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SHORT COMMUNICATION

Assessment of the physical activity level with two questions: validation with doubly labeled water

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Objective: To validate a two-question questionnaire on physical activity with the doubly labeled water (DLW) method.
Design: Cross-sectional study.
Subjects: Nine volunteers, age 33–75 years, with a mean body mass index (BMI) (kg m^{-2}) of 27.4.
Measurements: A questionnaire with one question on physical activity at work and one question on physical activity during leisure time. The answers were converted into a PAL (physical activity level = energy expenditure/basal metabolic rate) value, which was validated with the DLW method.
Results: The mean values (s.d.) of PAL for the questionnaire and DLW measurements were 1.7 (0.1) and 1.7 (0.1), respectively, with a mean difference of 0.004 (0.172).
Conclusions: The results were promising to the extent that they could be used in large-scale epidemiological studies.
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Keywords: energy expenditure; doubly labeled water method; physical activity questionnaire; validation

Introduction

Energy expenditure (EE) is a function of body size and physical activity, where the first can be predicted from height, weight, age and gender, whereas the physical activity can be very different between subjects and we lack a comparable easy method for assessment.

The doubly labeled water (DLW) method is the most accurate method for measuring EE. Unfortunately, this method is expensive and requires a specialized laboratory for sample analysis. Therefore, other methods are used to estimate EE, such as minute-by-minute heart rate monitoring, accelerometers, pedometers, activity diaries and physical activity questionnaires (reviews of these methods are given in Sjöström *et al.*[1], Andrén Aronsson[2] and Matthiessen *et al.*[3]) Here, the focus is on a simplified activity questionnaire.

As measuring EE or PAL (PAL = energy expenditure/basal metabolic rate) is essential for many purposes, such as in validating dietary surveys and evaluating the significance of EE, for instance for estimating the relationship to health/disease variables, it would be valuable to obtain a quick and reliable method to estimate EE (PAL).

Therefore, the aim of this study was to validate two questions on physical activity, at work and at leisure time, for energy expenditure.

Subjects and methods

Subjects were 6 women and 3 men, age 33–75 years, mean age (s.d.) 60 (11) years, with a mean BMI (kg m^{-2}) of 27.4 with a s.d. of 4.5, minimum = 21.5 and maximum = 34.3. They were rheumatoid arthritis patients participating in a 3-month dietary intervention study. The EE (PAL) was measured in two ways, with a questionnaire and by the DLW method.

The first version of the questionnaire was constructed by Professor Bengt Saltin, Karolinska Institute, Stockholm, Sweden, in the 1960 s (B Saltin, personal communication) and was first published 1968.[4] Since then, the questionnaire has been modified in various ways (Table 1). The PAL values in the boxes are estimates performed by one of the authors (GJ) and are based on the literature on physical activity and energy expenditure (Table 2). Physical activity during the previous 3 months was recorded by the volunteers.

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Table 1 The physical activity questionnaire used in this study

Describe your physical activity at work (even work at home, sick leave at home and studying, for instance in a university)
1. Very light, e.g., sitting at the computer most of the day or sitting at a desk
2. Light, e.g., light industrial work, sales or office work that comprises light activities
3. Moderate, e.g., cleaning, staffing at kitchen or delivering mail on foot or by bicycle
4. Heavy, e.g., heavy industrial work, construction work or farming

Describe your physical activity at leisure time. If the activities vary between summer and winter, try to give a mean estimate
1. Very light: almost no activity at all
2. Light, e.g., walking, nonstrenuous cycling or gardening approximately once a week
3. Moderate: regular activity at least once a week, e.g., walking, bicycling, or gardening or walking to work 10–30 min day^{-1}
4. Active: regular activities more than once a week, e.g., intense walking or bicycling or sports
5. Very active: strenuous activities several times a week

Table 2 The scheme for estimating physical activity levels

Physical activity in leisure time	*Physical activity at work*			
	Very light	*Light*	*Moderate*	*Heavy*
Very light	1.4	1.5	1.6	1.7
Light	1.5	1.6	1.7	1.8
Moderate	1.6	1.7	1.8	1.9
Active	1.7	1.8	1.9	2.1
Very active	1.9	2.0	2.2	2.3

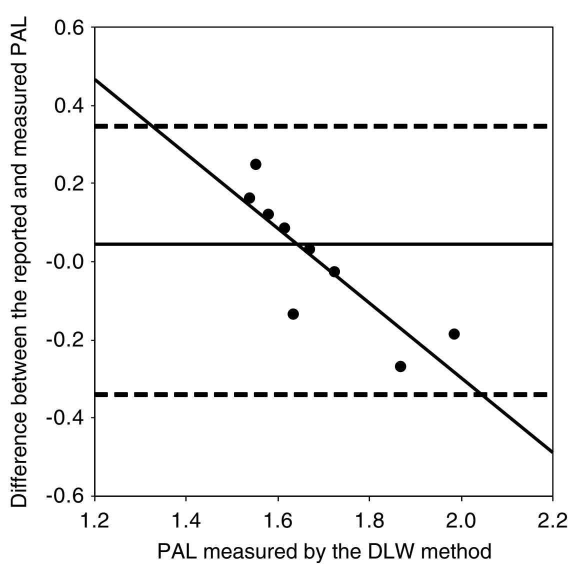

Figure 1 Validation of a short questionnaire on physical activity with the double-labeled water method ($n=9$, $r=0.89$).

