ABSTRACT

**Background:** No study has attempted to use the doubly labeled water (DLW) method to validate a physical activity questionnaire administered to a Japanese population. The development and refinement of such questionnaires require that physical activity components related to physical activity level be examined.

**Methods:** Among 226 Japanese men and women 20 to 83 years of age, total energy expenditure (TEE) was assessed using the Japan Arteriosclerosis Longitudinal Study Physical Activity Questionnaire (JALSPAQ), and the results were compared with TEE measured by the DLW method as a gold standard. Resting metabolic rate (RMR) was measured using the Douglas Bag method.

**Results:** The median TEE by DLW and physical activity level (PAL: TEE/RMR) were 11.21 MJ/day and 1.88, respectively, for men, and 8.42 MJ/day and 1.83 for women. JALSPAQ slightly underestimated TEE: the differences in mean and standard error were $-1.15 \pm 1.92$ MJ/day. JALSPAQ and DLW TEE values were moderately correlated (Spearman correlation $= 0.742$, $P < 0.001$; intraclass correlation coefficient $= 0.648$, $P < 0.001$), and the 95% limit of agreement was $-4.99$ to $2.69$ MJ. Underestimation of TEE by JALSPAQ was greater in active subjects than in less active subjects. Moderate and vigorous physical activity and physical activity during work (ie, occupational tasks and housework) were strongly related to physical activity level. However, the physical activity components that differentiated sedentary from moderately active subjects were not clear.

**Conclusions:** Physical activity level values on JALSPAQ and DLW were weakly correlated. In addition, estimation of TEE in active subjects should be improved, and the use of a questionnaire to differentiate activity in sedentary and moderately active subjects must be reassessed.

**Key words:** physical activity questionnaire; doubly labeled water; physical activity; energy expenditure

INTRODUCTION

Accurate assessment of physical activity level is fundamental in epidemiological studies that examine the effect of physical activity on disease prevention and health promotion. Although there are several methods for estimating physical activity level, questionnaires are the most common assessment tool in such studies. Many types of physical activity questionnaires are used in epidemiological studies, but a validation study of such questionnaires suggested that the reliability and validity of measurements of habitual physical activity are quite low.1–3 In addition, Neilson et al suggested that the ability of physical activity questionnaires to predict total energy expenditure (TEE) is limited. Westerterp et al suggested that questionnaires are satisfactory as an instrument for ranking physical activity level, but not as tools for assessing absolute TEE.4 We previously examined the International Physical Activity Questionnaire (IPAQ) and reported that it was difficult to distinguish sedentary from moderately active individuals in the Japanese population.5 Although the IPAQ was developed for international use, we maintain that questionnaires designed to suit each country or culture would increase the validity of assessments of physical activity level. The Japan Arteriosclerosis Longitudinal Study Physical Activity Questionnaire (JALSPAQ) was developed to assess physical activity in the Japan Arteriosclerosis Longitudinal Study.6,7 This questionnaire was developed using data from physical activity records for the Japanese

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METHODS

Subjects
The study participants were 226 Japanese men and women age 20 to 83 years (mean ± standard deviation, 50.4 ± 17.1 years) who volunteered at community health care centers and workplaces or enrolled via the internet homepage of our institute. The inclusion criteria of the present study were as follows: absence of any condition affecting energy or water metabolism (eg, thyroid or kidney disease), not pregnant or breast-feeding, residence in home prefecture 2 weeks before the study period, at the same time of day. Except for the baseline collection, all urine samples were collected by the participants during the study period, at the same time of day. They were also free from emotional stress and were familiar with the apparatus used.

The volume of expired air was measured with a certified gas meter (DC-5, Shinagawa, Tokyo, Japan), the accuracy and precision of which were maintained within 1% of the coefficient of variation (CV). Concentrations of oxygen and carbon dioxide were measured with a mass spectrometer (ARCO-1000, Arco Systems, Chiba, Japan). The precision of expired gas measurement was 0.02% for oxygen and 0.06% for carbon dioxide. RMR was calculated using Weir’s equation.9

DLW energy measurement
After providing a baseline urine sample, a single dose of approximately 0.06 g/kg body weight of ²H₂O (99.8 atom%, Cambridge Isotope Laboratories, MA, USA) and 1.4 g/kg body weight of H₂¹⁸O (10.0 atom%, Taiyo Nippon Sanso, Tokyo, Japan) was given orally to each subject. Then subjects were asked to collect urine samples at 8 predetermined times during the study period, at the same time of day. Except for the baseline collection, all urine samples were collected by the participant, and the time of sampling was recorded. All samples were stored by freezing at −30°C in airtight parafilm-wrapped containers and then analyzed in our laboratory.

