Effect of coffee temperature on the physical performance during exercise

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Abstract

Effect of coffee temperature on the physical performance during exercise

Aim The purpose of the present study is to investigate the effect of temperature of coffee on endurance performance and lipolysis. **Methods** Four healthy college student over 20 years old performed a light exercise with a bicycle ergometer before and after drinking coffee. Between the first exercise (EX1) and second exercise (EX2), they intake 125cc of water and 160cc of hot coffee or ice coffee. We compared oxygen consumption (VO2), heart rate (HR) and rate of perceived exertion (RPE) to see these changes. **Results** In EX2, HR of the placebo group was significantly higher than EX1, whereas the coffee group was significantly lower. On the other hand, HR was a slightly lower for iced coffee than for hot coffee ($p < 0.05$). Regarding VO2, there was no difference between the two groups after drinking ($p > 0.05$). Individual RPE showed no difference between hot coffee group and ice coffee group ($p > 0.05$). **Conclusion** We suggested that drinking coffee before exercise can increase the endurance ability and energy metabolism, and also, both hot coffee and iced coffee are effective.

コーヒーの温度差が運動中の身体能力に与える効果

本研究の目的は、コーヒーの温度差が持久性運動能力の向上と脂肪燃焼効果に及ぼす影響の有無を調査することである。20 歳以上の健康な大学生 4 名が自転車エルゴメーターによる軽運動を行った。被検者は 1 回目(EX1)と 2 日目(EX2)の運動の間に、125cc の水と 160cc のホットコーヒーまたはアイスコーヒーを飲用した。各運動時の酸素摂取量(VO2)、心拍数(HR)、および自覚的運動強度(RPE)を比較し、変化の有無を確認した。EX2 の HR において、対照飲料摂取群の数値は EX1 よりも有意に高かった。それに対し、コーヒー摂取群は EX1 よりも有意に低下した。コーヒーの温度差別の変化率は、アイスコーヒー摂取群がホットコーヒー摂取群よりもわずかに低かった($p < 0.05$)。VO2 に関しては飲料摂取後の両群の違いは認められなかった($p > 0.05$)。個人の RPE は、コーヒー摂取の前後で両群の変化に差は見られなかった($p > 0.05$)。これらの結果から、運動前のコーヒー飲用は、アイスコーヒー、ホットコーヒーのどちらも持久性運動能力と脂肪燃焼効果の向上に繋がることが示唆される。

Efecto de la temperatura del café sobre la capacidad de resistencia fisica.

El propósito de este estudio es investigar si la diferencia de la temperatura del café afecta o no la capacidad de resistencia fisica y el efecto de quema de grasa. Cuatro estudiantes universitarios varones sanos mayores de 20 años realizaron un ejercicio ligero con un ergómetro de bicicleta antes y después de tomar café. Los participantes tomaron 125cc de agua y 160cc de café caliente y/o frío entre el primer y el segudo ejercicio. La ingesta de oxígeno (VO2), la frecuencia cardíaca (HR) y la tasa de esfuerzo percibido (RPE) se compararon para confirmar si hay un cambio. El HR para el grupo que tomó café frío fue menor ($p < 0.05$) a comparacion con el grupo que tomó café caliente ($p < 0.05$) aunque la diferencia no es significativamente grande. El VO2 no difirió entre los dos grupos después de beber ($p > 0.05$). El RPE individual no mostró diferencias entre los dos grupos ($p > 0.05$). Como resultado, tomar café frío o caliente antes del ejercicio conduce a una mejora en la capacidad de resistencia fisica y al efecto de quema de grasa.

