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Original Paper

Effects of Eating or Skipping Breakfast on Heart Rate and Oxygen Uptake

Yuka NOSE[*], Masayoshi HIRAO[**], Kazuki NISHIMURA[***], Keita ARAKANE[****], Tatsuya SAITO[****], Terumasa TAKAHARA[*] and Sho ONODERA[*****]

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Abstract

The purpose of this study was to compare changes in heart rate, oxygen uptake, blood pressure and oral temperature between subjects eating breakfast and subjects skipping breakfast when they exercise each day at 11:00AM and 2:00PM. The study design included two different groups, a breakfast group and a skipping group. Subjects rested for five minutes, and they exercised on a pendulum ergometer for twenty minutes. After exercising, the resistance was returned to zero for a one minute cool down followed by five more minutes of complete rest (recovery phase). Oral temperatures of the skipping group were lower than those of the breakfast group at 11:00AM. Diet induced thermogenesis (DIT), which increases core body temperature, is generated by eating breakfast. In the skipping group, the resting heart rates at 11:00AM were lower than at 2:00PM. A significant difference in heart rate after the first minute of exercise was seen between 11:00AM and 2:00PM in the skipping group. These results suggested that when skipping breakfast, the heart rate response immediately after beginning exercise is slow in the morning. Although all subjects did cooling down for one minute after exercising, oxygen uptake during the recovery phase in the skipping group at 11:00AM was significantly higher than at rest. These results suggest that eating breakfast has a physiological influence on both heart rate and oxygen uptake.

Introduction

The trend of skipping breakfast is increasing every year among people in their twenties and thirties in Japan. Skipping breakfast was reported to cause nutritional deficiencies, indefinite complaints such as tiredness and increased susceptibility to hypothermia [1, 2].

David and Parker [1] reported that the time taken for recall was significantly greater when the subjects fasted than when they ate breakfast. Achievement test scores among schoolchildren who ate breakfast every day were higher by about 10 percent than those of schoolchildren who skipped breakfast all or most of time, and the physical strength of people who ate breakfast were greater than that of someone who skipped

* Doctoral Program in Health Science, Graduate School of Health Science and Technology, Kawasaki University of Medical Welfare, Kurashiki, Okayama 701-0193, Japan
E-Mail: w8509002@kwmw.jp
** OG Giken CO. , Ltd. Okayama, Okayama 703-8261, Japan
*** Department of Global Environment Studies, Hiroshima Institute of Technology, Hiroshima, Hiroshima 731-5193, Japan
**** Master's Program in Health and Sports Science, Graduate School of Health Science and Technology, Kawasaki University of Medical Welfare, Kurashiki, Okayama 701-0193, Japan
***** Department of Health and Sports Science, Faculty of Health Science and Technology, Kawasaki University of Medical Welfare, Kurashiki, Okayama 701-0193, Japan

breakfast even occasionally [3]. Breakfast intake influences both scholarship and physical strength a like.

There are already some reports concerning the effects of breakfast intake on intelligence and incidental tasks. However, there is little physiological research on the relationship between breakfast intake and physical strength. The purpose of this study was to compare changes in heart rate, oxygen uptake, blood pressure and oral temperature between subjects eating breakfast and subjects skipping breakfast when they exercise each day at 11:00AM and 2:00PM.

Methods

1. Subjects

The study design included two different groups. We recruited thirteen students and asked for their breakfast frequency. Subjects who ate breakfast every day will be called the “breakfast group”, and subjects who ate breakfast only two times or less during the week will be called the“skipping group”. Each of the subject's characteristics was shown in Table 1. Their age and anthropometric measures were presented in Table 1. Both groups had movement customs. None of the participants had a disease or received drugs. All subjects were recruited by a notice board within the university and gave a signature of informed consent before inclusion.

Table 1 Subjects' characteristics

	age (years)	height (cm)	weight (kg)
Breakfast group （n＝7）	21.8±1.2	169.0±5.3	62.2±4.5
Skipping group （n＝6）	22.1±1.9	167.3±6.7	64.3±6.7

Values are means ±SD.

