Influence of Physical Activity Intensity and Aerobic Fitness on the Anthropometric Index and Serum Uric Acid Concentration in People with Obesity

Yuichiro Nishida¹, Minako Iyadomi², Yasuki Higaki³, Hiroaki Tanaka³, Megumi Hara¹ and Keitaro Tanaka¹

Abstract

Background and Objective  Physical activity (PA) is considered an important approach to prevent and treat obesity and hyperuricemia. The purpose of the present study was to examine the influence of PA intensity and aerobic fitness on anthropometric indices and serum uric acid in obese individuals.

Methods  PA was examined using a single-axial accelerometer and aerobic fitness was assessed by electric cycle ergometry in obese middle-aged men (n=71, 47.2 ± 4.4 years). PA was defined as light (<3 metabolic equivalents [METs]), moderate (3.0-6.0 METs) or vigorous (>6.0 METs) intensity from the corresponding METs multiplied by time spent at the corresponding intensity levels. Serum uric acid was measured by the uricase peroxidase method.

Results  The association between aerobic fitness index (lactate threshold) and serum uric acid did not reach statistical significance after adjustment for potential confounding factors (age, body mass index [BMI], and alcohol consumption) (β=-0.110, p=0.138). Light intensity PA was inversely associated with BMI and waist circumference, even after adjustment for age and alcohol consumption (BMI: β=-0.543, p=0.023; waist circumference: β=-1.333, p=0.016). Moderate intensity PA, but not light or vigorous intensity PA, was inversely correlated with the uric acid level and this remained significant after adjustment for age, BMI, and alcohol consumption (β=-0.222, p=0.036).

Conclusion  Our results suggest that light intensity PA may have an important role in weight control while moderate intensity PA may be associated with the lower uric acid concentrations in obese individuals.

Key words: lactate threshold, metabolic equivalents, hyperuricemia

Introduction

Uric acid is the metabolic end product of the purine nucleotides that are components of cellular energy molecules, such as ATP, and of DNA and RNA. Hyperuricemia increases the risk of gout through the formation of urate crystals. However, hyperuricemia is not just important in gout but it is also an independent risk factor for hypertension, atherosclerosis, insulin resistance and type 2 diabetes (1-4).

Although obesity is associated with hyperuricemia (5-7), the precise role of hyperuricemia in obesity is not clear. It could be due to an increased uric acid production coupled with triglyceride synthesis (8, 9) and decreased uric acid excretion into urine as a result of hyperinsulinemia or insulin resistance, which accompany obesity (10, 11). Unlike the deleterious influence of hyperuricemia on the development of gout and lifestyle-related disease, uric acid is considered to be a powerful antioxidant (12, 13). Therefore, researchers have suggested that hyperuricemia might be a compensatory response to counteract excessive oxidative stress (12). Indeed, oxidative stress induced by intensive exercise was re-
duced by venous infusion of uric acid (14). Since obesity is associated with increased oxidative stress (15), hyperuricemia may represent a response to this increased oxidative stress.

PA/exercise is generally considered important in the prevention and treatment of hyperuricemia accompanying obesity. Several guidelines and reviews have endorsed light to moderate intensity aerobic exercise as a non-pharmacological therapy for the treatment of hyperuricemia and gout in obese individuals (16-18). Despite these endorsements, there is surprisingly little evidence on the relationship between daily PA and the circulating uric acid level. One study that showed that daily PA, assessed by a questionnaire, was inversely related to the prevalence of hyperuricemia (19), while another study showed an inverse association between daily PA and the circulating uric acid level. One study that surprisingly little evidence on the relationship between daily PA and the circulating uric acid level. One study that showed that daily PA, assessed by a questionnaire, was inversely related to the prevalence of hyperuricemia (19), while another study showed an inverse association between walking distance and uric acid level (20). On the other hand, another study reported that questionnaire-assessed daily PA was not associated with uric acid levels in young healthy men (21). Although questionnaires are widely used to assess daily PA because of their convenience, they have inherent limitations because subjects can easily overestimate or underestimate PA (22). Furthermore, the certainty and validity of recall are limited, and questionnaires vary quantitatively depending on whether the information is based on relative or absolute evaluations when the activity duration and intensity were assessed (23). In contrast, monitoring of activity using an accelerometer is a useful method to collect objective and precise information on the intensity and duration of daily PA (24). However, to our knowledge, the association between the intensity of daily PA, as measured by an accelerometer, and uric acid levels in obese individuals has never been investigated.

