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ABSTRACT

BOUTEN, C. V., W. D. VAN MARKEN LICHTENBELT, and K. R. WESTERTERP. Body mass index and daily physical activity in anorexia nervosa. *Med. Sci. Sports Exerc.*, Vol. 28, No. 8, pp. 967–973, 1996. The level of daily physical activity in 11 non-hospitalized women with anorexia (age: 21–48 yr, body mass index (BMI): 12.5–18.3 kg·m^{-2}), compared with 13 normal-weight women (age: 20–35 yr, BMI 19.2–26.7 kg·m^{-2}), was studied in relation to BMI. Daily physical activity over a 7-d period was determined from movement registration and by combining measurements of average daily metabolic rate (using the doubly labeled water method) and sleeping metabolic rate (measured in a respiration chamber). Group averages of daily physical activity were similar for subjects with anorexia and control subjects. However, women with anorexia had either a low or a high level of daily physical activity, whereas most control subjects had a moderate level of daily physical activity. In the women with anorexia, daily physical activity was significantly related to BMI ($r = 0.84$). Subjects with a BMI ≥ 17 kg·m^{-2} were equally or more active compared with control subjects, while subjects with a BMI < 17 kg·m^{-2} were equally or less active compared with control subjects. The increased physical activity at BMI ≥ 17 kg·m^{-2} is considered to be facilitated by an improving physical capacity combined with the advantages of a low body mass during weight-bearing activities. At lower BMI, undereating and declining physical capacity may have caused the observed decrease in daily physical activity.

MOVEMENT REGISTRATION, DOUBLY LABELED WATER, PHYSICAL CAPACITY, FREE-LIVING CONDITIONS

Anorexia nervosa is often associated with excessive physical activity (11,18). Sometimes the overactivity is seen as the cause of anorexia, as in activity-based anorexia, where strenuous exercise reduces the value of food reinforcement and results in decreased food intake (10). More often, however, it is considered as an attempt to enhance weight reduction in combination with reduced food intake (28), as a denial of the enervating effects of excessive dieting (25), or as periodic restlessness (6). This overactivity is paradoxical because, given the emaciation and the low energy intake, a reduced level of physical activity combined with fatigue, or even exhaustion, is expected (17,19). It is therefore suggested that, as a protective adjustment to starvation, prolonged malnutrition in anorexia nervosa leads to a sparing of energy expenditure during rest as well as during physical activity. Many studies have reported a reduced resting metabolic rate in anorexia nervosa. Some authors showed that this effect is brought about by a reduction in body mass (21,23). Others, however, found that resting metabolic rate was reduced to a greater extent than would be expected from tissue loss alone, indicating an increased efficiency in energy expenditure at rest (7). A comparable efficiency in energy expenditure due to physical activity has not been demonstrated. Bruce et al. (5) and Melchior et al. (21) found lower values for energy expenditure during standardized walking and cycling exercise in women with anorexia compared with normal-weight controls, but in both studies the decrease in energy expenditure could be explained from the difference in body mass between the groups. Thus, the apparent sparing of energy expenditure due to physical activity in women with anorexia is related to the lower body mass in these subjects. As pointed out by Durnin (9), subjects with a low body mass in relation to height, expressed as the body mass index (BMI = body mass × height^{-2}, in kg·m^{-2}), have less difficulty moving their body during weight-bearing activities, like walking or stair climbing, than subjects with a higher BMI. As most daily activities are weight-bearing, these subjects may reach similar or even higher levels of physical activity compared with subjects with a higher BMI. On the other hand, a low BMI (<17 kg·m^{-2}) is often accompanied by a reduced physical work capacity, mainly caused by a reduction in muscle mass. Therefore, the same level of physical activity would impose a greater stress on subjects with a low BMI, eventually resulting in reduced levels of daily physical activity. It is not known how the above-mentioned phenomena are related to each other and whether they are present in anorexia nervosa.