Gas samples for the isotope ratio mass spectrometer (IRMS) were prepared by equilibration of the urine sample with a gas. CO₂ was used to equilibrate ¹⁸O, and H₂ was used for ²H. Pt catalyst was used for equilibration of ²H. The gas sample of the CO₂ and H₂ was analyzed by IRMS (DELTA Plus; Thermo Electron Corporation, Bremen, Germany). Each sample and the corresponding reference were analyzed in duplicate. The average standard deviations for the analyses were 0.5‰ for ²H and 0.03‰ for ¹⁸O. TEE was expressed as mean TEE per day over the study period.

Calculations of isotopic abundance and TEE
The ²H and ¹⁸O zero-time intercepts and elimination rates (k₁ and k₂) were calculated using a least-squares linear regression on the natural logarithm of isotope concentration as a function.
of the elapsed time from dose administration. Zero-time intercepts were used to determine the isotope pool sizes. Total body water (TBW) was calculated from the mean value of the isotope pool size of $^2$H divided by 1.041 and that of $^{18}$O divided by 1.007. The mean $k_o/k_d$ of the present study was 1.28 ± 0.06 (range, 1.15–1.56). All $k_o/k_d$ values were maintained within the recommended range (1.1 to 1.7) for quality control of the analysis, as recommended by the International Atomic Energy Agency. Calculation of TEE (kcal/day) was performed using a modified Weir’s formula based on the $CO_2$ production rate ($rCO_2$) and food quotient (FQ). FQ was calculated from the dietary survey during the study period. The calculation assumed that under conditions of perfect nutrient balance, the FQ must equal the respiratory quotient (RQ). The average FQ of each occupational group was used for each group (FQ = 0.85–0.95). However, FQ values stratified by occupational group, sex, and age were not significantly different. Physical activity level (PAL) was calculated as TEE/RMR.

Physical activity questionnaire

The physical activity questionnaire developed for the Japanese Arteriosclerosis Longitudinal Study (JALSPAQ) was used in this study. This questionnaire comprises 14 questions on occupation, locomotion, housework, sleep time, and leisure-time physical activities. In this questionnaire, occupational work was assessed as duration of sitting, standing, walking, and heavy work. Heavy work was defined as lifting more than 10 kg or manual labor of similar intensity. Leisure-time physical activity was assessed by type, duration, and frequency. Questionnaire data were converted to the intensity of each physical activity expressed in metabolic equivalents (METs), according to the Compendium by Ainsworth et al, and summarized as METs/h/day and energy expenditure. In the present study, we used TEE per day, METs/h/day, and PAL as indices of physical activity level from JALSPAQ. Duration of light (<3 METs), moderate (3–5.9 METs), and vigorous (≥6 METs) physical activities was calculated for all physical activities (including occupational activity, housework, and leisure-time physical activity), as well as for leisure-time physical activity only. Working time, including occupational and housework time, was divided into the duration of sitting (<2 METs), standing (2 to <3 METs), walking (3 to <6 METs), and heavy work (≥6 METs), including housework. We calculated the durations of occupational activity and housework together because their frequencies and durations were quite complicated.

Dietary assessment

Dietary habits were assessed by using a brief self-administered diet history questionnaire (BDHQ)—a 4-page structured questionnaire that requested information on the consumption frequencies for a total of 56 food and beverage items, with specified serving sizes described in terms of the servings commonly consumed in the general Japanese population. Energy and macronutrient intakes were calculated using a computer algorithm for the BDHQ, which was based on the Standard Tables of Food Composition in Japan. FQ was calculated by using the equation of Black et al.

