Evaluation of a Wearable Body Monitoring Device During Treadmill Walking and Jogging in Patients With Fibromyalgia Syndrome

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Objective: To evaluate the reliability and validity of a body monitoring device against measures obtained from indirect calorimetry (IC) in patients with fibromyalgia syndrome (FMS) during various incremental exercise intensities.

Design: Cross-sectional reliability and validity study.

Setting: Testing was completed in a university exercise physiology laboratory.

Participants: Women (N = 25) with FMS, with a mean age ± SD of 48.6 ± 8.4 years and a median symptom duration of 15 years (25th–75th percentiles, 10–23y), were recruited to the study.

Interventions: Not applicable.

Main Outcome Measures: Patients walked and jogged on a treadmill at 4 intensities (50m·min–1, 0% grade [n = 25]; 83.3m·min–1, 0% grade [n = 25]; 116.7m·min–1, 0% grade [n = 21]; 116.7m·min–1, 2.5% grade [n = 13]) during 2 measurement conditions, while IC and a multiple-sensor body monitor measured energy expenditure (EE). The differences between the readings (test 1 – test 2) and the SD of the differences, intraclass correlation coefficient (ICC), 95% confidence interval (CI) for the ICC, coefficient of repeatability, intrapatient SD, standard error of mean (SEM), minimal detectable change, Wilcoxon signed-rank test, and Bland-Altman graphs were used to examine reliability. The magnitude of the associations between IC and the body monitoring device, ICC, 95% CI for the ICC, paired t tests, and Bland-Altman graphs were used to examine the validity of the body monitoring device versus the IC.

Results: Moderate to excellent test-retest reliability was found for the 4 bouts of exercise (ICCs = .73–.76). The SEM and minimal detectable change were satisfactory for the 4 bouts of exercise (ICC = .87–.99). The differences for all bouts between the 2 methods were nonsignificant, except for the second bout (P < .001). The ICCs and Bland-Altman plots of EE for the 4 bouts showed high agreement (ICC = .84–.99) and sufficient accuracy for quantifying EE during exercise in patients with FMS.

Conclusions: The body monitoring device provided a valid and reliable estimate of EE in patients with FMS during walking on horizontal and inclined surfaces in a laboratory setting across various exercise intensities.

Key Words: Exercise; Fibromyalgia; Rehabilitation.

FIBROMYALGIA IS CHARACTERIZED by the concurrent existence of chronic, widespread musculoskeletal pain and multiple sites of tenderness.1 Core symptoms include sleep disturbance,2 debilitating fatigue,3 and joint stiffness,3 and patients may also experience conditions such as cognitive disturbances,4 anxiety, and depression.5 Patients with fibromyalgia syndrome (FMS) show lower functional capacity for daily activities and health-related quality of life than healthy age- and sex-matched people.6 One of the most important aspects for patients with FMS is the impairment of daily functional performance,7 and it can be explained by the reduced physical activity level caused by the symptoms8 or due, at least in part, to metabolic disturbances that have been postulated.9 Therefore, the assessment of physical activity and energy expenditure (EE) in this clinical population is very important to provide information about the relationship between health and physical activity.

For this reason, the use of measuring instruments (both objective and subjective) in patients with FMS has gained importance.10–11 Among these, the most commonly used technique to assess physical activity is the administration of self-report questionnaires because they are easy and inexpensive to administer and are nonreactive (ie, they do not influence the behavior of the respondent).12 In this sense, most studies have reported physical activity levels in patients with FMS with...
retrospective self-reported data. However, this method often leads to an underestimation or overestimation of events. Also a very few studies have used newer technologies such as pedometers or actigraphy to document objective physical activity levels in patients with FMS.