The association between PA and the uric acid level may be dependent on the intensity of PA. A single bout of intensive exercise induces a transient increase in the serum uric acid level (25-27), indicating that the intensity of PA is an important modulator of the circulating uric acid level. Because vigorous exercise induces excessive oxidative stress (28), which is presumably associated with the compensatory increase in uric acid level, low or moderate intensity PA intensity is likely to be associated with lower uric acid concentrations. On the other hand, moderate exercise stimulates the expression of several antioxidant enzymes (29) and improves insulin sensitivity (30, 31). Thus, we hypothesized that more frequent moderate intensity PA would be associated with lower uric acid levels in obese individuals. To date, little is known about the influence of physical fitness on the circulating uric acid in obese individuals. To the best of our knowledge, only one study has investigated the relationship between aerobic fitness and serum uric acid levels in people with chronic heart failure (32). Therefore, we investigated the associations between light, moderate or vigorous PA and aerobic fitness with serum uric acid levels in obese individuals.

Materials and Methods

Subjects

Seventy-one men with obesity and/or abdominal obesity (47.2 ± 4.4 years) who were employees at a silicon wafer manufacturing factory and participated in a health checkup were enrolled in this study. For this study, obesity was defined as a body mass index (BMI) ≥25 kg/m², according to the Japan Society for the Study of Obesity criteria (33), and a waist circumference ≥85 cm, according to the criteria of Japanese Committee of Criteria for Metabolic Syndrome (34). Of the 71 subjects, 24 had abdominal obesity (waist circumference ≥85 cm), four were obese (BMI ≥25 kg/m²) and the remaining 43 had both. ‘Obesity Disease’ is defined as obesity with at least one of the obesity-related complications, such as impaired glucose tolerance, hypertension, dyslipidemia, and hyperuricemia (33). Among the 71 current participants, 65 had at least one of the above-mentioned obesity-related complications (fasting plasma glucose ≥110 mg/dL; systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg; serum total cholesterol [TC] ≥220 mg/dL and/or triglyceride ≥150 mg/dL and/or low-density lipoprotein cholesterol [LDL-C] ≥140 mg/dL, and/or high-density lipoprotein cholesterol [HDL-C] <40 mg/dL; serum uric acid ≥7.0 mg/dL); therefore, most of the present subjects (92%) were suspected as having ‘Obesity Disease’. Eighteen of the participants regularly performed exercise (≥30 min/day, ≥2 days/week, for ≥1 year), while the remaining 53 did not. None of the subjects was taking a hypouricemic medication and none had a history of type 2 diabetes, hypertension, cerebral stroke or myocardial infarction. None of the subjects had an abnormal resting 12-lead electrocardiogram. Before starting the study, the nature, purpose and risks of the study were explained to all subjects and written informed consent was obtained. The protocol was approved by the ethics committee of Saga Medical School.

Anthropometric and aerobic fitness measurements

BMI was determined by dividing body weight in kilograms by the square of height in meters. Waist circumference was measured at the level of umbilicus. Aerobic fitness was determined by a graded exercise test performed on an electric cycle ergometer (Model EC-3600, CatEye Inc., Osaka, Japan). The work rate was initially set at a workload corresponding to three metabolic equivalents (METs), and then it was increased every 3 min to a workload corresponding to four, five, six and seven METs. The METs (or oxygen consumption) were estimated using the American College of Sports Medicine leg ergometer equation (35). The end point of the exercise test was determined on the basis of either achieving a blood lactate concentration of 4 mmol/L or the American College of Sports Medicine criteria (36). Blood samples were obtained from the earlobe every 3 min.
to measure blood lactate levels using a blood lactate test meter (Lactate Pro, ARKRAY, Inc., Kyoto, Japan). The blood lactate concentration was plotted against the exercise workload for each subject and the workload, estimated oxygen consumption or METs at the first breakpoint of the lactate concentration was used as the lactate threshold (LT). The LT was determined for each subject by visual inspection the graph by an exercise physiologist who was blinded to all data except for the blood lactate concentration. In four of 71 subjects, the LT was not determined because of insufficient lactate values to visually determine the LT.