Statistical analysis

Statistical analyses were performed using SPSS for Windows (version 16.0f; SPSS Inc., IL, USA). Physical characteristics are classified using the sex and age groups outlined in the Dietary Reference Intake (DRI) of Japan. The estimated energy expenditure data were generally not normally distributed; therefore, medians and interquartile ranges are used to describe these results. Sex and age-group differences were compared using 2-way analysis of covariance. The Bonferroni procedure was used as the post-hoc test. The relation between TEE as estimated by DLW and JALSPAQ was expressed as Spearman correlations, intraclass correlation coefficient (ICC), and 95% limits of agreement (95% LOA: mean difference ± 2 × SD of the mean difference). Bland-Altman plots were also created to evaluate the differences between the 2 methods. To examine the type of physical activities that affected physical activity level, we used 1-way analysis of covariance, Pearson’s correlation coefficients, and partial correlation coefficients adjusted for sex and age group.

RESULTS

The physical characteristics of the subjects are shown in Table 1. Body weight did not change significantly during the study period ($P = 0.313$). Among all subjects, 2.8% of men and 6.8% of women were classified as lean (body mass index [BMI] <18.5 kg/m²), and 31.5% of men and 17.8% of women were classified as obese (BMI ≥25 kg/m²) according to the criteria for Japanese. The average TBW was 37.3 ± 7.1 kg in men and 25.9 ± 2.8 kg in women. When 73.2% was defined as the proportion of water in fat-free mass, the percent of fat mass was 24.3 ± 6.1% in men and 33.4 ± 7.0% in women. Three men aged 30 to 49 years had a body weight higher than 100 kg; however, they were fit and their percent of fat mass was less than 25%. In addition, in the assessment of TEE by DLW and JALSPAQ, they did not significantly differ from other subjects.

The medians plus interquartiles for RMR, TEE, and PAL by DLW, TEE by questionnaire, and the differences between the 2 methods are shown by sex and age group in Table 2. The respective medians of TEE and PAL were 11.21 MJ/day and 1.88 for men and 8.42 MJ/day and 1.83 for women. PAL significantly differed by age group, but not by sex. PAL in subjects older than 70 years was significantly higher than in those aged 30 to 49 years ($P = 0.016$) and 50 to 69 years.
Table 1. Characteristics of study subjects

| Age group, years | n  | Age (years) | Height (cm) | Body weight pre (kg) | Body weight post (kg) | Body weight change (kg) | BMI (kg/m²) | TBW (kg) |
|-----------------|----|-------------|-------------|----------------------|-----------------------|------------------------|-------------|----------|
| Male            |    |             |             |                      |                       |                        |             |          |
| 20–29           | 18 | 25.0 ± 2.5  | 171.5 ± 6.0 | 62.1 ± 7.9           | 62.3 ± 8.0            | 0.2 ± 0.7              | 21.1 ± 2.0 | 36.4 ± 3.7 |
| 30–49           | 42 | 36.7 ± 5.3  | 173.8 ± 6.6 | 74.8 ± 16.7          | 74.9 ± 16.6           | 0.0 ± 1.1              | 24.6 ± 4.7 | 41.8 ± 8.3 |
| 50–69           | 31 | 60.2 ± 6.5  | 163.8 ± 6.6 | 63.9 ± 8.1           | 64.0 ± 8.3            | 0.1 ± 0.9              | 23.8 ± 2.4 | 34.5 ± 4.1 |
| ≥70             | 17 | 75.1 ± 4.0  | 162.1 ± 5.0 | 60.7 ± 8.1           | 60.8 ± 7.8            | 0.2 ± 0.9              | 23.1 ± 2.7 | 32.0 ± 4.2 |
| Female          |    |             |             |                      |                       |                        |             |          |
| 20–29           | 8  | 25.3 ± 2.4  | 157.0 ± 3.9 | 51.3 ± 2.5           | 51.2 ± 2.5            | −0.1 ± 0.8             | 20.9 ± 1.6 | 25.5 ± 1.5 |
| 30–49           | 42 | 38.7 ± 4.4  | 158.0 ± 5.4 | 53.7 ± 8.3           | 53.7 ± 8.3            | 0.0 ± 0.7              | 21.5 ± 3.2 | 26.9 ± 3.1 |
| 50–69           | 49 | 62.0 ± 5.1  | 154.0 ± 4.6 | 54.6 ± 7.8           | 54.7 ± 7.9            | 0.1 ± 0.7              | 23.0 ± 3.2 | 25.8 ± 2.7 |
| ≥70             | 19 | 73.4 ± 3.9  | 148.0 ± 4.4 | 50.2 ± 6.1           | 50.1 ± 6.1            | 0.1 ± 0.6              | 22.9 ± 2.8 | 24.1 ± 2.0 |

All values are mean ± SD, unless otherwise indicated.
BMI: body mass index; TBW: total body water measured by doubly labeled water method.

