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

1. Effects of two exercise protocols on body fat deposition

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Summary

The present study aimed to examine the effects of walking exercise on the body fat deposition of rats. Twenty-five male rats, aged 4 weeks old, were used. They were fed in individual cages located in a temperature-controlled room (21 ± 2 °C). Preliminary feeding was conducted for 10 days and rats were then selected for walking exercise groups. Four experimental groups were made as follows: supplementary group, free-moving control group, fixed-speed (14m/min.) group and accelerated-speed (14 to 28m/min. for 4 weeks) group. Walking exercise was conducted for 3 hours every day using a motor walking wheel; rats in the free-moving control group had their feed removed for 3 hours. At the starting point of the experiment, the rats in the supplementary group were killed with diethyl ether while the other rats were killed similarly at the end of the experiment (4 weeks later). Chemical composition of the body was analyzed, then compared with the other groups. Body weight gain in both walking exercise groups had significantly (P<0.01) lower values than those of the free-moving control group, and there was no significant difference among the walking exercise groups. Total feed intake and feed efficiency showed similar results or tendency as body weight gain. In the accumulated ratio of chemical composition from feed intake, the values for crude protein and crude ash showed no significant difference among the three experimental groups, but the values for ether extracts in both walking exercise groups were significantly lower than those of the free-moving control group. Present results suggest that the different exercise protocols examined in this study have no significant effect on the body weight gain and body fat deposition of rats.

Key Words: Walking exercise, Body weight gain, Body fat deposition, Rats

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Introduction

It is well known that appropriate exercise is useful for the physical and mental health. Many studies propose that endurance exercise like a walking or swimming has effects on the body composition. In these previous studies, body fat reduction was demonstrated by endurance exercise. However, it seemed that the reduction of body fat by exercise was induced via various mechanisms of the utilization of fat as a source of energy for the exercise. Accumulation of body fat was altered by feed composition, environmental temperature, protocol of exercise and a combination of these factors. Authors grappled with the improvement of meat quality by fattening swine with the walking exercises. It is necessary to study the fundamental knowledge about the effect of walking exercise on the body composition of experimental animals under different environmental temperatures before experimenting on domestic animals such as fattening swine.

In the present study, two types of walking exercise protocol under the appropriate environmental temperatures for the rats were evaluated from the analysis of chemical composition of carcasses of rats fed ad libitum using the same feed.

Materials and methods

Twenty-five male Sprague-Dawley strain rats were used. At age 4 weeks old, they were purchased from Japan Clea Co. Ltd. Animals were kept and fed in individual cages (38 × 25 × 21 cm) in a temperature-controlled room (21±2°C). Daylight period was from 6:00 am to 6:00 pm. Selection of rats for the walking exercise was carried out at random during pre-experiments for 10 days. They were given commercial feed (CE-II: Japan Clea Co. Ltd.) and water freely without the exercise period. Chemical composition of feed is shown in Table 1. Selected rats were classified into the following 4 groups: supplementary group (7 rats), free-moving control group (6 rats), fixed-speed walking group (6 rats) and accelerated-speed walking group (6 rats). 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 walking period was 3 hrs/day. Though six rats in the control group did not walk, their feed was removed for 3 hrs/day. In the fixed-speed walking group, rats walked for 3 hrs below the speed of 14 m per 1 minute. In the accelerated-speed group, the speed of walking was evenly increased from 14 m per 1 minute to 20 m per 1 minute for 4 weeks. Walking exercise was conducted using a motor walking wheel, the circumference of which was one meter (products by NITSUME Seisakusho). The walking exercise period of 3 hrs was created at random during this daytime period because the circadian rhythm of rats affects their physiological response. Body weight was determined every week and feed intake was determined every day. After the 4-week exercise period, they were killed and their whole body was processed with a meat chopper to determine the chemical composition. Determination of chemical composition (moisture (M), crude protein (CP), ether extracts (EE) as a crude fat, crude ash (CA) and calorie (Cal)) was conducted using the usual method for meat. Statistical treatment was conducted using one-way analysis of variance (P<0.01) and the mean separation was conducted with SCOTT-KNOTT's cluster analysis.

