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SHORT REPORT

Poor agreement between a portable armband and indirect calorimetry in the assessment of resting energy expenditure

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KEYWORDS
Resting energy expenditure;
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Summary
Background & aims: To evaluate the agreement between resting energy expenditure (REE) estimated by a portable armband and measured by indirect calorimetry.
Methods: One-hundred and twenty-seven women and 42 men with a mean (SD) age of 44 (12) years and a body mass index of 30.2 (5.4) kg/m^2 were studied. REE was estimated using the Sense Wear Pro 2 Armband (SWA), measured using the Sensor Medics 29 metabolic cart (V_{max}), and estimated using Schofield's equation. The limits of agreement (LOA) and the concordance correlation coefficient (CCC) were used to evaluate the interchangeability of the methods.
Results: The LOA between REE_{SWA} and $REE_{V_{max}}$ were wide in both women (−269 to 378 kcal/day) and men (−330 to 545 kcal/day) and CCC was low (0.579 in females and 0.583 in males, $p < 0.0001$ for both). $REE_{Schofield}$ agreed with $REE_{V_{max}}$ to a similar degree (CCC = 0.563 in females and 0.500 in males, $p < 0.0001$ for both).
Conclusions: SWA and indirect calorimetry are not interchangeable methods for the assessment of REE in normal-weight and obese subjects.

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Introduction

The assessment of energy expenditure plays a central role in the evaluation and management of the overweight patient.[1] The direct measurement of total energy expenditure (TEE) by direct calorimetry or doubly labeled water cannot be employed on field so that, in clinical practice, TEE is usually estimated from resting energy expenditure (REE) and physical activity.[2] Although REE can be measured by indirect calorimetry, this latter is expensive and not routinely available so REE is often estimated from algorithms whose accuracy is highly variable at the individual level.[2] The Sense Wear Pro 2 Armband (SWA) is a portable device that monitors various physiological parameters (heat flux, skin temperature, galvanic skin response and near-body temperature) and movement (accelerometer).[3] SWA has a great potential for the assessment of REE but has undergone few validation studies so far.[3,4] The aim of the present study was to establish the agreement between SWA and indirect calorimetry for the assessment of REE in a sample of normal-weight and obese subjects.

Materials and methods

Subjects

A convenience sample of 169 subjects (127 women and 42 men) with a mean (SD) age of 44 (12) years was consecutively recruited by word of mouth among the University personnel and the overweight patients cared for at the ICANS. All subjects underwent a clinical history and a physical examination. Acute and chronic organ diseases were reasons for exclusion. The study protocol was approved by the local Ethical Committee and all subjects gave their written consent to participate in the study.

Anthropometry

Weight and height were measured according to standard guidelines. BMI was calculated as weight (kg)/stature $(m)^2$.

Indirect calorimetry

REE was measured with an open-circuit ventilated-hood system [Sensor Medics 29 (V_{max}), Anaheim, CA, USA]. All measurements were made in a thermoneutral environment (24—26 °C) and in the absence of external stimuli. At least 30 min of respiratory gas exchange data were collected. The data collected during the first 5—10 min were discarded to allow the subjects to acclimatize to the canopy and instrument noise.[5] REE was calculated from Weir's equation.[6] For comparison, REE was also estimated from Schofield's equation based on weight and age.[7]

SWA

The Sense Wear Pro 2 Armband (BodyMedia Inc, Pittsburgh, PA, USA) was positioned over the triceps muscle 10 min before data collection.[3,4] SWA data were collected for at least 30 min contemporary to indirect calorimetry. Energy expenditure was estimated by the Innerview Research Software version 4.0.

Statistical analysis

Values of continuous variables are reported as mean and standard deviation (SD). Between-group comparisons were performed using Student's unpaired *t*-tests. Bland and Altman's method was used to calculate the limits of agreement (LOA) between REE_{SWA} or $REE_{Schofield}$ and $REE_{V_{max}}$.[8] Bias was defined as the difference between REE_{SWA} or $REE_{Schofield}$ and $REE_{V_{max}}$. Pitman's test was used to evaluate proportional bias.[8] Lin's concordance correlation coefficient (CCC) was calculated as further measure of agreement.[9] Comparison of measured and predicted values was performed using Student's paired *t*-tests.

Results

Table 1 gives the measurements of the study subjects. Women, who made up to 75% of the study sample, were lighter and shorter than men but had a similar BMI. Expectedly, REE was higher in men independently from the measurement method and 82 out of 169 subjects (48%) were obese as defined by a BMI ≥ 30 kg/m^2.

