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Running head: Validity of an activity monitor on children

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ABSTRACT

Purpose: To examine the ability of the SenseWear Pro2 Armband (SWA) to accurately assess energy expenditure in free-living overweight or obese children during a two-week period, by comparison with energy expenditure measured using the doubly labeled water (DLW) method. A second aim was to examine which software version, Innerview Professional 5.1 or Sensewear Professional 6.0, are the most appropriate for use together with SWA in overweight and obese children.

Method: A random sample of 22 healthy, overweight or obese children (11 girls and 11 boys) aged 8-11 years was recruited from an ongoing intervention study. Energy expenditure in free-living conditions was simultaneously assessed with the SWA and DLW methods during a 14-day period. All data from the SWA were analyzed using InnerView Professional software versions 5.1 (SWA 5.1) and 6.1 (SWA 6.1).

Results: An accurate estimation in energy expenditure was obtained when SWA 5.1 was used, showing a non-statistically significant difference corresponding to 17 (1200) kJ·d⁻¹ compared with the energy expenditure measured using the DLW method. However, when SWA 6.1 was used a statistically significant (18%) underestimation of energy expenditure was obtained, corresponding to 1962 (1034) kJ·d⁻¹ compared with the DLW method.

Conclusion: The SWA together with software version 5.1, but not 6.1, is a valid method for accurately measuring energy expenditure at group level of free-living overweight and obese children.

Keywords: doubly labeled water, activity monitor, physical activity, overweight children

INTRODUCTION

Paragraph Number 1 Low physical activity is an important and independent risk factor for obesity. It is associated with an increased risk of diseases such as metabolic syndrome and cardiovascular disease, which are most often manifested in adulthood (28). However, low physical activity among children has also been shown to be associated with increased metabolic risk factors already in childhood (1, 15). An inverse association between physical activity and clustering of risk factors for cardiovascular disease has been found among children (16). Furthermore, it has been shown that low physical activity in adolescence independently predicts obesity in adulthood (19), and that levels of physical activity in youth track into adulthood (18, 30). Consequently, promotion and measurement of physical activity in early childhood is of great importance.

Paragraph Number 2 Accurate assessment of the total amount of children's physical activity is important in further examining the relationship between physical activity and health. Today, a wide range of methods for measuring physical activity of children are being used. These include self-reports such as questionnaires, activity logs and diaries as well as more objective methods such as accelerometers, pedometers and heart rate monitors (26, 27). The objective methods are performed through the registration of either body movements or the physiological consequences of the movements, like increased heart rate, heat loss or oxygen consumption. However, the most valid method for measuring energy expenditure in free-living subjects is the doubly labeled water (DLW) method, which measures carbon dioxide production during a one to two-week period (22). This method is regarded as the gold standard and the most suitable criterion method. Validation studies have shown that the precision of the DLW method in measuring energy expenditure is 2-8%, depending on the isotope dose and the duration of the elimination period (10). However, because of its

excessive cost, the DLW method is usually not possible to use within large populations (23). Consequently, less expensive objective methods like accelerometers, pedometers and heart rate monitors need to be used (27). Another advantage of using these methods instead of the DLW method is that, they not only give information about energy expenditure, but also the dimension of physical activity e.g. duration, frequency, intensity and type of activity. However, the limitation of accelerometers and pedometers is that it is not possible to measure estimate increased energy expenditure associated with walking upstairs or an incline, or to accurately estimate activities such as skating and cycling, which are common activities for many children (27). Heart rate monitors also have limitations since they respond to a person's emotions (such as anxiety) and increased body temperature, which might lead to overestimated energy expenditure. They also tend to lag momentarily behind changes in movement and remain elevated after the termination of the movement (27). This is a limitation that may be of significance in measuring children's activities, since an intermittent activity pattern is common among children.