Table 2. Resting metabolic rate (RMR) and total energy expenditure (TEE) measured by doubly labeled water (DLW) method and questionnaire

| Age group, years | RMR (MJ/day) | TEE by DLW (MJ/day) | PAL | TEE by JALSPAQ (MJ/day) | Difference between DLW and JALSPAQ (MJ/day) (%) |
|-----------------|--------------|----------------------|-----|-------------------------|-----------------------------------------------|
| Male            |              |                      |     |                         |                                               |
| 20–29           | 6.27 (0.92)  | 12.00 (0.19)         | 1.89 (0.35) | 9.60 (2.12)            | −1.69 (2.89)                                 |
| 30–49           | 6.72 (1.53)  | 12.88 (4.64)         | 1.87 (0.45) | 11.14 (2.85)           | −1.18 (3.30)                                 |
| 50–69           | 5.50 (1.30)  | 10.81 (2.11)         | 2.08 (0.55) | 9.18 (1.61)            | −2.02 (1.99)                                 |
| ≥70             | 5.76 (1.41)  | 11.76 (3.59)         | 2.11 (0.52) | 8.03 (1.65)            | −0.97 (2.34)                                 |
| Female          |              |                      |     |                         |                                               |
| 20–29           | 4.73 (0.27)  | 8.10 (1.18)          | 1.86 (0.22) | 7.43 (1.01)            | −1.09 (1.85)                                 |
| 30–49           | 4.83 (0.82)  | 8.82 (1.80)          | 1.84 (0.32) | 7.33 (1.75)            | −1.26 (1.73)                                 |
| 50–69           | 4.58 (0.95)  | 8.53 (1.42)          | 1.86 (0.37) | 8.12 (1.28)            | −0.43 (1.76)                                 |
| ≥70             | 4.62 (0.99)  | 8.56 (0.86)          | 1.86 (0.41) | 7.08 (1.33)            | −0.36 (1.68)                                 |

P value Sex <0.001 Age group <0.001 Sex by age 0.010

All values are median (interquartile), unless otherwise indicated.
PAL: physical activity level (TEE/RMR); JALSPAQ: Japan Arteriosclerosis Longitudinal Study Physical Activity Questionnaire.

(J ≤ 0.001). JALSPAQ slightly underestimated TEE, with differences in mean and standard error of the mean of −1.15 ± 1.92 MJ/day and −0.020 ± 0.030 MJ/kg/day. TEE values by JALSPAQ and DLW were moderately correlated (Spearman correlation = 0.742, P < 0.001; ICC = 0.648, P < 0.001). The 95% LOA was −4.99 to 2.69 MJ. The absolute difference between TEE values by DLW and JALSPAQ was significantly greater in men than in women, but the percent difference was not significantly different. The Spearman correlation coefficient and ICC for PAL were 0.423 (P < 0.001) and 0.332 (P < 0.001), respectively, and the 95% LOA for PAL was −0.86 to 0.46. Use of Bland-Altman plots to compare TEE and PAL by DLW and JALSPAQ suggested that TEE tended to be underestimated in subjects with higher TEE (Spearman correlation, −0.201; P = 0.002); however, most values were within the 2 SD of the difference in TEE as determined by the 2 methods (Figure). PAL was not underestimated even in subjects with higher PALs (Spearman correlation, −0.011; P = 0.866); however, individual differences were widely distributed.

Using PAL determined using TEE measured by DLW, the subjects were divided into 3 groups according to Dietary Reference Intake (Table 3). The proportions of active (PAL >1.9), moderately active (PAL 1.6 to <1.9), and sedentary (PAL <1.6) individuals were 45.4%, 43.5%, and 11.1% in men, respectively, and 40.7%, 41.5%, and 17.8% in women. TEE by JALSPAQ in the sedentary group was significantly lower than in moderately active and active adults. Total METs assessed by JALSPAQ was lower in sedentary and moderately active individuals than in active individuals. The differences between the 2 methods in the TEE of sedentary and moderately active adults were significantly smaller than in active adults. The total duration of each intensity of physical activity, including occupational and housework activity and leisure-time physical activity, was compared among physical activity levels. The duration of moderate and vigorous
physical activity in sedentary and moderately active adults was significantly shorter than in active adults. When we compared only leisure-time physical activity, there was no difference in duration of physical activity. Regarding physical activity during work, duration of walking was significantly shorter in sedentary individuals than in moderately active and active individuals. In addition, walking duration was significantly shorter in moderately active adults than in active adults. The proportion of heavy work differed significantly among groups; greater activity was associated with heavier work.