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The purpose of the present study was to investigate the level of daily physical activity in women with anorexia nervosa in comparison with normal-weight women, and to determine whether daily physical activity is affected by the BMI in these subjects. Physical activity was quantified during a 7-d period under free-living conditions by using the doubly labeled water method and a Tracmor motion sensor (3). The first method was used to indicate the overall physical activity level (PAL) in terms of energy expenditure, by expressing the average daily metabolic rate during the 7-d period as a multiple of the sleeping metabolic rate (measured in a respiration chamber). The Tracmor was used to directly provide information about the amount of body movement over intervals of 1 min.

SUBJECTS AND METHODS

Subjects

Eleven adult, non-hospitalized women with anorexia nervosa were selected according to the DSM-III-R criteria for mental disorders (1) and to a BMI of $\leq$ 18 $kg\cdot m^{-2}$. The duration of anorexia nervosa ranged from 5 to 28 yr. All anorexia nervosa subjects were classified as food restrictors according to the Eating Disorder Inventory (13). Their body mass had been stable ($\pm$0.5 kg) during the 3 months prior to the experiment. Seven subjects had amenorrhea of $\geq$3 months duration. The other four had more or less regular withdrawal bleeding induced by the use of oral contraceptive pills. The control group consisted of 14 adult normal-weight women who were free of eating disorders and certified to be in good physical health by a staff physician. Control subjects were students or had full-time or part-time employment. The majority of the subjects with anorexia were not engaged in occupational work, but performed voluntary work. All subjects gave written informed consent to participate in the study after procedures were explained to them. The study protocol was in accordance with the University Ethics Committee guidelines.

Movement Registration

Body movement was measured with a portable motion sensor, the Tracmor, consisting of a body-fixed triaxial accelerometer and a data unit for on-line registration, processing, and storage of acceleration signals. The triaxial accelerometer (50 $\times$ 30 $\times$ 8 mm, 16 g) is composed of three uniaxial accelerometers (ICSensors, 3031-010). Using an elastic belt around the waist, the triaxial accelerometer can be attached to the low back of subjects with measurement directions along the antero-posterior, medio-lateral, and longitudinal axes of the trunk. A flexible cable runs from the accelerometer to the data unit. The data unit measures 110 $\times$ 70 $\times$ 35 mm and weighs 250 g, including two 9 V batteries for registration and processing of acceleration signals over a period of 8 d. In the data unit, acceleration signals from the three measurement directions are amplified and filtered (0.11–20 Hz) as described before (3). Next, acceleration signals are processed to obtain the sum of the rectified and integrated acceleration curves from all three measurement directions, as described by Bouten et al. (4). The time period for integration is set at 1 min, and the finally obtained output from the Tracmor is expressed as $counts\cdot min^{-1}$. The output is stored in a data memory chip that can be read out to a computer for further data processing. Batteries and other electronic components of the data unit are built in a housing of PVC that can be opened for replacement of batteries and calibration of the accelerometer. The data unit is worn around the waist in a small bag (fanny pack) or is attached directly to a waist belt using slits on both sides of the PVC housing. In the present study, 10 different Tracmors were used, which were calibrated identically to produce an output of 1000 $counts\cdot min^{-1}$, corresponding to an acceleration of 1 g (1 g = 9.812 $m\cdot s^{-2}$ at the experimental site) for each measurement direction.

Subjects were instructed to wear the Tracmor during all waking hours of the 7-d period following the respiration chamber measurements (see below), except during bathing, swimming, or taking a shower. They recorded the amount of time and specific activities when they were, for any reason, not wearing the equipment. This information was used to calculate the average weekly Tracmor output, using only the time intervals of movement registration, i.e., when the equipment was worn. Before calculation of average Tracmor output, Tracmor recordings were corrected for offset values, usually about 1500 $counts\cdot min^{-1}$, and high Tracmor outputs (>8000 $counts\cdot min^{-1}$) that did not arise from voluntary human movement, but merely resulted from vibrations produced by transportation means, like cars, trains, or buses. Previous evaluation of the Tracmor under free-living conditions showed a significant correlation ($r = 0.79$) between Tracmor output and the energy costs of daily physical activity (2). It is assumed that Tracmor output is not influenced by body mass, i.e., providing that body movement is measured at the same location on the human body and providing identical calibration, the same movement will produce similar Tracmor outputs in subjects with low and high body mass.