Paragraph Number 3 During recent years, activity monitors that combine different parameters such as accelerometry and physiological parameters have been developed to increase the accuracy in assessing physical activity (9). One of these is the SenseWear Armband (SWA) (BodyMedia, Inc., Pittsburgh, PA, USA), which combines different sensors that detect movements and body heat production into one device that is attached around the upper arm. Data registered by the SWA is converted into energy expenditure using the computer software InnerView Professional (later software versions named SenseWear Professional), which uses activity-specific algorithms. SWA also provides estimates of intensity (MET-level), frequency and duration of physical activity. An advantage with SWA is its design, which allows children to wear the device without preventing them from

participating in everyday activities (4). In a previous study, SWA in combination with software version 4.02, has been validated in free-living adults, showing that total energy expenditure was underestimated by 5% compared with the DLW method (24). However, to our knowledge there have only been a few validation studies including healthy children (2, 3, 14) and none including overweight or obese children during a longer period of free living. Therefore, the aim of the present study was to examine the ability of the SWA to accurately assess energy expenditure in free-living overweight and obese children during a two-week period through comparison with energy expenditure measured using the DLW method. A second aim was to examine which software version, Innerview Professional 5.1 or Sensewear Professional 6.0, is the most appropriate for use together with SWA in overweight and obese children.

METHODS

Subjects

Paragraph Number 4 Twenty-two overweight and obese children (11 girls and 11 boys) aged 8-11 years were randomly selected from 105 children participating in an ongoing intervention study in the SELFH (Studies of the Effect of Lifestyle and Food habits on Health) project at Umeå University in Sweden. The aim of the two-year intervention study is to improve the food habits, physical activity and health of overweight and obese children. All children participating in the intervention study were recruited during a ten-month period, August 2006- May 2007. The inclusion criteria were: born 1995-1998, living in or near the northern Sweden city of Umeå, age and gender-adjusted BMI > 25 (8), no chronic disease that could influence metabolic parameters, and no attention deficit disorder. Written informed consent was obtained from the children's parents and verbal consent was obtained from each child through their parents. The study was approved by the Regional Research Ethics Review

Board (Ref nr: 05-088M), and all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the study.

Doubly labeled water method

Paragraph Number 5 Total energy expenditure was measured using the DLW method on all 22 children during a consecutive 14-day period. The DLW method is largely based on supplying the body water with stable isotopes of deuterium (^2H) and oxygen (^{18}O) and then assessing the time it takes to wash the isotopes out, as the concentration declines exponentially toward the natural concentration. Each child gave three baseline urine samples before ingesting an oral dose of 0.25g ^{18}O and 0.12g ^2H per kg estimated body water (12, 22). After the dose was ingested, the bottle was rinsed with tap water which also was ingested by the child to ensure that all the DLW had been consumed. Single urine samples were collected 12 h and 24 h after dose administration and again on days 8, 13 and 14. The urine samples were stored at -18°C until analyzed. Body weight was measured to the nearest 0.1 kg using a digital scale (AJ Medical, Stockholm), with the child lightly clothed, both before and 14 days after administration of the DLW dose. The children consumed their normal diets, were in good health and remained in their home region during the 14-day study period. Isotope concentrations in the urine were analyzed using isotope ratio mass spectrometry (Aqua Sira, VG, UK) (29). Energy expenditure was calculated using the Schoeller multipoint method (22), and the respiratory quotient was set at 0.85 (5).

SenseWear Pro₂ Armband

Paragraph Number 6 The SWA is a multiple-sensor device that collects data from a skin temperature sensor, heat-flux sensor, near-body temperature sensor, galvanic skin response sensor and a biaxial accelerometer. The information from the sensors together with

information about age, gender and handedness as well as measured weight and height were included in proprietary algorithms to estimate energy expenditure. The same day as the dose of DLW was administered to the child, the SWA was put on the child's right arm over the triceps muscle according to manufacturer recommendations. Each child was instructed to wear the SWA during the following consecutive 14 days and to remove it only when bathing or participating in other water activities. Total energy expenditure was registered by the SWA at one-minute intervals, and during the time off-body the InnerView software estimated the energy expenditure as equal to the child's basal metabolic rate (BMR). The SWA-wearing period was 14 days, but since the memory capacity of the device was only ten days the child had to change to a new SWA on day seven. Due to practical reasons and the high demand of the other measurements and activities while participating in the intervention study, it was unreasonable to ask the children to visit the university in order to download data from the first seven days and then use the same armband for the rest of the period. Therefore, a second SWA with empty memory was given to the child to be used during the last seven days of the measurement period.