There is growing interest in functional performance assessment by the indirect but objective measurement of physical activity. Several methods for measuring daily activity have been described that have shortcomings, including being cumbersome, inaccurate, or expensive. The most accurate and commonly used criterion standard in the exercise laboratory is indirect calorimetry (IC) for the determination of EE during acute bouts of exercise; in addition, doubly labeled water is used for the determination of EE over time. Neither of these techniques are always available or easily applicable in all settings because they are expensive and technologically complex, and they also require trained personnel and specialized laboratory equipment. In addition, radioisotope methodology is time-consuming and intrusive, and it cannot provide information on the specific pattern of activity. In contrast, pedometers, which comprise the simplest method, measure walking fairly well in active groups, but they are unable to accurately measure body movement during nonwalking activities or slow walking, which are activities particularly relevant in severely affected patients with FMS. Direct observation is both time-consuming and intrusive, and self-report questionnaires and diaries that rely on memory are imprecise, especially in subjects with cognitive deficiency such as patients with FMS. Each method has specific strengths and limitations regarding accuracy, reliability, expense, and portability. Consequently, none provides a simple, accurate, inexpensive, and practical approach for determining EE during an array of exercise and physical activities, including activities involved in daily living and recreational tasks.

A wearable body monitoring device for the assessment of EE has been recently introduced and validated in healthy subjects and various clinical populations. The portability, patient acceptability, low cost, and the basic skill required by users and the administering personnel are the strengths of this body monitoring device in clinical practice. Thus, its use may be of benefit to patients with FMS. However, to our knowledge, no information about the reliability, validity, or feasibility of this new method in such a population has yet been provided.

The purpose of the present study was to evaluate the reliability and validity of this body monitoring device by using measures obtained from IC in patients with FMS during walking and jogging across various levels of incremental exercise intensities.

METHODS

Participants and Study Design

We contacted a local association of patients with FMS in Seville (Spain), and an invitation to participate in the study was sent to all women aged 18 to 60 years (n = 250). Twenty-five potentially eligible patients responded. All gave their written informed consent after receiving detailed information in a meeting about the aims and study procedures. Informed consent was never obtained on the day of the meeting. There was a period of at least 1 week between when the information was provided in the meeting and the obtaining of the informed consent. The exclusion criteria included a history of morbid obesity, known cardiopulmonary diseases, uncontrolled endocrine or allergic disturbances, severe trauma, orthopedic or musculoskeletal limitations that precluded ambulation, frequent migraines, inflammatory rheumatic diseases, and severe psychiatric illness according to the criteria of the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition.

In addition, subjects with any type of tremor, subjects with other diseases that prevent physical loading, and subjects who were pregnant were also excluded. The Spanish version of the revised Physical Activity Readiness Questionnaire was also administered to identify persons at risk for adverse events while exercising. In addition, all patients were instructed to refrain from consuming any food or performing any exercise for 3 hours before testing to ensure that EE would not be elevated.

The research protocol was reviewed and approved by the Committee on Biomedical Ethics of the University Pablo de Olavide. The study was developed following the ethical guidelines of the Declaration of Helsinki, last modified in 2000. Two measurement conditions, separated by 1 week, were performed in a sample of patients with FMS during appointments that took place at the university to estimate the validity, reliability, and stability of the SenseWear armband (SWA), a wearable body monitoring device for the assessment of EE. During the first appointment, the medical records of the patients and anthropometric measurements were examined by a physician, and a diagnosis of FMS was confirmed as per the American College of Rheumatology classification criteria. In addition, patients completed an incremental staged test in random order. During the second appointment, the patients were carefully interviewed to ensure that they were not restricting caloric intake during the study period. They completed the same incremental staged test in the same order as the first session.

EE at Different Workloads of Exercise

After a 3-minute warm-up period at a speed of 50m-min⁻¹, the patients performed 4 bouts of exercise during an incremental test, starting at 50m-min⁻¹, with an increase of 33.3m-min⁻¹ every 3 minutes up to 116.7m-min⁻¹. After that, a 2.5% slope inclination was included. The testing protocol was performed for walking and jogging on a treadmill. Gas exchange data were continuously collected during the test through an automated breath-by-breath system, and EE was measured with the SWA. In this study, EE during each test was estimated by applying a generalized proprietary algorithm (SenseWear Professional Software version 6.1) developed by the manufacturer. For the last 2 minutes of each bout of exercise, EE (kcal-min⁻¹) was computed by multiplying the oxygen uptake (L-min⁻¹) by the nonprotein caloric equivalent based on the respiratory exchange ratio.