No significant differences between breakfast group and skipping group

2. Experimental design

All subjects got up no later than 9:00AM. Breakfast group subjects ate breakfast no later than 9:00AM. And after ingestion, they were allowed water only until 11:00AM. All subjects ate lunch between 12:00PM and 12:30PM, and they were allowed water only until 2:00PM. The subjects were studied at 11:00AM and 2:00PM.

3. Protocol

Subjects rested for five minutes. After that, they exercised on a pendulum ergometer for twenty minutes. They warmed up with thirty seconds of pedaling with no resistance. Then the machine was re-calibrated to a setting of 1.3kp of resistance. Subjects were instructed to pedal at a frequency of 60rpm. After nineteen and a half minutes more of exercise, the resistance was returned to zero for a one minute cool down followed by five more minutes of complete rest. The measurements taken were heart rate, oxygen uptake, blood pressure and oral temperature. Heart rate was measured at one-minute intervals throughout all trials using an HR monitor(POLAR:S610i). A total of six breath samples per subject were collected using the Douglas bag method when the subjects were at rest, and every five minutes during exercise and recovery (ARCO SYSTEM:ARCO-2000). Each exhaled breath sample was collected into a Douglas bag for a period of five minutes during the resting and recovery phases and for four two-minute periods during exercise, from the third minute to the fifth, from the eighth to the tenth, from the thirteenth to the fifteenth, and from the eighteenth to the twentieth minute. Blood pressure was measured at rest and at every five minutes during exercise and recovery (YAMASU:ANEROID SPHYGMOMANOMETER). Oral temperature was measured before exercising using the electronic clinical thermometer (OMRON:MC-672L).

4. Statistical analysis

Two-way analysis of variance for repeated measurements (condition × time course) and the paired t-test were used for comparison of each measured value between 11:00AM and 2:00PM and an unpaired t-test was used for comparison of each measured value between the breakfast group and the skipping group at rest. Differences were considered significant at $p<0.05$. All results are presented as means±SD.

5. Results and discussion

No significant differences in timing for rising and eating breakfast were shown between the breakfast group and the skipping group (Table 2).

Table 2 Wake up time and breakfast time

	Breakfast group	Skipping group
Wake up time	8:00AM ± 47.3min	8:37AM ± 37.5min
Breakfast time	8:31AM ± 31.0min	Not eating

Values are means ±SD.
No significant differences between breakfast group and skipping group

The oral temperatures of the skipping group were lower than those of the breakfast group at 11:00AM($p<0.05$), (Table 3). Diet induced thermogenesis (DIT), which increases core body temperature, is generated by eating breakfast. Hypothermia decreases work capability. Stephan et al. [4] reported that measurements of intellectual capability and brain function such as the time taken to calculate and to work correlate with instability of body temperature.

Table 3 Changes in oral temperature at rest

	11:00AM	2:00PM
Breakfast group	36.6 ± 0.2	36.6 ± 0.4
Skipping group	36.2 ± 0.2* **	36.5 ± 0.3

Values are means ±SD.
*Significant difference between 11:00AM and 2:00PM($p<0.05$)
**Significant difference between breakfast group and skipping group($p<0.05$)

No significant differences in blood pressure were shown in either group throughout the study (Fig.1). Earlier studies [5] have reported that fasting causes hypotension. Breakfast group subjects fasted more than twelve hours, but this study does not agree with that claim.

Changes in the heart rate were shown in Fig.2. In the skipping group, the resting heart rates at 11:00AM were lower than those at 2:00PM($p<0.05$)(Table 4). Pivic [6, 7] reported that subjects who skipped breakfast showed a significant slowing of heart rate, while heart rate among those who ate breakfast rose to significantly higher levels after eating. Because eating is accompanied by increased blood flow to facilitate digestion, significant eating-related heart rate increase has been reported in adults [8, 9]. Additionally, postprandial heart rate increases have been associated with indications of reduced parasympathetic activity (decreased HF ; [10, 11] or increased LF variability [12]. Postprandial heart rate increases continue for at least two and a half hours after eating. Because the skipping group subjects took lunch, the heart rate had significantly increased at 2:00PM.