**Measurement of PA and lifestyle factors**

PA was assessed using an uniaxial accelerometer (Life- corder, Suzuken Co. Ltd, Nagoya, Japan). Subjects were instructed to wear the accelerometer on their waist just above the center of the knee, except when sleeping or bathing. After 10 days of continuous wear, the device was retrieved and the data were downloaded into a computer and analyzed using Microsoft Excel software (Microsoft, Redmond, VA). To minimize any potential influence of wearing the device on PA and to assess the typical daily PA level, data from the last 10 days of continuous wear, the device was retrieved and the data were downloaded into a computer and analyzed using Microsoft Excel software (Microsoft, Redmond, VA). To minimize any potential influence of wearing the device on PA and to assess the typical daily PA level, data from the first 3 days were discarded. In addition, only the days from among the last 7 days on which the accelerometer was worn for ≥ 8 h/day were used for data analyses. Based on the accelerometry pattern, the device can separately determine light (<3 METs), moderate (3-6 METs) and vigorous (>6 METs) intensity PA; calculations were made from the corresponding METs multiplied by the time spent at the corresponding intensity levels (MET-h) (24), as well as the number of steps taken per day (counts/day). There is known to be a close correlation between METs and the activity levels recorded by the accelerometer (r=0.929, p=0.001) (24). The physical activity level (PAL) is a way to express the amount of PA in multiples of the basal metabolic rate and it is calculated as the total energy expenditure divided by the basal metabolic rate, as previously described (24). The accelerometer is designed to estimate the total energy expenditure (TEE) from the accelerometric signals resulting from the subjects’ movements (zero, 0.5 and 1-9) and anthropometric data. Here, TEE was calculated with following equation:

\[
\text{TEE}=\text{EE}_{\text{act}}+(1/10) \text{TEE}+\text{EE}_{\text{minorAct}}+\text{basal metabolic rate (BMR)}
\]

The accelerometric signals (1-9) are converted to energy expenditure (EE_{\text{act}}):

\[
\text{EE}_{\text{act}} = \text{Ko} \times \text{weight (kg)}
\]

where ‘Ko’ is a constant with nine values (1=minimal intensity of PA, 9=maximal intensity of PA) experimentally determined by the manufacturer to reflect acceleration under various conditions and is considered to be confidential by the manufacturer. (1/10) TEE (kcal) is dietary-induced thermogenesis. EE_{\text{minorAct}} is EE due to minor activities corresponding to an accelerometric signal 0.5 (e.g., posture changes, light desk work, etc), which is calculated by using BMR and a constant Kx:

\[
\text{EE}_{\text{minorAct}} = \text{Kx} \times \text{BMR (kcal/min)}
\]

‘Kx’ is not given here, since it is considered to be confidential by the manufacturer. BMR was calculated with the following equation:

\[
\text{BMR (kcal)} = \text{KB} \times \text{body surface area (BSA)} \times t \times 1/10,000
\]

where ‘KB’ is a standard value of Japanese (kcal/m2/h) and t is time (h) (37). BSA was calculated with following equation (38):

\[
\text{BSA (cm}^2\text{)} = \text{weight}^{0.444} \times \text{height}^{0.725} \times 88.83
\]

The accuracy of the step counts detected by this device was calibrated during the manufacturing process according to the Japanese Industrial Standards, and the error of the step counts must be <3% (39). This accelerometer is described in more detail elsewhere (24, 39, 40).

History of lifestyle-related diseases (type 2 diabetes, hypertension, cerebral stroke and myocardial infarction), use of medications, and lifestyle factors other than PA, including smoking and alcohol consumption, were evaluated by a questionnaire. Alcohol consumption was categorized as every day, sometimes, or seldom.

**Blood sampling and analysis**

Blood samples were obtained from an antecubital vein after an overnight fast. Serum uric acid was determined by the uricase peroxidase method. TC and triglyceride levels were analyzed enzymatically. HDL-C and LDL-C levels were analyzed by direct methods. HbA1c was measured by a latex aggregation immunoassay.

**Statistical analysis**

Values are shown as the means ± standard deviation. Univariate correlations were determined using Pearson’s correlation test. Associations were also assessed by multiple regression analysis with adjustment for potential confounding factors (age, BMI, PAL, and alcohol drinking). Statistical analyses were performed using SAS software (version 9.1 for Windows, SAS Institute, Cary, NC, USA). Values of p<0.05 were considered statistically significant.

