Abstract: Body fat distribution and abdominal fatness are indicators of risks for coronary heart disease. However, the relationships between resting energy expenditure (REE) and the body fat distribution or the abdominal fatness are unclear. We examined the relationships of REE with whole-body fat distribution (waist, hip and waist-to-hip ratio: WHR) and abdominal fatness (intra-abdominal fat: IF and subcutaneous fat: SF) after adjustment for body composition. 451 men and 471 women were subdivided into two groups, 40–59 years: middle-aged group and 60–79 years: elderly group. REE was measured by an indirect calorimetry system. Percentage of fat mass (%FM), fat mass (FM) and fat-free mass (FFM) were assessed by a dual-energy x-ray absorptiometry method. The IF area (IFA) and SF area (SFA) at the level of the umbilicus were measured using computed tomography. Circumference of waist and hip were measured in a standing position. The WHR, waist circumference and SFA did not significantly (p > 0.05) associate with the REE after adjusting for FM, FFM and age in any of the groups. The adjusted REE was significantly and inversely correlated with hip (r = 0.159, p < 0.05) and IFA (r = 0.131, p < 0.05) in the elderly men. These results suggest that lower REE may contribute to greater hip and IFA rather than WHR and waist in elderly men. J Physiol Anthropol 22 (1): 47–52, 2003 http://www.jstage.jst.go.jp/en/

Keywords: resting energy expenditure, body fat distribution, waist-to-hip ratio, intra-abdominal fat area

Introduction

Obesity occurs when energy intake exceeds energy expenditure over a long period. Energy expenditure consists of physical activity, diet-induced thermogenesis and resting energy expenditure (REE). REE is the largest component of total daily energy expenditure and maintains the basic physiologic functions (e.g., heart, renal, hepatic and muscle functions, respiration) [Goran, 2000]. A longitudinal study [Ravussin et al., 1988] observed that the initial REE negatively correlates with the change in body weight. Several cross-sectional studies [Albu et al., 1997; Carpenter et al., 1998; Forman et al., 1998; Foster et al., 1997] found that a lower REE might be related to a higher prevalence of obesity. Upper-body obesity (android-type of obesity) was found to be more greatly associated with various obesity-related complications, compared with lower-body obesity, by Vague [1956]. Upper-body obesity is generally estimated by the waist-to-hip ratio (WHR) as an index of body fat distribution. Several studies revealed that WHR was closely associated with risk factors for coronary heart disease (CHD), e.g., impaired glucose tolerance, insulin resistance, lipoprotein metabolic disorder and hypertension [Kissebah et al., 1982; Kissebah and Peris, 1989; Micciolo et al., 1991]. More recently, intra-abdominal fat area (IFA) and subcutaneous fat area (SFA) at the L4-L5 level were estimated using computed tomography [Tokunaga et al., 1983]. An increase in IFA has been demonstrated to be closely associated with CHD risk factors, e.g., hyperlipidemia [Nakamura et al., 1994], hypertension [Kanai et al., 1990] and low insulin sensitivity [Macor et al., 1997]. Thus, IFA is an important indicator for predicting the prevalence of CHD risk factors.

Whether REE plays a role in the alteration in body fat distribution and abdominal fatness is controversial. Several investigators [Tataranni et al., 1994; Weststrate et al., 1990] found significant and positive correlations between REE and WHR or the waist-to-thigh ratio adjusted for body composition, whereas some [Armellini et al., 1992; Schutz et al., 1992] did not. To our knowledge, studies investigating the relationships between REE and IFA using computed tomography (CT) are rare [Macor et al., 1997; Nicklas et al., 1995]. The studies by Macor et al. [1997] and Nicklas et al. [1995] used obese people as the subjects; therefore, there is no study for non-obese and healthy population. Moreover, very few studies have clarified the effects of sex and age on the relationships between REE and WHR or IFA, and the sample...
sizes of these studies were insufficient for the findings to be
generalized. Therefore, the aim of this study was to examine
the influence of \(\text{REE} \) on the body fat distribution (WHR, waist
and hip circumferences) and abdominal fatness (IFA and SFA)
assessed by the new method (CT) in a relatively large sample
size of the Japanese population.

It may be necessary to take menopausal transition into
consideration in women. A longitudinal study [Poehlman et al.,
1995] in American women showed that the normal menopausal
transition decreased in \(\text{REE} \) by approximately 100 kcal/day
compared to premenopausal women. Thus, we also examined
whether the menopausal transition has any influence on \(\text{REE} \)
and various physical variables in Japanese women.