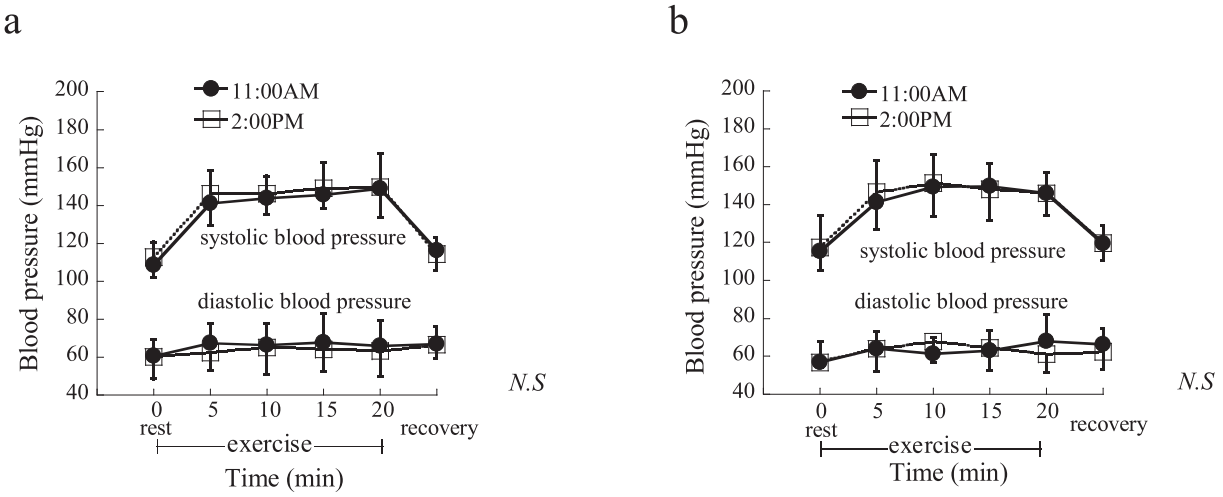

Fig.1 Changes in blood pressure

Graph shows changes in blood pressure between 11:00AM and 2:00PM.

Value are means ± SD.

a : Breakfast group and b: Skipping group

N.S. : No significant differences following a two-way ANOVA.

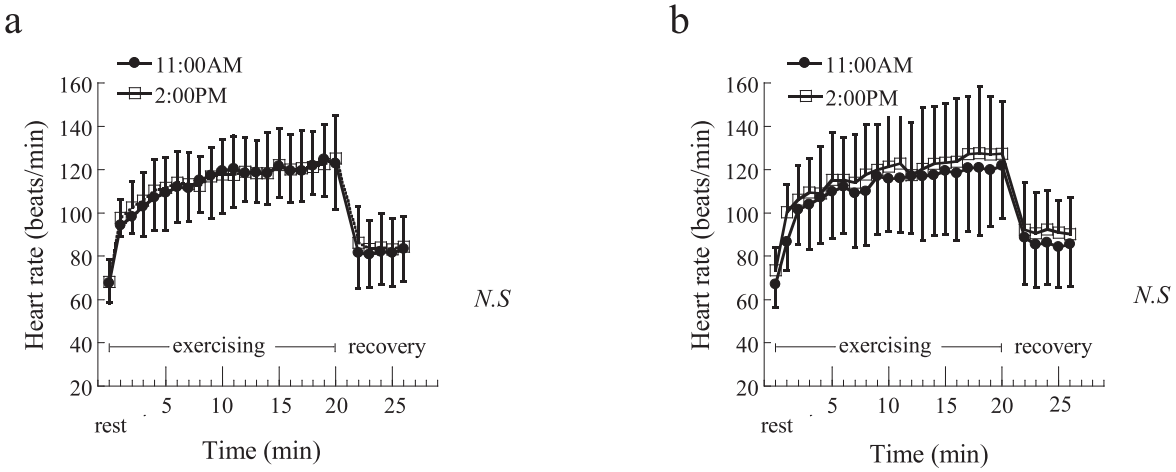

Fig.2 Changes in heart rate

Graph shows changes in heart rate between 11:00AM and 2:00PM.