Paragraph Number 7 When the data collection of the study started, only InnerView Professional software version 5.1 (BodyMedia, Inc., Pittsburgh, PA, USA) was available. However, during the data collection period version 6.1 was released and all data registered by the SWA during the 14-day period were therefore downloaded to and analyzed using both software versions (for ease of reference, the two versions of the data results are referred to here as SWA 5.1 and SWA 6.1). In order to provide information on what activities the children participated in when being physically active, they were asked to fill in a questionnaire at the end of each SWA-wearing day.

Data analysis and statistics

Paragraph Number 8 Energy expenditure was simultaneously estimated using the SWA and DLW methods during a 14-day period of free living, and comparisons were made with the DLW as the criterion method. Days with SWA registration of less than 19 hours ($< 80\%$) of wearing time were excluded before data analyses were done. The motives for using the cutoff of ≥ 19 hours of wearing time were to capture a majority of the energy expenditure during a day as well as to enable the inclusion of a majority of the 14 days of monitoring. When days of the 14 d measured period was missing average energy expenditure, calculated from the measured days, was added so that each participant had 14 d of measuring for comparison. During non-monitoring e.g. off body time energy expenditure corresponding the child's estimated BMR according to Innerview software was added by the software. The BMR of overweight children was calculated by the author based on gender, age and weight, and the BMR of those with obesity was calculated based on gender, age, weight and height according to equations presented by Dietz et al. (13). Physical activity level (PAL) was calculated as the ratio of energy expenditure to BMR for each method: PAL_{SWA} and PAL_{DLW} , respectively.

Paragraph Number 9 All data were checked for normality before being statistically analyzed, and the results are expressed as means (standard deviations). Paired t -tests were performed to determine differences between the mean values obtained with the SWA and the DLW, and Bland & Altman plots (6) were used to evaluate the agreement between the two methods. Pearson's product moment correlation was used to determine the relationship between the SWA and the DLW. Student's t -test for independent samples was used to analyze differences between boys and girls in wearing time and time performing activities at different metabolic equivalents (MET), and the Wilcoxon signed rank test was performed to determine differences between SWA 5.1 and SWA 6.1 in energy expenditure at different

MET levels. All statistical analyses were performed using SPSS version 15.0 (SPSS INC., Chicago, IL, USA) and the significant level was set at $p < 0.05$.

RESULTS

Paragraph Number 10 Information on physical activity at group level, estimated by the SWA, was collected during 265 days (86%) of the planned 308 days. Twenty-two days had to be excluded due to less than 19 h wearing time for the SWA, and 21 days were missing due to children not wearing the SWA during the whole 14-day period. The mean number of days monitored was 12 (2.4) days per child, range 7-14 days, and an average of energy expenditure for missing day was used so each participant had 14 d of data for comparison. The mean wearing time of the SWA was 23.3 (0.98) h per day, which corresponds to 97% of the day. No statistically significant differences between boys and girls were found regarding wearing time. Neither were there any differences between boys and girls regarding any of the characteristics presented in table 1. Of the participating children, 77% were overweight and 23 % were obese when included in the study.

Paragraph Number 11 The mean difference between energy expenditure estimated by SWA 5.1 and 6.1, respectively, compared with the DLW method is illustrated in a Bland & Altman plot (Figure 1). SWA 5.1 showed a non-significant underestimation in energy expenditure corresponding to 17 (1200) $\text{kJ} \cdot \text{d}^{-1}$ (95% CI: -549, 515) (Figure 1). At group level there was no statistically significant difference in energy expenditure estimated by SWA 5.1 compared with that measured with the DLW method (Table 2). In nine (41%) of the 22 children, the energy expenditure estimated by SWA 5.1 was within $\pm 5\%$ of the energy expenditure individually measured with the DLW method, which corresponds to $\pm 538 \text{ kJ} \cdot \text{d}^{-1}$. Six (27%) of the measurements were above the $\pm 5\%$ interval, while seven (32%) were below it.