Abbreviations:

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

Introduction

According to National Coffee Association of United States of America (NCA), the proportion of Americans drinking coffee increase. In Europe, viewing a survey conducted by Centre for Economics and Business Research (CEBR), their coffee consumption has jumped 35% in the 10 years from 2008 to 2018. In China, the annual consumption of coffee per person is still relatively low, but the statistics show an average annual growth of 16% over the past 10 years (Alizila, 2018). In this way, opportunity to drink coffee are increasing year by year in the world. On the other hand, in fact, Japan is the major coffee-consuming country next to European Union (EU) and United States of America (USA) (ICO, 2018). According to All Japan Coffee Association, the quantity of the coffee which one drinks a week is 11.09 cups on man and woman average (AJCA, 2016). The consumption of the youth is less than average, but it gradually increases from 18 years old. Woman aged 40 to 59 years old consumes 14.40 cups per week in average so they consume the most. Consequently, coffee is required not only for workers but also for a wide range of age groups from students to seniors.

Coffee consumption in Japan has increased by nearly 1.5 times in 20 years from 1996(AJCA, 2018), and it is presumptive that this trend will continue in the future. For instance, AJINOMOTO AGF INC. has developed stick-type coffee for the first time in 2003 (AJINOMOTO AGF, INC. 2019). Using this product, we can make and drink easily without measuring the quantity for the cupful, and they have been trying to improve the quality to now (AJINOMOTO AGF, INC. 2019). On the other hand, the demand for coffee of convenience store such as Seven-Eleven, Lawson, and Family Mart is also expanding. At these stores, it became possible to purchase a cup of coffee at low price of 100 to 150 yen. It means we became able to enjoy the freshly brewed coffee anytime. Furthermore,

in recent years, coffee shop and cafe are receiving attention mainly on young people. The following points can give as reasons. First, photo sharing service "Instagram" announced that Monthly Active User (MAU) of the whole world broke through 1 billion people in 2018 (Statista. 2019). In the whole world, 41 percent of users are 24 years of age or younger (Statista. 2019). The number of hashtags people put on photos posted to Instagram has increased endlessly. So I used the Instagram service (Top-HashTags.com) to find out the hashtags and the number of posts. As of the statistics of 2016, #Coffee ranks 112 and is used for 8.148 million articles. Furthermore, #cafe ranks 416 and is used for 3,184 million articles. This indicates that the number of coffee and cafe postings is overwhelmingly different from the 1.8 billion #restaurant and 2.2 billion #tea, and that coffee and cafe are more interesting. Second, the total sales of 1180 cafe owners in 2017 increased 4.6% from the previous year to 64,532 million yen (TDB, 2018), and the expansion trend continues. As these reasons, it may be associated with the expansion of the cafe that is particular about the interior, and the trend of young people to publish photographs on SNS. In addition, specialty coffee shops by baristas who are particular about coffee increase little by little. In a word, interest in coffee is gradually changing.

A number of studies indicate that there is a relationship between coffee and health, and that is the other reason for increased consumption. For example, it is investigated the metabolic effects of caffeine on recovery. This study concluded that by taking about 1.5 to 2 cups of caffeine in coffee after light exercise, endurance ability is restored, and heart rate and respiratory exchange ratio at the time of light exercise again decrease significantly (Sasagawa et al, 2015). Similarly, in experiments using caffeine, caffeine consumption resulted in a 3% reduction in Rating of perceived exertion (RPE) (Gregory, 2002). From this, it became evident that caffeine

intake an hour ago is ideal for during cycling within 60 minutes (Gregory, 2002). According to an interview with some cyclists by the road bike channel Global Cycling Network (GCN), they drink 1 to 4 cups of coffee before the competition (GCN, 2017). Many of them say that coffee has an impact on performance. It assumed that caffeine contained in coffee expected to improve the ability of endurance sports. Alternatively, caffeine has the effect of breaking down fat. By promoting the breakdown of fat, it increases activated sweat gland density (ASGD) and free fatty acids (FFA) (Tae-Wook Kim et al, 2010). Therefore, it usually takes time to burn the fat, but it can burn efficiently. As a result, it can predict that diet effect can expect by combining caffeine intake and exercise.