Energy Expenditure

Sleeping metabolic rate was measured during the night prior to the field measurements in a 14 m^3 respiration chamber, as described previously (27). This chamber is ventilated with fresh air at a rate of about 50 $l\cdot min^{-1}$. The ventilation rate through the chamber is measured with a dry-gas meter (Schlumberger, G4) and oxygen (O_2) and carbon dioxide (CO_2) concentrations in ingoing and out-

TABLE 1. Subject characteristics.

	Subjects with Anorexia (N = 11)			Control Subjects (N = 13)		
	Mean	SD	Range	Mean	SD	Range
Age (yr)	33.6*	7.8	21–48	26.0	4.9	20–35
Height (m)	1.66	0.06	1.65–1.75	1.64	0.05	1.58–1.76
Body mass (kg)	45.9***	4.6	38.3–55.0	63.5	6.8	53.6–77.2
BMI (kg · m^{-2})	16.7***	1.6	12.5–18.3	23.6	2.0	19.2–26.7

BMI = body mass index.
* $P < 0.05$; *** $P < 0.001$, significant differences between groups.

going air with a paramagnetic analyzer (Hartmann & Braun, Magnos 6G) and an infrared analyzer (Hartmann & Braun, Uras 3G), respectively. O_2 consumption and CO_2 production in the subjects were computed on-line from the ventilation rate and O_2 and CO_2 concentrations. Sleeping metabolic rate was determined from the O_2 consumption and the CO_2 production over a 3-h interval between 0230 and 0700, when subjects were asleep (Doppler radar observations). Average daily metabolic rate was measured with doubly labeled water according to the procedures described by Westerterp et al. (29). At 2200 the evening before the start of the field measurements, subjects drank a weighed amount of ^{18}O and ^{2}H after collecting a baseline urine sample. The dosage of the stable isotopes was based on body mass in order to create an ^{18}O excess of 300 ppm and an ^{2}H excess of 150 ppm. Further urine samples were collected from the second and last voiding at the first day (day 1) and the last day (day 8) of the field measurements. Isotope quantities in the urine samples were measured with an isotope ratio mass spectrometer (VG Isogas, Aqua Sira), and CO_2 production was calculated from isotope ratios in baseline, day 1, and day 8 samples with the equations from Schoeller et al. (26). All samples were measured in duplicate and the difference between duplicates was always < 1 ppm. CO_2 production was converted to average daily metabolic rate using an energy equivalent based on the individual macronutrient composition of the diet, as determined from dietary records. Average daily metabolic rate and sleeping metabolic rate were expressed as Watt (W). The ratio between average and sleeping metabolic rate was calculated to determine the overall physical activity level in terms of energy expenditure (PAL). This measure can be used to compare subjects with different active cell mass (fat-free mass), as the latter is reflected in the sleeping metabolic rate (20).

Data Analysis

Based on the ranges in average weekly Tracmor output and PAL, subjects were divided into three activity groups with a low, moderate, or high level of daily physical activity. The cut-off points used to create the three groups were 900 and 1150 counts·min^{-1} for average Tracmor output, and 1.60 and 1.85 for PAL. Since Tracmor output is stored at intervals of 1 min, the number of minutes spent in a given activity category, quantified by movement registration, can be calculated. Using previous data from Tracmor registrations in combination with activity recordings in diaries (2) three activity categories were defined. Lying, standing, and sedentary activities were associated with Tracmor outputs < 1000 counts·min^{-1}, walking and cycling activities with outputs ranging from 1000 to 3000 counts·min^{-1}, and household activities, exercise, and sports activities with outputs > 3000 counts·min^{-1}. The time spent in these specific categories was expressed as a percentage of the total waking monitoring time. Differences between groups were calculated using unpaired Student's t-test (two-tailed), while differences within subjects were calculated using paired Student's t-test (two-tailed). Associations between variables were evaluated with regression analysis according to the least squares principle.

