Effects of walking exercise on body weight gain and body composition of rats

2. Effects of walking exercise on body fat deposition under environmental temperature of 30°C

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Abstract

The present study aims to learn the effects of walking exercise on the body fat deposition of rats fed under high environmental temperatures. Nineteen healthy male rats, aged 3 weeks, were used. They were fed in individual cages located in a temperature-controlled room (30±2°C). They were given commercial feed. Preliminary feeding was conducted for 7 days. Experimental groups were divided into three as follows: supplementary group (7 rats), free-moving control group (6 rats) and walking exercise (14m/min.) group (6 rats). Selection of rats for the walking exercise was carried out at random after the pre-experiments of 7 days. The rats in the walking exercise group were trained to walk for 30min/day during this period. Walking exercise was conducted for 3 hours every day using a motor walking wheel. The rats in the control group had their feed removed for 3 hours every day. At the start of the experiment, the rats in the supplementary group were killed with diethyl ether while the rest of the rats were killed similarly at the end of the experiment (4 weeks later). Chemical composition of the bodies was analyzed, then compared with those of the other groups. Body weight gain, total feed intake and feed efficiency showed no significant difference among the experimental groups. But the results for the accumulated ratio of ether extracts and calories from feed were significantly (P<0.01) lower in the exercise group compared to those of the control group. The present study failed to recognized the effect of high environmental temperature on the accumulation of body fat, walking exercise under 30°C environmental temperatures also reduced the accumulation of body fat, as were observed in previous results for under 21°C environmental temperatures. A rat in the control group was lost due to our error. This accident suggests that 14m/min. for 3 hours of walking might be too strenuous for an inexperienced rat.

Key Words: Walking exercise, Environmental temperature, Body fat deposition, Rats

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Introduction

In a previous study\(^1\), it was recognized that walking exercise reduced body fat deposition of rats and that walking exercise at a determined level (for 3 hours under a speed of 14 to 28 m/min.) had a constant effect on the body fat deposition. The body composition of animals varies according to their growth and changes from differences in nutritional intake and environmental temperature. Generally animals reduce body weight gain in summer, because their appetite reduction controls heat production which is induced by digestion and energy metabolism. Body fat deposition is reduced in accordance with body weight gain reduction under high environmental temperature conditions\(^1\,\,2\). Earlier studies\(^3\,\,3\,\,4\,\,5\) demonstrated that body fat was reduced by endurance exercise, but few studies have been carried out under peculiar, hot or cold environmental conditions. The present experiment aims to recognize similar effects of walking exercise on body fat deposition of rats under high environmental temperatures (30°C) when compared to those recognized under appropriate temperatures determined in the previous study\(^1\). The effects of walking exercise on growth and body composition were evaluated from the analysis of chemical composition of carcasses of rats after the feeding test.

Materials and methods

Nineteen healthy male Sprague-Dawley strain rats were used. At age 3 weeks, they were purchased from Japan Clea Co. Ltd. Animals were fed in individual cages (38 × 25 × 21 cm) and were kept in a temperature-controlled room (30 ± 2°C). Daylight period was from 6:00 a.m. to 6:00 p.m. They were given commercial feed (CE-II: Japan Clea Co. Ltd.) and water freely outside their exercise period. Chemical composition of the feed is shown in Table 1. Rats were distributed into 3 groups, supplementary group (7 rats), free-moving control group (6 rats) and walking (14 m/min.) exercise group (6 rats) and had the same mean initial body weight during the pre-experiment for 7 days. Seven rats in the supplementary group were killed with diethyl ether on the first day of experiments to determine the chemical composition of their whole body. The animals in the walking exercise group were trained to walk for 30 min/day during the pre-experiment. The walking period was 3 hrs/day in this experiment. Walking exercise was conducted using a motor walking wheel (made by Natsume Seisakusho), the circumference of which was one meter. The walking exercise period of 3 hrs was distributed at random during the daytime period because the circadian rhythm of rats affects their physiological response\(^6\). Though six rats in the control group were not made to walk by force, their feed was removed for 3 hrs/day. Body weight was determined every week and feed intake was determined every day. At the end of experimental period of 4 weeks, all of rats in control and walking exercise groups were killed and their whole body was processed with a meat chopper to determine the chemical composition. Determination of chemical composition (moisture, crude protein, ether extracts as crude fat, crude ash) and calories was conducted using the usual methods for meat\(^7\) analysis. Statistical

<table>
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<th>Table 1. Chemical composition of feed</th>
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<td>Moisture (%)</td>
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<td>Crude protein (%)</td>
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<td>Ether extracts (%)</td>
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<td>Nitrogen free extracts (%)</td>
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<td>Calorie (kcal/100g)</td>
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Body fat reduction of rats by walking in 30°C room

treatment was conducted with one-way analysis of variance (P<0.01).

