Physical Activity and Body Composition in Outpatients Recovering From Anorexia Nervosa and Healthy Controls

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The study aimed to compare differences in physical activity, the relationship between physical activity and body composition, and seasonal variation in physical activity in outpatients with anorexia nervosa (AN) and healthy controls. Physical activity (CM-AMT) and time spent in different intensities of 10 female individuals with AN and 15 female controls was assessed across three seasons along with the percentage body fat. The two groups did not differ in their physical activity and both demonstrated seasonal variation. The percentage body fat of individuals with AN, but not that of the controls, was negatively related to CM-AMT and time spent in low-moderate intensity activity (LMI). Seasonal variation in physical activity emerged with increases in engagement in LMI during the summer period for both groups. Possible interpretations of the finding that decreased physical activity was related to a normalization of percentage body fat in the individuals with AN are discussed and implications for treatment are highlighted.

Apart from a severe and deliberate reduction in food intake, significantly elevated levels of physical activity are considered to be among the most striking characteristics of individuals with anorexia nervosa (AN; Casper, 1998; Exner et al., 2000; Gull, 1874; Hebebrand et al., 2003; Holtkamp et al., 2004; Katz, 1996; Shroff et al., in press). A review of studies investigating excessive exercising reported prevalence estimates ranging from 33–100% (Hebebrand et al., 2003; Katz, 1996). In addition to excessive exercise, fidgeting and restlessness have frequently been observed in individuals with AN (Beumont, Arthur, Russell, & Touyz, 1994; Casper, 1998; Hebebrand et al., 2003). The interest in increased physical activity...
(including both excessive exercise and restlessness) is largely due to its demonstrated deleterious effects for individuals with AN. Among these are increases in energy expenditure with subsequent resistance to weight gain (Van Wymelbeke, Brondel, Marcel Brun, & Rigaud, 2004).

Given the potentially serious consequences of elevated physical activity for individuals with AN, there has been a surprising lack of research regarding its associated features (Shroff et al., in press). Moreover, the few studies on physical activity in individuals with AN have been limited by a range of methodological problems such as the absence of a healthy control group and the use of assessment tools of questionable reliability (Hebebrand et al., 2003). Regarding the latter, some studies have used self-report measures such as retrospective recall of leisure-time sports (Davis, Brewer, & Ratusny, 1993; Davis et al., 1997; Davis, Blackmore, Katzman, & Fox, 2005), while others investigated patients’ and clinicians’ estimates of motor restlessness (Exner et al., 2000; Holtkamp et al., 2003). There are many advantages associated with self-report methods including the fact that they are inexpensive, feasible for large populations, nonreactive, allow for the possibility of assessing various components of physical activity, and are generally acceptable to both the respondent and administrator (Montoye, Kemper, Saris, & Washburn, 1996; Sallis & Saelens, 2000). There are limitations of self-report measures that are especially relevant in the context of individuals with AN, however (Shaw & Garfinkel, 1990). These limitations are the possibility of socially desirable responding (which may lead to an underreporting of physical activities in individuals suffering from AN), the limited access of clinicians to behaviors occurring in secret, and the complexity of accurately recalling physical activities (Baranowski, 1988). Objective assessment via accelerometry (e.g., the Tracmor device; Plasqui, Joosen, Kester, Goris, & Westerterp, 2005) can help to overcome the limitations of self-report measures. Today, such devices are relatively unobtrusive due to their small size (e.g., the Tracmor weighs 22g, 7 × 2 × 0.8cm) and patterns of physical activity can be obtained under free-living conditions (Freedson & Miller, 2000). While objective assessment is not without its own limitations (e.g., possible reactivity by raising awareness of physical activity assessment), its use can help to supplement the findings obtained from self-report methodologies. Yet despite the advantages offered by objective assessment, there are currently few published studies that have used an objective assessment of physical activity in individuals with AN (Bouten, van Marken Lichtenbelt, & Westerterp, 1996; Falk, Halmi, & Tryon, 1985; Holtkamp et al., 2006; Kaye et al., 1986), and even fewer to have explored its relationship with anthropometric variables (e.g., body weight and body composition; Bouten et al., 1996; Falk et al., 1985; Holtkamp et al., 2006).

In one of the few studies to have used an objective assessment, Falk, Halmi, and Tryon (1985) assessed the association between body weight and physical activity in 20 hospitalized female individuals with AN, with activity levels measured using actometers (wristwatches) placed at the participants’ wrists and ankles. A positive relationship was found between percentage of target weight and both average wrist activity ($r = .81, p < 0.01$) and average ankle activity ($r = .76, p < 0.01$), indicating that higher body weight was associated with more activity.