Table 1. Chemical composition of feed

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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Moisture (%)</td>
<td>7.8</td>
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<tr>
<td>Crude protein (%)</td>
<td>23.6</td>
</tr>
<tr>
<td>Ether extracts (%)</td>
<td>4.4</td>
</tr>
<tr>
<td>Crude fiber (%)</td>
<td>4.9</td>
</tr>
<tr>
<td>Crude ash (%)</td>
<td>6.6</td>
</tr>
<tr>
<td>Nitrogen free extracts (%)</td>
<td>52.7</td>
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<tr>
<td>Calorie (Cal/100g)</td>
<td>345</td>
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</tbody>
</table>
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Results

Body weight gain: The mean initial body weight at the starting point of the experiment was 114.3 ± 2.5 g. Final mean body weight of the control group was 364.6 ± 6.2 g; their mean body weight gain was 249.1 ± 5.3 g. The body weight of rats in the fixed-speed walking group increased by 181.0 ± 10.2 g and in the accelerated-speed walking group, it also increased by 185.4 ± 9.3 g (Fig. 1). Experimental groups were significantly lower (P < 0.01) than the control group with no significant difference among the experimental groups.

Total feed intake: There was no significant difference among the total feed intake of the three groups during 28 days of experiment. Their values were as follows: control group, 755.8 ± 13.7 g; fixed-speed walking group, 683.4 ± 25.4 g; accelerated-speed walking group, 683.8 ± 18.9 g (Fig. 2).

Feed efficiency: Significant differences (P < 0.01) were recognized in the comparison of feed efficiency (Fig. 3) calculated with the body weight gain and feed intake during the test period. The fixed-speed walking group (26.4 ± 1.0%) and the accelerated-speed walking group (27.3 ± 1.7%) had lower efficiency than the control group (33.0 ± 0.8%).

Chemical composition of whole body: Chemical composition of the whole body is shown in Fig. 4. Moisture in the supplementary group was 73.3 ± 0.4%. The values in the three groups were as follows: control group, 64.7 ± 0.8%; fixed-speed walking group, 70.4 ± 0.3%; accelerated-speed
walking group, 69.8±0.4%. The values of crude protein, ether extracts, crude ash and calories were calculated to a dry matter ratio with the above mentioned moisture values. These values were as follows in the same order of moisture value: Crude protein, 65.6±0.7%, 54.9±2.3%, 69.2±0.8%, 69.6±1.6%; ether extracts, 24.0±1.5%, 38.1±2.8%, 21.3±1.1%, 20.0±0.9%; crude ash, 11.1±0.8%, 8.2±0.6%, 12.4±0.8%, 11.8±0.7%; calories, 5.9±0.0kcal/g, 6.0±0.1kcal/g, 5.7±0.1kcal/g, 5.7±0.1kcal/g. Significant difference (P<0.01) was recognized in each subject without moisture values in a comparison of the control group with the walking groups.

Accumulated ratio of chemical composition from feed intake: 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 by the values at the finishing point minus the mean value of supplementary groups at the starting point. Furthermore the ratios between these values and the net volume of each chemical composition in feed intake were calculated as the chemical composition accumulated ratio (Fig. 5). In these ratios, crude protein and crude ash showed no significant differences. Crude protein showed the following values: control group, 26.5±1.0%; fixed-speed walking group, 22.5±0.8%; accelerated-speed walking group, 23.8±1.7%. In the same order, the values of crude ash were follows: 13.1±1.0%, 13.3±0.8%, 13.3±0.9%. On the other hand, ether extracts and calories showed significant differences (P<0.01), with exercise groups commonly significantly lower than the control group. In the same order as the above mentioned, the values of ether extracts were as follows: 91.8±7.8%, 34.6±2.9%, 34.2±3.0%; calorie: 17.0±0.6%, 10.4±0.5%, 11.0±0.7%.