RESULTS

Data from one control subject were excluded due to excessive sports activity, resulting in values for PAL (2.57) and average Tracmor output (2017 counts·min^{-1}), which deviate more than 3 times the standard deviation from the group averages. Personal characteristics of the remaining 24 subjects are summarized in Table 1. The subjects with anorexia were, on average, older than the control subjects ($P < 0.05$), but this difference in age was not related to the other personal characteristics and did not affect the investigated level of daily physical activity. Women with anorexia and the control group were similar in height, but, as expected, there were significant differences with respect to body mass and BMI ($P < 0.001$).

Table 2 displays data on sleeping metabolic rate, average daily metabolic rate, and physical activity. Sleeping metabolic rate and average daily metabolic rate were significantly lower in women with anorexia than in control subjects ($P < 0.001$). In the group with anorexia, sleeping metabolic rate was below the resting metabolic rate predicted from body mass, height, and age using the World Health Organization formulas (30) (51.6 ± 5.8 W vs 58.3 ± 2.9 W, $P < 0.05$), while similar values for measured and predicted resting metabolic rates were found for the control group (70.9 ± 4.8 vs 69.1 + 4.8). There was no difference in the average duration of sleep and of activity monitoring with the Tracmor, although subjects with anorexia showed different sleep and waking

TABLE 2. Sleeping metabolic rate, average daily metabolic rate, daily physical activity level in terms of energy expenditure (PAL), average Tracmor output, and average daily sleeping and monitoring hours in the two experimental groups.

	Subjects with Anorexia			Control Subjects		
	Mean	SD	Range	Mean	SD	Range
Sleeping metabolic rate (W)	53.7***	5.9	41.9–60.3	71.1	4.9	64.3–79.4
Average daily metabolic rate (W)	87.6***	16.7	54.8–108.80	126.3	18.8	85.9–152.8
PAL	1.70	0.29	1.07–2.27	1.73	0.20	1.38–2.03
Tracmor output (counts · min^{-1})	1144	318	742–1763	1085	311	831–2017
Sleeping (h)	8.6	0.8	6.8–9.4	8.6	0.9	7.4–10.5
Monitoring (h)	13.7	1.5	11.0–16.9	13.5	0.9	12.3–15.2

PAL = average daily metabolic rate/sleeping metabolic rate.
*** $P < 0.001$, significant differences between groups.

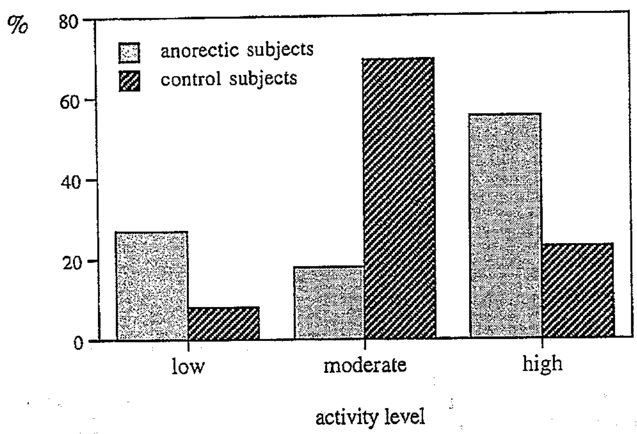

Figure 1—Number of subjects with anorexia and control subjects, expressed as the percentage of both experimental groups, assigned to a low, moderate, or high level of daily physical activity.

structures, accompanied by nocturnal and early morning awakening. Daily physical activity was also not different between groups. However, when subjects were divided into three levels of daily physical activity based on average weekly Tracmor output or PAL values, women with anorexia were more frequently assigned to the low or the high activity levels, whereas normal-weight control subjects were more frequently assigned to the moderate activity level. There were no differences between the two methods for activity assessment in assigning subjects to the three activity levels. The number of subjects per activity level, expressed as the percentage of the total number of subjects in both experimental groups, is shown in Figure 1.

