Assessment of Physical Activity in Anorexia Nervosa and Treatment Outcome

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ABSTRACT

ALBERTI, M., C. GALVANI, M. EL GHOCH, C. CAPELLI, M. LANZA, S. CALUGI, and R. DALLE GRAVE. Assessment of Physical Activity in Anorexia Nervosa and Treatment Outcome. *Med. Sci. Sports Exerc.*, Vol. 45, No. 9, pp. 1643–1648, 2013. **Purpose**: The aim of this study was to compare objective and subjective assessments of physical activity (PA) in patients with anorexia nervosa and its effect on treatment outcome. **Methods**: Both Actiheart (AH) and International Physical Activity Questionnaire (IPAQ) were used to assess PA in 52 female patients with anorexia nervosa during the first week of inpatient treatment. **Results**: No correspondence between PA estimated by IPAQ, which had a tendency to underestimate PA, and that measured using AH emerged. However, a significant association was found between the change in Eating Disorder Examination global score at the end of the treatment and light PA measured by AH (beta = −0.12, $t = -2.44$, $P = 0.019$), but not that estimated by IPAQ. **Conclusions**: PA in patients with anorexia nervosa is underestimated by subjective assessment when compared with objective measurement. Only time spent in light PA, assessed objectively with AH, showed a negative association with improvement in eating disorder psychopathology. **Key Words:** EATING DISORDERS, INPATIENT TREATMENT, PHYSICAL EXERCISE, ACCELEROMETER, OUTCOME

Excessive physical activity (PA) is a common behavior observed among patients with anorexia nervosa (11,37) and particularly in eating disorder inpatient units, in which patients usually regain weight more rapidly compared with outpatient settings (16). Excessive PA in anorexia nervosa has been associated with an increased risk of overuse injuries, bone fractures, and osteoporosis (26). It tends to be seen in younger patients (37), in those with a lower percentage of body fat (28) and body mass index (BMI) (37), in those with greater severity of eating disorder psychopathology (4,16,37,38) and general psychopathology (4,38), and in those with specific personality features (e.g., perfectionism, high persistence, and low novelty seeking and reward dependence) (16,37). It also seems to play an important role in the development and maintenance of eating disorders (19) and has been associated with longer inpatient treatment (38), quicker relapse (39), and poor treatment outcome (16).

Excessive PA may take different forms (25): it may be incorporated into routine daily activities (e.g., walking most of the hours in the day, standing rather than sitting while studying, or watching television), structured sports activities (e.g., training above and beyond a planned schedule or going to the gym several times a day), or abnormal exercising (e.g., doing extreme numbers of push-ups or sit-ups at home or in unusual places such as public rest rooms). This heterogeneity makes assessment of excessive PA a difficult task. Many previous studies have relied on direct interview or self-reported questionnaires to assess the role of excessive PA in treatment outcome (10,16,39). However, as denial is a common process in anorexia nervosa (41), it can be hypothesized that some patients underestimate the amount of their PA in such subjective methods, leading to significant bias and therefore inaccuracy of data regarding both its extent and its role in treatment outcome. Indeed, the only two studies to date comparing objective and subjective methods of quantifying PA confirmed that patients with anorexia nervosa underestimate the amount they do (8,40), whereas females from the general population tend to overreport the amount of PA measured by objective assessment (36). The unreliability of patient reporting has led some authors to

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recommend the adoption of objective means of assessing PA in anorexia nervosa, such as multiaxial waterproof activity monitors (21).

To provide a clearer picture, the purposes of this study were to compare such objective and subjective assessments of PA in a large group of anorexia nervosa patients and to explore any correlations with treatment outcome, something that no study has yet undertaken.

METHODS

Participants

The sample consisted of 52 female patients consecutively admitted to the eating disorder inpatient unit of Villa Garda Hospital (Northern Italy) between January 2010 and April 2012. Patients were eligible to participate in the present study if they met the following criteria: (a) age, 13–65 yr; (b) BMI < 17.5 $kg \cdot m^{-2}$; (c) diagnosis of anorexia nervosa as determined by the Eating Disorder Examination interview (24,32); and (d) failure of less intensive outpatient treatment or an eating disorder of clinical severity not manageable in an outpatient setting. Patients who were in an acute psychotic state ($N = 1$) or had significant substance abuse problems ($N = 1$) were excluded. Inclusion and exclusion criteria were evaluated during an eligibility interview conducted by a specialist in the field (RDG).

