Appetite after rope skipping may differ between males and females

Hiroshi Kawanoa,*, Fumiya Motegib, Takafumi Andoc, Yuko Gandoa, Mayuko Minetac, Shigeharu Numaoa, Masashi Miyashitaa, Shizuo Sakamotoa, Mitsuru Higuchia

a Faculty of Sport and Sciences, Waseda University, Japan
b College of Sport and Sciences, Waseda University, Japan
c Graduate School of Sport and Sciences, Waseda University, Japan

Received 1 April 2011; received in revised form 30 June 2011; accepted 4 July 2011

KEYWORDS
Rope skipping exercise;
Gender;
Hunger

Summary
Background: When previously sedentary males and females follow the same exercise training programs with ad libitum feeding, males reduced body mass, but females do not, which suggests that females may increase appetite in response to exercise training compared with males. Rope skipping is traditional exercise modality that everyone had experienced during elementary school years in Japan. The purpose of this study was to determine whether there is a sex difference on appetite after acute rope skipping exercise.

Methods and results: Thirteen healthy young males (22.5 ± 0.8 years, 172.2 ± 1.7 cm, 68.8 ± 2.3 kg, 18.4 ± 0.9%) and 13 females (22.9 ± 0.8 years, 160.6 ± 1.5 cm, 52.9 ± 1.6 kg, 25.0 ± 1.0%) participated in this study. Subjects consumed their lunch by 13:00, and performed a total of 20 min rope skipping exercise (2 sets × 10 min with 5 min interval) from 16:00. In females, appetite significantly increased from immediately after the exercise to 30 min after the exercise (from 13 mm to 30 mm), but remained unchanged in males. Although heart rate, ratings of perceived exertion, and lactate concentrations increased from baseline to immediately after exercise, there were no differences in the increase between males and females. Blood glucose concentrations at baseline and 30 min after exercise were higher in females than in males.

Conclusion: These results indicated that rope skipping exercise induces an increase in appetite in females, but not in males. This increased appetite in females after the rope skipping exercise was induced without change in blood glucose concentrations.

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* Corresponding author at: 2-579-15 Mikajima, Tokorozawa, Saitama, Japan. Tel.: +81 4 2947 6833; fax: +81 4 2947 6833.
E-mail address: hiroshi@aoni.waseda.jp (H. Kawano).

doi:10.1016/j.orcp.2011.07.003
Introduction

Body mass is regulated by a balance between food intake and energy expenditure [1]. Recently, in developed countries, a prevalence of obesity in adult humans is increasing, which is caused by energy unbalance (i.e., both physical inactivity and excessive eating).

Habitual exercise or physical activity is widely recognized as playing an important role in weight management. However, although an acute bout of exercise is an effective treatment tool of increasing energy expenditure, and it may, paradoxically, lead to a short-term hunger suppression [2–7], chronic exercise or increase in physical activity alone (i.e., no restriction of energy intake) tend to be ineffective in causing weight reduction [8], which may be induced by exercise-related increased appetite. With regard to exercise-induced body mass reduction, both the reporting of weight reduction as mean values and the failure to differentiate between males and females distort the exercise-induced body mass reduction effect. For example, Donnelly et al. [9] have reported that although supervised aerobic exercise 5 days/week for 16-month reduced body mass in males who are ad libitum, females did not demonstrate change in body mass with this exercise program. These data suggest that when increasing physical activity, males do not sufficiently increase energy intake to balance their new higher energy expenditure. In contrast, females more precisely match energy intake with energy expenditure and therefore maintain body mass, which suggest that females may increase appetite response to exercise compared with males. However, it is unclear that whether this sex difference in appetite in response to aerobic exercise is immediately affected.