Regarding the types of physical activity that were correlated with PAL, correlation coefficients and partial correlation coefficients adjusted for sex and age group are shown in Table 4. Duration of total, moderate, and vigorous physical activity were weakly correlated with PAL. However, duration of leisure-time physical activity was not correlated with PAL. During working time, duration of standing, walking, and heavy work were weakly correlated with PAL.

**DISCUSSION**

This study used the DLW method as a gold standard to examine the validity of a physical activity questionnaire designed for the Japanese population in a large number of subjects with widely varying physical activity levels. With the DLW method as the gold standard, JALSPAQ estimated TEE relatively well, but underestimation was more frequent at higher physical activity levels.

The body height and weight of the present subjects were similar to the standard values for the Japanese population. RMR was also similar to the standard RMR values for the Japanese population presented in Dietary Reference Intake. Thus, we conclude that the present subjects had the general physical characteristics of the Japanese general population. However, the physical activity level of the present subjects was higher than that noted in our previous studies: 42.9% of the present subjects were classified as active, using the definition in the Dietary Reference Intake. We recruited...
As compared with these results, JALSPAQ showed a smaller negative mean difference of −1.15 MJ/day and a higher correlation (Spearman correlation, 0.742; P < 0.001). A comparison of individual-level agreement indicates that the width of the 95% LOA in our study (7.68 MJ/day) was smaller than that in most other questionnaires described in the review of Neilson and colleagues (1133 to 17 948 kcal/day; 4.74 to 75.09 MJ/day).2 The relatively good agreement in this study partly resulted from the greater number of subjects (n = 226 in the present study vs n = 13 to n = 65 in previous studies) and the wide variation in TEE. Standard deviation was 2.77 MJ in the present study vs 0.35 to 3.51 MJ in previous studies. A study by Racette showed the lowest 95% LOA (−2.42 to 0.16 MJ/day).15 However, that study was part of an investigation of a 17-week outpatient weight loss treatment, so the subjects were thought to be highly motivated and to have answered the questionnaire carefully. One reason why TEE is assumed to have greater accuracy than the existing questionnaire is that it is believed to have more detailed questions regarding occupational activity, housework, and leisure-time physical activity.

JALSPAQ tended to greatly underestimate TEE in more active subjects, possibly because the algorithm for the calculation of TEE for JALSPAQ only includes duration of activity of similar intensity, such activity was not used to calculate TEE. Thus, underestimation would be greater in subjects who expended considerable energy at work. In the

| Physical activity level | I (Sedentary) | II (Moderately active) | III (Active) | P       |
|-------------------------|---------------|------------------------|--------------|---------|
| TEE by DLW (MJ/day)     | 8.11 (1.39)   | 9.12 (2.29)            | 10.76 (4.25) | <0.001  |
| TEE by questionnaire (MJ/day) | 7.78 (1.21)   | 8.45 (2.87)            | 8.90 (3.06)  | 0.006   |
| Total METs (METs·h/day) | 33.5 (4.1)    | 34.4 (4.8)             | 35.8 (6.4)   | <0.001  |
| Difference in TEE between DLW and PAQ (MJ/day) | -0.07 (0.50)  | -0.80 (1.62)           | -2.02 (2.23) | <0.001  |
| Difference in TEE between DLW and PAQ (%) | -0.9 (18.3)   | -8.4 (17.8)            | -19.1 (19.0) | <0.001  |
| Total duration of physical activity (h/day) | 3.41 (3.58)   | 4.14 (3.50)            | 4.16 (3.72)  | 0.155   |
| Duration of leisure-time physical activity (h/day) | 1.65 (1.81)   | 2.06 (2.07)            | 2.53 (3.89)  | <0.001  |
| Moderate (3–5.9 METs)   | 0.00 (0.09)   | 0.00 (0.20)            | 0.00 (0.54)  | 0.007   |
| Vigorous (≥6 METs)      | 0.00 (0.26)   | 0.00 (0.07)            | 0.00 (0.09)  | 0.766   |
| Duration of work (h/day) | 0.01 (0.17)   | 0.02 (0.23)            | 0.03 (0.27)  | 0.965   |
| Moderate (3–5.9 METs)   | 0.00 (0.08)   | 0.00 (0.02)            | 0.00 (0.00)  | 0.556   |
| Vigorous (≥6 METs)      | 0.00 (0.26)   | 1.55 (4.61)            | 0.00 (4.29)  | 0.129   |
| Duration of leisure-time physical activity (h/day) | 1.75 (2.20)   | 1.42 (2.14)            | 2.00 (2.85)  | 0.176   |
| Sitting                 | 0.00 (2.86)   | 0.15 (4.61)            | 0.00 (4.29)  | 0.129   |
| Standing                | 0.25 (0.86)   | 0.54 (1.90)            | 1.00 (3.07)  | <0.001  |
| Walking                 | 6.1           | 24                     | 36.1         | 0.003   |