The research was scrutinized and approved by the institutional review board of Villa Garda Hospital, Verona, and all participants (or their legal guardians for patients younger than 18 yr) gave informed written consent for the anonymous use of their personal data.

Treatment

The cognitive behavioral treatment that the patients undertook has been described elsewhere (15,18). The treatment is manual based, lasts 20 wk, and comprises 13 wk of inpatient therapy followed by 7 wk of day-hospital. The treatment included specific procedures and strategies to address excessive PA (from light to vigorous) because its persistence maintains the eating disorder psychopathology, obstructs weight restoration, and increases the risk of medical complications (17). The main procedures and strategies adopted were the following (17): (i) helping patients to decide to address excessive PA using motivational enhancement and educating them about the potential negative effects of this form of PA; (ii) suggesting patients keep a real-time monitoring record of the frequency, duration, and type of PA they are engaged in; (iii) encouraging patients to substitute excessive PA with healthy and social exercising practiced, in the absence of medical contraindications, in twice weekly sessions conducted by a physiotherapist; these sessions include calisthenic exercises to improve the restoration of muscular strength, flexibility, posture, and some aerobic exercises to improve cardiovascular fitness; and (iv) helping patients to adopt some functional mood modulatory behaviors (e.g., listening music, taking a bath, and communicating with others) and to use exercise as a means of modulating mood.

Assessment

Body weight and body mass index. Body weight and height were measured, respectively, using medical weighing scales and a stadiometer by a medical doctor involved in the study. Participants were weighed before breakfast wearing only underwear and no shoes. Their BMI was determined according to the standard formula of body weight measured in kilograms divided by height in meters squared.

PA assessment. All patients were subjected to both objective and subjective assessment of their PA. Objective PA assessment was carried out using Actiheart (AH), which has been validated under different conditions (3,7,14) and combines an HR monitor with a piezoelectric accelerometer (frequency range of 1–7 Hz (3 dB)). AH is also able to assess activity energy expenditure (AEE) and duration and intensity of PA. An AH was placed on the left side of each patient's chest, attached to the skin by two standard ECG electrodes, on the second day of hospitalization and was kept in place for three consecutive days (72 h). To increase the precision of the estimate of PA level using the PA monitor, AH was individually calibrated as proposed by Rennie et al. (35). For this purpose, we measured the resting energy expenditure (REE) and the sleeping HR of our subjects (two non–exercise-based individual calibrations). REE was assessed using indirect calorimetry (Fitmate; Cosmed, Rome, Italy) already validated in anorexia nervosa (23), during a test lasting 15 min; the average of the values collected between the 5th and the 10th minute was used to calculate REE. This test was performed in the early morning, while the subjects were lying quietly on a bed. Sleeping HR was derived as the average of the highest values of the 30 lowest minute-by-minute HR readings during the 72-h period (33).

The short, 7-d, self-administered format of the International Physical Activity Questionnaire (IPAQ) was used for subjective PA assessment (13). IPAQ is an instrument designed primarily for population surveillance of PA (13). It covers three domains of PA: walking, moderate-intensity activities, and vigorous-intensity activities. The questionnaire also includes questions about time spent sitting as an indicator of sedentary behavior. In each of the four domains, the number of days per week and the time spent per day in both moderate and vigorous activity or sedentary behavior during the last 7 d are recorded. The IPAQ was administered to all patients on the eighth day of hospitalization. IPAQ is considered to have reasonable measurement properties for monitoring population levels of PA in diverse settings.

The AH data collected were compared with the self-reported PA estimates determined by IPAQ. The outcome measures compared, expressed as mean daily values, were as follows: AEE, minutes of moderate PA (MPA), minutes of vigorous PA

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TABLE 1. Clinical characteristics of the sample at baseline.