The EE (PAL) of the nine subjects was measured over 14 days by means of the DLW method.[5] This was performed during the last weeks of the study period. After collecting three background urine samples, the subjects ingested an oral dose of 0.12 g ^2H_2O and 0.25 g $H_2^{18}O$ per kilogram estimated body water.[6,7] After ingestion of the DLW, the dose bottle was rinsed with 50 ml tap water, which was also consumed. One urine sample was taken 24 h after the dose was consumed, and again 5, 8 and 14 days after ingesting the dose. The samples were stored at $-20\,^{\circ}C$ until analysis took place. The subjects were instructed to drink water only from their home and not to change their eating or drinking habits during the time of the EE measurement. The time of dosing and voiding times were recorded, and body weight was measured to nearest 0.1 kg at the time of the dose and after final voiding. The isotopes deuterium (2 H) and oxygen-18 (^{18}O) in the urine were analyzed by isotope ratio mass spectrometry (Optima, VG Isogas Ltd, Middlewich, Cheshire, UK). The CO_2 production rate was calculated from the elimination rates of the two stable isotopes using the equation of Schoeller.[6] The respiratory quotient (RQ) of the diet was taken as 0.85,[8] and the EE was calculated based on the CO_2 and the RQ. The food quotient (FQ) was, however, calculated from the diet history interviews for comparison. The FQ was calculated according to the following equation:

$$FQ = (p\times0.81) + (f\times0.71) + (c\times1.00) + (a\times0.67)$$

where p, f, c and a represent the fraction of the total metabolizable energy contributed by protein, fat, carbohydrates and alcohol, respectively.[8]

The PAL was calculated by dividing the EE by estimated basal metabolic rate (BMR). The BMR was estimated based on body weight, age group and sex, according to standard equations.[9] The analyses were blinded, that is, none of the authors knew the results of the DLW analyses or of the two questions before analyzing the data.

This study was approved by the ethics committee at the Faculty of Health Sciences at Linköping University and followed the ethical principles of the Helsinki Declaration Principles.

Results

The mean values (s.d.) of PAL for the questionnaire and DLW measurements were 1.7 (0.1) and 1.7 (0.1), respectively, with a mean difference of 0.004 (0.172). We have constructed a Bland–Altman plot where the PAL measured with the DLW method was on the *x* axis, and the difference between the reported PAL with the questionnaire and the PAL measured with the DLW method on the *y* axis (Figure 1). The analysis showed there was a difference of ±0.2 from the mean value for the most extreme values. It also showed that for low reported PAL values, there was an overestimation, and for high reported values, there was an underestimation. However, the differences were small. The best estimates were around PAL 1.6 and the *r*-value for the slope was 0.89. The EE can be calculated by multiplying PAL with BMR. In this study, the EE according to the questionnaire was 10.8

(1.8) MJ and according to DLW was 10.9 (2.7) MJ with a difference of 0.08 (1.20) MJ.

Discussion

This study showed that it is possible to estimate PAL in a simple and quick way. However, the study had limitations. It was a small study with RA patients, and the study should be enlarged, with a wider range of people with different physical activities, to be fully accepted as a valid method. The questionnaire has previously been validated against a 7-day physical activity record in 20 young physical active women (student dissertation, Umeå, 1999, Erica Näslund, AnnaCarin Rowa). The result was almost identical (no statistical differences), PAL 2.0 with both methods. These two studies with different samples and good results make it worthwhile to extend the validation of this questionnaire.

Another drawback with this study is that the BMR was estimated with the Schofield equations and not measured. Nevertheless, this is general practice to present BMR in large-scale epidemiological studies. We recently showed for Caucasians, as were the subjects in the current study, that measured values were not different from values as predicted from age, weight and gender with the Schofield equations.[10]

These results give people working with public health and large epidemiological studies, a quick and easy tool in their work with the significance of EE. It also enables nutritionists performing dietary surveys to evaluate the energy intake (EI) and food intake level (FIL = EI/BMR) by direct comparison with EE, instead of using a nonspecific minimum PAL value such as the Goldberg cut-off.

Earlier studies showed similar or weaker associations between a questionnaire and doubly labeled water derived activity score. The Baecke questionnaire tended to show the highest correlation ($r = 0.69$, $P < 0.001$),[11] and next best was the physical activity scale for the elderly ($r = 0.67$, $P < 0.01$)[12] and the Tecumseh questionnaire ($r = 0.64$, $P < 0.01$).[11] The index of the Five-City questionnaire was not related to the doubly labeled water assessed physical activity level.[11]

In conclusion, the results of the two-question questionnaire are promising to the extent that it could be used in large-scale epidemiological studies.

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