Value are means ± SD.

a : Breakfast group and b: Skipping group

N.S. : No significant differences following a two-way ANOVA.

Table 4 Changes in heart rate at rest

	11:00AM	2:00PM
Breakfast group	67.5 ± 9.0 bpm	68.0 ± 10.3 bpm
Skipping group	67.0 ± 10.6 bpm	73.0 ± 10.6 bpm*

Values are means ±SD.

*Significant difference between 11:00AM and 2:00PM($p<0.05$)

Immediately after the beginning of exercise, the active muscles need an increased supply of oxygen. Therefore the heart rate increases rapidly, and overshoots at about fifteen seconds, and it increases in exponential function at the third minute, and rapidly to a rate that delivers the necessary oxygen [13]. The

heart rate after the first minute of exercise of the skipping group at 2:00PM had risen to the same level as the breakfast group's heart rates were at both 11:00AM and 2:00PM (Table 5). At 11:00AM, the skipping group heart rate did not reach this level until after the second minute of exercise, and heart rate only achieved this level after the second minutes of exercise at 11:00AM in the skipping group.

Table 5 Initial heart rate response to exercise in the first minute of exercise

	11:00AM	2:00PM
Breakfast group	26.6 ± 5.7 bpm	29.5 ± 10.9 bpm
Skipping group	19.7 ± 6.2 bpm	26.7 ± 6.9 bpm*

Values are means ±SD.
*Significant difference between 11:00AM and 2:00PM($p<0.05$)

Changes in oxygen uptake were shown in Fig.3. The skipping group's oxygen uptake at rest at 11:00AM was significantly lower than at 2:00PM. This result agrees with the lack of DIT in the skipping group at 11:00AM. Increases of the oxygen uptake continue about three hours after meals. Subjects had lunch before conducting the experiment at 2:00PM : from one hour and a half to two hours before. Also, when the temperature falls one degree, the metabolism drops by thirteen percent. This decrease of heart rate and oral temperature induces a lower level of oxygen uptake.

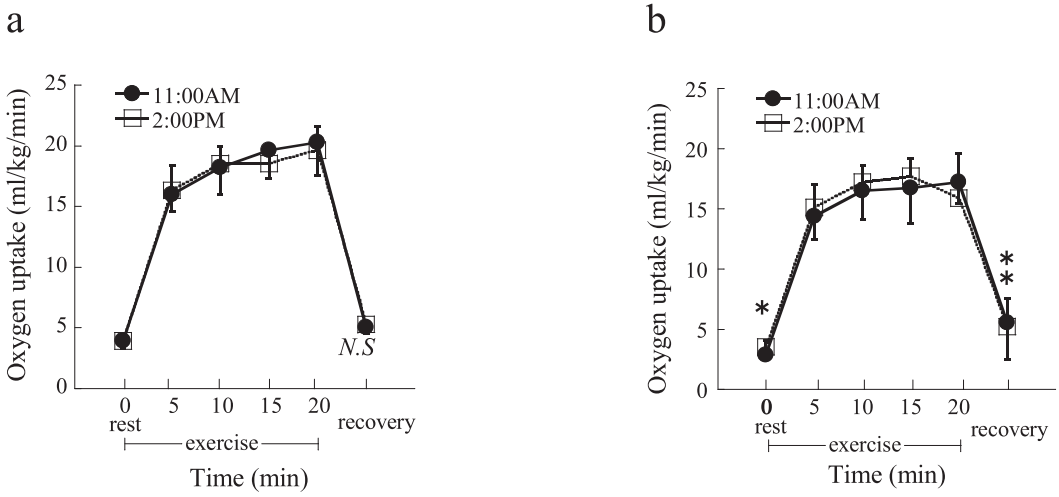

Fig.3 Changes in oxygen uptake
Graph shows changes in heart rate between 11:00AM and 2:00PM.
Value are means ± SD.
a : Breakfast group and b: Skipping group
N.S. : No significant differences between 11:00AM and 2:00PM.
**p<0.05 11:00AM vs 2:00PM*
***p<0.05 rest vs recovery at 11:00AM*