Paragraph Number 12 When the energy expenditure estimated by SWA 6.1 was observed, statistically significant lower energy expenditure was obtained compared with the DLW method (Table 2). Compared with energy expenditure measured using the DLW method, the energy expenditure estimated by SWA 6.1 was significantly underestimated by 18%. This underestimation in energy expenditure corresponds to 1962 (1034) kJ·d⁻¹ (95% CI: -2420, -1503) (Figure 1), and was significantly underestimated for both genders. For girls the underestimation in energy expenditure was 1884 (833) kJ·d⁻¹ (95% CI -2445, -1325), and for boys 2039 (1241) kJ·d⁻¹ (95% CI -2872, -1205). For only one of the 22 children was the energy expenditure estimated by SWA 6.1 within $\pm 5\%$ of the energy expenditure individually measured with the DLW method, which corresponds to ± 538 kJ·d⁻¹. For all the other 21 children, the estimated energy expenditure was below the $\pm 5\%$ interval.

Paragraph Number 13 When dividing and analyzing the children in subgroups; compliant (8 children with 14 d of SWA data) versus non compliant (14 children with < 14 d of SWA data) participants, there is still no significant difference in energy expenditure estimated by SWA 5.1 and DLW. Energy expenditure of compliant participants was none significantly overestimated with 3% by SWA 5.1, which corresponds to 344 (1051) kJ·d⁻¹ (95% CI: -535, 1223), $p=0.385$. Meanwhile, energy expenditure of none-compliant participants was none significantly underestimated with 1% which corresponds to 224 (1267) kJ·d⁻¹ (95% CI: -955, 507), $p=0.520$. However, when using SWA 6.1 there is a significant underestimation of energy expenditure compared to energy expenditure measured by DLW. Energy expenditure of compliant participants was underestimated with 19%, which corresponds to 1957 (1063) kJ·d⁻¹ (95% CI: -2845, -1068), $p=0.001$. Meanwhile, energy expenditure of none-compliant participants was underestimated with 18%, which corresponds to 1965 (1058) kJ·d⁻¹ (95% CI:

-2576, -1354), $p < 0.001$. There were no significant differences in neither background variables nor physical activity level between the two subgroups (data not shown).

Paragraph Number 14 For all different MET levels there was a statistically significant difference in estimated time between SWA 5.1 and SWA 6.1 (Table 3). Estimates with SWA 5.1 showed that boys were physically active 1 h more per day than girls at MET levels ≥ 3 , boys 5.3 (0.9) $\text{h} \cdot \text{d}^{-1}$ and girls 4.3 (1.1) $\text{h} \cdot \text{d}^{-1}$ ($p = 0.03$). In comparison, the results of estimates with SWA 6.1 showed that boys were physically active 0.8 h more per day than girls at MET levels ≥ 3 , boys 3.4 (1.0) $\text{h} \cdot \text{d}^{-1}$ and girls 2.6 (0.9) $\text{h} \cdot \text{d}^{-1}$ ($p = 0.04$).

Paragraph Number 15 Estimated energy expenditure from activities at different MET levels, according to SWA 5.1 and SWA 6.1 respectively, is illustrated in Figure 2. No significant differences in energy expenditure from sedentary activities, 5724 (939) $\text{kJ} \cdot \text{d}^{-1}$ given by SWA 5.1 and 5910 (1091) $\text{kJ} \cdot \text{d}^{-1}$ given by SWA 6.1, were found ($p > 0.05$). However, for the three MET level intervals (3- <6, 6- <9 and ≥ 9) there was a statistically significant difference in estimated energy expenditure between SWA 5.1 and SWA 6.1 ($p < 0.001$). According to SWA 5.1, energy expenditure from moderate activities (MET level 3- <6) was 3524 (1071) $\text{kJ} \cdot \text{d}^{-1}$, while according to SWA 6.1 the energy expenditure derived from this activity level was 2365 (738) $\text{kJ} \cdot \text{d}^{-1}$ ($p < 0.000$). Furthermore, at MET levels ≥ 9 , the derived energy expenditure was 391 (615) $\text{kJ} \cdot \text{d}^{-1}$ according to SWA 5.1 compared with 108 (136) $\text{kJ} \cdot \text{d}^{-1}$ using SWA 6.1 ($p = 0.001$).

DISCUSSION

Paragraph Number 16 The present study was conducted to validate the energy expenditure of overweight and obese children when estimated by the SWA. An accurate estimate of the

children's energy expenditure was obtained when using the InnerView software version 5.1; however, when using version 6.1 an 18% lower energy expenditure was obtained.