In the subjects with anorexia, daily physical activity measured with the Tracmor was related to the BMI of the subjects. PAL showed also some dependency on BMI, but this relationship did not reach significance ($P = 0.09$). For the normal-weight control subjects, and when pooling all subjects, no relationships between physical activity and BMI were observed. The association between average weekly Tracmor output and BMI is shown in Figure 2 for both experimental groups. In the women with anorexia, average Tracmor output increased with BMI at BMI values above 15 kg·m^{-2} ($r = 0.84$, $P < 0.01$). Below this value, physical activity was assumed to reach a minimum. Although the subject with anorexia with the lowest BMI (12.5 kg·m^{-2}) did not show the lowest level of daily physical activity quantified by Tracmor output, an extremely low PAL of 1.07 was found for this subject. This PAL is below the demonstrated minimum level of energy requirement for maintenance of the essential processes of life, corresponding to a PAL value of 1.2 (15).

With respect to the time spent in specific activity categories, equal fractions of the total observation time per activity category were found for both subject groups. Considering the subjects with anorexia and control subjects respectively, 60 ± 12% vs 64 ± 9% of the observation-time Tracmor outputs below 1000 counts·min^{-1} were recorded, corresponding to lying, standing, and sedentary activities. Tracmor outputs between 1000 and 3000 counts·min^{-1}, associated with locomotory activities like walking and cycling, were observed for 29 ± 7% vs 28 ± 5% of the monitoring time, and outputs above 3000 counts·min^{-1} (household activities, exercise, sports) were observed for 11 ± 5% vs 8 ± 5% of the monitoring time. Again, in women with anorexia, the extent of physical activity, expressed as the percentage of time spent in different activity categories, was related to BMI. The occurrence of Tracmor outputs below 1000 counts·min^{-1}

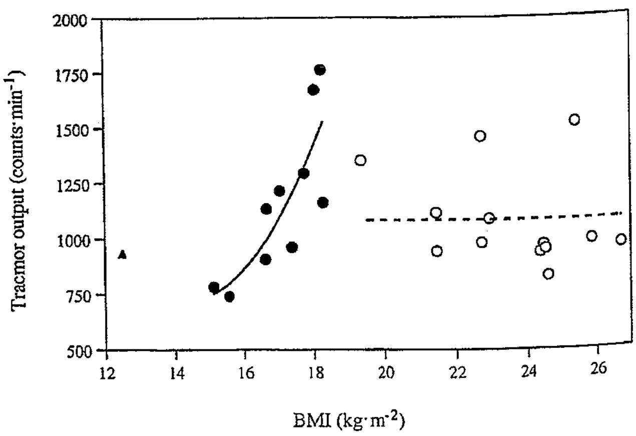

Figure 2—Scattergram for body mass index (BMI) versus physical activity, quantified by the average weekly Tracmor output, in subjects with anorexia (●) and normal-weight (○) subjects. In women with anorexia Tracmor output increased significantly with BMI at BMI values ≥ 15 kg·m^{-2}. The line of best fit is given by: average Tracmor output = 766.66 + 1.12·10^{-5} × e^{BMI} ($r = 0.84$, $P < 0.01$). The *dashed line* represents the average level of physical activity in normal-weight control subjects (1085 + 311 counts min^{-1}). ▲ refers to data from the subject with anorexia with the lowest BMI (12.5 kg·m^{-2}).