Rope skipping is traditional exercise modality that everyone who had experienced in Japanese school program. Previous studies have reported that oxygen consumption during rope skipping was reached more than 70% of maximal oxygen consumption [10,11], suggesting that rope skipping is a relatively high-intensity aerobic exercise. In addition, although walking or jogging, be needed safety course and road, must perform in wider field, rope skipping can be performed in field area less than walking and jogging. Moreover, to play rope skipping, it does not need to use too expensive technical machine, and it does only need a jump rope. These suggest that if there is a jump rope, everyone can play relatively high-intensity aerobic exercise at every time. However, it has never been reported the effect of acute rope skipping exercise on appetite in males and females.

Accordingly, we hypothesized that, compared with males, females would keep and enhance their appetite after acute rope skipping exercise, when characteristics of rope skipping is similar aerobic and endurance exercise such as jogging or bicycle exercise. The purpose of this study was to determine whether appetite after acute rope skipping exercise is different between males and females.

Methods

Subjects

Thirteen healthy young males (22.5 ± 0.8 years, 172.2 ± 1.7 cm, 68.8 ± 2.3 kg, 18.4 ± 0.9%) and 13 females (22.9 ± 0.8 years, 160.6 ± 1.5 cm, 52.9 ± 1.6 kg, 25.0 ± 1.0%) participated in this study. All subjects gave their written, informed consent to participate in this study. All procedures were reviewed and approved by the Human Research Committee of Waseda University.

Procedure

Measurements in each subject were carried out in a day. In the morning, subjects were examined physical fitness parameters such as handgrip strength, and 3-min walk. At 3-h after lunch, they were determined body mass, blood glucose and lactate concentrations, heart rate (HR) at the standing position, ratings of perceived exertion and hunger assessed by questionnaire. The subjects then performed the rope skipping test.

Physical fitness tests

Handgrip strength

Handgrip strength was measured with a handheld dynamometer (Grip-D; Takei Instruments, Niigata, Japan), with the subject standing and the arms extended by their sides [12]. The subjects then gripped the dynamometer as strongly as possible for 3 s without pressing the instrument against their body or bending at the elbow, and values (in kg) were recorded as the averages of two trials for each arm. The 2 values for the right and left arms were averaged to obtain the value of handgrip strength.

3-min walk

To determine endurance fitness of each subject, the 3-min walk was measured by using 20 m straight course. All subjects were instructed to walk at the 13 of ratings of perceived exertion (RPE). From distance (m) covered by this 3-min walk, maximal oxygen consumption (VO2max) in each subject was
Rope skipping and appetite

estimated by using equation reported by Cao et al. [13].

Rope skipping test

Protocol
All subjects were instructed to avoid exercise except for physical fitness tests in the testing day. Subjects were performed two, 10 min rope skipping exercise at a rate of 120 min⁻¹ separated by an interval of 5 min. Before first bout of exercise, and immediately and 30 min after second bout of exercise, blood glucose and lactate, heart rate, and RPE and hunger was measured. In addition, RPE, heart rate and hunger were also determined between first and second bouts of exercise.

Glucose and lactate concentrations
To measure glucose and lactate concentrations, capillary blood was taken by pricking a third or fourth fingertip with a lancet (BD Microtainer Contact-Activated Lancet, Becton Dickinson Co. Ltd. Franklin Lakes, NJ, USA). The first drop of capillary blood was discarded. Blood glucose and lactate concentrations were measured by One-Touch ASYST (LIFESCAN Inc., Milpitas, CA, USA) [14] and Lactate Pro (ARKRAY Inc., Kyoto, Japan) [15], respectively. Blood samples were collected before, immediately and 30 min after rope skipping exercise.

Heart rate
HR was determined by using manipulation method by their self for 20 s in each subject, and following evaluated per minute. HR was measured before, at immediately after the first bout of rope skipping exercise, at immediately and at 30 min after the second bout of rope skipping exercise.

Hunger
At the beginning of rope skipping exercise, subjects rated how hungry they felt using a 10 cm visual-analog scale (VAS) that ranged from left edge “not hunger” to right edge “very hunger” [16]. Hunger scales were recorded before the first bout of rope skipping exercise, at interval periods, immediately and 30 min after the second bout of rope skipping exercise.