In summary, research has shown that caffeine intake by coffee as well as anhydrous caffeine such as tablets leads to improved endurance exercise performance and fat burning effect. However, little attention has been paid to the effect of temperature in the coffee. Previous studies have used caffeine diluted in water, but specific temperature is not indicated (Sasagawa et al, 2015). Another study used hot water at 92-96 ℃, but they did not compare it with iced coffee (Hudgson et al, 2013). Therefore, I estimated that temperature is not important in foreign country because they have less opportunity to drink iced coffee. A survey of major coffee shops and cafes in Japan showed that 100% of stores had ice coffee on the menu. However, 15% of them offer cold brew, i.e., Soak coffee beans directly in water and slowly extract for a long time. It made in American coffee shops, as iced coffee. In terms of this, those stores based on American or other countries coffee culture concepts do not tend to sell iced coffee dripped like hot coffee. Similarly, for comparison I investigated major coffee shops in France, Italy, Spain, UK and USA. Thirty-five percent of the surveyed shops have iced coffee on the menu.

However, 83% of them offer cold brew or Americano i.e., a coffee prepared by diluting espresso with water. Based on my field survey in Spain, Torch Coffee Roasters do not list iced coffee. Nevertheless, when customers asked about it, the cafe staff provided cold coffee. Iced coffee is not on the menu at 65% of the stores in foreign countries. In those stores, it is normal that they give a glass of ice with hot coffee or espresso as iced coffee. Moreover, stores targeted at tourists tend to have cold drinks such as iced coffee. Hence, it is presumed that there are few people who have a habit of drinking iced coffee in foreign countries. It indicated that hot coffee is the mainstream in most countries, while the majority of Japanese prefer iced coffee in summer. Therefore, for those who like iced coffee, it is interesting to see if the same effect can obtain.

The purpose of the present study is to reveal the effect of temperature of coffee on endurance performance and lipolysis. Caffeine has sublimation property and the sublimation point is said to be 178℃ (Mohammad Uppal Zubair, 1986). The appropriate temperature for hot coffee is around 68-70℃, and 92-96℃ when extracting. In view of the fact that the sublimation point of caffeine is not be reached even at the time of extraction, it is considered that the amount of caffeine does not change with temperature change. Based on this, it is assumed that the same effect can obtain even if the temperature is change.

Materials and Methods

Participants

The participants are 4 healthy men aged 20 and over (Mean±SD: Age 21±1y, Weight 66±6kg). In order to eliminate the error due to the tolerance to caffeine, take a questionnaire on their habit of drinking coffee in

advance. In addition, those without extreme exercise experience, smokers, and those with cardiovascular disease were exclude.

Experimental design

An exercise had conducted using a bicycle ergometer (KONAMI SPORTS CLUB Exercise Bike 75 XL III, Kanagawa, Japan). The participants had prohibited from alcohol intake, caffeine intake, and intense exercise on the day before the experiment, and the wake-up time on the day was standardized. In order to avoid hunger and satiety, they had instructed to take an appropriate amount of breakfast or lunch 1 hours before test. Since the load was constant according to the weight of the participants, the weight of the participants was measure before the experiment (TANITA Body composition meter with automatic height scale DC-250, Tokyo, Japan).

The experimental protocol is shown in Fig. 1. First, participants performed a light exercise with a bicycle ergometer for 10 minutes(EX1). The amount of load was set to 6 Mets, which corresponds to light jogging for each participants (National Institute of Health and Nutrition, 2012). This workload is estimated from the individual body weight. That is corresponded with physical activity intensity. Cadence of pedal is set at 60 rpm. After the exercise, the participants drink 125cc of water within 5 minutes for hydration. Five minutes after, they intake coffee within 10 minutes. Since the amount of caffeine contained in coffee is 90 mg per 100 ml, they should drink a cup of coffee (160 cc). The reason is that, according to Spriet (2014), although there are individual differences in the intake at which the effect of caffeine can obtain, it indicates to be about more than 2 mg per kg body weight. Rest for 60 minutes, including time to drink coffee (Laura et al, 2004). After that, performed the same level of bicycle exercise for 30 minutes(EX2).

