人類生態班

Resting energy expenditure and physical activity level of rice farmers in Lao PDR during the post-harvest season

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ABSTRACT

Objective: To estimate the daily physical activity level (PAL) of traditional rice farmers in rural Lao PDR during a post-harvest season.

Design: Cross-sectional study.

Setting: A rice-farming village in Savannakhet Province, Lao PDR.

Subjects: 12 husband/wife pairs.

Interventions: Resting energy expenditure (REE) while sitting was measured by indirect calorimetry, and anthropometric indices were recorded. The total daily energy expenditure (TEE) and daily step frequency (STP) were estimated by accelerometry. PAL values were derived from TEE and REE values.

Results: The mean REE (kcal/day) was significantly ($P < 0.0001$) higher for men (1,899 ± 227) than for women (1496 ± 139). The difference between men and women was reduced when adjusted for body weight by an analysis of covariance and became non-significant after adjustment for fat-free mass. The mean PAL values of the subjects were relatively low (1.77 and 1.71 for men and women, respectively) compared with those of rice-farming populations observed during intensive agricultural seasons. A significant negative relationship was found between the physical activity indices (TEE and STP) and the percentage of body fat, but not between these indices and the body mass index (BMI).

Conclusions: PAL values of Lao rice farmers were relatively low during the post-harvest season. A better understanding of their behavioral and energetic adaptations will require estimates of both time allocation and energy expenditure. Maximization of food security will require surveys of physical activity, diet, and nutritional status during intensive agricultural seasons, which are associated with high PAL values and a negative energy balance.

Introduction

Agricultural populations have higher levels of physical activity than other subsistence populations, such as hunter-gatherers and horticulturists, in traditional societies (Sackett 1996). The high level of physical activity in traditional agriculture is not necessarily allocated equally throughout a year, however. For example, in traditional rice farming in paddy fields, a large variation in the intensity of physical activity can be observed from planting to harvesting; the intensity of activity is dependent on seasonal environmental conditions and the growth status of the paddy. Many studies on physical activity in traditional agricultural societies have focused on physical activity during labor-intensive periods (*e.g.*, planting and harvesting seasons). In contrast, little attention has been paid to physical activity in less labor-intensive periods, the so-called "slack seasons" (e.g., post-harvest seasons). The exceptions are studies that have focused on variations in physical activity arising from seasonal changes in labor demands.

Despite the fact that the level of physical activity in slack agricultural seasons is generally lower than that in intensive agricultural seasons, slack-season activity is still an important parameter. In the slack season, the habitual activity patterns of farmers can be observed because farmers are able to freely allocate their time. In contrast, no choice of activity other than farming exists during intensive agricultural seasons, thus masking individual habitual activity patterns. The influence of a market economy on activity patterns can also be assessed more easily in slack seasons. In addition, gender-specific activities derived from the division of labor are more easily observed in slack seasons.

The objective assessment of free-living physical activity can be based on physiologic (*e.g.*, energy expenditure and heart rate monitoring) or biomechanical (*e.g.*, accelerometry) methods. Free-living energy expenditure is usually measured using the doubly labeled water (DLW) method, which provides an average measure of total daily energy expenditure (TEE) over 1-3 weeks (Westerterp et al. 1999). The use of the DLW method is limited in practice by high cost, however, and it provides only average measurements obtained over periods of more than one week.

The heart-rate monitoring method, which is based on the relationship between heart rate and oxygen consumption (energy expenditure), is also a feasible method for assessing physical activity in free-living conditions (Yamauchi *et al.* 2001; Leonard 2003). Wearing a heart-rate monitor (pulse receiver) on the chest can be a major burden to subjects, however, and thus heart rates are difficult to monitor for more than a few continuous days (Benefice 1998; Yamauchi & Ohtsuka 2001). Small, light activity monitors based on accelerometry were developed in the mid-1980s and have been used for continuous assessment of habitual physical activity over periods of a week or a month. Accelerometry has been validated against the DLW method and proven to be a reliable method for the assessment of physical activity (Bouten *et al.* 1996; Ekelund *et al.* 2001; Hoos *et al.* 2004), but most accelerometer-based studies have focused on obese and normal-weight adults and children in developed countries; few studies of the physical activity of traditional farmers in developing countries have been reported.