As compared with these results, JALSPAQ showed a smaller negative mean difference of −1.15 MJ/day and a higher correlation (Spearman correlation, 0.742; P < 0.001). A comparison of individual-level agreement indicates that the width of the 95% LOA in our study (7.68 MJ/day) was smaller than that in most other questionnaires described in the review of Neilson and colleagues (1133 to 17 948 kcal/day; 4.74 to 75.09 MJ/day).2 The relatively good agreement in this study partly resulted from the greater number of subjects (n = 226 in the present study vs n = 13 to n = 65 in previous studies) and the wide variation in TEE. Standard deviation was 2.77 MJ in the present study vs 0.35 to 3.51 MJ in previous studies. A study by Racette showed the lowest 95% LOA (−2.42 to 0.16 MJ/day).15 However, that study was part of an investigation of a 17-week outpatient weight loss treatment, so the subjects were thought to be highly motivated and to have answered the questionnaire carefully. One reason why TEE is assumed to have greater accuracy than the existing questionnaire is that it is believed to have more detailed questions regarding occupational activity, housework, and leisure-time physical activity.
The present study, 16 subjects were engaged in shipbuilding, and the differences between TEE by DLW and JALSPAQ ranged from −10.98 to 0.34 MJ/day; TEE was overestimated by JALSPAQ in only 2 subjects.

Although TEE estimated by JALSPAQ showed a relatively good correlation with TEE by DLW, RMR accounted for a large part of TEE. To lessen the contribution of RMR, PAL was compared between the two methods. The results for PAL were poor, and individual differences were widely distributed. Therefore, JALSPAQ must either be improved or another new questionnaire should be developed to assess individual PAL.

We also attempted to identify a physical activity that characterized physical activity level. Our results showed that total time spent in moderate physical activity was significantly greater in the active group. In addition, moderate and vigorous physical activity had a weak but significant correlation with PAL. Thus, moderate physical activity is an important component of physical activity level, as Westerterp has suggested. However, the duration of moderate physical activity did not differ in the sedentary and moderate groups. Wareham et al used a very brief questionnaire that only included physical activity during work and recreational activities and found that physical activity ratio (daytime energy expenditure/resting metabolic rate), which was estimated using a heart rate monitor, did not differ between inactive and moderately inactive groups, even though VO2max was different between these groups. Another method of classifying physical activity in sedentary subjects should thus be considered.

The present results also suggest that intensity and duration of physical activity during work (including occupational activity and housework) strongly affect PAL, whereas leisure-time physical activity does not. Both work and leisure-time physical activity play fundamental roles in total physical activity, which explains why previous brief physical activity questionnaires assessed only physical activity during work and leisure activity.

In conclusion, PAL by JALSPAQ weakly correlated with PAL by DLW, although TEE by JALSPAQ was better correlated with TEE by DLW than with TEE assessed by the questionnaires used in previous studies. TEE under-estimation was greater in active subjects than in sedentary and moderately active subjects. In addition, in this population, total moderate physical activity and physical activity during work were related to physical activity level, whereas leisure-time physical activity was not. To improve the physical activity questionnaire, an algorithm for heavy work should be added. In addition, to better differentiate sedentary subjects from moderate subjects, additional questionnaire items should be added or the algorithm should be reevaluated.

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