Methods

Subjects

The subjects were 613 men and 564 women who participated in
the second wave examination of NILS-LSA (National Institute for Longevity Sciences, Longitudinal Study
of Aging) from April 2000 to May 2001. They were age- and
sex-stratified random samples aged from 40 to 79 years and
living in the neighborhood of the NILS. Details of the NILS-
LSA have been described elsewhere [Shimokata et al.,
2000]. Patients who had concomitant renal, hepatic or cardiac disease
or diabetes mellitus, or who were being treated with drugs such
as beta blockers, which could affect the variables of the study,
in particular \(\text{REE} \), were excluded. Additionally, patients with
thyroid disease, assessed by careful clinical and laboratory
estimation (e.g., history of thyroid disease and level of free
thyroxine and free triiodothyrinine) were also excluded.
Subsequently, the numbers of subjects who took part in this
study were 451 men and 471 women. The subjects were
subdivided into two groups in each sex by age (middle-aged
group: 40 to 59 years and elderly group: 60 to 79 years). The
aim and design of the study were explained to each subject
before they gave their written informed consent. The study was
approved by the Committee of the Chubu National Hospital.
All measurements were performed at the Chubu National
Hospital.

Anthropometric variables

Body weight was measured to the nearest 0.01 kg using a
digital scale, height was measured to the nearest 0.1 cm using a
wall-mounted stadiometer, and BMI was calculated as weight
(kg) divided by height squared (m\(^2\)). Circumference of the
waist was measured at the level of the umbilicus to the nearest
0.1 cm with the subjects in the standing position.

Resting energy expenditure (REE)

REE was estimated by a computerized, open-circuit, indirect
calorimetry system (\(V_{\text{max}} \quad 29, \quad \text{SensorMedics} \)) that measured
resting oxygen intake and resting carbon dioxide excretion
using a ventilated canopy. The subjects were asked to refrain
from all vigorous activity before the measurement. \(\text{REE} \)
measurement was performed during the morning (between
9:00 and 12:00) after an overnight fast in a comfortable and
thermoregulated room with an examiner and a subject. After a
15-minute steady-state period, values were recorded each
minute for 10 minutes. Twenty-four hour energy expenditure
due to \(\text{REE} \) was calculated using an equation derived by
Bursztein et al. [1989]:

\[
\text{REE (kcal/24 h)} = [3.581 \times \dot{V}_\text{O}_2 (L/min) + 1.448 \\
\times \dot{V}_\text{CO}_2 (L/min) - 0.002] \times 1440 \text{ min}
\]

Body composition

Whole-body fat mass (FM), fat-free mass (FFM) and
percentage FM (%FM) were assessed by dual-energy x-ray
absorptiometry (QDR-4500, Hologic). Transverse scans were
used for the measurement of FM and FFM, and pixels of soft
tissue were used to calculate the ratio (R value) of mass
attenuation coefficients at 40 to 50 keV (low energy) and 80 to
100 keV (high energy), using software version 1.3Z.

Abdominal fat area

The IFA and SFA were measured at the level of the
umbilicus (L4-L5). All CT scans (SCT-6800TX, Shimadzu)
were performed with the subjects in the supine position. The
IFA and SFA were calculated using a computer-software
program (FatScan, N2 system) [Yoshizumi et al., 1999]. A
region of the SF layer was defined by tracing its contour on
each scan, and the range of CT values (in Hounsfield units) for
fat tissue was calculated. Total fat area was calculated by
delineating the surface with the mean CT value plus or minus
2 standard deviations. The IFA was measured by drawing a line
within the muscle wall surrounding the abdominal cavity. The
SFA was calculated by subtracting the amount of IFA from the
total fat area. The intra-class correlation for repeated IFA
determinations in our laboratory is 0.99. The IFA-to-SFA ratio
(ISR) was calculated.

Definition of peri- and postmenopausal women

Menopause is defined as the permanent cessation of
menstruation resulting from the loss of ovarian follicular
activity. Thus, the criterion to define the postmenopausal state
is the absence of menses for at least 12 months [Wich and
Carnes, 1995]. Perimenopausal women were defined as the
women who were not clearly diagnosed at the menopausal
state.