In the present study, we attempted to assess the physical activity levels (PALs) of rice farmers living in Lahanam Zone, Savannakhet Province, which is located in the southern part of Lao PDR, during a slack season of farming (post-harvest season). We compared these levels with PALs obtained in intensive agricultural seasons. In addition, the sex-dependent relationships between body composition and physical activity indices were assessed.

Method

Study area and subjects: In Lahanam Zone, the agricultural calendar is based on the farming of rice, which is planted and harvested twice a year, from June to December and from January to May. Historically, only one rice crop was grown annually, from June to December, but a second crop was made possible by the installation of irrigation canals in the village in 1994. The inhabitants grow their staple food, lowland glutinous rice, in the rain-fed paddy fields, and they grow vegetables and harvest river fish for personal consumption as well as for market. The inhabitants also raise chickens, cattle, and buffalo, which are used for tillage. During the study periods encompassing the slack season, some women weave tapestries on traditional looms for sale to a textile company. In addition to these major subsistence activities, the inhabitants undertake minor subsistence activities, such as fabricating various kinds of wood or bamboo tools for daily use, catching frogs in the paddy fields, and gathering bamboo shoots in the forest. Fieldwork was conducted during late November to early December 2004 after the rice harvest had been completed earlier than usual, and the post-harvest season had begun.

The Dongbang village, which is one of the five villages that compose the Lahanam Zone, was selected for this study. This village had 39 households, and pairs of married men and women from 12 households were selected as the test subjects. Hence, the subjects represented approximately one-third of all households in the village. The ages of the 12 married couples fell into one of four categories: 20-29 years (two couples), 30-39 years (three couples), 40-49 years (five couples), or 50-59 years (two couples). The subjects were fully informed about the procedures and purpose of the study, and their consent was obtained. This study was approved by the Ethics Committee of the National Institute of Public Health, Lao PDR.

Anthropometry and body composition: Anthropometric dimensions were measured following the standard protocol of Weiner and Lourie (1981). Stature was measured to the nearest 1 mm using an anthropometer (GPM, Switzerland), and weight was measured to the nearest 0.05 kg using a portable digital scale (UC-321, A&D, Japan). Body-mass index (BMI; kg/m^2) was then calculated as weight in kg/(stature in m)^2. Upper-arm, waist, and hip circumferences were measured with a flexible tape measure. A skinfold caliper (Holtain, Briberian, UK) was used to measure biceps, triceps, subscapular, and suprailiac skinfold thicknesses to the nearest 0.2 mm. The four-site skinfold equation of Durnin and Womersley (1974) was used in combination with the equation of Siri (1956) to estimate the body-fat percentage (% fat). Blood pressure was measured with the subject in a sitting position using a digital sphygmomanometer (HEM-757, Omron, Japan), and the average of two readings for systolic and diastolic blood pressure (SBP and DBP) was used for analyses.

Resting energy expenditure (REE): REE was measured in the sitting position using indirect calorimetry with the Douglas bag technique (Douglas 1911; Yamauchi & Ohtsuka 2000). Measurements were taken between 7:00 and 9:00 a.m. after subjects had fasted overnight. While the subjects were sitting quietly on the floor, reclining against a cushion with their legs extended, a facemask was attached. Ten minutes was allowed for stabilization, and then expired air was collected twice for 5 min. The two values were averaged, and when the difference between the two values was larger than 3% (only occurring in three cases), a third measurement was done. A portable gas monitor (AR-1, Arco System, Chiba, Japan) was used to determine the O_2 and CO_2 contents and the volume of the expired air. The energy values were automatically calculated using the equation of Weir (1949).

Energy expenditure (EE) estimation by accelerometry: For each participant, a portable activity monitor based on a uniaxial accelerometry sensor (Lifecorder Suzuken Co. Ltd., Japan) was attached at the waist, and acceleration was recorded for seven consecutive days. Being small and light (62 × 46 × 26 mm, 40 g), the activity monitor did not disturb the subjects’ behavior. The device provided good assessments of energy expenditure (EE) compared with indirect calorimetry, activity diaries, or heart-rate monitoring (Kumahara *et al.* 2004), and it also effectively measured EE in free-living conditions when compared with recall of physical activity (Suzuki *et al.* 1997). TEE, total-step frequency (STP), and raw accelerometry data were recorded at 2-min intervals and downloaded to a personal computer.