**Results**

The characteristics of the subjects are shown in Table 1. The mean (range) daily step count, PAL, and LT were 10,355 (3,663-18,991) counts/day, 1.52 (1.33-1.77) and 4.77 (3.70-6.0) METs, respectively. The mean serum uric acid concentration (6.3 mg/dL) was high but in the normal range (≤7.0 mg/dL). Waist circumference was positively correlated with uric acid (r=0.28, p=0.02), while the relationship between BMI and uric acid was not statistically significant (r=0.18, p=0.14). The aerobic fitness index at the LT was inversely correlated with uric acid (r=-0.261, p=0.033, Fig. 1), but this became non-significant after adjusting for potential confounding factors (age, BMI and alcohol consumption). The daily step count was inversely correlated with waist circumference (r=-0.26, p=0.03), but was not significantly correlated with BMI (r=-0.14, p=0.25). PAL was not correlated with either BMI (r=-0.04, p=0.71) or waist circumference
Table 1. Subject Characteristics

<table>
<thead>
<tr>
<th>n</th>
<th>71</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>47.2 ± 4.4</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.9 ± 2.3</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>90.6 ± 5.4</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>125.1 ± 11.0</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>82.2 ± 8.5</td>
</tr>
<tr>
<td>Fasting plasma glucose (mg/dL)</td>
<td>100.5 ± 9.7</td>
</tr>
<tr>
<td>HbA1c (%)</td>
<td>5.1 ± 0.3</td>
</tr>
<tr>
<td>Triglycerides (mg/dL)</td>
<td>139.2 ± 71.3</td>
</tr>
<tr>
<td>HDL-C (mg/dL)</td>
<td>51.2 ± 10.6</td>
</tr>
<tr>
<td>LDL-C (mg/dL)</td>
<td>132.4 ± 26.4</td>
</tr>
<tr>
<td>TC (mg/dL)</td>
<td>211.1 ± 31.3</td>
</tr>
<tr>
<td>Serum uric acid (mg/dL)</td>
<td>6.3 ± 1.1</td>
</tr>
<tr>
<td>Number of steps (counts/day)</td>
<td>10355 ± 3299</td>
</tr>
<tr>
<td>PAL</td>
<td>1.52 ± 0.09</td>
</tr>
<tr>
<td>Estimated oxygen uptake at LT (mL/kg/min)</td>
<td>16.7 ± 1.9</td>
</tr>
<tr>
<td>Estimated METs at LT (METs)</td>
<td>4.8 ± 0.5</td>
</tr>
</tbody>
</table>

Values are means ± standard deviation. BMI: body mass index; HDL-C: high-density lipoprotein cholesterol; LDL-C: low-density lipoprotein cholesterol; TC: total cholesterol; PAL: physical activity level; LT: lactate threshold; METs, metabolic equivalents. Estimated oxygen uptake and estimated METs were determined in 67 subjects.

Figure 1. Relationship between the LT and serum uric acid levels in obese individuals. LT: lactate threshold

Figure 2. Relationship between light intensity PA and body mass index BMI. BMI: body mass index, PA: physical activity

Discussion

The main findings of this study were that 1) greater light intensity PA was associated with lower BMI and waist circumference; and 2) greater moderate intensity PA was associated with lower uric acid concentrations in obese middle-aged men.

The finding that greater PAL was associated with lower uric acid concentrations is consistent with a previous study that used assessed daily PA using a questionnaire (19). To more precisely assess the intensity and duration of PA, we used a reliable single-axial accelerometer and found that serum uric acid concentrations were not significantly correlated with either light or vigorous intensity PA, while...
greater moderate intensity PA was significantly associated with lower uric acid levels in obese men. We previously showed that moderate level exercise at the LT improves insulin sensitivity in previously sedentary men (30, 31). Since the LT in the current participants was 4.8 METs on average, moderate intensity PA at 3.0-6.0 METs, which is close to their LT intensity, might have an insulin-sensitizing effect. An other plausible explanation for the beneficial effect of moderate intensity PA at the LT is that uric acid excretion is enhanced because of an increased urine volume. It has been shown that moderate level exercise, corresponding to the LT, has a diuretic effect by increasing the circulating taurine concentrations (41).

The current results showing that obese middle-aged men might benefit from moderate intensity PA, instead of vigorous intensity activity, in the control of uric acid concentrations are important for obese individuals who cannot participate in vigorous intensity PA. Yamanaka et al (25) reported that the anaerobic threshold is the threshold for the acceleration of purine nucleotide degradation. They stated that muscle exercise, at a degree that does not exceed the anaerobic threshold, does not cause major purine nucleotide degradation and should be beneficial for people with gout or hyperuricemia (25, 26). On the other hand, there is a report showing that longer running distance was associated with lower uric acid levels in male runners (42). Although the relative intensity (or percent maximal oxygen uptake) of habitual running in individual runners is unclear in the previous study, this result may indicate that chronic (instead of acute) vigorous intensity PA may not be necessarily harmful in the control of uric acid concentration. Further study is needed to clarify the influence of habitual vigorous intensity PA on the basal uric acid levels in obese people.