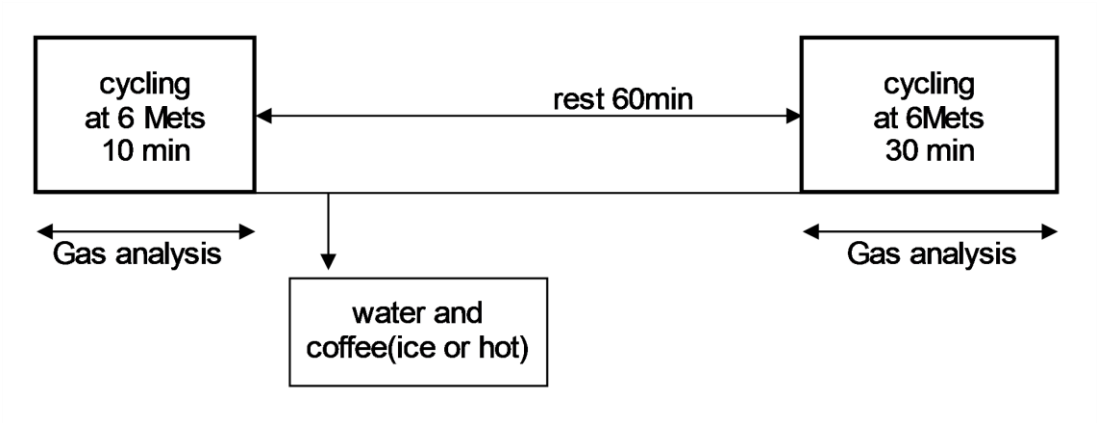


Fig. 1 Mean experimental protocol. In Borg Scale, 6 Mets corresponds to light jogging. EX1: cycling exercise before drink coffee or placebo. EX2: cycling exercise after drink coffee or placebo.

Measuring methods

During exercise with a bicycle ergometer, the participant's heart rate (HR) was measured using a bicycle ergometer clip-type heart rate monitor (KONAMI SPORTS CLUB Exercise Bike 75 XL III, Kanagawa, Japan) every 5 minutes, and oxygen intake (VO2) were measured using expired gas analyzer (Nippon photoelectric aero monitor AE-310S, Minato Medical Science CO., LTD, Tokyo, Japan). The participants had been asked to conduct four experiments including drinking hot coffee, iced coffee, hot water and cold water. In this experiment, two comparisons were made: placebo vs coffee (Measurement A), hot coffee vs iced coffee (Measurement B). Placebo in Measurement A shows both cold and hot water, and two people were targeted. In Measurement B, 4 people were targeted. The time for half of caffeine in the body is said to be about 4 hours (Knutti R et al, 1981), but there is an individual difference of 2 to 8 hours, so those experiments was separate by 1 day or more. The order of the trials with hot coffee and iced coffee were random. The coffee used for the experiment is MAXIM. of AJINOMOTO AGF INC. The temperature of hot water was 92 to 96℃. On the other hand, iced coffee unified to 4 to 6℃.

Statistics

We compared HR and VO2 before and after each coffee intake to see if there was any change. VO2 calculated using AT analysis software and the mean value excluding 2 minutes after the start of exercise. The data was compared using Wilcoxon test. With this, VO2, HR and RPE were compared between coffee and placebo. Likewise, these were compared between iced coffee and hot coffee. Thereby, it clarified whether there is a difference in the magnitude of change due to the difference in temperature of coffee.

Results

In EX2, HR increased with placebo but significantly decreased with hot coffee (Participant A water: hot water: hot coffee =143.7:116.2:129.5, Participant B water: hot water: hot coffee =108.0:107.3:104.0) (Table 1). There were individual differences in iced coffee (Table 1). Regarding VO2, there was no significant difference between these drinks (Table 2).