Data analysis

Values are expressed as mean±standard deviation (SD) in
the tables. Differences between age groups, or between sexes
were tested using the Student’s \(t\)-test. Relationships between
REE and age, the body fat distribution or anthropometric
variables were assessed by Pearson’s correlation coefficients.
Partial correlation coefficients adjusted for age, FM and FFM
were calculated to assess the relationships between REE and
WHR, waist circumference, hip circumference, IFA or SFA for
Table 1 Physical characteristics of the subjects by sex and age group

<table>
<thead>
<tr>
<th></th>
<th>Middle-aged (n=222)</th>
<th>Elderly (n=229)</th>
<th>Middle-aged (n=233)</th>
<th>Elderly (n=238)</th>
<th>Sex difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height m</td>
<td>1.68±0.06</td>
<td>1.63±0.11</td>
<td>1.54±0.05</td>
<td>1.50±0.11</td>
<td>Men&gt;Women2; Men&gt;Women2</td>
</tr>
<tr>
<td>Weight kg</td>
<td>65.1±9.2</td>
<td>59.6±8.21</td>
<td>53.9±7.9</td>
<td>51.2±8.21</td>
<td>Men&gt;Women2; Men&gt;Women2</td>
</tr>
<tr>
<td>BMI kg/m²</td>
<td>23.1±2.8</td>
<td>22.5±2.83</td>
<td>22.7±3.4</td>
<td>22.8±3.2</td>
<td>NS</td>
</tr>
<tr>
<td>%FM %</td>
<td>20.6±4.5</td>
<td>21.4±4.3</td>
<td>30.3±5.0</td>
<td>31.7±4.8</td>
<td>Women&gt;Men2; Women&gt;Men2</td>
</tr>
<tr>
<td>FM kg</td>
<td>13.6±4.4</td>
<td>12.9±3.8</td>
<td>16.6±4.6</td>
<td>16.5±4.7</td>
<td>Women&gt;Men2; Women&gt;Men2</td>
</tr>
<tr>
<td>FFM kg</td>
<td>51.4±6.0</td>
<td>46.7±5.51</td>
<td>37.4±4.3</td>
<td>34.7±4.31</td>
<td>Men&gt;Women2; Women&gt;Men2</td>
</tr>
<tr>
<td>REE kcal/24 h</td>
<td>1414±202</td>
<td>1284±198</td>
<td>1144±186</td>
<td>1078±163</td>
<td>Men&gt;Women2; Women&gt;Men2</td>
</tr>
<tr>
<td>REE/weight kcal/24h/kg</td>
<td>21.7±3.1</td>
<td>21.4±3.0</td>
<td>21.1±3.0</td>
<td>21.0±3.3</td>
<td>NS</td>
</tr>
<tr>
<td>REE/FFM kcal/24h/kg</td>
<td>27.3±3.6</td>
<td>27.2±3.5</td>
<td>30.4±3.9</td>
<td>30.8±4.0</td>
<td>Women&gt;Men3; Women&gt;Men2</td>
</tr>
<tr>
<td>Waist cm</td>
<td>84.4±7.8</td>
<td>84.0±8.0</td>
<td>81.4±8.7</td>
<td>85.1±9.5</td>
<td>Men&gt;Women3; NS</td>
</tr>
<tr>
<td>Ht cm</td>
<td>93.3±5.1</td>
<td>90.5±4.7</td>
<td>91.8±5.0</td>
<td>89.7±5.6</td>
<td>Men&gt;Women3; NS</td>
</tr>
<tr>
<td>Waist-to-hip ratio</td>
<td>0.90±0.05</td>
<td>0.93±0.06d</td>
<td>0.89±0.07</td>
<td>0.95±0.07d</td>
<td>NS</td>
</tr>
<tr>
<td>IFA cm²</td>
<td>86.1±45.9</td>
<td>93.9±55.0</td>
<td>51.3±33.1</td>
<td>74.8±38.4d</td>
<td>Women&gt;Men2; Men&gt;Women2</td>
</tr>
<tr>
<td>SFA cm²</td>
<td>109.5±46.8</td>
<td>101.9±41.4</td>
<td>160.5±66.3</td>
<td>166.2±63.4</td>
<td>Women&gt;Men2; Women&gt;Men2</td>
</tr>
<tr>
<td>IFA to SFA ratio</td>
<td>0.81±0.37</td>
<td>0.93±0.40D</td>
<td>0.32±0.15</td>
<td>0.47±0.21D</td>
<td>Men&gt;Women2; Men&gt;Women2</td>
</tr>
</tbody>
</table>

Values are given as mean±SD.
%FM: percentage of fat mass; FM: fat mass; FFM: fat-free mass; REE: resting energy expenditure; IFA: intra-abdominal fat area; SFA: subcutaneous fat area.