Table 2. Associations between PA Intensity, Age and Alcohol Consumption with Anthropometric Indices

<table>
<thead>
<tr>
<th></th>
<th>Waist circumference</th>
<th>p value</th>
<th>BMI</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β (95% CI)</td>
<td></td>
<td>β (95% CI)</td>
<td></td>
</tr>
<tr>
<td>Light-intensity PA</td>
<td>-1.333 (-2.393, -0.274)</td>
<td>0.016</td>
<td>-0.543 (-1.001, -0.085)</td>
<td>0.023</td>
</tr>
<tr>
<td>Age</td>
<td>-0.465 (-0.729, -0.202)</td>
<td>0.001</td>
<td>-0.102 (-0.216, 0.012)</td>
<td>0.085</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>0.732 (-0.838, 2.301)</td>
<td>0.364</td>
<td>0.886 (0.207, 1.564)</td>
<td>0.013</td>
</tr>
<tr>
<td>Moderate-intensity PA</td>
<td>-0.385 (-1.416, 0.645)</td>
<td>0.466</td>
<td>0.203 (-0.239, 0.646)</td>
<td>0.371</td>
</tr>
<tr>
<td>Age</td>
<td>-0.416 (-0.690, -0.142)</td>
<td>0.004</td>
<td>-0.091 (-0.209, 0.026)</td>
<td>0.132</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>0.699 (-0.943, 2.332)</td>
<td>0.404</td>
<td>0.884 (0.182, 1.585)</td>
<td>0.016</td>
</tr>
<tr>
<td>Vigorous-intensity PA</td>
<td>-2.770 (-6.360, 0.802)</td>
<td>0.135</td>
<td>-0.876 (-2.433, 0.608)</td>
<td>0.274</td>
</tr>
<tr>
<td>Age</td>
<td>-0.426 (-0.696, -0.157)</td>
<td>0.003</td>
<td>-0.086 (-0.203, 0.031)</td>
<td>0.153</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>0.679 (-0.934, 2.291)</td>
<td>0.412</td>
<td>0.867 (0.168, 1.566)</td>
<td>0.018</td>
</tr>
<tr>
<td>PAL</td>
<td>-10.957 (-24.422, 2.508)</td>
<td>0.115</td>
<td>-1.461 (-7.353, 4.431)</td>
<td>0.629</td>
</tr>
<tr>
<td>Age</td>
<td>-0.432 (-0.701, -0.164)</td>
<td>0.002</td>
<td>-0.087 (-0.204, 0.031)</td>
<td>0.153</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>0.748 (-0.862, 2.358)</td>
<td>0.366</td>
<td>0.882 (0.178, 1.587)</td>
<td>0.017</td>
</tr>
</tbody>
</table>

Adjusted for age, BMI and alcohol consumption. PA, physical activity; PAL, physical activity level; CI, confidence interval.

Table 3. Associations between PA Intensity, Age, BMI and Alcohol Consumption with Uric Acid

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>β (95% CI)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light-intensity PA</td>
<td>-0.136 (-0.366, 0.093)</td>
<td>0.249</td>
</tr>
<tr>
<td>Age</td>
<td>-0.088 (-0.144, -0.032)</td>
<td>0.003</td>
</tr>
<tr>
<td>BMI</td>
<td>0.053 (-0.062, 0.169)</td>
<td>0.371</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>-0.089 (-0.432, 0.254)</td>
<td>0.612</td>
</tr>
<tr>
<td>Moderate-intensity PA</td>
<td>-0.222 (-0.425, -0.019)</td>
<td>0.036</td>
</tr>
<tr>
<td>Age</td>
<td>-0.076 (-0.130, -0.021)</td>
<td>0.008</td>
</tr>
<tr>
<td>BMI</td>
<td>0.085 (-0.024, 0.194)</td>
<td>0.132</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>-0.126 (-0.459, 0.208)</td>
<td>0.463</td>
</tr>
<tr>
<td>Vigorous-intensity PA</td>
<td>-0.205 (-0.946, 0.536)</td>
<td>0.589</td>
</tr>
<tr>
<td>Age</td>
<td>-0.083 (-0.139, -0.027)</td>
<td>0.005</td>
</tr>
<tr>
<td>BMI</td>
<td>0.068 (-0.045, 0.181)</td>
<td>0.245</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>-0.106 (-0.450, 0.238)</td>
<td>0.547</td>
</tr>
<tr>
<td>PAL</td>
<td>-3.304 (-5.956, -0.652)</td>
<td>0.017</td>
</tr>
<tr>
<td>Age</td>
<td>-0.085 (-0.139, -0.031)</td>
<td>0.003</td>
</tr>
<tr>
<td>BMI</td>
<td>0.064 (-0.044, 0.171)</td>
<td>0.249</td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>-0.089 (-0.420, 0.241)</td>
<td>0.598</td>
</tr>
</tbody>
</table>