No significant differences in oxygen uptake were shown between at resting and recovery phase at 11:00AM and 2:00PM in the breakfast group and at 2:00PM in the skipping group. Because all subjects were cooling down for one minute before recovery phases. But oxygen uptake at recovery phases in the skipping group were significantly higher than at resting in 11:00AM. Earlier studies [14] reported that heart rate and oxygen uptake became correlated immediately after the exercise began. It was suggested

that the oxygen uptake level in the skipping group at 11:00AM rose more slowly than the levels of the skipping group at 2:00PM and the breakfast group at 11:00AM and 2:00PM. As for results, the oxygen deficit at 11:00AM in the skipping group was higher than that of the other groups. Because of the lower time resolution of the Douglas bag gas sampling method, we could demonstrate neither a larger oxygen deficit nor EPOC. But oxygen deficit influences EPOC. It is possible that the EPOC of the skipping group at 11:00AM is higher than at 2:00PM in the skipping group and 11:00AM and 2:00PM in the breakfast group. Insufficient oxygen uptake at 11:00AM in the skipping group resulted in an inability to recover within the cooling down period.

Conclusion

In the skipping group, the resting heart rates and oral temperatures at 11:00AM were lower than those at 2:00PM. The decrease in the resting heart rates and oral temperatures when skipping breakfast may reflect lower metabolism as demonstrated by lower resting oxygen uptake levels. Initial heart rate responses to exercise in the morning were significantly lower in the skipping group.

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References

1. David Benton, Parker PY: Breakfast, blood glucose, and cognition. *Am J Clin Nutr* 67(suppl):772S-778S, 1998.
2. Dickie NH, Bender AE: Breakfast and performance in schoolchildren. *Br J Nurtr* 48:483-496, 1982.
3. Ministry of Education, Culture, Sports, Science and Technology : Japan
4. Stephan K: Circadian Rhythms in the Central Nervous System, Eds. *P.H.Redfern Weinheim*, 1985.
5. Mattson MP, Wan R: Beneficial effects of intermittent fasting and Caloric restriction on the cardiovascular and cerebrovascular systems. *J Nutr Biochem* 16:129-137, 2005.
6. Pivik RT, Dykman RA, Tennal K, GuY: Skipping breakfast: Gender effects on resting heart rate measures in preadolescents. *Physiol Behav* 89:270-280, 2006.
7. Pivic RT, Dykman RA: Cardiovascular effects of morning nutrition in preadolescents. *Physiol Behav* 82:295-295, 2004.
8. Uijtdehaage SHJ, Shapiro D, Jaquet F: Effects of carbohydrate and protein meals on cardiovascular levels and reactivity. *Biol Psychol* 38:53-72, 1994.
9. Kelbeak H, Munck O, Christensen NJ, Godtfredsen J: Central hemodynamic changes after a meal. *Brit Heart J* 61:506-509, 1989.
10. Lu C-L, Zou X, Orr WC, Chen JDZ: Postprandial changes of sympathovagal balance measured by heart rate variability. *Digest Dis Sci* 44:857-861, 1999.
11. Vaz M, turner A, Kingwell B, Chin J, Koff E, Cox H: Postprandial sypatho-adrenal activity, its relation to metabolic and cardiovascular events and to changes in meal frequency. *Clin Sci* 89:349-357, 1994.
12. Lipsitz LA, Ryan SM, Parker JA, Freeman R, Wei JY , Goldberger AL: Hemodynamic and autonomic nervous system responses to mixed meal ingestion in healty young and old subjects and dysautonomic patients with postprandial hypotension. *Circulation* 87:391-400, 1993.
13. Linnarsson D: Dynamics of pulmonary gas exchange and heart rate changes at start and end of exercise. *Acta Physiol Scand Suppl* 415:1-68, 1974.
14. Ishida K, Sato Y, Katayama K, Miyamura M: Initial ventilatory and circulatory responses to dynamic exercise are slowed in the elderly. *J Appl Physio* 89:1771-1777, 2000.