Paragraph Number 17 The algorithms used by the SWA to calculate energy expenditure are proprietary to the manufacturer; therefore it has not been possible to make the comparison between SWA 5.1 and 6.1 transparent at all stages of data processing. Nonetheless, it is of great interest to evaluate the results from both SWA 5.1 and 6.1 as the SWA is being used to estimate people's physical activity and energy expenditure. According to release information from the manufacturer (BodyMedia Inc, 2007; Software Release Notes for BMS version 5.1, Sept 2005 to November 2007), changes have been made in SWA 6.1 to improve the following:

- 1) The ability to accurately estimate energy expenditure in children being sedentary
- 2) The ability to accurately estimate energy expenditure in obese people
- 3) Calorie estimates for exercise sessions
- 4) Equations for the calculation of resting metabolic rate

Paragraph Number 18 In a previous study on healthy children, the validity of the SWA, when using software version 4.0 and only during specific activities, showed an overestimation of energy expenditure by 16% during sleep and 43% during treadmill exercise at 60% $\text{VO}_{2\text{max}}$ compared with indirect room calorimetry (IRC) (14). Since then this old software version, with algorithms based on adult data, has been updated with algorithms for activities such as resting, walking, running (on-road and treadmill) and biking (on-road and stationary) suitable for children. To date, two studies have evaluated the validity of the SWA when using software version 5.1 (2, 3), and two studies have evaluated the validity when using software version 6.1 (2, 7). In the first study evaluating version 5.1, the SWA was

validated on healthy children performing specific physical activities (not total energy expenditure) (3). This study evaluated SWA 5.1 against indirect calorimetry, and showed that SWA 5.1 underestimate energy expenditure when children were resting in different positions. The underestimation was 19 % and 26% for lying quietly and sitting playing mobile game respectively. Furthermore, it was shown that SWA 5.1 underestimates energy expenditure in 11 of 14 tested activities, and that the underestimation increases with increased physical activity intensity. The underestimation ranged from 9 to 51% for the different activities, where the lower figure represents walking 4 km·h⁻¹ and the higher represents stationary biking. Accurate estimates of energy expenditure were obtained for activities such as jumping on a trampoline and slow-to-normal walking. In the second study, evaluating version 5.1, the SWA's ability to estimate total energy expenditure of free-living healthy children was validated against measurements by DLW (2). The results showed that total energy expenditure was overestimated with 9% among children. In the present study on the other hand, we showed that there was no statistically significant difference between total energy expenditure estimated by SWA 5.1 and the DLW at group level (Figure 1). It should, however, be noted that there is a relatively broad limit of agreement; mean $\pm$ 2 SD was -2417 to 2383 kJ·d⁻¹, indicating that SWA 5.1 might not be a valid method for assessing energy expenditure at an individual level.

Paragraph Number 19 In the first study evaluating SWA together with software version 6.1, the SWA was validated on free-living healthy children (2). This study evaluated SWA 6.1 against DLW, and showed that SWA 6.1 underestimates total energy expenditure with 6%. In the second study, evaluating version 6.1, the SWA was validated against indirect calorimetric on children participating in a range of activities (7). The results showed no difference in overall estimates of energy expenditure across the 41 min trial. Further, the study showed no

significant differences in estimated energy expenditure for the main part of the performed activities, except for biking which was significantly underestimated with 25% (7). However, in the present study we show that SWA 6.1 underestimates the total energy expenditure among overweight and obese children by 18% compared with the DLW method (Table 2). The underestimation remained when the data was divided and analyzed separately for compliant (14 d of SWA data) versus non-compliant (< 14 d of SWA data) participants, 19% and 18% respectively. This indicates that the changes in SWA 6.1 described above have impaired, rather than improved, the validity of assessing energy expenditure at group level.