Results

During the experimental period, we took a rat from the control group and put it into the walking exercise group owing to our mistake. The rat from the control group, suddenly forced to exercise, could not continue walking for 3 hours and died. Therefore, the mean ± S.D. of each determined value in the control group was calculated with 5 replications.

Body weight gain: The mean initial body weight at the start of the experiment was 92.6 ± 1.4g (n=18). Final mean body weight for the control group was 282.9±19.4g (n= 5 ); their mean body weight gain was 190.3±17.1g. The final mean body weight for walking exercise group was 279.0±5.4g (n= 6 ); their mean body weight gain was 186.4±5.8g. There was no significant difference (P>0.01) in the body weight gain between the control and walking exercise groups.

Total feed intake: There was no significant difference (P>0.01) between the total feed intake of the two groups. Their values were as follows: control group, 530.4±17.1g (n= 5 ); walking exercise group, 517.1±19.3g (n= 6 ).

Feed efficiency: There was no significant difference (P>0.01) between feed efficiency of the two groups, which was calculated using body weight gains and feed intake during the test period. The value of feed efficiency in the control group was 35.8±1.3% (n= 5 ) and for the walking exercise group was 36.2±3.0 % (n= 6 ).

Chemical composition of the whole body: Chemical composition of the whole body is shown in Table 2. Moisture in the supplementary group was 71.8±0.3% (n= 7 ). The values for the two groups were as follows: control group, 66.3±0.6% (n= 5 ); walking exercise group, 67.5±0.9% (n= 6 ). The values for crude protein, ether extracts, crude ash and calories were calculated to a dry matter ratio using the above-mentioned moisture values. Significant differences (P<0.01) were recognized in crude protein, ether extracts, crude ash and calories in a comparison between the control and walking groups, but there was no significant difference in moisture values.

Accumulated ratio of chemical composition from feed: The net volume (g) of each chemical composition was calculated with the above-mentioned percentages and body weight. Accumulated values during the test period were calculated using the following expression: (the value at the finishing point)-(the mean value of the supplementary group at the starting point). Furthermore the ratios between these values and the net volume of each chemical composition from feed were

| Table 2. Chemical composition and calories of whole body |
|---------------------------------|----------------|-----------------|-----------------|-----------------|
|                                | Moisture(%)    | Crude protein (DM%) | Ether extracts (DM%) | Crude ash (DM%) | Calorie (kcal/DMg) |
| Supplementary group (n= 7)     | 71.8±0.3       | 62.1±0.6         | 23.7±0.9          | 10.9±0.8        | 5.8±0.0           |
| Control group (n= 5 )          | 66.3±0.6       | 59.5±0.6*        | 29.9±1.6*         | 9.8±0.2*        | 6.2±0.2*          |
| Walking exercise group (n= 6)  | 67.5±0.9       | 66.2±1.2*        | 19.8±1.9*         | 12.4±0.8*       | 5.6±0.1*          |

Mean ± S.D. in the same vertical line not sharing a common superscript letter are significantly different (P<0.01) in comparison of control group and walking exercise group.
calculated as the chemical composition accumulated ratio (Fig. 1). In these ratios, crude protein and crude ash showed no significant difference. On the other hand, the values of ether extracts and calories in the walking exercise group were significantly (P < 0.01) lower than those in the control group.