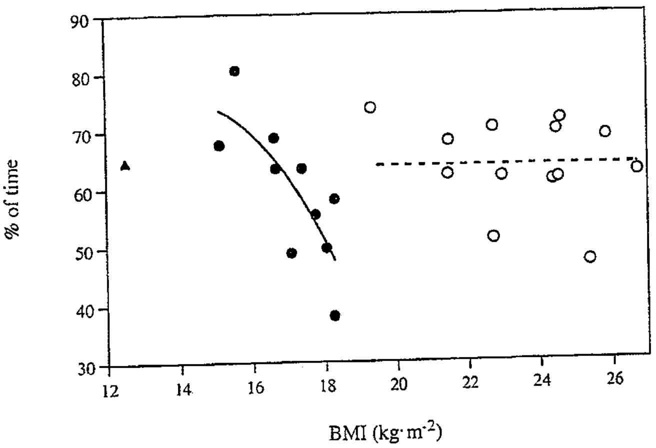

Figure 3—Association between body mass index (BMI) and the percentage of monitoring time spent on activities with Tracmor outputs <1000 counts·min^{-1} in the group with anorexia (●) and control (○) group. In the women with anorexia the occurrence of outputs <1000 counts·min^{-1} decreased with BMI. In analogy with Figure 2, data from the subject with the lowest BMI (▲) were not included in the regression analysis. The line of best fit is given by: %time = 71.99 − 3.54·10^{-7} × e^{BMI} (r = 0.78, P < 0.05). The *dashed line* corresponds to the average percentage of time spent in this specific activity category in the control group (64 ± 9%).

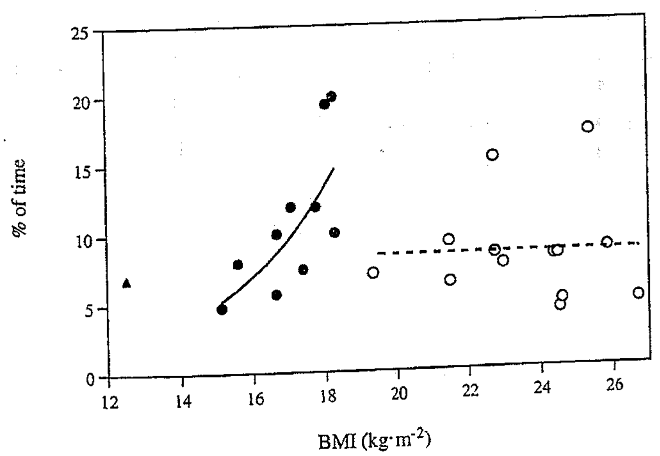

Figure 4—Association between body mass index (BMI) and the percentage of monitoring time spent on activities with Tracmor outputs >3000 counts·min^{-1} in the group with anorexia (●) and control (○) group. In women with anorexia the occurrence of outputs >3000 counts·min^{-1} increased significantly with BMI. The line of best fit (without ▲) is given by: %time = 5.39 + 1.56·10^{-7} × e^{BMI} (r = 0.78, P < 0.01). The *dashed line* corresponds to the average percentage of time spent in this activity category in the control group (8 ± 5%).

decreased with increasing BMI (r = 0.78, $P < 0.05$, Fig. 3), whereas the occurrence of Tracmor outputs above 3000 counts·min^{-1} increased with increasing BMI (r = 0.78, $P < 0.01$, Fig. 4). For Tracmor outputs between 3000 and 8000 counts·min^{-1} and in control subjects, no such relationships were found.