Age, mean (yr)	24.4 ± 8.4
Marital status, *n* (%)	
Single, never married	46 (88.5)
Married or living as such	6 (11.5)
Separated or divorced	0
Duration of eating disorder, median [IQR] (yr)	5 [9]
Lowest body mass index ($kg \cdot m^{-2}$)	13.9 ± 2.8
Highest body mass index ($kg \cdot m^{-2}$)	21.2 ± 2.9
Body weight (kg)	37.1 ± 5.4
Body mass index ($kg \cdot m^{-2}$)	14.3 ± 1.7
Eating disorder psychopathology	
Overall severity (global EDE)	3.8 ± 1.3
Dietary restraint (EDE subscale)	4.2 ± 1.5
Eating concern (EDE subscale)	3.5 ± 1.5
Shape concern (EDE subscale)	4.0 ± 1.5
Weight concern (EDE subscale)	3.6 ± 1.8
Eating disorder behavior (EDE)	
Objective bulimic episodes, *n* (%) present	15 (28.8)
If present, episodes/28 d, median [IQR]	10 [27]
Subjective bulimic episodes, *n* (%) present	27 (51.9)
If present, episodes/28 d, median [IQR]	12 [16]
Self-induced vomiting, *n* (%) present	16 (30.8)
If present, episodes/28 d, median [IQR]	21.5 [66]
Laxative misuse, *n* (%) present	6 (11.5)
If present, episodes/28 d, median [IQR]	11.5 [23]
Diuretic misuse, *n* (%) present	1 ± 1.9
If present, episodes/28 d, median [IQR]	—
General psychiatric features, GSI	87.7 ± 19.2

Data are shown as mean ± SD unless otherwise indicated.
IQR, interquartile range; EDE, Eating Disorder Examination (version 12.0D); GSI, Global severity index.

(VPA), and sum of the minutes spent in moderate and vigorous PA (MVPA). For both assessment tools, MPA was defined as 3–6 METs, and VPA was defined as >6 METs (34).

AEE and PA intensity readings from the AH were automatically calculated according to the Branched model (Actiheart Software, version 4.0; CamNtech, Inc., Cambridge, UK) [6]) and expressed in kilocalories per day and in METs, respectively. To convert the results obtained from IPAQ to daily AEE, we applied the following procedure. First, the selected MET values were derived from data from the IPAQ reliability study (13) and the compendium of Ainsworth et al. (1). On the basis of these values, an average MET score was assigned to each type of activity recorded with IPAQ. Walking (all types of walking were included), moderate-intensity activity, and vigorous-intensity activity were assigned average values of 3.3, 4.0, and 8.0 METs, respectively. We then calculated the total number of hours spent doing each of the three activities during the 7-d period. Assuming that 1 MET equaled 1 $kcal \cdot kg^{-1} \cdot h^{-1}$ for all patients, the energy expenditure for each type of activity for 7 d was calculated. The sum of these daily expenditures yielded the total amount of energy spent by a given subject for 1 wk, which, once divided by 7, yielded the mean daily AEE in kilocalories per day (27,31). Finally, the net AEE in kilocalories, that is, the activity above the resting metabolic rate (i.e., the total AEE minus the REE), was also calculated.

Eating disorder features. These were assessed using the validated Italian version of the 12th edition of the Eating Disorder Examination (EDE) interview (24,32). The EDE was administered by assessors who were trained and supervised by RDG, an expert in the use of the tool. The assessors had no involvement with the treatment itself. The main outcome variable measured was the change in the severity of eating disorder features, as measured by global EDE scores.

General psychiatric features. These were measured using the validated Italian version of the Brief Symptom Inventory from which a Global Severity Index was calculated (20,22).

Statistical Analysis

Statistical analysis was carried out by using StatView version 5.0 and SPSS version 20.0 (SPSS Inc., Chicago, IL). Continuous variables were categorized as mean ± SD or median (interquartile range), and categorical variables were presented as frequency and percentage. Results were considered significant when $P < 0.05$.

A paired *t*-test was used to determine any differences between objective and subjective PA. A one-way ANOVA was used to evaluate disparities between time spent in different intensity thresholds with the Scheffé *post hoc* test. The significance of any changes in clinical variables from baseline to end-of-therapy scores was also determined in completers using the *t*-test for paired data, or the McNemar test as appropriate. Cohen's *d* effect size was also determined.