Similarly, Bouten et al. (1996) measured physical activity using accelerometry in adult individuals with AN and again found that daily activity was positively related to Body Mass Index ($\text{BMI} = \text{kg/m}^2; r = .84, p < 0.01$): the lower the BMI...
the more time participants spent in low intensity activity, while the higher the BMI (> 17.5), the more time participants spent in high intensity activity. In addition, individuals with AN who had a BMI greater than 17 were more active than a group of normal-weight controls. Holtkamp et al. (2006) replicated the finding of a positive association between BMI and physical activity (measured via accelerometry) in an adolescent sample of 26 female hospitalized individuals with AN.

Together, these studies suggest that individuals with AN engage in significantly higher levels of activity compared with healthy controls and that engagement in physical activity among hospitalized individuals with AN increases as weight/BMI increases (Bouten et al., 1996; Falk et al., 1985; Holtkamp et al., 2006). The latter may be due to several mechanisms, including increasing levels of dissatisfaction regarding body shape/weight as weight normalizes and/or extremely severe emaciation resulting in a reduced capacity for physical activity (Bouten et al., 1996; Holtkamp et al., 2006).

Each of the reviewed studies investigating the relationship between physical activity and body weight focused solely on individuals with AN during the acute phase of the disorder, prior to weight restoration (Bouten et al., 1996; Falk et al., 1985; Holtkamp et al., 2006). Examining the relationship between physical activity and anthropometric constructs in individuals who are recovering from the disorder and have attained weight normalization has been neglected, despite the reported difficulties in managing increased activity levels in this population (Hechler, Beumont, Marks, & Touyz, 2005). Indeed, Frey et al. (2000) found that former individuals with AN continued to report elevated activity levels 10 years after inpatient treatment compared with healthy controls matched for BMI. Since those with a history of AN also evidenced reduced percentage body fat (percent BF) compared with the controls, Frey et al. (2000) proposed that elevated activity had a negative impact on body composition. Yet, since the relationship between physical activity levels and percent BF was not assessed, the assertion that altered body composition was a result of elevated physical activity remains speculative. It does, however, suggest that the possible negative association between physical activity and percent BF among weight restored individuals with AN stands in contrast to the positive association found for those during the acute phase of illness.

Also limiting previous research is the fact that the relationship between physical activity and variables other than weight and BMI is underexplored. Among the various indices of body composition, low percent BF is known to be associated with important health indices such as reduced heart rate, lowered blood pressure, and hematological abnormalities (Lambert et al., 1997; Misra et al., 2006). Thus understanding potential contributors to percent BF in individuals with AN is paramount. Among such possible contributors is physical activity, with previous research demonstrating an inverse relationship between physical activity (assessed via objective methods) and percent BF in the general population (Stevens et al., 2004; Tudor-Locke & Myers, 2001; Westerterp, Meijer, Janssen, Saris, & ten Hoor, 1992). Importantly, several of these studies were prospective in nature thus strengthening claims regarding the causal role of increased physical activity in reducing percent BF (Stevens et al., 2004; Westerterp et al., 1992). This research awaits replication in a sample of AN patients.

In addition to body composition, another possible covariate of physical activity in individuals with AN is season of the year. Studies in the general population have
demonstrated considerable seasonal variation in physical activity, with increases in physical activity components (especially in moderate intensity activities) during spring/summer and decreases during winter (Matthews et al., 2001; Plasqui, 2004). Prior to the 1990s, research into seasonality in eating disorders was lacking. Nielsen (1992) was among the first to publish reports on season of birth in individuals with AN and to highlight the importance of studying seasonality in eating disorders and the potential impact of environmental factors (e.g., ambient temperature) on behaviors related to the disorder (e.g., physical activity). An awareness of the seasons in which those with AN may be at elevated risk for increased physical activity would have important treatment implications such as focusing on a reduction of elevated physical activity through education on physical activity, self-monitoring, and challenging dysfunctional beliefs (Hechler et al., 2005).

The current study therefore has three objectives: (a) to investigate differences in physical activity in outpatients with AN and healthy controls utilizing an objective assessment of activity; (b) to examine the relationship between physical activity and percent BF; and (c) to repeatedly measure physical activity and body composition across three seasons. It is hypothesized that individuals with AN will show significantly higher activity levels and spend more time in various intensities of physical activity than controls. In addition, a negative correlation between physical activity and percent BF is expected to emerge in this outpatient sample of individuals with AN (in contrast to the positive association found in hospitalized AN individuals). Finally, it is hypothesized that physical activity will vary across the seasons in both the group with individuals with AN and the control group in terms of increases during summer and decreases during autumn and winter.