1 Significantly smaller than middle-aged group (p<0.001).
2 Significant difference between men and women (p<0.001).
3 Significantly smaller than middle-aged group (p<0.05).
4 Significantly larger than middle-aged group (p<0.001).
5 Significant difference between men and women (p<0.01).
6 Significant difference between men and women (p<0.05).
7 Significantly larger than middle-aged group (p<0.01).

Each sex and age group. Additionally, the effect of the menopausal transition on the body fat distribution or anthropometric variables was assessed by an analysis of covariance. In the analysis of covariance, we used age as the covariate because a significant difference was observed in age between pre- (45±5 y) and post menopause (54±5 y) in the middle-aged women. Twenty perimenopausal women were excluded from the analyses. In each statistical analysis, probability values below 0.05 were regarded as significant. Data were analyzed with the Statistical Analysis System (SAS) release 6.12.

Results

Table 1 shows the physical and anthropometric characteristics of the subjects. The results are presented by sex and age, which indicate age and sex differences derived from the Student’s t-test. REE was smaller in women or elderly subjects compared to men and middle-aged, respectively. Although no difference was found in REE divided by FFM (REE/FFM) between the middle-aged and elderly groups, sex differences existed in both the two age groups.

The possible role of the menopausal transition as a confounding factor in the relationships between REE and body fat distribution or physical variables was examined by analysis of covariance using pre- (n=109) and postmenopausal women (n=104) in the middle-aged group. Table 2 shows no differences in REE (1121 kcal/24h and 1141 kcal/24h in pre- and postmenopausal women, respectively), FM (16.4 kg and 16.7 kg), FFM (37.8 kg and 36.9 kg), WHR (0.88 and 0.89), waist circumference (81.1 cm and 81.6 cm), hip circumference (92.2 cm and 91.2 cm), IFA (51.7 cm² and 51.5 cm²) and SFA (154.1 cm² and 166.0 cm²).

Because no menopausal effect was found in REE or any physical variables in the middle-aged women, the menopausal transition was not taken into consideration in the following analyses (Tables 3 and 4).

Table 3 shows the correlation coefficients of age, body composition, body fat distribution and anthropometric variables with REE. FFM had the highest correlation coefficients (r=0.496 to 0.616) of all. REE did not correlate with age in the elderly women or ISR in any of the groups.

Table 4 shows the partial correlation coefficients of the body fat distribution (WHR, waist and hip circumferences) or abdominal fatness (IFA and SFA) with REE adjusted for age, FFM and FM. Table 4 indicates that the WHR, waist circumference and SFA did not significantly (p>0.05) associate with the REE after adjusting for FM, FFM and age in any of the groups. Elderly men had a significant and inverse correlation (r=-0.159, p<0.05) between the hip and REE. IFA inversely correlated (r=-0.131, p<0.05) with the adjusted REE in the elderly men. No association was found in
Table 2 Comparison of resting energy expenditure, fat mass, fat-free mass, waist-to-hip ratio, waist, hip, intra-abdominal fat area and subcutaneous fat area between pre and postmenopausal women after adjusting for age.

<table>
<thead>
<tr>
<th></th>
<th>Premenopausal</th>
<th>Postmenopausal</th>
<th>Group difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>REE kcal/24 h</td>
<td>1121 ± 166</td>
<td>1141 ± 175</td>
<td>NS</td>
</tr>
<tr>
<td>FM kg</td>
<td>16.4 ± 4.5</td>
<td>16.7 ± 4.7</td>
<td>NS</td>
</tr>
<tr>
<td>FFM kg</td>
<td>37.8 ± 4.4</td>
<td>36.9 ± 4.6</td>
<td>NS</td>
</tr>
<tr>
<td>WHR</td>
<td>0.88 ± 0.07</td>
<td>0.89 ± 0.07</td>
<td>NS</td>
</tr>
<tr>
<td>Waist cm</td>
<td>81.1 ± 8.6</td>
<td>81.6 ± 8.8</td>
<td>NS</td>
</tr>
<tr>
<td>Hip cm</td>
<td>92.2 ± 5.1</td>
<td>91.2 ± 5.2</td>
<td>NS</td>
</tr>
<tr>
<td>IFA cm²</td>
<td>51.7 ± 33.6</td>
<td>51.5 ± 32.9</td>
<td>NS</td>
</tr>
<tr>
<td>SFA cm²</td>
<td>154.1 ± 62.8</td>
<td>166.0 ± 63.5</td>
<td>NS</td>
</tr>
</tbody>
</table>

Values are given as mean±SD.

