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Original Article

The effects of gum chewing while walking on physical and physiological functions

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Abstract. [Purpose] This study examined the effects of gum chewing while walking on physical and physiological functions. [Subjects and Methods] This study enrolled 46 male and female participants aged 21–69 years. In the experimental trial, participants walked at natural paces for 15 minutes while chewing two gum pellets after a 1-hour rest period. In the control trial, participants walked at natural paces for 15 minutes after ingesting powder containing the same ingredient, except the gum base, as the chewing gum. Heart rates, walking distances, walking speeds, steps, and energy expenditure were measured. [Results] Heart rates during walking and heart rate changes (i.e., from at rest to during walking) significantly increased during the gum trial compared with the control trial. Walking distance, walking speed, walking heart rate, and heart rate changes in male participants and walking heart rate and heart rate changes in female participants were significantly higher during the gum trial than the control trial. In middle-aged and elderly male participants aged ≥40 years, walking distance, walking speed, steps, and energy expenditure significantly increased during the gum trial than the control trial. [Conclusion] Gum chewing while walking measurably affects physical and physiological functions.

Key words: Walking, Gum chewing, Physical and physiological functions

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INTRODUCTION

Obesity has become widespread, and a global obesity pandemic has been reported[1]. Obesity has been reported to be related to the development of various chronic illnesses such as cardiovascular diseases, metabolic diseases, musculoskeletal disorders, and cancer[2]. To prevent the onset and progression of these chronic diseases, effective preventive methods and treatments for obesity are needed.

Gum chewing has been reported to stimulate sympathetic nervous activity, and increase heart rate and energy expenditure[3–8]. Therefore, because gum chewing increases the body's energy expenditure, it may be an effective method of weight management. In addition, because exercise increases the energy expenditure, gum chewing while simultaneously exercising is expected to increase this metric more than either exercise or gum chewing alone. Combining exercise and gum chewing may be an effective way to manage weight. However, although previous studies have examined the effect of gum chewing while at rest on physiological functions such as heart rate and energy expenditure, to date, no studies have focused specifi-

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Table 1. Characteristics of the participants

	All (n=46)		Young group (n=20)		Middle-aged/elderly group (n=26)	
	Male (n=22)	Female (n=24)	Male (n=10)	Female (n=10)	Male (n=12)	Female (n=14)
Age (years)	43.4 ± 14.6	44.2 ± 14.9	29.9 ± 4.7	29.9 ± 6.2	54.6 ± 9.4	54.4 ± 9.9
Height (cm)	170.1 ± 5.3	158.7 ± 5.5	170.8 ± 3.8	159.2 ± 4.7	169.5 ± 6.4	158.2 ± 6.1
Body mass (kg)	71.8 ± 7.6	62.7 ± 7.3	71.5 ± 6.6	62.4 ± 6.0	72.1 ± 8.6	62.9 ± 8.3
BMI (kg/m^2)	24.8 ± 2.1	24.9 ± 2.5	24.5 ± 2.0	24.6 ± 2.6	25.0 ± 2.3	25.1 ± 2.6

All values are given as the mean ± SD. BMI: body mass index.

cally on the effect of gum chewing while exercising. Currently, the effects of gum chewing while exercising on physical functions as well as physiological functions are not well understood. Walking is the most widely performed movement in Japan[9]. Accordingly, this study focused on walking, and the effect of gum chewing while walking on physical and physiological functions was investigated.

SUBJECTS AND METHODS

This study enrolled 50 participants aged 20s to 60s; five male and five female participants were enrolled in each 10 year age group. The participants were recruited so that there was little variation in the body mass index (BMI) within each age group. The selection criteria for this study required participants aged 20–69 years, have a BMI of 22–30 kg/m^2 and with a habit of gum chewing at least once per week. Two prospective participants met the study exclusion criteria (BMI >30 kg/m^2 and gum chewing less than once per week), and two participants' measurement values were outliers. Therefore, four participants were excluded from the study, and 46 were ultimately included (Table 1). This study was conducted with the approval of the Waseda University Ethical Review Committee (approval number: 2016-314). Participants were briefed regarding this study both orally and in writing, and their written informed consent was obtained.

This study was conducted as a two-arm, randomized, open crossover study. In the experimental arm (gum trial), participants walked at a natural pace for 15 minutes while chewing two pellets of gum after a 1-hour rest period. In the control trial, participants walked at a natural pace for 15 minutes after ingesting powder containing the same ingredient, except the gum base, as the chewing gum. This powder was provided to the participants after being dissolved in 30 ml of water. In the gum trial, participants ingested 30 ml of water before walking. The experiments were performed in our university's sports hall at a temperature of 24 ± 2 °C [mean ± standard deviation (SD)], with 47 ± 9% humidity.

In the gum trial, participants chewed two gum pellets (1.5 g and 3 kcal per pellet); in the control trial, participants ingested water containing dissolved powder that contained the same ingredients (6 kcal) as the gum. The test material for the gum trial consisted of maltitol, sweetener (xylitol), flavoring (apple flavor), thickener (gum arabic), starch, and gum base. For the control trial, participants ingested a powder containing the same ingredients, except the gum base, that were dissolved in water.