Anthropometry

All anthropometric measurements were performed by the same operator according to the Anthropometric Standardization Reference Manual. Weight was measured to the nearest 100g, and height was measured to the nearest 0.1cm using an electronic balance with an incorporated stadiometer, with subjects in their underwear. Body mass index was calculated as body mass (kg) divided by height (m) squared. Skinfold thicknesses were measured with a caliper. Skinfold thicknesses (biceps, triceps, subscapular, suprailliac, calf, and midthigh) were measured to the nearest millimeter using calipers on the right-hand side of the body. The sum of the 6 skinfold thicknesses was used as an indicator of total body fat. All skinfold measurements were repeated 3 times, and the 3 values were averaged.
Statistical Analysis

Test-retest reliability is assessed by calculating the differences observed between the readings (test 1 – test 2). SDs of the differences, intraclass correlation coefficient (ICC), \(^{35,36}\) 95% confidence interval (CI) for ICC, coefficient of repeatability, intraindividual SD, standard error of mean (SEM), and minimal detectable change (MDC). \(^{36}\) A 95% confidence level for the MDC corresponding to a \(z\) value of 1.96 was established. An ICC greater than .75 is considered excellent, those between .40 and .75 are considered fair to good, and those less than .40 reflect poor reliability. \(^{37}\)

The Wilcoxon signed-rank and \(t\) tests were used to determine whether there were significant differences between the 2 appointments. Additionally, Bland-Altman plots \(^{38}\) were used to provide a visual illustration of the relationship between tests 1 and 2 from the reliability component of this investigation for each of the 4 incremental workloads.

Linear correlations between variables were analyzed according to the Spearman test for nonparametric variables and the Pearson test for parametric variables. The ICCs are a class of statistics suitable for evaluating the extent of agreement between at least 2 measures of the same construct. We used the ICC (ie, a 1-factor random effect). The ICC can be conceptualized as the ratio of between-subject variance to the total variance. The closer the ICC is to 1.0, the greater is the concordance between measures. We used the Cronbach \(\alpha\) coefficient. The Cronbach \(\alpha\) coefficient may be estimated when a 1-dimensional variable is assessed, and particularly when it is difficult to conduct a validation study against a criterion standard. \(^{39,40}\) Bland-Altman plots were constructed to show the relationship among the mean differences (ie, activity monitor minus IC) for EE at various incremental exercise intensities.

The mean differences and limits of agreements were calculated according to Bland and Altman. \(^{38}\) Paired \(t\) tests were performed to determine the differences between the mean values obtained with the armband versus the IC. All tests were 2-tailed, and the level of significance was set at .05 for all the analyses. SPSS version 18.0 \(^f\) for Windows was used for the statistical analyses.

RESULTS

Sample Characteristics

Twenty-five volunteer subjects with diagnosed FMS were included in the analyses. Of the 25 subjects who participated in this study, completed data were available for 13 subjects for treadmill walking exercise at 4 incremental workloads, 21 subjects for 3 incremental workloads, and 25 subjects for 2 and 1 workloads. The age of the 25 subjects varied from 32 to 59 years, with a mean age ± SD of 48.6 ± 8.4 years. All of the patients were women, white, and born in Spain. Most of the patients were married (80%), were housewives (64%), and reported an elementary level education or higher (92%). None of the patients reported any problems related to the SWA, and the body monitor did not fail during the assessment period. Clinical and demographic data are presented in table 1.

Test-Retest Reliability

The mean differences, SDs of the differences, intraindividual SD, ICCs, 95% CIs for the ICCs, SEMs, and 95% CIs for the MDCs are presented in table 2. The ICCs varied from moderate to excellent for the 4 bouts of incremental exercise (from .72 to .76) and were comparable to the reliability of IC (from .71 to .77). The SEMs and MDCs were satisfactory for the 4 bouts of incremental exercise; the MDCs varied from 1.51 to 3.28 kcal·min\(^{-1}\), and the SEMs varied from .54 to 1.18 kcal·min\(^{-1}\).

The differences mean between test and retest were lower than the SEM for the 4 bouts of exercise, varying from −1.7 to 1.14 kcal·min\(^{-1}\), No systematic differences were observed for assessments that were completed during the 2 different appointments, as determined using the Wilcoxon signed-rank test and \(t\) test. Figure 1 shows the Bland-Altman graph for the 4 bouts of incremental exercise. The limits of agreement indicated that the differences between repeated tests would lie within 2 SDs in 95% of the cases. The coefficient of repeatability was less than 2 SDs for the 4 bouts of incremental exercise (2.25, 1.19, 1.25, and 2.59).