Univariate regression analyses were performed to evaluate the significance of associations between the PA measured objectively and estimated subjectively and the change in EDE global score from baseline to the end of treatment. Limits of correspondence were calculated as mean of the difference − 2 SD and mean of the difference + 2 SD.

RESULTS

Clinical characteristics of participants. The characteristics and clinical features of the sample are shown in Table 1. The participants were all female, and 12 (23.1%) were younger than 18 yr. All patients were extremely underweight: 67.3% (35/52) had a BMI lower than 15.0 $kg \cdot m^{-2}$, and 86.5% (45/52) had received prior treatment for the illness.

TABLE 2. Comparison of AH and IPAQ measurement of PA in 52 patients with anorexia nervosa.

	AH	IPAQ	Paired *t*-test	*P*	Effect Size[a]
AEE ($kcal \cdot d^{-1}$)	471.0 ± 240.5	89.5 ± 156.6	11.41	<0.001	1.58
MPA ($min \cdot d^{-1}$)	93.5 ± 111.9	50.9 ± 84.9	2.41	0.020	0.33
VPA ($min \cdot d^{-1}$)	6.0 ± 12.0	3.8 ± 17.6	1.20	0.237	0.17
MVPA ($min \cdot d^{-1}$)	99.5 ± 120.1	54.7 ± 89.1	2.43	0.019	0.34

Data are presented as mean ± SD.
[a]Classification of effect size: small, >0.20; moderate, >0.50; large, >0.80 (12,29).
AH, Actiheart; IPAQ, International Physical Activity Questionnaire; AEE, activity energy expenditure; MPA, minutes of moderate PA; VPA, minutes of vigorous PA; MVPA, sum of the minutes spent in moderate and vigorous PA.

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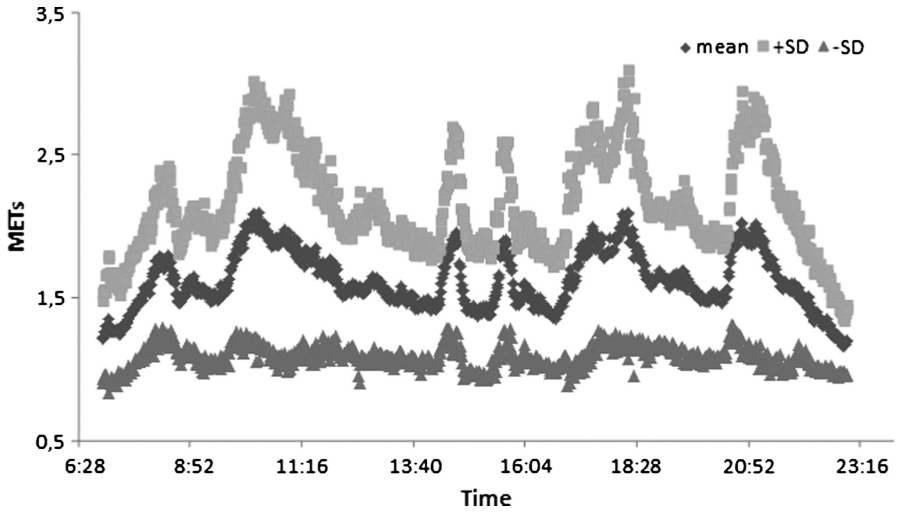

FIGURE 1—AN patient's PA patterns depicted as mean ± SD.

PA assessment and characteristics. IPAQ assessment was found to significantly underestimate PA in comparison with AH. In particular, AEE, MPA, and MVPA were significantly lower when measured using IPAQ with respect to AH. Only VPA showed no significant differences between objective and subjective assessment (Table 2).