Next, changes in VO2 are shown in Fig. 2. Looking at the rate of changes of VO2 between with placebo and coffee, with coffee is lower than placebo, still the difference is small (Participant A water: hot water: ice coffee: hot coffee=1.05:1.03:1.02:1, Participant B water: hot water: ice coffee: hot coffee=1:1.02:1.01:1). The rate of changes in HR is illustrated in Fig. 3. With hot coffee decreased (Participant A:0.98, Participant B:0.95), while with placebo has increased (Participant A water: hot water=1.1:1.0, Participant B water: hot water=1.01:1.09). There were individual differences in iced coffee.

Additionally, the coffee group was divided into ice group and hot group. The results of HR and VO2 during exercise are shown in Table 3. The decrease in HR from EX1 to EX2 were seen in both groups. Regarding VO2, there was no significant difference between both groups in EX1 and EX2. Fig. 4 illustrated the changes in HR, and Fig. 5 illustrated the changes in VO2. As regards HR, the decrease in ice coffee group is larger than that in hot coffee group (hot coffee: ice coffee = 0.974 ± 0.02: 0.955 ± 0.04) ($P < 0.05$). As for VO2, the rate of change in both groups was almost the same (hot coffee: ice coffee = 1.016 ± 0.02: 1.016 ± 0.01) ($p > 0.05$).

RPE during exercise is expressed in Borg Scale. In EX1, the ice coffee group was 10.4 ± 2.4 and the hot coffee group was 10.5 ± 2.8 (Table4). In EX2, the ice coffee group showed 9.5 ± 1.9 and the hot coffee group

showed 9.8 ± 2.6, namely, both of which decreased after taking caffeine ($p < 0.05$) (Table4). Borg Scale 9-10 showed “very light”, “fairly light” and there was no significant difference between the two groups.

Table. 1 Mean HR during exercise with coffee and placebo. EX1: cycling exercise before drink coffee or placebo. EX2: cycling exercise after drink coffee or placebo. In EX2, HR increased with placebo but significantly decreased with hot coffee (Participant A water: hot water: hot coffee =143.7:116.2:129.5, Participant B water: hot water: hot coffee =108.0:107.3:104.0).

	Hot coffee		Ice coffee		Hot water		Water	
	EX1	EX2	EX1	EX2	EX1	EX2	EX1	EX2
Participant A	131.5	129.5	126.5	115.5	116.5	116.2	130.0	143.7
Participant B	109.0	104.0	114.5	116.0	98.5	107.3	107.0	108.0

Table. 2 Mean VO2 during exercise with coffee and placebo. EX1: cycling exercise before drink coffee or placebo. EX2: cycling exercise after drink coffee or placebo.

	Hot coffee		Ice coffee		Hot water		Water	
	EX1	EX2	EX1	EX2	EX1	EX2	EX1	EX2
Participant A	20.8	20.9	20.8	21.3	21.0	21.6	21.7	22.8
Participant B	20.5	20.5	20.8	21.0	19.6	20.0	21.3	21.3