The activity monitor measures vertical acceleration and categorizes the activity into one of 11 activity levels (0, 0.5, and 1-9) based on the pattern of the accelerometric signal. The activity levels are subsequently converted to EE (kcal) by a proprietary algorithm. The TEE assessed by the device is calculated from the sum of the thermic effect of food (TEF = 0.1 TEE), EE, and basal metabolic rate (BMR); BMR is calculated from body weight, stature, sex, and age using a standard formula (Health Promotion and Nutrition Division, Health Service Bureau, Ministry of Health and Welfare of Japan, 1996). The details of this device have been provided elsewhere (Kumahara *et al.* 2004).

We did not use the TEE automatically provided by the device; instead, we calculated TEE values based on the principle that sleeping EE (= 0.9 × MET; 1 MET or metabolic equivalent = VO_2 of 3.5 mL・kg^{-1}・min^{-1}; Ainsworth *et al.* 2000) corresponds to an activity level (AL) of 0, and non-structured activity (AL = 0.5) corresponds to 1.4 × MET. We used the regression equation developed by Kumahara *et al.* (2004): physical activity ratio = 0.640 AL [0.5-9] + 1.27. In addition, the estimated MET values (Kumahara et al. 2004, Table 2) were adopted for ALs of 1-9: 1.8, 2.3, 2.9, 3.6, 4.3, 5.2, 6.1, 7.1, and 8.3 MET, respectively. The EE corresponding to 1.0 × MET was determined as the measured resting metabolic rate (RMR) divided by 1.2 based on the relationship between the sitting EE and BMR: sitting EE = 1.2 × BMR (FAO/WHO/UNU 1985, James and Schofield 1990, FAO 2004). For each subject, Σ MET × time was calculated each day, and the TEE was estimated in combination with his/her measured RMR. The physical activity level (PAL) was determined as the ratio of TEE to sleeping EE (0.9 × MET, Ainsworth *et al.* 2000) instead of using the BMR, which was not measured in this study.

Statistical analyses: The data are expressed as the mean ± SD. Sex-based differences were examined using the paired t-test. Correlations between two variables were found using Pearson's correlation test. All analyses were conducted with the JMP statistical package (SAS Institute Inc., Cary, NC, USA) with statistical significance assigned at $P < -0.05$.

Results

Nutritional status and blood pressure: Anthropometric and blood pressure measurements are shown Table 1. Men were significantly taller than women ($P < 0.0001$), and women had significantly higher % fat ($P < 0.001$) and skinfold thicknesses ($P < 0.005$ for suprailiac; $P < 0.001$ for biceps, triceps, and subscapular). In contrast, no significant sex-based differences were observed in body weight, the three circumferences (upper arm, waist, and hip), or blood pressure (SBP and DBP). According to WHO criteria (WHO 2000), the mean BMI values were within the normal range ($18.5 \leq \text{BMI} < 25.0$) for both sexes. However, individual analysis revealed that two men were underweight ($\text{BMI} < 18.5$) and five men were normal weight ($18.5 \leq \text{BMI} < 25.0$). In contrast, no women were underweight, but nine were normal and three were overweight. No subject was categorized as obese ($\text{BMI} \geq 30.0$). Based on the definition of hypertension given by the WHO International Society of Hypertension (WHO-ISH) Guidelines ($\text{SBP} \geq 140$ mmHg or $\text{DBP} \geq 90$ mmHg (WHO-ISH 1999)), the mean values of SBP and DBP

Table 1. Nutritional status and blood pressure

	Men (N = 12)	Women (N = 12)	*P*
Age (years)	41.3 ± 8.6	40.7 ± 9.4	NS
Height (cm)	161.0 ± 1.38	151.6 ± 1.38	0.0001
Weight (kg)	59.0 ± 8.5	53.3 ± 6.1	NS
BMI (kg/m^2)	22.8 ± 3.0	23.2 ± 2.3	NS
%Fat (%)	19.4 ± 6.7	34.3 ± 5.8	<0.0001
UAC[1] (cm)	27.2 ± 3.5	26.2 ± 1.8	NS
Waist circumference (cm)	81.3 ± 14.9	80.0 ± 9.4	NS
Hip circumference (cm)	90.6 ± 6.0	91.2 ± 4.2	NS
Biceps skinfold (mm)	5.3 ± 1.8	9.6 ± 3.2	0.001
Triceps skinfold (mm)	9.5 ± 4.4	17.5 ± 5.5	0.001
Subscaplar skinfold (mm)	15.4 ± 7.8	28.0 ± 8.0	0.001
Supura-illiac skinfold (mm)	8.8 ± 5.8	17.5 ± 7.0	0.005
SBP[2] (mmHg)	112.8 ± 9.2	112.9 ± 13.6	NS
DBP[3] (mmHg)	68.3 ± 7.4	74.0 ± 9.5	NS