Data yielded by AH showed that our anorexia nervosa patients spent significantly longer periods in activity classified as sedentary (SED) and light than performing activities classified as moderate or vigorous: SED, 495.0 ± 189.1 min·d^{-1}; light PA (LPA), 343.4 ± 151.9 min·d^{-1}; MPA, 93.5 ± 111.9 min·d^{-1}; VPA, 6.0 ± 12.0 min·d^{-1}; and MVPA, 99.5 ± 120.1 min·d^{-1}. Statistical analysis showed that time spent in SED was significantly larger than that spent in LPA, MPA, VPA, and MVPA (all $P < 0.001$); time in LPA was significantly larger than that in MPA, VPA, and MVPA (all $P < 0.001$); and finally, time spent in MPA was significantly larger than that in VPA ($P < 0.001$). If the minutes spent in PA are analyzed on a patient-by-patient basis, a great intrasubject variability is evident, with MPA ranging from 499 to 0 min·d^{-1}, VPA ranging from 65 to 0 min·d^{-1}, and MVPA ranging from 546 to 0 min·d^{-1}. Indeed, the activity pattern measured with AH was characterized by several peaks throughout the day: one in the morning, one in the late afternoon, and one after the evening meal (Fig. 1).

PA and treatment outcome. Forty-three patients (82.7%) completed treatment, whereas nine patients (17.3%) were classified as dropouts after a voluntary treatment discontinuation before the planned 20 wk had elapsed. The mean ± SD BMI of completers increased from 14.5 ± 1.5 kg·m^{-2} on admission to 19.0 ± 1.0 kg·m^{-2} at discharge ($t_{40} = -21.77$, $P < 0.001$). Twenty-nine patients (70.7%) reached a BMI ≥ 18.5.

Across the patient spectrum, the four EDE subscales, the EDE global score, and the Brief Symptom Inventory were significantly improved at the end of treatment. No significant

TABLE 3. Clinical state of the sample before and after treatment among those patients who completed treatment ($N = 43$).

	Before Treatment	After Treatment	Effect Size[a]
Body weight (kg)	37.5 ± 5.3	49.4 ± 4.6*	3.2
Body mass index (kg·m^{-2})	14.5 ± 1.5	19.0 ± 1.0*	3.3
Eating disorder psychopathology			
Overall severity (global EDE)	3.9 ± 1.3	2.0 ± 1.1*	1.7
Dietary restraint (EDE subscale)	4.2 ± 1.6	1.5 ± 1.1*	1.7
Eating concern (EDE subscale)	3.6 ± 1.3	1.3 ± 1.1*	1.8
Weight concern (EDE subscale)	3.8 ± 1.7	2.3 ± 1.4*	1.0
Shape concern (EDE subscale)	4.1 ± 1.6	2.9 ± 1.5*	0.8
Eating disorder behaviors (EDE)			
Objective bulimic episodes, *n* (%) present	12 (27.9)	7 (16.3)	
If present, episodes/28 d, median [IQR]	19 [69]	4 [3]	
Objective bulimic episodes, *n* (%) present	25 (58.1)	18 (41.9)	
If present, episodes/28 d, median [IQR]	12 [16]	3 [8]	
Self-induced vomiting, *n* (%) present	13 (30.2)	9 (20.9)	
If present, episodes/28 d, median [IQR]	28 [92]	4 [5]	
Laxative misuse, *n* (%) present	6 (14.0)	1 (2.3)	
If present, episodes/28 d, median [IQR]	11.5 [23]	—	
Diuretic misuse, *n* (%) present	1 (2.3)	—	
If present, episodes/28 d, median [IQR]	—		
General psychiatric features, GSI	87.5 ± 18.9	63.3 ± 14.7*	1.4

Data are shown as mean ± SD unless otherwise stated.
*$P < 0.05$.
[a]Classification of effect size: small, >0.20; moderate, >0.50; large, >0.80 (12,29).
IQR, interquartile range; EDE, Eating Disorder Examination (version 12.0D); GSI, Global severity index.

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differences were found in the number of objective and subjective bulimic episodes, episodes of self-induced vomiting, or laxative misuse (Table 3).

Linear regression analyses showed that only LPA measured by AH was significantly and negatively related with the change in global EDE score from admission to discharge (beta = −0.12, $t = -2.44$, $P = 0.019$).