**Discussion**

It is well known that exercise effects the chemical composition of the body. YAMASHITA and SAKURAI (12), KATAYAMA et al. (13), PACHECO-SANCHEZ and GRUNEWALD (13), THORLING and OVERVED (13) and YOU et al. (14) reported that endurance exercises like walking induced a decrease in body weight. They proposed that
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extended time endurance exercise was more effective than a short time active one. The present study aims to study the effects of acceleration of exercise for a fixed period on body composition. Rats in the control group could freely move in their individual cages. But they did not move actively, they usually had time for eating, grooming and sleeping as shown in a previous observation of their behavior. Forced exercise was necessary for experimental rats in this study. Generally a treadmill was used for forced exercise, a wheel-type apparatus was used for voluntary exercise. Though it was reported that the effects of exercise on the development of muscles could differ between swimming and walking, there was no difference among the effects in walking apparatus. The present study used the motor walking wheel with speeds lower than those used in previous reports with a treadmill; the exercise period was also longer. Walking speed of 14 m per 1 minute in this study was decided during the preliminary walking test. The rats, aged 4 weeks old, could not walk firmly at higher speeds than 14 m per 1 minute. Because in the case of higher speed than 14 m/minute, the rats began to run in the wheel. The forced walking using a motor walking wheel apparently increased their momentum. Their appetite did not increase by walking; on the contrary the animals in walking groups showed a slightly lower feed intake but there was no significant difference. In the previous reports, the effects of exercise on feed intake were shown on both sides, i.e. increase and/or decrease of feed intake. And they commonly showed a decrease of body weight gain. Therefore, the present results were understood as being induced by walking exercise.

Two groups of walking exercise showed the similar results in body weight gain, feed intake, feed efficiency, chemical composition of whole body and accumulated ratio of chemical composition from feed intake. Döhm et al. reported that the acceleration of walking speed from 20m/min. to 30m/min. showed the significant difference only in the weight of heart among the different speed groups. And they commonly showed significant differences in comparison with those from the control group. The reduction of ether extracts and energy values mean the consumption of energy for exercise and the protein value relative increased for the decrease of ether extracts value. Therefore their values were especially optimum indicators of walking exercise in body composition. The accumulated ratios of ether extracts and energy from feed intake in walking exercise groups were significantly lower, about 1/3 and 1/2, than that from the control group and the values of protein showed no significant difference. This suggests that ether extracts were utilized for energy of momentum in the walking groups and the protein was not used for the energy.

The consumption of ether extracts as an energy source for momentum did not differ among the fixed-speed walking group and the accelerated-speed group. This suggests that walking exercise which over a determined level has a uniform effect on the body composition. From the present results, walking for 3 hrs under the speed of 14 m per 1 minute was an appropriate level for rats aged 4-8 weeks old, and it is not necessary to accelerate walking speeds for momentum on to effect body composition.

Present study was conducted under appropriate environmental temperature conditions for rats, and should be recognized when re-creating the effects of walking exercise on body composition under low and/or high temperature conditions, in order to induce changes in the accumulation ratio of protein, ether extracts and energy independently.

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References


歩行運動がラットの増体量と体成分に及ぼす影響
1. 体脂肪減少に対する2種類の運動計画の影響

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要 約

本試験はラットの歩行運動が体脂肪減少に及ぼす影響を検討するために行った。試験には4週齢で健康な25匹のラットを用い、個別ケージに収容して、21±2℃で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形飼料を用いた。10日間の予備飼育を行い、その後に歩行運動区に供試するラットを選抜した。試験区は対照区、自由行動の対照区、一定速度（14m/分）の歩行区、加速度（4週間の間に14m～28mまで加速）歩行区の4試験区とした。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。試験開始当初に補正区のラットはジ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。体験全体の化学成分は常法で分析し、その結果を相互の区間で比較した。結果として、歩行運動を行った2区の増体量は対照区よりも有意に少なかったが、歩行運動区間には有意な差はみられなかった。飼料摂取総量と飼料効率においても増体量と同様の結果が示された。飼料由来の化学成分の蓄積割合において、粗タンパク質、粗灰分は対照区と歩行運動区の間に有意な差はみられなかったが、歩行運動を行った両試験区の粗脂肪の蓄積割合は対照区の値よりも有意に低かった。本試験成績は今回の試験条件において、歩行運動の方法が異なってもラットの増体量ならびに体脂肪の減少に対する有意な差を示さなかった。

キーワード：歩行運動、増体量、体脂肪、ラット

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