[1] Upper arm circumference.
[2] Systolic blood pressure.
[3] Diastolic blood pressure.

were within the normal range for both sexes, but two men and two women were categorized as hypertensive.

REE: The measured REE values and the REE values adjusted for body weight and fat-free mass (FFM) using analysis of covariance (ANCOVA) are given in Table 2. The mean REE (kcal/day) was significantly higher for men than for women ($P < 0.0001$). In men, the adjustment for body weight caused a decrease in RMR, which decreased further when also adjusted for FFM. In women, adjustment for weight increased RMR, which increased further when also adjusted for FFM. The gender differences in RMR persisted after the adjustment for weight, but decreased to the point of insignificance when adjusted for FFM.

Table 2. Resting energy expenditure (REE)

	Men (N = 12)	Women (N = 12)	*P*
BW (kg)	59.0 ± 8.5	53.3 ± 6.1	NS
REE	1899 ± 226.9	1496 ± 138.5	< 0.0001
REE adjusted for			
BW by ANCOVA	1891 ± 238.0	1504 ± 135.0	0.0002
FFM by ANCOVA	1753 ± 187.1	1642 ± 126.4	NS

Physical activity indices: The mean values of the physical activity indices (TEE, PAL, and STP) over seven consecutive days are shown in Table 3. A significant sex-based difference was observed for TEE ($P < 0.0001$) but not for PAL or STP. According to the work levels of FAO/WHO/UNU (1985), the PALs were "light to moderate" for both sexes. On the other hand, using the new classification of lifestyles proposed by the FAO (2004), these

Table 3. Physical activity indices

	Men (N = 12)	Women (N = 12)	*P*
TEE[1] (kcal/day)	2533 ± 382	1920 ± 182.6	< 0.0001
PAL[2]	1.77 ± 0.10	1.71 ± 0.08	NS
STP[3] (step/day)	14,913 ± 4,468	11,514 ± 3,876	NS(0.059)

[1] Total daily energy expenditure (7 days average).

[2] Physical activity level calculated by TEE and sleeping energy expenditure (see text ir

[3] Daily step frequency (7 days average).

Table 4. Physical activity variables assessed by accelerometry

	Men (n = 12)	Women (n = 12)	*P*
Sleep[1] (min/day)	385 ± 100	353 ± 52	NS
Light activity[2] (min/day)	1002 ± 97	1057 ± 55	NS
Moderate activity[3] (min/day)	50 ± 37	29 ± 12	NS
Vigorous activity[4] (min/day)	3 ± 3	1 ± 1	NS
Total (min/day)	1440	1440	

[1] Activity level (AL) = 0.

[2] AL = 0.5-3 (MET < 3.0).

[3] AL = 4-6 (3.0≦MET < 6.0).

[4] AL = 7-9 (MET≧6.0).

PAL values were "moderate activity lifestyle" for men and "light activity lifestyle" for women. Like the PAL, the STP exhibited no significant sex difference, although men took 30 % more steps (3,399) per day than women did. On average, the daily step frequencies exceeded 10,000 steps/day for both sexes. Moreover, 20 (ten of each sex) of the 24 subjects averaged more than 10,000 steps/day over seven days.

The free-living physical activity data obtained by accelerometry are summarized in Table 4. No significant sex-based differences were observed for any of the variables. On average, men and women slept for 6.4 and 6.0 h/day, respectively. Although the differences were not statistically significant, men spent less time performing light activity and more time performing moderate or vigorous activity than women did.