A heart rate monitor (RCX 3, Polar Co., Kempele, Finland) was attached to the chest, and the heart rate was measured. The heart rate while walking and that at rest were measured, and heart rate changes from at rest to during walking were calculated. The walking distance was measured by having participants walk for 15 minutes on a 98.04 m track in our university's sports hall. Participants walked individually in a counterclockwise direction and at a natural pace. The walking speed was calculated based on the walking distance and time (15 minutes). A stride sensor (s3+ stride sensor W.I.N.D., Polar Co., Kempele, Finland) was attached to the shoelaces of the participants' right shoes, and cadence was measured. The steps were calculated based on the cadence value. In addition, the oxygen uptake was estimated based on the walking speed, and energy expenditure was calculated from the estimated oxygen uptake value and participants' body masses (using the American College of Sports Medicine's formula)[10]:

Estimated oxygen uptake (ml/kg/min) = 3.5 (ml/kg/min) + 0.1 (ml/kg/m) × walking speed (m/min)

Energy expenditure (kcal/min) = estimated oxygen uptake (l/min) × 4.9 (kcal)

A paired t-test was performed using the SPSS Statistics version 24 statistical analysis software (IBM Corp., Armonk, NY, USA), and the level of statistical significance was designated as $p<0.05$. All values are expressed as the mean ± SD. Previous studies have reported that the effects of gum chewing vary, depending on the participant's gender and age[11, 12]. Therefore, stratified analyses were performed with respect to differences in gender and age groups (the "young" group was defined as participants aged 20s–30s, and the "middle-aged/elderly" group was defined as participants aged 40s–60s).

RESULTS

Overall, significant differences between the gum and control trial results were observed only for the walking heart rate and heart rate changes, and these values were significantly higher in the gum trial than those in the control trial (Table 2).

The stratified analysis by gender showed that among the male participants, significant differences between the trials were

Table 2. Physical and physiological data stratified by gender and age, in the control and gum trials

	All (n=46)		Young group (n=20)				Middle-aged/elderly group (n=26)			
			Male (n=10)		Female (n=10)		Male (n=12)		Female (n=14)	
	Control	Gum	Control	Gum	Control	Gum	Control	Gum	Control	Gum
Walking distance (m/15 min)	1,409 ± 145	1,421 ± 152	1,448 ± 166	1,460 ± 161	1,384 ± 200	1,376 ± 185	1,438 ± 135	1,488 ± 135*	1,374 ± 82	1,369 ± 113
Walking speed (m/min)	93.9 ± 9.7	94.8 ± 10.1	96.5 ± 11.1	97.3 ± 10.8	92.3 ± 13.4	91.8 ± 12.3	95.8 ± 9.0	99.2 ± 9.0*	91.6 ± 5.5	91.3 ± 7.6
Steps (counts/min)	124 ± 7	125 ± 7	122 ± 10	121 ± 9	125 ± 7	127 ± 9	123 ± 5	125 ± 6*	126 ± 8	127 ± 6
Heart rate (beats/min)										
Resting	74 ± 9	73 ± 9	70 ± 4	69 ± 5	75 ± 6	74 ± 6	76 ± 12	74 ± 11*	74 ± 10	76 ± 12
Walking	111 ± 14	114 ± 14*	107 ± 8	107 ± 8	115 ± 12	118 ± 14	107 ± 17	111 ± 18*	114 ± 15	119 ± 12*
Changes heart rate	37 ± 10	41 ± 10*	37 ± 7	38 ± 5	39 ± 13	44 ± 16*	30 ± 9	37 ± 10*	40 ± 8	43 ± 8
Energy expenditure (kcal/15 min)	63.8 ± 10.9	64.2 ± 11.2	69.2 ± 9.4	69.6 ± 8.6	58.6 ± 10.0	58.4 ± 10.1	69.6 ± 11.3	71.3 ± 11.5*	58.6 ± 8.2	58.3 ± 8.0

All values are given as the mean ± SD. *$p<0.05$, control trial vs. gum trial.

observed regarding the walking distance (control trial vs. gum trial: 1,442 ± 146 vs. 1,475 ± 144 m/15 min), walking speed (96.2 ± 9.8 vs. 98.3 ± 9.6 m/min), resting heart rate (74 ± 10 vs. 71 ± 9 beats/min), walking heart rate (107 ± 13 vs. 109 ± 15 beats/min), and heart rate changes (33 ± 9 vs. 38 ± 8 beats/min). Energy expenditure also exhibited statistically significant trends between the trials (69.4 ± 10.3 vs. 70.5 ± 10.1 kcal/15 min, $p=0.059$). Among the female participants, significant differences between the trials were observed with respect to the walking heart rate (114 ± 13 vs. 118 ± 12 beats/min) and heart rate changes (40 ± 10 vs. 43 ± 11 beats/min).