DISCUSSION

Physical activity in women with anorexia and normal-weight women was measured with doubly labeled water and by registration of body movement with a Tracmor motion sensor under free-living conditions. Results show that both groups were on average equally active, but when subjects were assigned to low, moderate, or high levels of daily physical activity, a u-shaped distribution was found for the women with anorexia, while control subjects were more normally distributed with respect to the different activity levels (Fig. 1). The u-shaped distribution in women with anorexia was found to be related to the BMI of the subjects, with relatively low BMI values corresponding to low levels of daily physical activity and relatively high BMI values corresponding to high levels of daily physical activity. When comparing physical activity in women with anorexia and normal-weight control subjects, it must, however, be remembered that the heavily exercising subject in the control group was excluded and that only small, unmatched subject groups were used. The finding of similar average values for physical activity in the group with anorexia and control group is in agreement with Platte et al. (23). In hospitalized female patients with anorexia and healthy age-matched women, these authors observed similar values for the energy compartment ADMR minus resting metabolic rate, which mainly reflects energy expenditure for physical activity. Casper et al. (7), on the contrary, found that the energy compartment for physical activity in female outpatients with anorexia nervosa represents 48% of ADMR compared with 30% of average daily metabolic rate in age-, sex-, and height-matched control subjects. Also, average daily metabolic rate expressed as a multiple of the resting metabolic rate was significantly higher in the women with anorexia than in the control subjects (1.96 ± 0.34 vs 1.50 ± 0.20). It should be noted, however, that the values for average daily metabolic rate minus resting metabolic rate (47.1 ± 23.0 W in women with anorexia vs 32.0 ± 13.3 W in control subjects), as well as average daily metabolic rate as a multiple of resting metabolic rate in the control group of Casper et al. (7), were relatively low. Values for the group with anorexia, on the other hand, were comparable with results from the present study and other investigations (22,23). This points to inactivity in the control group rather than to hyperactivity in the group with anorexia.

Sleeping metabolic rate in the women with anorexia was reduced to a greater extent than would be expected by predicting the resting metabolic rate from body mass, height, and age. This is in accordance with several earlier studies (5,7) and confirms the findings observed in starving subjects (17). The greater-than-expected reduction in resting metabolic rate is thought to be the consequence of metabolic adaptation to starvation. This hypothesis is supported by low thyroid hormone concentrations, mainly triiodothyronine (T3), and a reduced activity of the sympathetic nervous system, reported in anorexia nervosa and starvation (14,22). It is unclear why some authors found this sparing of energy expenditure at rest, while others did not (21,23). It is evident, however, that the use of predicted values for resting energy expenditure based on body mass, height, sex, and age, should be considered with caution when studying energy metabolism and physical activity in anorexia nervosa. In the present study, daily physical activity quantified by average daily metabolic rate as a multiple of predicted resting energy expenditure was significantly lower than average daily metabolic rate as a multiple of measured resting energy expenditure (sleeping metabolic rate) in women with anorexia (1.49 ± 0.25 vs 1.70 ± 0.29, $P < 0.001$), whereas no differences were found in control subjects (1.82 ± 0.27 vs 1.73 ± 0.20).

There were no differences between PAL and average weekly Tracmor output in assigning subjects to different activity levels. In the control group these activity measures were significantly correlated to each other ($r = 0.50$, $P < 0.05$), yet in the group with anorexia no such relationship was found. In these subjects the deviations between average Tracmor output and PAL tended to increase at lower BMI. The discrepancy between movement registration and energy expenditure in this group might be explained by the above-mentioned changes in energy metabolism. Furthermore, the high degree of fidgeting sometimes seen in women with anorexia (6,22), might have been underestimated by the Tracmor at the low back, resulting in an underestimation of PAL from Tracmor output.