Table 2 reports the agreement between REE_{SWA} and $REE_{Schofield}$ with $REE_{V_{max}}$ and Fig. 1 gives the corresponding LOA and CCC plots. The fixed bias of REE_{SWA} was 55 in females and 108 kcal/day in males ($p < 0.0001$). Even if the mean bias is not especially high its SD is causing wide LOA (−269 to 378 kcal/day in females and −330 to 545 kcal/day in males). The fixed bias of $REE_{Schofield}$ was higher than that of REE_{SWA} (91 kcal/day in females and 197 kcal/day in males, $p < 0.0001$) but the lower SD caused LOA similar to REE_{SWA} (−178 to 361 kcal/day in females and −185 to 580 kcal/day in males). $REE_{Schofield}$ but not REE_{SWA} showed negative proportional bias in both genders. The CCC of REE_{SWA} and $REE_{Schofield}$ was similarly low in both women ($p = 0.579$ *vs.* 0.563, $p < 0.0001$ for both) and men ($p = 0.583$ *vs.* 0.500, $p < 0.0001$ for both).

Discussion

Our study shows a poor agreement between REE estimated by SWA and measured by indirect calorimetry.

Table 1 Measurements of the study subjects

	Females ($n = 127$)	Males ($n = 42$)	p Value[a]
Age (years)	44 (12)	44 (11)	0.8782
Weight (kg)	76.9 (14.1)	94.8 (13.2)	<0.0001
Stature (m)	1.60 (0.10)	1.74 (0.07)	<0.0001
BMI (kg/m^2)	29.8 (5.7)	31.2 (4.4)	0.1016
$REE_{V_{max}}$ (kcal/day)	1409 (188)	1784 (283)	<0.0001
REE_{SWA} (kcal/day)	1463 (183)	1892 (238)	<0.0001
$REE_{Schofield}$ (kcal/day)	1500 (137)	1982 (190)	<0.0001

Abbreviations: BMI = body mass index; REE = resting energy expenditure.

[a] Unpaired Student's *t*-test.

Table 2 Agreement between SWA and Schofield's equation with indirect calorimetry for the assessment of resting energy expenditure

	Females ($n = 127$)			Males ($n = 42$)		
	Fixed bias mean (SD) [LOA]	Proportional bias	CCC [95%CI]	Fixed bias mean (SD) [LOA]	Proportional bias	CCC [95%CI]
SWA	55 (165)* [−269 to 378]	$r = -0.034$, $p = 0.707$	0.579** [0.467−0.691]	108 (224)* [−330 to 545]	$r = -0.221$, $p = 0.180$	0.583** [0.397−0.768]
Schofield's equation	91 (138)* [−178 to 361]	$r = -0.400$, $p < 0.001$	0.563** [0.466−0.661]	197 (195)* [−185 to 580]	$r = -0.508$, $p = 0.007$	0.500** [0.340−0.659]

*Significantly different from 0 at p value < 0.0001; **$p < 0.0001$.
Abbreviations: SD = standard deviation; LOA = limits of agreement; CCC = concordance correlation coefficient; 95%CI = 95% confidence interval.

Malavolti et al. performed a similar study in 52 females and 47 males with a mean (SD) age of 38 (14) years and a BMI of 23 (3) kg/m^2.[4] REE_{SWA} was 1540 (280) kcal/day and $REE_{V_{max}}$ was 1700 (330) kcal/day. Unfortunately, they do not report the mean (SD) bias, even if the first can be approximated by the between-mean difference of −160 kcal/day, which is reported as not statistically significant. Besides being lower, our $SWA_{V_{max}}$ bias was positive (55 and 108 kcal/day in women and men, respectively). However, our LOA, and possibly those of Malavolti et al. (as can be judged from calculations performed on the basis of the unclearly labeled axes of their LOA plot),[4] are too high for SWA and V_{max} to be considered as interchangeable measures of REE. Malavolti et al. reported Pearson's correlation coefficient of 0.86 between the two measures of REE ($p = 0.001$).[4] Even if there is no gold-standard method to evaluate agreement, the correlation coefficient does not take into account within-individual variability and is not a good measure of agreement.[8] We used Lin's CCC because it is one of the less biased measures of agreement.[9] The CCC value for the SWA *vs.* V_{max} comparison (0.579 for females and 0.583 for males, $p < 0.0001$ for both) confirms the lack of agreement already shown by LOA. The CCC for the SWA *vs.* Schofield comparison was very similar (0.563 for females and 0.500