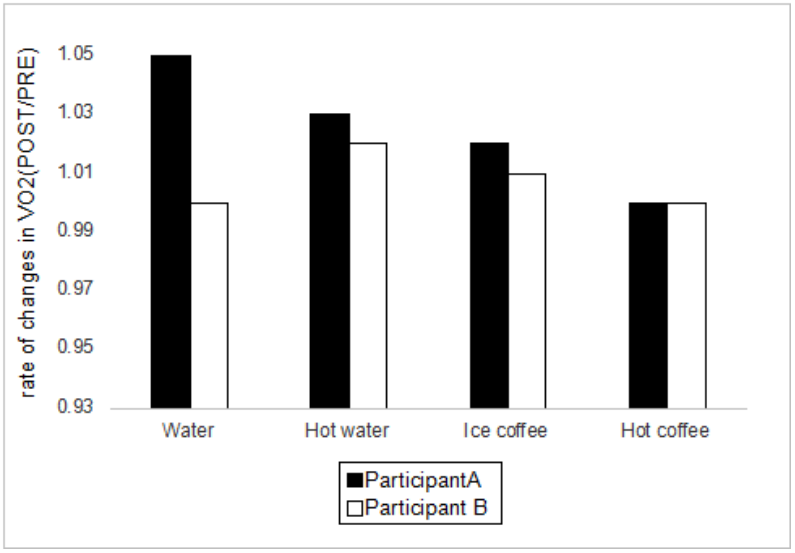


Fig. 2 Mean the changes in VO2 between with water, hot water, ice coffee and hot coffee. With coffee is lower than placebo, still the difference is small (Participant A water: hot water: ice coffee: hot coffee=1.05:1.03:1.02:1.0, Participant B water: hot water: ice coffee: hot coffee=1.0:1.02:1.01:1.0).

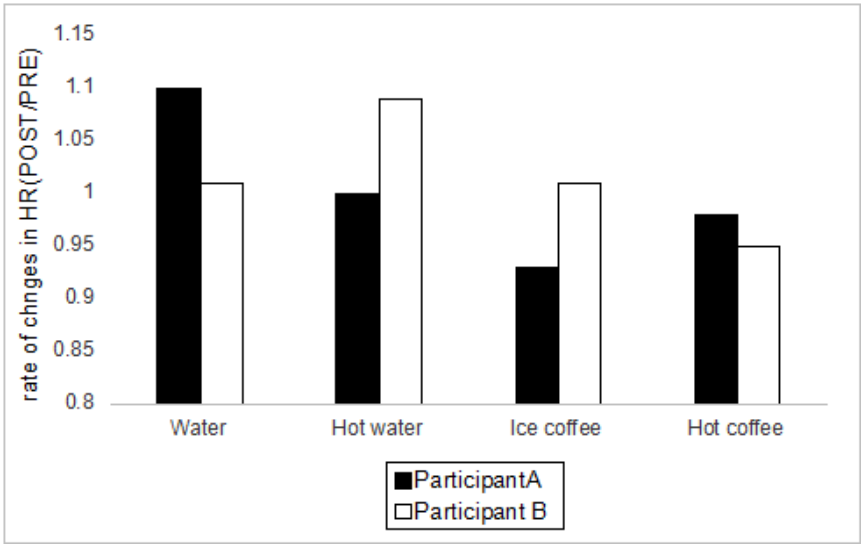
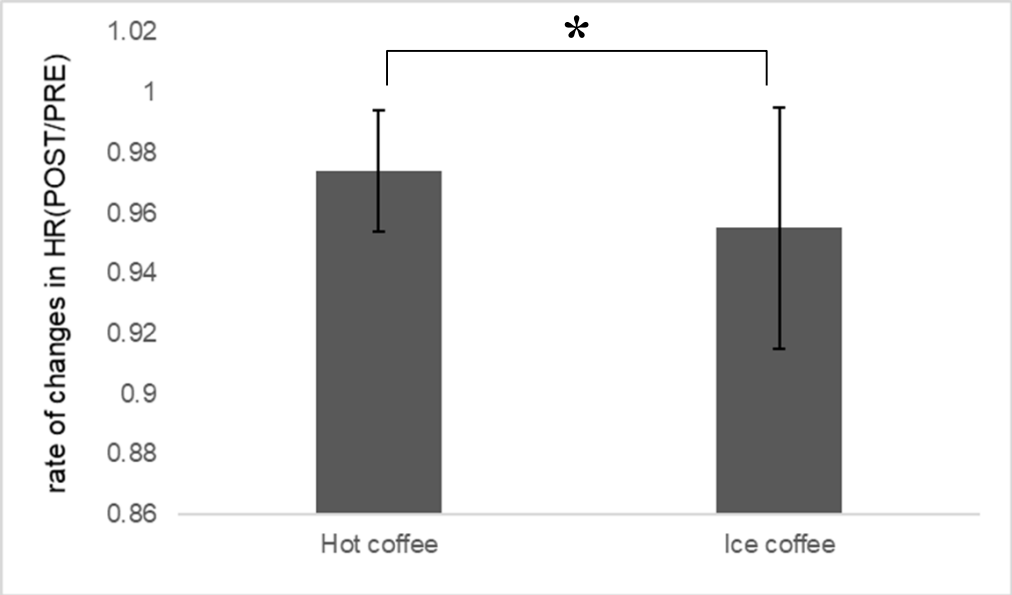


