設置し外国人を「管理」から「統合」へと方針を転換した。2007 年には「訪問就業制」を導入し、これにより、就ける業種が拡大しただけでなく、従来の就業管理制度に比べ手続きも簡略化した。また、同年に「在韓外国人処遇基本法」を制定し、「国と地方自治体に対して、国民と外国人の相互理解や尊重の促進に必要な措置を取る努力義務が課された」（野村, 2019, p. 114)。韓国は人手不足に悩まされており、加えて近年少子化が進行してきたことも労働者の待遇を改善する要因となった。

4　ドイツ、韓国の歴史から日本へ

ここまでドイツと韓国の外国人や、外国人労働者に対する政策の歴史を辿ってきた。異なる国の歴史であるが、外国人政策の中には日本との類似点を見つけることができた。ここではそれらの歴史をみて、現在、外国人労働者の問題を多く抱える日本に足りないものは何かを模索する。

ドイツにおけるポイントとなるのは「血統主義」から「出生地主義」への移行である。日本と同じく血統主義であり、移民国家を否定した歴史を持つドイツが、現在では年に 100 万、200 万人を超える難民を受け入れる移民国家へと変貌を遂げた。日本国内の外国人の割合は

2%（佐藤, 2019）と、ドイツの 26. 7%[10]に比べると少なく感じる。しかし、外国人の人口は年々増加傾向にあり、外国人が特に多い地域では外国人と日本人の共生は始まっている。では、日本では何故ドイツのように出生地主義へ転換しないのかというと、国民的アイデンティ意識の違いによるものが大きい。社会学者ナイカ・フォロタンの「ドイツ人であること」の基準とは何かの調査結果（佐藤, 2019）によれば、8270 人のうち 96. 8%の人が「ドイツ語を話せる」ことは重要であると回答し、「ドイツ国籍を持っている」ことが重要であると回答したのは 78. 9%であった。しかし、血統の部分である「ドイツ人の先祖をもっている」ことが重要であると回答したのは 37%であった。つまり、ドイツ人の国民的意識は現在のドイツの国籍法にある程度のっとったものであり、血統を強く重視しない風潮が生まれてきていることがわかる。日本では日本国籍を持たない人同士の間で生まれた子どもには日本で生まれたとしても日本国籍は付与されない。また、国民意識の中には未だに純血を意識する傾向にあるため、たとえ日本国籍を持っていたとしても見た目が純日本人とは異なっていたり、親が純日本人でなければ日本人ではないと考えたり、逆に、純日本人であれば外国籍を取得していようが日本人であると見なしたりする。最近ではノーベル賞を受賞したアメリカに帰化した日系アメリカ人の学者を日本の首相が「日本人」と紹介したことが話題になった。血統に強く固執した文化では外国人は永遠に外国人のままで、その間の隔たりは消えることはない。根付いた国民アイデンティティの意識を変えることは容易ではなく、ドイツは出生地主義を取り入れて約 20 年たった今でもそれに反発する人は存在する。

国境という概念が薄くなりつつある現代社会において血統で縛られた○○人という考えは古いものになってきているのかもしれない。外国人問題の解決には日本人とは何かという国民概念の再定義を行い、国民アイデンティティ意識をどう変化させていくかが重要になる。

そして、韓国におけるポイントは外国人労働者政策がメインとなってくる。韓国は日本の研修生制度と類似した産業技術研修制度を導入したが、労働者の権利が保障されず、雇用者

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[10] 2020 年における移民背景を持つと答えた割合。ドイツ連邦統計局” Statistisches Bundesamt”p.32
https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Migration-Integration/Publikationen/Downloads-Migration/migrationshintergrund-2010220207004.pdf?__blob=publicationFile （2021 年 12 月 15 日取得）

にパワーバランスが傾いた欠陥だらけの制度であった。そのため、産業界の反対を押し切り、短期的ではあるものの政府主導で外国人労働者を正規労働者として雇用する「雇用許可制」に切り替えた。では、日本はどうであるか。研修生は技能実習制度に取って代わったが、外国人を受け入れるだけ受け入れて人権侵害や労基法違反などの問題は長年放置されている。外国人労働者が使い捨てられている状況を改善しようとしないまま、特定技能の在留資格を新設し、より外国人労働者を受け入れようとしている。韓国は経済発展とともに労働者送り出し国から受け入れ国に変化した。フィリピンからの労働者も現在では農村部出身者ばかりで、発展したマニラなどの都市からは随分と減少した。外国人労働者がいつまで無限にやってくるわけではないことを念頭に置き、これからやって来る超労働者不足社会に向けて外国人労働者に選ばれる国にならなくてはならない。

5　おわりに

日本の経済成長を陰で支えてきたのは外国人である。それにもかかわらず日本は外国人を都合よく雇い、解雇し、雇用の調整弁のように扱ってきた。まるで存在しないかのように、外国人に関する問題は改善されないまま見て見ぬふりをされてきた。

外国人の人口が膨らむ日本は今、分岐点に立たされている。「郷に入っては郷に従え」ということわざがあるが、このような一方的な態度では外国人との共生は実現しない。外国人を取り巻く問題は外国人だけの責任でないことを自覚し行動することが問題解決への近道である。外国人と日本人は同じく人類であり、また対等な立場であることを前提として考え、同時に日本社会では少数派であることを理解しサポートをする必要がある。しかし、それは「施し」などではなく当然の「権利」であることを忘れてはならない。それが外国人労働者問題を解決へと向かわせ、共生への第一歩となる。

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