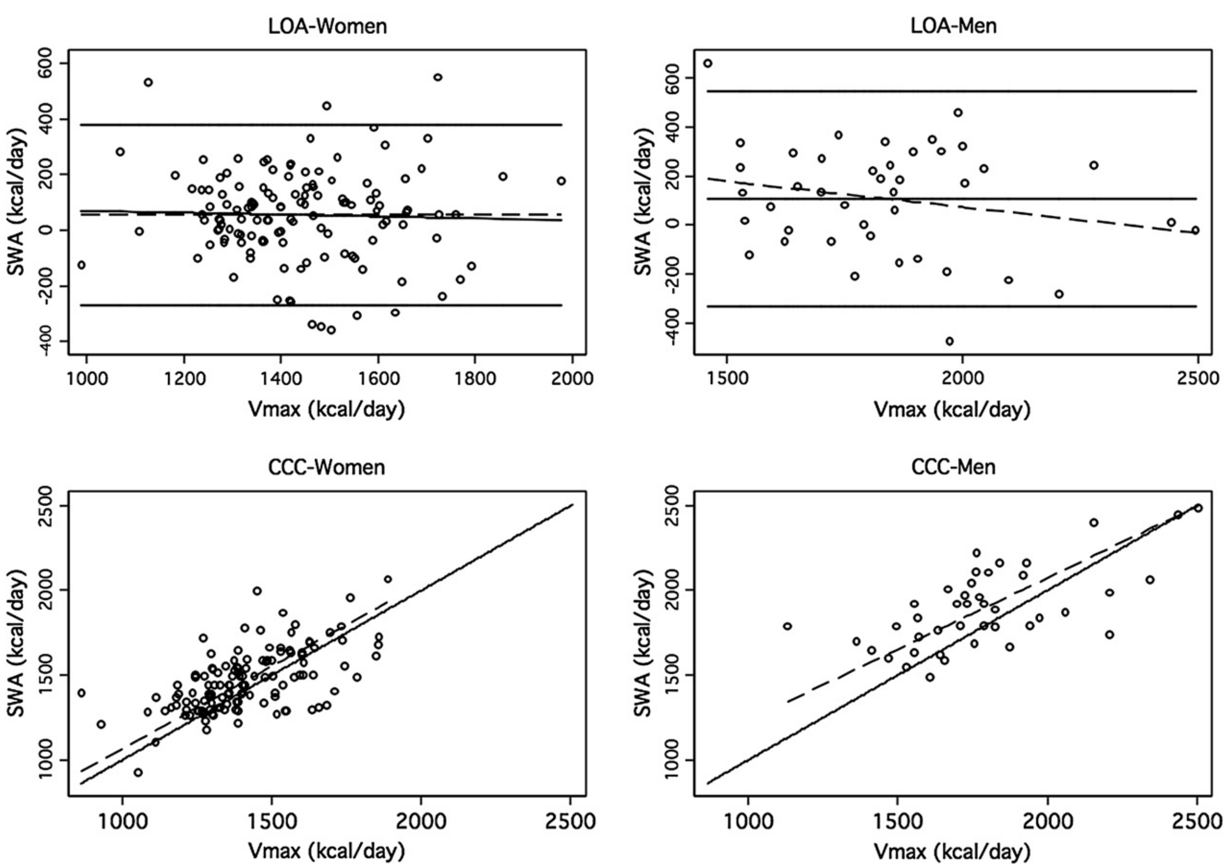

Figure 1 Plots of the limits of agreement (LOA) and concordance correlation coefficient (CCC) between SWA and indirect calorimetry. In LOA graphs, continuous lines are means and limits of agreement and dashed lines are correlation plots (Pitman's test). In CCC graphs, dashed lines are reduced major axes and continuous lines are the lines of perfect concordance.

for males, $p < 0.0001$ for both), showing no real advantage of SWA over Schofield's equation in our subjects.

Papazoglou et al. performed a similar study in 142 obese subjects with a mean (SD) age of 47 (14) years and a BMI of 42 (7) kg/m^2.[3] REE_{SWA} was 1811 (346) kcal/day and $REE_{V_{max}}$ was 1880 (382) kcal/day. Thus, there was a mean overestimation of 69 kcal/day for SWA *vs.* V_{max}. This compares well to our mean bias of 55 kcal/day in females and of 108 kcal/day in males. However, the authors concluded that SWA and V_{max} were not interchangeable because of high LOA.[3] In a subgroup analysis of subjects with BMI ≤ 30 kg/m^2, they found nonetheless a ''very good agreement'' between the two methods. In our study, the mean BMI of men and women ranged from 18.1 to 50.1 kg/m^2, the mean BMI was indicative of overweight or obesity, and nearly one in every two subjects was obese. We did not find, however, any association of the SWA−V_{max} bias with BMI (Pearson's $r = -0.004$, $p = 0.393$, $n = 169$).

It has been suggested that age and anthropometry may contribute substantially to the prediction of REE made by SWA.[3] Our data confirm this hypothesis since in our study, age, weight and stature contributed independently 80% of the variance of REE_{SWA} (*vs.* 64% of that of $REE_{V_{max}}$). Weight made the greatest contribution to REE_{SWA} [standardized beta regression coefficient = 0.633, $p < 0.0001$, followed by stature (0.236, $p < 0.0001$) and age (−0.142, $p < 0.001$)].

Conclusion

In conclusion, our study shows a poor agreement between SWA and indirect calorimetry for the assessment of resting energy expenditure. Our results strongly support the suggestion made by other authors that further research is needed before SWA can be considered as a good replacement of indirect calorimetry in clinical practice.[3]

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Conflict of interest statement

Authors have no conflict of interest.

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