Paragraph Number 20 Possible explanations for the differences in validity between SWA 5.1 and SWA 6.1 become more apparent when comparing the estimated time spent on different activity levels by the two software versions (Table 3). The data indicate that SWA 6.1 estimates significantly less total time spent on physical activity than SWA 5.1 does. When comparing time spent on sedentary activities ($MET < 3$), significantly less time was assessed by SWA 5.1 compared with SWA 6.1. The differences also became more apparent at higher METs. A significantly longer time spent on activities with $MET \geq 9$ was assessed by SWA 5.1 compared with SWA 6.1 (Table 3). Consequently, less estimated time spent on physical activity leads to lower total energy expenditure, which may be one explanation for the differences in validity between SWA 5.1 and SWA 6.1. This was also illustrated in a comparison of differences in accounts for energy expenditure derived from different activity levels when using SWA 5.1 and SWA 6.1 (Figure 2). Energy expenditure derived from time spent on sedentary activities accounts for 53% of the daily energy expenditure according to SWA 5.1, while the corresponding figure is 55% according to SWA 6.1. This may explain 2% of the 18% difference between SWA 5.1 and SWA 6.1. Furthermore, energy expenditure derived from activities at $MET 3 < 6$ accounts for 33% of the daily energy expenditure

according to SWA 5.1, while it accounts for 22% according to SWA 6.1. This may explain 11% of the 18% difference between SWA 5.1 and SWA 6.1.

Paragraph Number 21 The children's physical activity level (PAL) in the present study was 1.7 according to SWA 5.1 and 1.3 according to SWA 6.1. However, compared with other studies on Swedish children in the same age, a mean PAL of 1.3 seems to be an unlikely low activity level (11, 20). On the other hand a mean PAL of 1.7 as given by SWA 5.1 and the DLW, is comparable with moderate activity level as defined by Torun (25) and described in a validation study by Ekelund et al. (17). Information given by the children in the present study in a short questionnaire (data not shown) also suggests that this group of children has at least a moderate activity level. Most children, reporting walking or cycling to and from school, were physically active at playtime and participated in leisure activities. The results regarding time spent on at least moderate activity ($\text{MET} \geq 3$), $4.8 \text{ h} \cdot \text{d}^{-1}$ according to SWA 5.1 and $3.0 \text{ h} \cdot \text{d}^{-1}$ according to SWA 6.1, (Table 3) may be compared with the results of another study on Swedish children aged 8-11 years, where boys were active $3.5 \text{ h} \cdot \text{d}^{-1}$ at a level of at least moderate intensity and girls $3.2 \text{ h} \cdot \text{d}^{-1}$ (11). Despite the fact that there are few children in each group, the results of the present study shows that boys are more physically active than girls. This difference is congruent with results of other studies including children aged 8-13 years (10, 21).

Paragraph Number 22 A possible bias in the present study is the difference in day length between the SWA (average day comprise 23.3h) and DLW (24h) methods, which may have biased the data from the SWA towards underestimation. However, to reduce this possible underestimation the off-body function in the SWA was used, which means that during the time off-body the software program adds the child's estimated BMR to a more accurate

estimation of the total energy expenditure. Using off-body estimation may also affect the energy expenditure towards underestimation, especially when the SWA was removed during daytime. Included in the analyzes are 23 days with the armband removed between 1-3.5 h during the period between 8:00 a.m. and 7:00 p.m. Included in the analyzes are also 25 days with the armband removed between 1-3.5 h during the period between 7:00 p.m. and 8:00 a.m., a period of the day when most of the children were sedentary; thus resting metabolic rate would be a more appropriate estimate for their true energy expenditure. Another possible bias is that SWA was set to collect data at one-minute intervals, in order to increase the data collection memory, this may have limited the ability to capture the sporadic and short bursts of activities most often performed by children(21). The SWA-wearing period in the present study was 14 days, but the memory capacity of the SWA was only ten days. In order to cover the entire period, the children wore two different SWAs during the 14 days, despite the fact that confounding variables may have been introduced when two different monitors are used. The BMI of one boy participating in the present study decreased from overweight to normal weight during the one-month period between inclusion and the start of the measurement period. However, analyzing the results with and without this child (data not shown) did not change the results of the present study. Two children mentioned skin irritation toward the end of the 14-day wearing period, but both had solved the problem by changing the wearing arm for one to two days. Energy expenditure data from these two children did not differ from those of the rest of the group, and the change of the wearing arm has most likely not influenced the results significantly.

Paragraph Number 23 In conclusion, the results of the present study indicate that the SWA together with software version 5.1 is a valid method for accurately measuring energy expenditure at group level of free-living overweight and obese children. Furthermore, the

SWA together with software version 6.1 underestimated energy expenditure by 18% compared with the DLW method. Additional research is needed to further examine the SWA using software version 5.1 in other age groups of children and the applicability of the SWA with software version 6.1 in measuring energy expenditure of children.