Fig. 3 Mean the changes in HR between with water, hot water, ice coffee and hot coffee. With hot coffee decreased (Participant A:0.98, Participant B:0.95), while with placebo has increased (Participant A water: hot water=1.1:1.0, Participant B water: hot water=1.01:1.09).

Table. 3 Mean (± SD) HR and VO2 during exercise with the ice coffee group and the hot coffee group. EX1: cycling exercise before drink coffee or placebo. EX2: cycling exercise after drink coffee.

	Hot coffee		Ice coffee	
	EX1	EX2	EX1	EX2
HR(beat/min)	121.1±9.6	118±10.6	126.6±16.9	120.5±12.9
VO2(ml/kg/min)	21.2±1.8	21.5±1.9	20.7±0.3	21±0.3



*p < 0.05 between Hot and Ice coffee

Fig. 4 Mean the changes in HR between the ice coffee group and the hot coffee group. The decrease in ice coffee group is larger than that in hot coffee group (hot coffee: ice coffee = 0.974±0.02: 0.955±0.04) (P < 0.05).

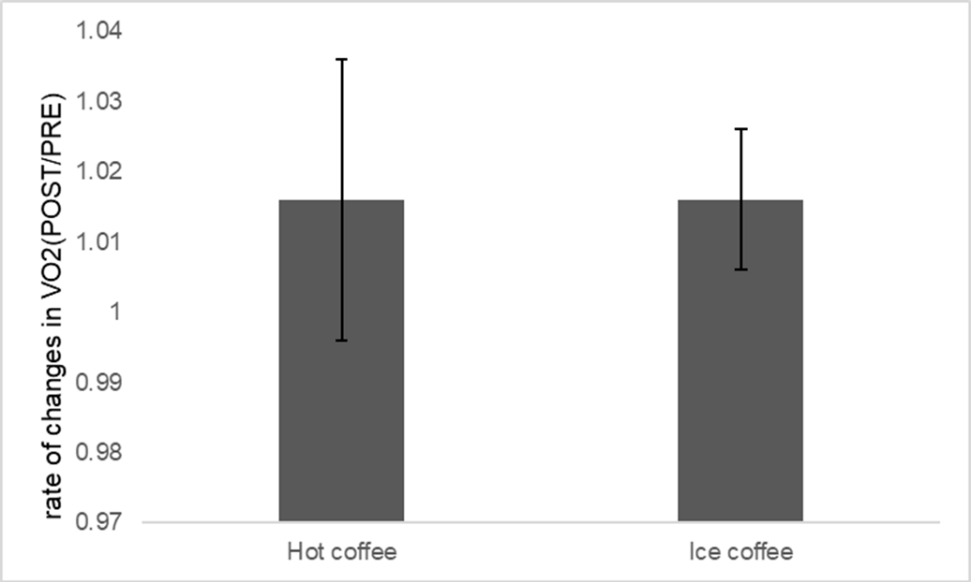


Fig. 5 Mean the changes in VO2 between the ice coffee group and the hot coffee group.

Table. 4 Mean (± SD) RPE during exercise with the ice coffee group and the hot coffee group. EX1: cycling exercise before drink coffee or placebo. EX2: cycling exercise after drink coffee. Both groups are significantly decreased ($p<0.05$).