Comparison with previous studies: The mean PAL values were compared with those reported in other studies of rice-farming populations during intensive agricultural seasons based on a review by Ulijaszek (1999) (Table 5). In general, the PAL values for both our male and female subjects were lower than those reported by other studies. Using the data set presented by Ferro-Luzzi and Martino (1996), we examined the PAL of rice farmers in Lao in a post-harvest season (Fig. 1). We found that male and female subjects in the present study were relatively heavier and their PAL values were near moderate level compared to rural Third World populations. Interestingly, the adjusted PAL values of the women were relatively higher than those of the men, although the absolute PAL values were higher in men than in women.

Relationship between physical activity indices and body composition: The % fat was significantly and negatively associated with STP and TEE in the men and women combined (STP: r = -0.43, P < 0.05; TEE: r = -0.54, P < 0.01; Fig. 2). The relationship between % fat and PAL was not significant (r = 0.34). In contrast to the % fat, a significant relationship was not found between the BMI and any of these three indices.

Table 5. Mean PAL of rice-farming populations

Populations/countries	PAL[1]	Reference
Adult men		
Northeast Thailand	2.36	Murayama & Ohtsuka 1999
Philippines*	2.25	de Guzman et al. 1974
Gurung / Nepal*	2.05	Stricland et al. 1997
Gurung / Myanmar*	2.02	Tin-May-than & Ba-Aye 1985
Tamil Nadu / India*	1.96	McNeill et al. 1988
Sundanese / Indonesia*	1.96	Suzuki 1988
Non-Gurung / Nepal*	1.91	Stricland et al. 1997
Lao PDR (Savannaket)	**1.77**	**Present study**
India*	1.56	Edmundson & Edmundson 1988
Adult women		
Northeast Thailand*	1.97	Murayama & Ohtsuka 1999
Tamang / Nepal*	1.82	Panter-Brick 1993
Guangzhou / China*	1.71	Ho 1984
Lao PDR (Savannaket)	**1.71**	**Present study**
India*	1.69	McNeill et al. 1988
Gurung / Nepal*	1.67	Stricland et al. 1997
Non-Gurung / Nepal*	1.56	Stricland et al. 1997

[1] Physical activity level.

*Source: Ulijaszek 1999.

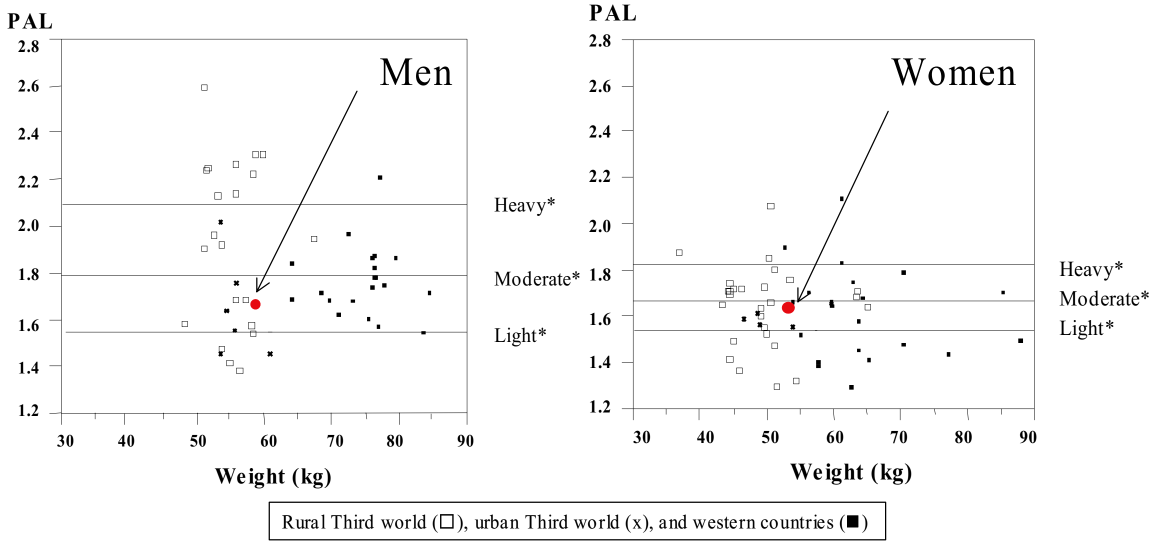

Figure 1. Relationship between body weight and PAL in a rice-farming population in rural Lao PDR and worldwide populations