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CONFLICTS OF INTEREST

There are no conflicts of interest

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TITLES AND LEGENDS OF FIGURES

Figure 1 Difference between energy expenditure estimated by the SenseWear Pro2 Armband, software versions 5.1 (SWA 5.1) and 6.1 (SWA 6.1), respectively, and energy expenditure measured using the doubly labeled water (DLW) method plotted against the mean of the two variables, for 22 overweight and obese children, 11 boys (▲) and 11 girls (□). Correlation coefficient for SWA5.1 was 0.03 (p=0.90) and the linear regression equation $y = -268 + 0.23x$. Correlation coefficient for SWA 6.1 was 0.06 (p=0.80) and the linear regression equation $y = -2338 + 0.038x$.

Figure 2 Energy expenditure at different activity levels (sedentary including sleep, 3-<6 MET, 6 -<9 MET, ≥9 MET) estimated by the SenseWear Pro2 Armband software versions 5.1 (SWA 5.1) and 6.1 (SWA 6.1), for 22 overweight and obese children.

Figure 1.

Figure 2.

Table 1 Characteristics of the participating children.

	All children (n=22)	Girls (n=11)	Boys (n=11)	P-value ³
	Mean (SD)	Mean (SD)	Mean (SD)	
Age (yr)	10.3 (0.99)	10.7 (1.04)	10.0 (0.86)	0.13
Weight (kg)	50.9 (10.3)	52.7 (10.1)	49.1 (10.6)	0.43
Height (cm)	149 (8.64)	152 (8.18)	146 (8.39)	0.11
BMI (kg·m ⁻²) ¹	22.8 (2.62)	22.8 (2.26)	22.9 (3.06)	0.88
BMR (kJ·d ⁻¹) ²	6473 (809)	6487 (831)	6459 (826)	0.94
EE (kJ·d ⁻¹)	10803 (163)	10634 (1774)	10972 (1536)	0.64
PAL	1.68 (0.26)	1.66 (0.33)	1.70 (0.18)	0.71

¹Body mass index.

²Basal metabolic rate was calculated according to Dietz et al. (13).

³ P-value for differences between boys and girls were evaluated using Student's t-test for independent samples.

Table 2 Energy expenditure (EE) and physical activity level (PAL) of overweight and obese children, measured with the doubly labeled water (DLW) method and SenseWear Pro₂ Armband (SWA), using software versions 5.1 and 6.1, respectively.

	DLW	SWA 5.1	P-value ¹	SWA 6.1	P-value ²
	(n=22)	(n=22)		(n=22)	
	Mean (SD)	Mean (SD)		Mean (SD)	
EE (kJ·d ⁻¹)	10803 (163)	10786 (166)	0.95	8841 (169)	0.00
PAL	1.68 (0.26)	1.68 (0.23)	0.90	1.37 (0.21)	0.00
EE _{SWA} /EE _{DLW}		1.00 (0.12)		0.82 (0.09)	

¹ P-values for differences between DLW method and SWA_{5.1} method were evaluated using paired sample t-test.

² P-values for differences between DLW method and SWA_{6.1} method were evaluated using paired sample t-test.

Table 3 Time spent on sleep and activities at different Metabolic Equivalents (MET), measured with SenseWear Pro₂ Armband (SWA) using software versions 5.1 and 6.1, respectively, in overweight and obese children.

	SWA 5.1 (n=22)	SWA 6.1 (n=22)	P-value ¹
Sleep (h·d ⁻¹)	Mean (SD) 7.36 (0.63)	Mean (SD) 7.33 (0.66)	0.437
Sedentary including sleep < 3 MET (h·d ⁻¹)	18.4 (2.07)	20.4 (2.43)	0.000
3-<6 MET (h·d ⁻¹)	3.90 (0.93)	2.78 (0.88)	0.000
6-<9 MET (h·d ⁻¹)	0.68 (0.52)	0.18 (0.17)	0.000
≥9 MET (h·d ⁻¹)	0.20 (0.34)	0.04 (0.05)	0.000
Total activity ≥3MET (h·d ⁻¹)	4.79 (1.07)	2.99 (1.02)	0.000

¹ P-values for difference between SWA 5.1 and SWA 6.1 were evaluated using paired sample t-test.