**Discussion**

The present study failed to recognize the effect of environmental temperature on the body composition of animals. It seemed that the present environmental temperature (30°C) is beyond the limits of the thermoneutral zone of rats. It is well known that high environmental temperatures reduce feed intake and suppress heat production. KURIHARA et al. reported that in rats fed under high environmental temperatures, energy intake decreased when environmental temperatures of 28°C and 33°C were compared, having been induced by a decrease in feed intake. In this study the body weight gain and the feed intake showed no significant difference in comparison with the control group and the walking exercise group. The values of feed efficiency also showed no significant difference between the both groups. In both groups (35.8±1.3% and 36.2±3.0%) in this study, these were demonstrated to be slightly higher than the value (33.0±0.8%) of the control (free-moving) group in the previous study conducted under 21°C, and the improvement of these values appears to be induced by high environmental temperatures. Generally, the feeding of animals under high environmental temperatures, within an animal's allowance range, demonstrates a high value of feed efficiency. KURIHARA et al. also reported that the energy accumulation ratio for energy intake did not vary between the environmental temperatures of 28°C and high environmental temperatures (33°C) in the study using 7 weeks-old male rats. Furthermore, KAWASHIMA and YANO reported that the feeding of male rats, which weighed about 90g, at a high environmental temperature (34°C) induced the change of protein into fat by a metabolic pathway with the fat accumulating in the peritoneal cavity. Therefore it seemed that the rats with the same feed intake levels accumulated the same amount of body fat in the two groups under the conditions in this study. Contrary to this hypothesis, the significant difference in the body fat level in this study seemed to be induced by walking exercise.

The rats in the exercise group showed a slightly smaller feed intake in comparison with that of the control group. Therefore feed intake was not accelerated by the exercise. A similar tendency was also shown in the previous study. Feed intake in both groups in this study cannot be compared to the previous results directly, because of the difference of age and environmental temperature. Present results also show the reduction of body fat deposition, energy and the accumulated ratio of ether extracts by exercise to be the same as in the previous study conducted under an environmental
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temperature (21°C). WANG and ITÔ reported similar effects of forced walking on the body fat deposition in broilers to the present results, their experiment being conducted under environmental temperatures which varied from 30 to 22°C. LACHICA and AGUILERA reported that the energy for exercise was produced from fatty acids because the RQ values were reduced by exercise. KURIHARA et al. also reported that a high environmental temperature (33°C) reduced heat production that was calculated by RQ values. Therefore, the effects of walking exercise on body fat deposition were also recognized under high environmental temperatures without effects on the accumulation rates of crude protein and crude ash.

In our previous study, the walking speed of 14 m per minute for 3 hours on the motor walking wheel reduced the body fat deposition at 21 ± 2 °C. The rat was able to endure an acceleration in walking speed to 20 m per minute, which took 4 weeks. Practice for the walking exercise is important in this study with the present conditions (walking speed of 14 m per minute for 3 hours) decided by previous results. Although the present walking conditions seemed to be easy for rats, an erroneously induced accident to the rat in this study suggested that the present walking speed and period of time may be severe for an inexperienced rat in its endurance exercise ability.

Acknowledgement

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Effects of walking exercise on body weight gain and body composition of rats

歩行運動がラットの成長と体成分に及ぼす影響

2. 高温環境下の歩行運動が体脂肪蓄積に及ぼす影響

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要約

本試験は高温環境下で飼育されるラットの体脂肪量に対する歩行運動の影響を検討するためを行った。試験には3週齢9匹の雄ラットを用いた。個別ケージに収容して、30±2℃に調温された飼育室で飼育した。給与飼料は市販の維持繁殖用固定飼料を用いた。7日間の予備飼育を行い、その後平均体重が等しくなるように各区にラットを振り分けた。試験区は補正区、自由行走の対照区、14m/分の歩行運動区の3試験区とした。歩行運動区のラットは予備試験中に短時間の歩行運動に慣らした。本試験期間中の歩行運動は毎日3時間モーター付きの回転槽で行い、対照区のラットも3時間は飼が摂取できないように回収した。試験開始時に補正区のラットはジーエチルエーテルで屠殺し、他のラットも4週間後の試験終了時に同様の処理を行った。体重全体の化学成分は肉類の分析に対する常法で分析し、その結果を相互の区間で比較した。増体重、飼料摂取量、飼料効率の結果に有意差は認められなかった。しかし、飼料に由来する蓄積化学成分において歩行運動区のラットでは粗脂肪およびカロリーが対照区において得られた値よりも有意に低くなった。本試験では30℃の環境温度下で实施した歩行運動が21℃の環境温度下で行った歩行運動と同様に粗脂肪の蓄積を抑制することが認められた。対照区のラットを試験区とまちがえたことにより、突然の運動を付加された対照区ラット（1匹）が事故死した。この事は運動未経験のラットにとって14m/分、3時間の歩行運動は過酷かもしれないことを示唆している。

キーワード：歩行運動、環境温度、体脂肪蓄積、ラット

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