Validity

The SWA tended to slightly underestimate EE for the 4 bouts of incremental exercise as compared with the IC method. However, the differences in EE for the 4 bouts of incremental exercise across the 2 methods were not significant, except for the second bout of incremental exercise (at a speed of 83.3m·min\(^{-1}\)) (\(P<.001\)) (table 3). EE for the 4 bouts of incremental exercise from the SWA was lower, from .22 to .63 kcal·min\(^{-1}\), as compared with that from the IC, representing an underestimation of EE of 6% to 9% for the 4 bouts of incremental exercise.

The simple correlation model revealed a significant association between the SWA and IC measurements of EE for the 4 bouts of incremental exercise (\(r\) varies from .87 to .99; \(P<.001\)).

Although there was a significant group mean difference in EE at the second bout of incremental exercise (at a speed of 83.3m·min\(^{-1}\)) between the values obtained with the SWA and IC methods, the individual values were relatively similar, as evidenced by the ICC of .88 (95% CI, .75–.95) in table 3. This
result indicates that 88% of the variance was explained by differences between individuals, whereas 12% of the variation was because of the variation between methods and error. The ICC of EE for the 4 bouts of incremental exercise exceeded .75, which is the generally accepted threshold for good agreement.

The Bland-Altman plot showed that the SWA was able to assess EE for the 4 bouts of incremental exercise with sufficient accuracy (95% CIs: –1.11 to 1.50 kcal·min⁻¹, –.38 to 1.20 kcal·min⁻¹, –1.61 to 2.01 kcal·min⁻¹, and –.55 to .81 kcal·min⁻¹, respectively, for the 4 incremental bouts) as compared with IC (fig 2). These results demonstrate that the difference between the 2 methods for assessing EE does not appear to be influenced by the magnitude of EE.

### DISCUSSION

To our knowledge, this study is the first to compare the use of an SWA to a criterion measure of EE across different intensities of exercise in patients with FMS. The results indicate that these measurements are valid for comparison to a standard exhaled breath-by-breath system at the walking and jogging speeds expected during the daily activities of patients with FMS. Furthermore, this study demonstrates that the SWA provides highly reproducible estimates of EE during walking and jogging on horizontal and inclined surfaces across various incremental exercise intensities in a laboratory setting in patients with FMS.

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**Table 2: Test-Retest Reliability of EE Estimated by SWA on a Treadmill at 6 Intensities in Patients With FMS**

<table>
<thead>
<tr>
<th>Workloads of Exercise</th>
<th>Difference Mean ± SD</th>
<th>Intraindividual SD</th>
<th>ICC</th>
<th>95% CI</th>
<th>Coefficient of Repeatability</th>
<th>SEM (kcal·min⁻¹)</th>
<th>MDC (kcal·min⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50m·min⁻¹, 0% grade (n=25)</td>
<td>–.10 ± 1.15</td>
<td>.59</td>
<td>.73</td>
<td>.47-.88</td>
<td>2.25</td>
<td>0.54</td>
<td>1.51</td>
</tr>
<tr>
<td>83.3m·min⁻¹, 0% grade (n=25)</td>
<td>–.01 ± 0.62</td>
<td>.33</td>
<td>.72</td>
<td>.45-.87</td>
<td>1.19</td>
<td>0.56</td>
<td>1.55</td>
</tr>
<tr>
<td>116.7m·min⁻¹, 0% grade (n=21)</td>
<td>–.17 ± 0.63</td>
<td>.33</td>
<td>.72</td>
<td>.42-.88</td>
<td>1.25</td>
<td>0.98</td>
<td>2.73</td>
</tr>
<tr>
<td>116.7m·min⁻¹, 2.5% grade (n=13)</td>
<td>.14 ± 1.37</td>
<td>.68</td>
<td>.76</td>
<td>.37-.92</td>
<td>2.59</td>
<td>1.18</td>
<td>3.28</td>
</tr>
</tbody>
</table>