Table 3 Correlation coefficients of age, body composition, fat distribution and anthropometric variables with REE

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Middle-aged</td>
<td>Elderly</td>
</tr>
<tr>
<td>Age</td>
<td>-0.215</td>
<td>-0.204</td>
</tr>
<tr>
<td>BMI</td>
<td>0.462</td>
<td>0.430</td>
</tr>
<tr>
<td>FM</td>
<td>0.369</td>
<td>0.309</td>
</tr>
<tr>
<td>FFM</td>
<td>0.496</td>
<td>0.606</td>
</tr>
<tr>
<td>Waist</td>
<td>0.411</td>
<td>0.415</td>
</tr>
<tr>
<td>Hip</td>
<td>0.432</td>
<td>0.436</td>
</tr>
<tr>
<td>Waist-to-hip ratio</td>
<td>0.244</td>
<td>0.286</td>
</tr>
<tr>
<td>IFA</td>
<td>0.320</td>
<td>0.219</td>
</tr>
<tr>
<td>SFA</td>
<td>0.279</td>
<td>0.295</td>
</tr>
<tr>
<td>IFA-to-SFA ratio</td>
<td>-0.002</td>
<td>-0.011 NS</td>
</tr>
</tbody>
</table>

FM: fat mass, FFM: fat-free mass, IFA: intra-abdominal fat area, SFA: subcutaneous fat area.

1 p<0.01.
2 p<0.001, significant relationship between REE and each variable.

Table 4 Partial correlation coefficients of resting energy expenditure with body fat distribution and abdominal fatness after adjustment for age, FFM and FM

<table>
<thead>
<tr>
<th></th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Middle-aged</td>
<td>Elderly</td>
</tr>
<tr>
<td>Waist-to-hip ratio</td>
<td>0.117</td>
<td>0.123</td>
</tr>
<tr>
<td>Waist</td>
<td>0.105</td>
<td>0.044</td>
</tr>
<tr>
<td>Hip</td>
<td>-0.057</td>
<td>-0.159</td>
</tr>
<tr>
<td>IFA</td>
<td>-0.052</td>
<td>-0.131</td>
</tr>
<tr>
<td>SFA</td>
<td>-0.039</td>
<td>-0.016</td>
</tr>
</tbody>
</table>

IFA: intra-abdominal fat area, SFA: subcutaneous fat area.

1 p=0.07.
2 p=0.06.
3 p<0.05, significantly correlate with REE.

Discussion

The purpose of the present study was to examine the relationship of REE with the body fat distribution and the abdominal fatness by sex and age group, and to confirm whether the menopausal transition has an influence on REE, body composition, the body fat distribution and the abdominal fatness in Japanese women. REEs divided by FFM (see Table 1) of this study were near by those (unit is kcal/24 h/kg, men: 28.4, women: 31.2–33.5, obese men: 29.2, obese women: 30.7) in previous studies [Tataranni et al., 1994; Weststrate et al., 1990]. Table 3 shows that REE is strongly associated with body composition (FM and FFM) and age except for in the elderly women, which supports the findings of the previous studies [Armellini et al., 2000; Karhunen et al., 1997; Lührmann et al., 2001; Neuhauser-Berthold et al., 2000]. Thus, the REE adjusted for FFM, FM and age was used in this study. The major findings were that: 1) the menopausal transition did not influence REE, body composition, body fat distribution or abdominal fatness in Japanese women; 2) no relationship was found between the waist circumference and REE in any groups; 3) the hip circumference and IFA were negatively and significantly associated with REE in the elderly men, which indicates that the hip circumference and IFA are greater in the subjects with lower REE.

Concerning the menopausal transition of the middle-aged women, Poehlman et al. [1995] reported that natural menopause was observed to be associated with reduced REE in a 6-year follow-up longitudinal study. They also found that this reduction was mainly attributable to a decrease in FFM [Poehlman and Tchernof, 1998]. In the present study, as shown in Table 1, REE and FFM decreased in parallel with aging. Additionally, Table 2 indicates that body composition, body fat distribution and abdominal fatness are not affected by the menopausal transition when adjusted for age. That is, REE and various physical variables were more strongly affected by aging itself rather than by the menopausal transition. It is probably for these reasons that no difference was found in REE between the pre- and postmenopausal middle-aged women of the present study.