**Method**

**Participants**

A prospective case-control study comprised of 10 females with AN and 16 healthy female controls was conducted. Individuals with AN were recruited from outpatient and day-patient eating disorder units affiliated with the University of Sydney and all had met *DSM-IV* (American Psychiatric Association, 1994) criteria for AN within the past 5 years (as diagnosed by experienced psychiatrists via clinical interviews) and had at least one inpatient admission due to their eating disorder. At the point of study entry, they were rediagnosed by one of the authors (PB). Four patients (40%) still fulfilled criteria for AN-restricting type, two patients (20%) fulfilled criteria for AN-purging type, and four patients (40%) fulfilled criteria for Eating Disorder Not Otherwise Specified (EDNOS). Participants with either a current or past diagnosis of AN were included (a) to avoid restrictions of range in the key variables of BMI and percent BF and hence the ability to detect significant relationships and (b) to investigate weight restored patients who have been neglected in previous research. The patients were in various stages of treatment ranging from nutritional rehabilitation to relapse prevention.

Sixteen healthy female control participants were recruited through advertisements from among students attending the University of Sydney enrolled in a range of degrees. Potential control participants were matched for age and gender and were excluded if they reported a current eating disorder (assessed via clinical
interview). One control participant commenced training for a marathon during
the course of the study and was thus excluded from the analyses, resulting in 15
controls. Participants came from the following faculties: Arts (n = 1, 7%), Biology
(n = 2, 13%), Dietetics (n = 5, 33%), Social Sciences (n = 3, 20%), Medicine (n
= 1, 7%), Psychology (n = 1, 7%) and Law (n = 2, 13%).
All participants gave written informed consent to participate in the research
and the study protocol was approved by the appropriate Ethics Committees.

**Apparatus**

**Physical Activity.** Physical activity was assessed by accelerometer using validated
triaxial accelerometers (Tracmor; Plasqui et al., 2005). The Tracmor used in this
study (Philips Research, Eindhoven, The Netherlands) was an improved version
(7 × 2 × 0.8cm; weight: 22g) of the triaxial accelerometer used by Westerterp
and Bouten in previous studies (Bouten et al., 1996; Westerterp & Bouten, 1997).
Using an elastic belt around the waist, the accelerometer was placed at the lower
back region and was worn for six consecutive days in each season during waking
hours except while in contact with water. Participants were asked to record the
time points when they removed the Tracmors and the total time the participant
wore the Tracmor was computed. Upon questioning at the completion of the study,
the majority of participants rated the Tracmor as nonintrusive and no participant
reported removing the Tracmor during the assessment period suggesting that the
data constitute an accurate estimation of physical activity.

The following variables were analyzed: (a) mean activity score calculated as
counts per minute over active monitoring time (CM-AMT) and (b) time (in min/
day) spent in various intensities of body movement. To derive various intensity
scores for the Tracmor-output, standard tests in the laboratory of the University
of Maastricht were conducted using 24 healthy participants. The participants ran
on a treadmill at three different speeds (5km/h, 7km/h, and 9km/h) for five min
at each speed. Between the different speed-trials, they rested for a few minutes so
that differences in the Tracmor-output could be identified. Table 1 shows the five
intensity categories that emerged.

For the assessment of physical activity, sample sizes for individuals with AN
and healthy individuals for each season were as follows: 10 individuals with AN and
15 healthy individuals for autumn, 8 individuals with AN and 15 healthy individuals
for winter, and 10 individuals with AN and 14 healthy individuals for summer.

**Anthropometry.** Percentage body fat (percent BF) was assessed using dual-
energy X-ray absorptiometry (DEXA) scans (Lunar Prodigy 5.60.003; GE Lunar
Corporation). The coefficients of variation were as follows: for lumbar spine 1.2%,
for femoral neck 1.5%, for total hip 0.7%, and for total body 1.6%. This was based
on bone mineral density measurements in 28 healthy, normal controls recruited
from hospital staff in whom two bone mineral density measurements were carried
out on the same day, to enable assessment of the reproducibility of bone mineral
density measurement in vivo. Between each bone mineral density measurement, the
normal control was walked for a few minutes before repositioning on the DEXA
table. The calibration of the DEXA was done daily with a phantom spine, which
had a reliability of ± 1%. Reliability of DEXA is generally excellent (0.97–0.99;
Heymsfield, Allison, Heshka, & Pierson, 1995). In validity studies, DEXA compared
favorably with fat estimates from neuron activation analysis, underwater weighing, and total body water assessment (Heymsfield et al., 1995). Orphanidou and colleagues (1997) concluded from their findings in individuals with AN that DEXA appeared to be a valid measurement for defining body composition changes. The same DEXA scanner (Lunar Prodigy 5.60.003; GE Lunar Corporation) was used for all participants to avoid differences in measurements due to different scanners. Participants were in a supine position with their arms down at their side. The scanner was placed directly above the top of the center of the head. Scanning of the whole body took up to 10 min. To compute BMI, measurement of height was taken at each assessment using a stadiometer (Seca; Mod. 220 CE). For weight assessments, beam balances (Wedderburn: Tanita BWB-600) were used with accuracy to the nearest of 0.1 kg.