**Fig 1.** Bland and Altman plots of the differences between tests 1 and 2 for (A) 50m·min⁻¹, 0% grade walking EE; (B) 83.3m·min⁻¹, 0% grade walking EE; (C) 116.7m·min⁻¹, 0% grade walking EE; and (D) 116.7m·min⁻¹, 2.5% grade walking EE. The means of the differences (solid lines) and limits of agreement (dashed lines) within ±2 SDs are shown.
The SWA tended to slightly underestimate EE of walking and jogging on a horizontal surface by 6% to 9% based on an increase in speed, and it also slightly underestimated EE of walking on a 2.5% grade by 7%, based on a change in intensity that occurs with an increase in incline. These results are not comparable to those reported in triaxial accelerometer studies.\textsuperscript{41-43} EE for walking on a horizontal surface was significantly overestimated by 12% to 49% with triaxial accelerometers.\textsuperscript{42,43} The elevated EE that occurs when walking on an incline was not detected by triaxial accelerometers;\textsuperscript{41} underestimation varied from 8 to 21%.\textsuperscript{41,42} The different magnitude of underestimation found between our study and triaxial accelerometer studies suggests that the accelerometer in the SWA does not carry the most weight in the prediction model when estimating exercise EE.

The improvement in the measurement accuracy of our study as compared with triaxial accelerometer studies may be due to the inclusion of thermal and perspiration-related sensors as well as accelerometers. The role of the additional sensors for the improved EE variance is biologically plausible because the

### Table 3: Comparison of EE Between IC and SWA on a Treadmill at 6 Intensities in Patients With FMS

<table>
<thead>
<tr>
<th>Workloads of Exercise</th>
<th>EE (kcal·min(^{-1}))</th>
<th>Pearson or Spearman Correlation Coefficients ((\rho))</th>
<th>Intraclass Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Measured (IC)</td>
<td>Estimated (Armband)</td>
<td>(P) Between Methods</td>
</tr>
<tr>
<td>50m·min(^{-1}), 0% grade ((n=25))</td>
<td>3.69±1.30</td>
<td>3.48±1.05</td>
<td>.159</td>
</tr>
<tr>
<td>83.3m·min(^{-1}), 0% grade ((n=25))</td>
<td>5.33±1.20</td>
<td>4.97±1.06</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>116.7m·min(^{-1}), 0% grade ((n=21))</td>
<td>7.09±1.96</td>
<td>6.46±1.86</td>
<td>.330</td>
</tr>
<tr>
<td>116.7m·min(^{-1}), 2.5% grade ((n=13))</td>
<td>7.71±2.11</td>
<td>7.19±2.36</td>
<td>.186</td>
</tr>
</tbody>
</table>

**NOTE.** Values are mean±SD or as otherwise indicated.

\(^*P<.05\); \(^*P<.01\); \(^*P<.001\).

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**Fig 2.** Bland and Altman plots of the differences between SWA estimate and IC measurement for (A) 50m·min\(^{-1}\), 0% grade walking EE; (B) 83.3m·min\(^{-1}\), 0% grade walking EE; (C) 116.7m·min\(^{-1}\), 0% grade walking EE; and (D) 116.7m·min\(^{-1}\), 2.5% grade walking EE. The means of the differences (solid lines) and limits of agreement (dashed lines) within ±2 SDs are shown.
galvanic skin resistance, heat flux, and body temperature sensors reflect physiologic surrogates of EE that are independent of bodily movement. The heat sensors provide a way to detect the subtle increases in EE associated with low-intensity activities. Previous research with the SWA has indicated that the SWA provides more accurate estimates of low-intensity activities in a healthy population than does the actigraph. However, we could not find information comparing the SWA with other monitoring devices in patients with FMS in the current literature. More research comparing different physical activity instruments in patients with FMS is needed.

To our knowledge, no studies have reported a best-estimated EE using the SWA as compared with IC during treadmill walking and jogging. Our findings suggest adequate agreement between the methods on the basis of ICCs and the Bland-Altman plots. However, similar validation studies using the SWA and the commercially available generalized algorithm have shown worse estimates of EE in healthy subjects, obese subjects and cardiac patients. As compared with studies in the literature that examined EE in free-living conditions, we observed that the correlation coefficients between physical activity monitors estimating EE versus IC seem to be lower during lifestyle activities as compared with activities such as walking and running on a treadmill at submaximal intensities.