Adjusted for age, BMI and alcohol consumption. PA, physical activity; BMI, body mass index; PAL, physical activity level; CI, confidence interval.

Figure 3. Relationship between moderate intensity PA and uric acid levels in obese individuals. PA: physical activity
We found an inverse correlation between the LT and uric acid concentrations, although this association became non-significant after adjusting for potential confounding factors (age, BMI and alcohol consumption). As described above, a previous report showed that, in people with chronic heart failure, the anaerobic threshold was inversely correlated with serum uric acid concentrations (32). The current study revealed a similar relationship in obese men.

We also found that, among three levels of PA intensity (i.e., light, moderate and vigorous PA), only light intensity PA was significantly associated with BMI. Because body weight is controlled by the balance between food intake and energy expenditure, a reduction in energy expenditure relative to energy intake leads to weight gain. Therefore, the magnitude of energy expenditure through PA should be important in the control of body weight. In the present study participants the amount of light intensity PA (2.74 ± 1.09 METs·h/day) was greater than that of moderate (2.29 ± 1.17 METs·h/day) and vigorous (0.25 ± 0.33 METs·h/day) intensity PA. Consequently, energy expenditure through light intensity PA must be greater than that through moderate and vigorous PA, and it is reasonable that light PA exerts the greatest influence on anthropometric indices. A previous study conducted in adult Japanese people aged 18-84 years revealed that the step count and time spent in moderate or vigorous PA were lower in overweight and obese individuals than in normal-weight individuals (39). The current results suggest that, in obese individuals, light intensity PA could be more important than moderate/vigorous PA in the control of body weight and fat.

In Dietary Reference Intakes for Japanese 2010, PAL was categorized into three levels (level I [<1.6], level II [1.6-1.9], and level III [≥1.9]) based on studies using doubly labeled water (43, 44). The current participants had a relatively high step count (>10,000 counts/day) and moderate intensity PA (2.29 ± 1.17 METs·h/day) which corresponded to 30-min brisk walking (4.5 METs), while their PAL (1.52 ± 1.17) intensity PA was due to enhanced urinary uric acid excretion; therefore, we could not determine whether the lower uric acid concentration in association with greater moderate intensity PA was due to enhanced urinary uric acid excretion and/or reduced uric acid production. Additionally, the inclusion of employees of a silicon wafer manufacturing factory may lead to physical inactivity (49). The current cross-sectional study, we are unable to establish a causal relationship between physical activity/aerobic fitness and uric acid concentration. There is also a previous longitudinal study indicating that obesity may lead to physical inactivity (49). The current cross-sectional study cannot exclude the possibility that higher BMI might lead to lower light intensity PA. Further longitudinal studies are needed to examine whether an increase in moderate intensity PA in daily life decreases the uric acid concentrations, and to explore the mechanisms underlying the beneficial effects of moderate level PA.

In conclusion, we found that daily light intensity PA was inversely associated with anthropometric indices (i.e., BMI and waist circumference) whereas greater moderate intensity PA was associated with lower uric acid concentrations in obese middle-aged men. It seems that distinct intensities of PA may have different roles in weight control and the regulation of uric acid concentrations in obesity.

The authors state that they have no Conflict of Interest (COI).
Acknowledgement

We thank all of the subjects for participating in the study. We also thank Dr. Hideaki Kumahara and Hiroaki Higuchi for workload correction of electric cycle ergometry. This work was partially supported by grants from the Japanese Ministry of Education, Culture, Sports, Science, and Technology (No. 19200049, Strategic Research Infrastructure) and the Global FU Program, funded by Fukuoka University.

References

35. ACSM’s Metabolic Calculations HANDBOOK. Lippincott Williams & Wilkins, Philadelphia, 2006.
40. Kumahara H, Tanaka H, Schutz Y. Daily physical activity assess-


© 2011 The Japanese Society of Internal Medicine
http://www.naika.or.jp/imindex.html