In the stratified analysis of the results obtained from the young and middle-aged/elderly participant groups, heart rate changes (38 ± 10 vs. 41 ± 12 beats/min) in the young group increased significantly during the gum trial than the control trial. In the middle-aged/elderly group, the walking heart rate (110 ± 16 vs. 115 ± 15 beats/min) and heart rate changes (36 ± 10 vs. 40 ± 9 beats/min) were also significantly higher during the gum trial than the control trial.

A stratified analysis was performed with respect to male and female participants in the young and middle-aged/elderly groups (Table 2). For male participants in the young group, no measurement items exhibited a statistically significant difference. For male participants in the middle-aged/elderly group, significant differences were observed between the trial results in the walking distance, walking speed, steps, resting heart rate, walking heart rate, heart rate changes, and energy expenditure. For female participants in the young group, heart rate changes increased significantly during the gum trial compared with the control trial. Meanwhile, for female participants in the middle-aged/elderly group, the walking heart rate increased significantly during the gum trial compared with the control trial.

DISCUSSION

The results revealed that the heart rate increased when the participants chewed gum while walking. This effect was particularly apparent in middle-aged and elderly male participants, in whom the walking distance, heart rate, and energy expenditure (estimated from walking speed) increased.

Gum chewing while at rest has been reported to stimulate sympathetic nervous activity, and increase heart rate[3, 4, 6, 7]. Hasegawa et al.[7] reported that participants' heart rates increased by 12 beats/min while chewing two sheets of gum (5.8 g) over a 5-minute period while at rest[7]. In addition, Suzuki et al.[3] reported that participants' heart rates increased by 8 beats/min while chewing two sheets of gum (6.18 g) over a 10-minute period while at rest[3]. By contrast, in the present study, the participants' heart rates increased by 3 beats/min while chewing two gum pellets (3 g) during a 15-minute walking period. Although the increases in heart rate during gum chewing while walking were small, consistent with the results of previous studies[3, 7], the present study found that the heart rate increased within the healthy range during gum chewing.

An increase in energy expenditure was observed, particularly in middle-aged and elderly male participants, due to gum chewing during walking. A previous study in which participants chewed 8.4 g of gum for 12 minutes while at rest reported that energy expenditure increased by 2.4 kcal due to gum chewing[5]. Meanwhile, here, chewing two gum pellets (3 g) for 15 minutes during a walking task increased the energy expenditure by 1.8 kcal in the middle-aged and elderly male participants. Energy expenditure was calculated based on the walking speed. The present findings suggest that in middle-aged and elderly male participants, energy expenditure may increase due to increased walking speed calculated by the walking distance and time. Since gum chewing stimulates sympathetic nervous activity, and increases heart rate and energy expenditure[3–8], gum chewing while walking may also affect energy expenditure. However, further investigation is necessary to verify this conclusion.

In the present study, gum chewing while walking increased various physical functions of middle-aged and elderly male participants, including walking distance and steps. Although the mechanism by which gum chewing while walking increases these physical functions is unknown, one possible mechanism is cardiac-locomotor synchronization (CLS) or cardiac-locomotor coupling, which involves synchronization of the heart rhythm and locomotor rhythm[13]. The physiological significance of CLS is believed to arise from an increase in the maximum blood flow to active muscles, reduced cardiac afterload, and increased systole volume accompanying increased venous return[13]. CLS is more likely to occur in elderly people than in young people[14]. In this study, middle-aged and elderly male participants exhibited the greatest difference in the heart rate between the gum and control trials compared with young male participants and young, middle-aged and elderly female participants. Gum chewing increased the heart rate, and CLS possibly led to increases in the physical functions of walking distance and steps.

The results of this study were affected by the participants' gender and age. Previous study indicated that females exhibit less masticatory muscle activity during chewing than males, while it did not differ by age in males[11]. Masticatory muscle activity during chewing in middle-aged and elderly females was less energy intensive than in young females[11]. The number of chews required to swallow food has also been reported to increase with age; that is, the effectiveness of chewing decreases with age[12]. It may, therefore, be inferred that, in this study, the effect of gum chewing while walking on physical and physiological functions may be affected by differences in gender and age.

The number of chews while walking could not be measured due to methodological limitations. In future studies, it will be necessary to measure the number of chews both at rest and while walking to compare these values. It will also be necessary to measure the amount of at-rest energy expenditure during gum chewing or after ingesting solutions containing the same ingredients as gum, as in this study. Collecting these additional data can allow for more detailed characterization of the effects of gum chewing while walking on physical and physiological functions.

The present study demonstrated that gum chewing during walking had a measurable effect on physical and physiological functions. These results also suggested that gum chewing during walking may increase the physical and physiological functions of middle-aged and elderly male participants in particular.

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Conflict of interest

S.K. and T.A. are employees of Lotte Co., Ltd. and were not involved in the data acquisition, statistical analysis, and interpretation of the results. M.M. has no professional relationships with the company involved in this study.

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