With the many recent health recommendations regarding moderate physical activity in patients with FMS and the high prevalence of FMS in various countries, the need for objective tools to monitor physical activity is evident. Motion sensors have a number of advantages over other forms of physical activity measurement. These small and unobtrusive devices have the capacity to store movement data for a long time, which eliminates many problems associated with the subjective recall of physical activity questionnaires, especially in subjects with cognitive deficiency such as patients with FMS. The capacity to provide objective measures of frequency, intensity, and duration make SWAs ideal for answering questions regarding patterns of physical activity, which cannot be determined by other measures of EE such as doubly labeled water or an extended duration of oxygen consumption.

Study Limitations

A potential limitation of this study is that the accuracy of the SWA was examined only during specific exercise modes (ie, walking and jogging) and exercise intensities (ie, light to moderate intensity), using 1 exercise duration (ie, 3min). However, it is unclear whether similar findings would be observed during resting EE, in the context of other modes of activity (eg, lifestyle activities), or in more vigorous activities that are either shorter or longer in duration, or under different environmental conditions. It is necessary to test the reliability of the SWA in estimating EE of other activities in various other populations before conclusions can be made about the overall reliability of this device. Because this was a laboratory-based study, subjects only had to wear the armband for a period of approximately 45 minutes. It cannot be determined from this study whether patients with FMS would be willing to wear the armband for longer periods. Moreover, this study was conducted in a laboratory setting and used IC as the criterion measure of EE. Future studies should consider examining EE under free-living conditions along with doubly labeled water as the criterion measure of EE.

In addition, our sample size is relatively small to generalize. Our patients do not represent the larger population of community-dwelling individuals who have FMS. Probably, the fact that some tests are not statistically significant may be because the study lacked the power to detect what might be considered clinically important.

Another limitation is the dropout rate of 48% for 4 incremental workloads, and 16% for 3 incremental workloads; however, these rates are logical because of the heightened intensity of the last 2 workloads and low functional capacity commonly shown in patients with FMS. An additional problem in the study was that 10 of the 25 patients had body mass index scores greater than 30 and an overall patient mean ± SD of 28.2 ± 5.0kg/m², which places them into the worldwide recognized “grade 1 overweight” category. The posterior side of the upper arm is a site for subcutaneous fat deposits, and our patients had 29.8mm of subcutaneous adipose tissue in the triceps skinfold thickness; therefore, good contact between the SWA and the arm throughout exercise testing was a problem for a few patients.

Another potential limitation of this study is the inability to accurately quantify the degree to which galvanic skin response and heat flux contributed to the calculation of EE using the SWA. General criticisms of belt-mounted physical activity monitors include the inability to detect arm movements, locomotion on a grade, or any external work performed by pushing, lifting, or carrying objects. The SWA may circumvent these issues by the incorporation of heat production measurements and placement on the upper arm.

Because little research has been published on this device, further research is warranted before firm conclusions on the reliability, validity, and utility of the SWA can be made. According to the manufacturer, EE estimation models of the SWA and the software are being improved. The most recent analysis software (SenseWear Professional Software version 6.1) is reported to have improved in its ability to detect context, but validation of this ability is mandatory to make the use of this device practical.

CONCLUSIONS

This study revealed that with the use of the generalized proprietary algorithm from the manufacturer, the SWA provided a valid and reliable estimate of EE in patients with FMS during walking and jogging across various incremental exercise intensities. The device was user-friendly in terms of easy attachment and detachment, minimal discomfort, and little or no interference with physical activity. Our results are only generalizable to women with FMS and to the few activities evaluated. More research is needed in patients with FMS and other populations, and eventually with free-living activities before this device is ready for widespread use.

References


Suppliers
a. SenseWear Pro3 Armband; BodyMedia Inc, One Gateway Center. 420 Ft Duquesne Blvd, Ste 1900, Pittsburgh PA 15222.

b. Pulsar 4.0; Cosmos, Am Sportplatz 8, DE 83365 Nussdorf-Traunstein, Germany.

c. CPX; Medical Graphics Corporation 350 Oak Grove Parkway St. Paul, MN 55127.

d. Seca 780; SECA Hammer Steindamm 9-25 22089 Hamburg, Germany.

e. Holtain T/W skinfold caliper. Holtain LD. Crosswell, Crymych, Pembs SA41 3UD, U.K.

f. SPSS Inc, 233 S Wacker Dr, 11th Fl, Chicago, IL 60606.