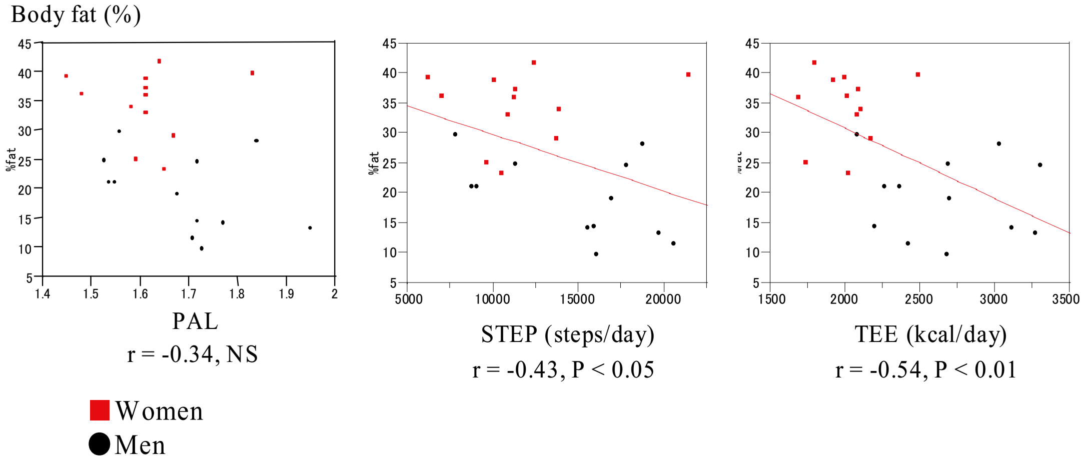

Figure 2. Relationship between physical activity indices and body composition (% fat)

Discussion

Prediction equations derived from Caucasian subjects are widely used but have been suggested to overestimate BMR in individuals of Asian origin by up to 10% (Liu *et al.* 1995; Case *et al.* 1997; Leung *et al.* 2000; Yao *et al.* 2002). In Southeast Asian populations, Poh *et al.* (1999) found that the FAO/WHO/UNU prediction equations overestimated the RMR of Malaysian children by 3–5%. The FAO/WHO/UNU equations overestimated RMR by 7–14 % in Vietnamese adults (Nhung *et al.* 2005). Based on the FAO/WHO/UNU predictive equation, the mean and SD of TEE for the subjects were 1,565 ± 101 and 1,291 ± 68 kcal/day for men and women, respectively. When these estimated BMR values were multiplied by 1.2 based on the association between BMR and sitting EE (FAO/WHO/UNU 1985; James & Schofield 1990; FAO 2004) and compared with the REE results of this study, the predicted and measured REE values were almost identical in men (1,878 vs. 1,899 kcal/day). However, the predicted REE was overestimated by 3.5% for women (1,549 vs. 1,496 kcal/day), which supports previous studies. Although few studies have measured sitting EE for Asian populations, our REE values were larger both for men (by 10%) and for women (by 8%) compared to Indian adults (Kanade *et al.* 2001).

The results of the present study together with those reported in previous studies suggest that the REE of the men in this study might be overestimated by up to 10%, whereas the REE of the women is reasonable. The subjects were probably slightly anxious during the REE measurement due to the unfamiliar equipment, such as the mouthpiece and nose-clip. Their anxiety should have no effect on the PAL if the REE and consequently the TEE were overestimated, since these overestimations would be offset in the calculation of the PAL.

We observed that the REE was significantly higher (by 27%) for men compared to women. This difference decreased to 26% when adjusted for body weight, but it became insignificant after adjusting for FFM. Kanada *et al.* (2001) noted that sex-based differences in REE appear to arise from differences in body composition in our population, in particular the larger FFM for men compared to women. In fact, the sex-based difference in FFM was 12.6 kg, which was twice the difference in body weight (5.7 kg).