WHR has been traditionally used as an index of upper-body obesity [Armellini et al., 1992; Nicklas et al., 1995; Schutz et al., 1992; Weststrate et al., 1990]. Weststrate et al. [1990] found that REE adjusted for FFM and FM was positively associated with WHR in a group of premenopausal obese women. Tataranni et al. [1994] used the waist-to-thigh ratio (WTR) in obese men and also observed a significant and positive correlation between WTR and REE. Lührmann et al. [2001] also found in elderly people that REE showed a significant increase with increasing WHR. Arner [1995] observed that the rate of lipolysis was relatively lower in the subcutaneous femoral/gluteal region and higher in the abdominal region. Therefore, the higher activity of the abdominal fat, e.g., the
higher activity of the triglyceride-free fatty acid cycle could explain the increased REE observed in men with upper-body obesity [Tataranni et al., 1994]. In the present study, as shown in Table 4, WHR tended to be higher in the middle-aged ($r=0.117$, $p=0.07$) and elderly men ($r=0.123$, $p=0.06$) with higher REE, which is likely to support the above reports.

However, WHR is no more than the ratio of the waist circumference to the hip. That is, it is unclear as to what a higher WHR means, larger waist circumference or relatively smaller hip. More recently, several studies have demonstrated that the waist circumference itself was also positively associated with the prevalence of CHD risk factors [Rexrode et al., 1998; Onat et al., 1999; Gray et al., 2000]. Thus, it is interesting to examine the relationships between the waist circumference and REE. The results of this study indicate, however, that no significant correlations exist between the waist circumference and REE in any of the study groups, which suggests that not all the subjects with larger waist circumferences have higher REE.

Ravussin et al. [1988] observed that initial energy expenditure negatively correlated with the rate of change in body weight over a two-year follow-up period. In the United States, obesity is more prevalent in African-Americans than in Caucasians. Several investigators have studied the relationship between obesity and REE using African-Americans and Caucasians [Albu et al., 1997; Carpenter et al., 1998; Forman et al., 1998; Foster et al., 1997]. They found that African-Americans had a lower REE than Caucasians, and that it may be related to the differences observed in the prevalence of obesity between African-Americans and Caucasians. In Pima Indians, it was revealed that people with lower REE due to a familial (genetic) factor had a higher prevalence of obesity [Bogardus et al., 1986]. These findings may indicate that lower REE leads to an increase in body weight. The results of this study indicate that the hip was significantly and negatively associated with REE in the elderly men, suggesting that adipose tissue would be likely to be accumulated in the hip of the subjects with lower REE.

As shown in Table 4, although IFA significantly and negatively correlated with REE in the elderly men, no associations were observed between SFA and REE in any of the groups. Armellini et al. [1992] reported that no difference was observed in IFA between the highest and lowest quartiles of REE adjusted for age and FFM. Leenen et al. [1992] examined this without adjusting for FFM or FM and found that an increase in IFA was positively correlated with a higher level of REE in women but not in men. Our observations are inconsistent with these two findings because they did not adjust REE for age, FFM or FM.

In this study, significant associations between REE and hip circumference or IFA were observed only in the elderly men. Several reasons for the results should be mentioned. Physical activity energy expenditure is the most variable component of total energy expenditure in free-living individuals [Goran and Poehlman, 1992] and decreases with age [Crespo et al., 1996]. Correlations between REE and hip circumference or IFA may be diminished by relatively larger variances of physical activity energy expenditure in the middle-aged subjects compared to the elderly. Although lower correlation coefficients of women between REE and IFA may be partially explained by smaller variances of those compared with men, detailed causes of the differences could not be well explained in the current data.

In conclusion, our data show that REE is affected by age, but not diminished by the natural menopausal transition in Japanese middle-aged women. Lower REE may be closely related to greater hip and IFA in elderly men.

**Acknowledgments** We are grateful to the participants in the study. We also thank all the investigators, research assistants and laboratory technicians who have contributed to this study. This study was supported by a Grant-in-Aid for comprehensive Research on Aging and Health from the Ministry of Health, Labour and Welfare of Japan.

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Received: May 8, 2002

Accepted: November 25, 2002

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