In the group with anorexia the level of daily physical activity, expressed as average Tracmor output or as the percentage of time spent in specific activity categories, was related to the BMI of the subjects. Subjects with a relatively low BMI had lower levels of daily physical activity and spent less time on activities like sports and exercise, and more time on activities like standing, lying, or sitting than subjects with a higher BMI. This is in accordance with the reduction in physical activity in the course of chronic energy deficiency and human starvation (15,19). The decrease of daily physical activity with BMI in women with anorexia was not related to the age of the subjects, since no association between BMI and age was found, and multiple regression analysis using BMI and age as predictors of daily physical activity (Tracmor output, percentage of time spent in different activity categories) did not reveal a significant influence of age on the assessment of daily physical activity. In an attempt to analyze the influence of diminishing BMI on physical activity and physical work capacity, Durnin (9) concluded that below a BMI of 17 kg·m^{-2}, physical activity is affected by a reduced physical work capacity. Above this value, physical work capacity will probably be sufficient to maintain a "normal" level of physical activity, while the relatively low body mass facilitates the performance of weight-bearing activities. The reduction in physical work capacity below a BMI of 17 kg·m^{-2} is primarily brought about by a reduction in muscle mass, accompanied by a reduced maximal oxygen uptake. In anorexia nervosa, malnutrition, diminished muscular functions, cardiovascular disorders, and osteoporosis may further affect the already reduced physical capacity (12,24). Interestingly, in the present study the average level of physical activity in normal-weight subjects, either expressed as average Tracmor output or as the percentage of time spent in different activity categories, corresponds to that of the subjects with anorexia at a BMI of 17 kg·m^{-2} (Figs. 2–4). Thus, subjects with anorexia with a BMI below 17 kg·m^{-2} might be characterized as underactive, whereas subjects with a BMI above 17 kg·m^{-2} might be characterized as overactive with respect to the average activity level of normal-weight control subjects. The latter finding confirms the increase in physical activity in women with anorexia during weight gain (11). It is also in agreement with the studies of Kaye et al. (16) who observed higher than normal levels of physical activity in recently weight-recovered women with anorexia. In long-term, weight-recovered women with anorexia, physical activity levels tended to return to normal.

With diminishing BMI, physical activity is assumed to asymptotically reach a minimal value. For the average Tracmor output (Fig. 2) this would correspond to a level of about 750 counts·min^{-1} at a BMI of 12 kg·m^{-2}, which is the absolute limit for BMI compatible with life (15). This minimum of 750 counts·min^{-1} might be explained by the fact that there is always some degree of body movement, even in severely malnourished subjects with a BMI as low as 12 kg·m^{-2} (8). With respect to the percentage of time spent in the lowest and highest activity categories, limits of 75–80% and 0–5%, respectively, may be reached (Figs. 3 and 4), the discrepancy being explained by the percentage of time spent in the locomotory activity category (1000–3000 counts·min^{-1}).

This is the first study that uses movement registration for the comparison of physical activity in free-living subjects with anorexia and normal-weight subjects. Falk et al. (11) and Kaye et al. (16) used actometers at the limbs and a mercury switch at the waist, respectively, to study changes in physical activity during weight recovery. However, both studies were performed in the restricted environment of a hospital and did not include measurements on energy expenditure. The major advantage of body-fixed motion sensors is that they provide a relatively cheap and objective method to directly obtain information about the amount of movement in time. The Tracmor used in this study measures acceleration, and hence provides information on the intensity of movement. In this way it is superior to the devices used by Falk et al. (11), and Kaye et al. (16), which only count body movement if a certain threshold is passed. The Tracmor stores information on body movement over intervals of 1 min and runs 8 d before batteries must be replaced. Therefore, it can be used under free-living conditions over periods long enough to represent normal daily life. The discomfort to subjects is minimal and the Tracmor does not interfere with the performance of daily activities. Although this is also true for the doubly labeled water method, this method can only provide information about overall levels of physical activity over periods of 1–3 wk.

By using movement registration in addition to the doubly labeled water method, the present study suggests that "paradoxical" overactivity in anorexia nervosa only occurs in subjects with a BMI of 17 kg·m^{-2} and above. In subjects with a lower BMI, physical activity decreases as a consequence of malnutrition and declining physical capacity. Due to the small number of subjects studied, however, the general validity of these conclusions is limited, and additional research is required to test their overall applicability in large populations. The Tracmor seems ideally suited for this purpose.

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