Statistics
Changes were assessed by two-way analysis of variance (sex × time) with repeated measures. In the case of significant F-values, a post hoc test (Newman–Keuls Method) was used to identify significant differences among mean values. Gender differences in various variables were analyzed using the unpaired t-test. Relations of interest were identified by univariate correlation and regression analyses. All data are presented as the means ± SEM. Statistical significance was set at P < 0.05 for all comparisons.

Results

Table 1 shows the comparison of subject characteristics between males and females. In males, height, body mass, handgrip strength, and estimated VO₂max were higher, and percentage of body fat and body mass index were lower, as compared with females (all P < 0.05). There were no significant differences in age and 3-min walk distance between males and females.

Table 2 shows HR, RPE, glucose, and lactate concentrations in response to rope skipping exercise. Although, the interactions between group and time were not significant for HR, RPE, glucose and lactate concentrations, there were significant effects of time for HR, RPE, and lactate concentrations (all P < 0.0001). These parameters increased during rope skipping and at immediately after rope skipping exercise, and returned to baseline at 30 min after rope skipping exercise.

Table 3 shows appetite and desires to eat sweet foods, salty foods, fatty foods and sour foods in response to rope skipping exercise, and Table 4 shows the appetite in response to rope skipping exercise of each subject. There were no significant interactions for all parameter (Table 3). However,
there were significant effects of time for appetite and desire to eat sweet foods and sour foods (all P<0.05). In addition, the magnitude of change in VAS hunger ratings in females increased 30 min after rope skipping exercise compared with interval period and immediately after rope skipping exercise (P<0.05), but unchanged in males (Fig. 1). There were no significant relationships between hunger and RPE, glucose or lactate concentrations.

**Discussion**

The present study was the first to show that effect of acute rope skipping exercise on appetite in young males and females. The main finding of this study was that the change in appetite after rope skipping exercise augments in females compared with males. This result may support the previous findings that when sedentary males and females follow the same exercise training programs with *ad libitum* feeding, males lose body mass and fat mass, but females do not [9]. Given these results, it may be necessary to care diet for weight reduction through exercise program in females.

Lactate concentration is one of parameters to objectively evaluate exercise intensity. In the

**Table 2** Heart rate, RPE, blood glucose, and blood lactate in response to rope skipping.

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>Interval</th>
<th>Immediately after</th>
<th>30 min after</th>
<th>Group effect</th>
<th>Time effect</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (bpm)</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Males</td>
<td>80 ± 3</td>
<td>153 ± 4</td>
<td>160 ± 4</td>
<td>98 ± 5</td>
<td>NS</td>
<td>P &lt; 0.0001</td>
<td>NS</td>
</tr>
<tr>
<td>Females</td>
<td>84 ± 4</td>
<td>145 ± 5</td>
<td>158 ± 5</td>
<td>91 ± 5</td>
<td>NS</td>
<td>P &lt; 0.0001</td>
<td>NS</td>
</tr>
<tr>
<td>RPE (arbitrary unit)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Males</td>
<td>8.4 ± 0.5</td>
<td>17.4 ± 0.4</td>
<td>17.9 ± 0.4</td>
<td>10.5 ± 0.5</td>
<td>NS</td>
<td>P &lt; 0.0001</td>
<td>NS</td>
</tr>
<tr>
<td>Females</td>
<td>7.9 ± 0.4</td>
<td>16.9 ± 0.4</td>
<td>17.5 ± 0.5</td>
<td>9.8 ± 0.5</td>
<td>NS</td>
<td>P &lt; 0.0001</td>
<td>NS</td>
</tr>
<tr>
<td>Glucose (mmol/L)</td>
<td></td>
<td></td>
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<tr>
<td>Males</td>
<td>5.3 ± 0.1</td>
<td>—</td>
<td>5.5 ± 0.2</td>
<td>5.0 ± 1</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Females</td>
<td>5.9 ± 0.1</td>
<td>—</td>
<td>5.3 ± 0.2</td>
<td>5.7 ± 0.2</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>Lactate (mmol/L)</td>
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<tr>
<td>Males</td>
<td>1.9 ± 0.2</td>
<td>—</td>
<td>7.1 ± 1.0</td>
<td>2.7 ± 0.3</td>
<td>NS</td>
<td>P &lt; 0.0001</td>
<td>NS</td>
</tr>
<tr>
<td>Females</td>
<td>1.9 ± 0.2</td>
<td>—</td>
<td>7.6 ± 0.9</td>
<td>2.9 ± 0.4</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