	Hot coffee		Ice coffee	
	EX1	EX2	EX1	EX2
RPE	10.5 ± 2.8	9.8 ± 2.6	10.4 ± 2.4	9.5 ± 1.9

Discussion

The purpose of this study was to examine the effects of ice and hot coffee consumption on the endurance ability during the second exercise after a light exercise with a bicycle ergometer. In this study, HR, RPE, and VO2 during exercise were calculated for healthy men. According to the previous study, exercise after drinking coffee and resting for 60 minutes showed a decrease in heart rate and an increase in oxygen intake, both of which were significant changes compared to before drinking coffee (Suzuki, 2010). However, they used only hot water and hot coffee. We focused on the temperature of the coffee and conducted an experiment to determine whether there was a change between hot coffee and iced coffee.

There was no significant difference between coffee and placebo regarding VO2. In previous studies, the amount of caffeine used was equivalent to about 2 cups of coffee, and an increase in oxygen intake after caffeine consumption was observed (Suzuki, 2010). Meanwhile, in this study, it was set to about 1 cup (160cc). That is, it is thought that VO2 does not increase with about a cup of coffee.

Each RPE decreased in both groups with exercise after consuming coffee (Table4). The exercise intensity set in this experiment is as low as 6 Mets, which corresponds to light jogging. Regarding the participants who felt slightly tight, it was considered that the temperature on the day was slightly high (22℃), the HR was higher than the average, and the amount of sweating was large. RPE was between 9 and 11 for most participants, no participants responded “tight”, and was appropriate for light exercise.

The participants of this study were a male university student. Considering that men have higher endurance than women (Japan Foundation for Aging and Health, 2019), it is unclear whether it can be applied to

women and ordinary people who are not accustomed to daily exercise. In addition, we excluded those who were caffeine resistant. Therefore, it is unclear whether a person with caffeine resistance can obtain the same result.

The coffee used in this study does not contain sugar or milk. Therefore, it is unknown whether it is effective other than black coffee. However, if you are focused on energy consumption for diet, coffee without sugar or milk is appropriate considering the ingredients contained in these. For the reason, sugar, milk and coffee whiteners have higher calories than coffee, and dairy products have higher fat (Ministry of Education, Culture, Sports, Science and Technology, 2015). In addition, since excessive drinking of coffee may adversely affect the body, it is desirable to utilize coffee intake and exercise on the premise that excessive intake is not performed (Health Canada, 2010).

In this study, HR was a slightly lower for iced coffee than for hot coffee (hot coffee: ice coffee = 0.974±0.02: 0.955±0.04) ($P < 0.05$). Knutti et al, 1981 showed that the half-life of caffeine in the body is about 4 hours. In this study, the time from caffeine intake to the second exercise was 60 minutes. Therefore, the effect was obtained without halving caffeine. However, as mentioned earlier, it is thought that VO2 does not increase with about a cup of coffee (Suzuki, 2010). According to Midoh et al, 2012, the amount of change in HR 60 minutes after drinking hot soup was larger than that of cold soup. Based on this, the reason why hot coffee has a higher HR value is presumed that the increase in body temperature due to a hot drink is related to the individual's sense of temperature and HR. Kondo et al, 2005 said that athletic performance decreases with increasing body temperature. Therefore, it is considered that the suppression of the rise in body temperature by drinking iced coffee influenced HR. That means iced coffee is suitable for obtaining a more effective in aerobic exercise. On the other hand, since both hot

coffee and iced coffee showed a reduction in HR, it can interpret that both are effective.

For this result, by improving endurance ability, it became possible to increase the exercise intensity of each participant. Therefore, it is estimated that free fatty acid can be consumed more as energy by exercising more. In conclusion, this study confirmed that iced coffee can suppress HR more than hot coffee and making it possible to increase exercise intensity or extend exercise time. It turned out that iced coffee is more effective in endurance and fat burning.

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