DISCUSSION

The main findings of the present study were as follows: (i) the levels of PA assessed using subjective IPAQ were significantly below those objectively measured using AH; (ii) patients with anorexia nervosa spend significantly longer periods in activity classified as sedentary and light, as compared with activities classified as moderate or vigorous; and (iii) higher LPA in the first days of inpatient treatment seems to be associated with less improvement in eating disorder psychopathology at the end of the program.

The study has two main strengths. First, the assessment of PA was performed using AH, a multisensor instrument that provides better accuracy than single sensor systems (2). The AH also has other advantages: it is waterproof and does not interfere with the performance of daily activities, and it allows nonwearing times to be easily identified, as its displacement causes a detectable loss of HR signal (42). Second, this is one of very few studies that have attempted a longitudinal assessment of the influence of objectively measured PA levels on treatment outcome using the EDE, a gold-standard instrument for assessing eating disorder psychopathology. Limitations of the study include the absence of a control group, the absence of longitudinal assessment of PA, and the evaluation of a single inpatient unit. Confirmation of our results using other inpatient and outpatient samples is therefore required. Finally, the IPAQ, a questionnaire developed to measure health-related PA in populations, might not be the most reliable tool to assess self-reported PA in patients with anorexia nervosa, who exercise mainly to control their shape and body weight in an inappropriate way. New investigations may be needed to evaluate the results obtained in this specific population using alternative PA estimation questionnaires.

Indeed, our data are difficult to compare with existing findings because different methods of PA assessments, sample sizes (from 6 to 36 subjects), lengths of PA monitoring period (from 2 to 7 d), and settings (inpatient, outpatient, and free living) have been used. Nevertheless, our data do confirm the results of the two previous studies in that it was observed that patients with anorexia nervosa tend to underreport the amount of daily PA they perform (8,40). In addition, the minutes per day of MVPA assessed by AH in our study are close to those measured by Bratland-Sanda et al. (9) in a population of seven inpatients with anorexia nervosa using an accelerometer (MVPA, 100 vs 93 $\text{min}\cdot\text{d}^{-1}$). Conversely, Hechler et al. (28) found far higher objective PA levels in outpatients with anorexia nervosa (232 $\text{min}\cdot\text{d}^{-1}$ from low to very high PA) than those measured in our sample. Time spent in sedentary activities in our sample is consistent with the data of Bouten et al. (5) when expressed as a percentage of monitoring time (53% vs 60%), but higher than the percentage of time spent in LPA, MPA, or VPA.

As previously observed (30), our data indicate that some patients with anorexia nervosa are consistently more active than others, in particular those with shorter duration of the disorder, with MVPA showing an interperson variation by up to 500 $\text{min}\cdot\text{d}^{-1}$. Despite the great range in MVPA across individuals, our data show a PA pattern common to inpatients with anorexia nervosa, featuring three distinct peaks during the day (in the midmorning, late afternoon, and after dinner).

Finally, the negative relation between change in global EDE score and baseline levels of LPA indicates that patients with a higher LPA in the first days of inpatient treatment show less improvement in their eating disorder psychopathology. The design of our study does not enable light to be shed on the reasons for this association, although we can speculate that excessive LPA, unlike MPA and VPA, is a behavior that is difficult to detect and may not have been adequately addressed by the treatment. As a consequence, the possible maintenance of high levels of LPA may have hindered improvement in the eating disorder psychopathology. Future studies, with a larger sample size, designed to assess LPA levels during the course or at the end of treatment, are needed to test this hypothesis.

Although methodological limitations preclude any firm conclusions, our data do have some clinical implications. First, the self-reported assessment of PA of patients with anorexia nervosa seems to be of scarce clinical utility, primarily because it provides greatly underestimated figures when compared with objective measurement and because it exhibits no association with treatment outcome. Our second interesting finding was that higher levels of LPA, assessed using AH, in the first days of inpatient treatment, are associated with poorer improvement of eating disorder psychopathology. This indicates the utility of including objective measurement of PA in the assessment of patients with anorexia nervosa. Third, our data suggest the need to devise additional strategies for the first week of inpatient cognitive behavioral treatment for patients with high levels of LPA, in particular to help them cope with the urge to exercise, which seems likely to strike in the midmorning, late afternoon, and after their evening meal.

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