Data are means ± SEM; RPE: ratings of perceived exertion.

**Table 3** Food cravings in response to rope skipping.

<table>
<thead>
<tr>
<th></th>
<th>Before</th>
<th>Interval</th>
<th>Immediately after</th>
<th>30 min after</th>
<th>Group effect</th>
<th>Time effect</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appetite (mm)</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>29 ± 8</td>
<td>22 ± 5</td>
<td>21 ± 6</td>
<td>29 ± 8</td>
<td>NS</td>
<td>P &lt; 0.0001</td>
<td>NS</td>
</tr>
<tr>
<td>Females</td>
<td>18 ± 4</td>
<td>14 ± 6</td>
<td>14 ± 5</td>
<td>32 ± 6</td>
<td>NS</td>
<td>P &lt; 0.01</td>
<td>NS</td>
</tr>
<tr>
<td>Desire to eat sweet foods (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>32 ± 6</td>
<td>22 ± 5</td>
<td>20 ± 6</td>
<td>32 ± 8</td>
<td>NS</td>
<td>P &lt; 0.01</td>
<td>NS</td>
</tr>
<tr>
<td>Females</td>
<td>23 ± 7</td>
<td>13 ± 5</td>
<td>17 ± 6</td>
<td>26 ± 6</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Desire to eat salty foods (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>25 ± 5</td>
<td>24 ± 8</td>
<td>19 ± 7</td>
<td>22 ± 6</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Females</td>
<td>21 ± 5</td>
<td>16 ± 7</td>
<td>17 ± 6</td>
<td>28 ± 6</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Desire to eat fatty foods (mm)</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>14 ± 4</td>
<td>12 ± 4</td>
<td>11 ± 6</td>
<td>12 ± 5</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Females</td>
<td>6 ± 2</td>
<td>2 ± 1</td>
<td>2 ± 1</td>
<td>5 ± 2</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td>Desire to eat sour foods (mm)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>31 ± 8</td>
<td>39 ± 7</td>
<td>37 ± 9</td>
<td>48 ± 9</td>
<td>NS</td>
<td>P &lt; 0.01</td>
<td>NS</td>
</tr>
<tr>
<td>Females</td>
<td>28 ± 7</td>
<td>23 ± 8</td>
<td>30 ± 7</td>
<td>41 ± 7</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

Data are means ± SEM.

**Figure 1** The amount of change in visual-analog scale hunger rating in males (●) and females (○). Data are mean ± SEM.
present study, there was a large variation in values obtained for lactate concentrations in both genders (males: 1.7–15.0 mmol/L, females: 2.2–13.2 mmol/L). Similarly, there was a large variation in values obtained for RPE in both genders (males: 14–20, females: 13–20). Considering that the acute effects of exercise on appetite or satiety sensation depends on the intensity of exercise [17,18], it is speculated the significant association between lactate concentrations and appetite at immediately after rope skipping exercise. However, our results indicated that the increase in lactate concentrations with exercise was not significantly related with appetite enhancement observed after 30 min rope skipping exercise, and there were no differences in change in lactate concentrations between males and females. Therefore, our results suggest that in the case of rope skipping exercise, increase in appetite after exercise may not depend on exercise intensity. Furthermore, we speculate idea that intense pumping with rope skipping may affect the exercise intensity-mediated change in appetite.