Among the subsistence activities, rice farming-related activities are generally recognized as energy-consuming work, and the TEE values of rice-farming populations during the intensive agriculture season have been reported to be considerably high (Sackett 1996; Murayama & Ohtsuka 1999; Ulijaszek 1999). As expected, the results of the present study demonstrate that the PAL of rice farmers during a slack season is not very high. Murayama and Ohtsuka (1999) reported the seasonal variation in PAL in a rice-farming population (Lao-Thai) that is similar to the present study's population in terms of ethnicity and geographic location (Northern Thailand). In their study, the lowest PAL values were 1.99 and 1.66 for men and women, respectively, during a slack season. Compared to these values, the PAL values obtained in our study were lower for the men but almost identical for the women. Murayama and Ohtsuka (1999) found that the PAL values increased by 13 % in men and by 19 % in women in the intensive agriculture season compared with those obtained in the slack season. Assuming that similar increases in PAL would be observed in our subjects during the intensive agriculture season, their PAL values would exceed 2.0 for both sexes and would be categorized as a "vigorously active lifestyle" (FAO 2004).

Although the differences were not significant, men had higher PAL values, walked more, and spent more time in moderate- or vigorous-intensity activities than women. These findings suggest that men were more active than women were during a slack season of farming. A possible explanation for this result is that during the survey period, many women devoted themselves to weaving on a traditional loom, which required a considerable amount of time.

Based on the time allocation survey administered during the acceleration monitoring period, five of the 12 women were engaged in weaving for > 6 h/day (Yamauchi, unpublished data). The weaving was performed mostly by women in a sitting position and is considered a sedentary activity, whereas men predominantly performed physically demanding work, such as livestock husbandry of cattle and buffalo, fishing, and house construction. Consequently, the men's daily PAL and STP were higher than those of the women, and men spent more time in moderate- or vigorous-intensity activities than women did.

The relationship between nutritional status (*e.g.*, BMI) and physical activity is controversial. However, many cross-sectional studies have found that overweight or obese subjects were less active than their control subjects (Schulz & Schoeller 1994; Davies *et al.* 1995; Westerterp & Goran 1997). The results of this study illustrate significant negative associations between % fat and STP or TEE (Fig. 2). In contrast, no significant relationship was found between BMI and the physical activity indices, possibly because the sample size was small, and the variation in BMI between individuals was relatively low; the coefficient of variation (CV) was 13 and 10% for men and women, respectively. In other words, the nutritional status of the subjects was relatively homogeneous. In fact, no subject was obese (BMI ≥ 30), and 67% of the subjects (16 of 24) were non-obese (BMI < 25.0).

Previous studies indicated that EE and TEE are underestimated by accelerometry. Bray *et al.* (1994) reported that the TEE of girls (N = 40, average age 13.0 y) estimated using uniaxial accelerometers (Caltrac, Hemokinetics Inc., WI, USA) was significantly lower (by 13%) than that obtained using a human calorimeter.

For healthy adults, Chen and Sun (1997) found that a triaxial accelerometer (Tritac-R3D, Hemokinetics Inc.) underestimated TEE (by 17%) compared with the TEE measured in a respiratory chamber. In a study using the same device (Lifecorder Suzuken Co. Ltd., Japan) as was used in the present study, the TEE was significantly underestimated (by 8 %) compared with that obtained using a human calorimeter (Kumahara et al. 2004). Indeed, the TEE automatically calculated by the accelerometer was lower by 292 kcal/day (13.0%) in men and by 86 kcal/day (4.7%) in women than the estimated TEE in this study.

Higuchi *et al.* (2003) posited two reasons for the underestimation of TEE by the accelerometer: a problem in the BMR estimation and a problem in the manufacturer's algorithm and predictive equations used for calculation of EE and TEE. To overcome these problems, we measured the REE and converted the activity levels provided by the accelerometer into the corresponding MET values based on predictive equations developed in a previous experimental study (Kumahara *et al.* 2004); we then estimated the TEE. Nevertheless, to validate the estimated TEE, simultaneous measurement by the DLW method must be considered in future studies.

In conclusion, the findings of the present study indicate that the PAL of rice farmers in rural Lao PDR was relatively low during a slack season compared with the level reported for rice-farming populations during an intensive agricultural season. The levels of physical activity were not low in general, however, and considerably higher levels of physical activity would be expected during intensive agricultural seasons, as suggested by previous studies. Maximization of food security will require surveys of physical activity, diet, and nutritional status during intensive agricultural seasons. In addition, to elucidate the time- and power-demanding tasks that significantly contribute to energy expenditure during work, studies that accurately estimate both the time allocation and energy expenditure are needed.

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