We found that appetite in females increased at 30 min after rope skipping exercise, as compared with at the interval and immediately after rope skipping exercise. Generally, it is thought that the appetite or satiety is affected by glucose changed at fasting or feeding via appetite-related hormones such ghrelin [19,20]. Although we did not measure insulin and free fatty acid concentrations, at least, trend of glucose was not linked with change if appetite with rope skipping exercise, in particular, at 30 min after rope skipping exercise. This suggests that an increased appetite at post rope skipping exercise in females may be independent from glucose concentrations.

Several hormones play an important role of appetite regulations in the short-term; for example, ghrelin, cholecystokinin, peptide YY, glucagon-like peptide-1 (GLP-1), or pancreatic polypeptide [21]. Although these hormones were not measured in the present study, in the previous studies focusing on effects of acute exercise on appetite regulating hormones [4,17,19,22–24], it is reported that exercise-induced increase or
decrease in appetite was related with the changes in ghrelin, cholecystokinin, peptide YY, GLP-1, and pancreatic polypeptide. Moreover, we speculate that the increase in appetite at 30 min after rope skipping exercise in females observed in the present study may also be affected by these appetite-associated hormones. Stensel has described in the previous review that a possible explanation in detail for sex difference of appetite after rope skipping exercise may be the necessity for females to maintain sufficient body mass or fat stores for reproductive success [25]. Hagobian et al. observed compensatory increases in acylated ghrelin in females but not males after 4 days of exercise training designed to induce an energy deficit [26]. Differences in the insulin response to a meal tolerance test after 4 consecutive days of exercise training were also observed between male subjects and female subjects indicating a tendency for lower circulating concentrations of insulin in female subjects [26]. In another study, 12 weeks of exercise training lowered leptin concentrations in females but not males [27]. These differences observed in previous studies [26,27] suggest that a tendency for appetite to be stimulated by exercise in females in contrast with males. Thereby, we speculate that compared with males, females may be more sensitive to energy deficit induced by exercise for maintaining body mass and/or body fat. Nonetheless, because it has never been determined these appetite-associated hormones during or after rope skipping exercise, the results of the present study must be confirmed in future prospective exercise study focusing on these hormones.

Although some studies reported that hunger is suppressed during and at immediately after exercise [4,19,22,23], we found no reduction in hunger during and at immediately after rope skipping exercise. To simulate realistic condition in daily living, exercise in the present study was performed at 3-h after lunch. Several studies have carried out exercise at morning with 12-h fasting [4,17,19,22,24,28]. Although this experimental procedure as a 12-h fasting, is valid and useful to focus on the decrease in appetite with acute exercise, it is thought that many people do not exercises in the morning with fasting in daily living. Therefore, rope skipping exercise in the present study was proposed and carried out at afternoon, simulating the time after business or during tea break. From these, we think significance of this study that sex difference in appetite in response to exercise presented under the realistic condition by using rope skipping exercise.

Study limitation
The reader should be aware of one limitation associated with the present study. Because our study was small sample size, the present finding should be confirmed by further study using larger sample size. Nevertheless, we cannot deny the possibility that the appetite in females increase after acute exercise.

Conclusion
The present study was designed to elucidate the sex different effects of acute exercise on appetite by using rope skipping. As a result, we found that appetite ratings at 30 min after rope skipping exercise in females were higher than immediately after rope skipping exercise, but not in males. Furthermore, this increased appetite in females after the rope skipping exercise was induced without change in blood glucose concentrations. These results support thought that for body mass control, a combination of exercise and diet may be effective in successful body mass control, particularly in females.

Acknowledgment
We specially thank all subjects in the present study. This study was supported by Grants-in-Aid for global COE program "Sport Sciences for the promotion of Active Life" from the Ministry of Education, Culture, Sports, Science and Technology of Japan.

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