### Procedure

Since climatic variables such as mean temperature and amount of rainfall are very similar for spring and summer in Sydney, Australia (Australian Surveying and Land Information Group, 2002), and since the procedure of the study was very extensive for the participants, they were assessed across three seasons only (i.e., autumn, winter, and summer) and were seen on two occasions each season. Assessments took place in the middle of each season. During the first meeting, participants were given the Tracmors, DEXA-scans were conducted, and height and weight were measured. After a one-week period, the participants returned the Tracmors.

### Statistical Analysis

SPSS software (version 14.0; SPSS, Chicago) was used for statistical analyses. Due to the varying sample sizes over the seasons and thus the presence of missing data, repeated measurements from autumn to summer were tested by formulating mixed models for normally distributed variables, treating season and group as fixed

<table>
<thead>
<tr>
<th>Intensity Category</th>
<th>Mean (counts/min/10000)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low to moderate:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking at 5km/h</td>
<td>2109</td>
<td>1484</td>
<td>2653</td>
</tr>
<tr>
<td>Moderate to high:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking/running at 7km/h</td>
<td>3962</td>
<td>2792</td>
<td>7753</td>
</tr>
<tr>
<td>High:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking/running at 9km/h</td>
<td>6605</td>
<td>5737</td>
<td>8444</td>
</tr>
<tr>
<td>Very high:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walking/running more than 9km/h</td>
<td>&gt;6605</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
factors and participant as a random factor. With the use of the Sharpened Bonferroni method, alpha-levels were adjusted for multiple comparisons. Pearson correlation coefficients (bivariate) were computed to analyze the relationship between physical activity and both percent BF and BMI.

Results

Characteristics of the Group of Individuals With AN and the Control Group

The mean age, BMI, and %BF for each season for both groups are displayed in Table 2. There was no significant age difference between individuals with AN and healthy females. The group with individuals with AN had a significantly lower BMI compared with the control group ($F = 4.29; p = 0.05$) and a significantly lower percent BF ($F = 4.28; p = 0.05$).

Physical Activity in the AN Versus Control Group

Mean physical activity scores for the group with individuals with AN and the control group are shown in Table 3. Individuals with AN and control participants did not differ in their mean activity score (CM-AMT) ($F = 1.96, p = 0.18$) nor did they differ in the time spent in any of the four intensities of physical activity (low-moderate intensity: $F = 0.80, p = 0.38$; moderate-high intensity: $F = 0.77, p = 0.39$; high intensity: $F = 1.07, p = 0.31$; very high intensity: $F = 0.23, p = 0.64$).

Table 2 Participants’ Characteristics Across the Seasons

<table>
<thead>
<tr>
<th></th>
<th>Individuals with AN</th>
<th></th>
<th>Control participants</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Autumn $n = 10$</td>
<td>Winter $n = 10$§</td>
<td>Summer $n = 10$</td>
<td>Autumn $n = 15$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Winter $n = 15$</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Summer $n = 15$§</td>
</tr>
<tr>
<td>Age</td>
<td>23± 5</td>
<td>23± 5</td>
<td>23± 5</td>
<td>24± 5</td>
</tr>
<tr>
<td>M±SD</td>
<td>15-32</td>
<td>16-33</td>
<td>16-33</td>
<td>15-35</td>
</tr>
<tr>
<td>Range</td>
<td></td>
<td></td>
<td></td>
<td>15-35</td>
</tr>
<tr>
<td>BMI</td>
<td>19.0±2.6</td>
<td>19.7±2.5</td>
<td>19.5±2.6</td>
<td>22.2±3.7</td>
</tr>
<tr>
<td>M±SD</td>
<td>15.2-24.3</td>
<td>16.1-25.0</td>
<td>16.1-25.2</td>
<td>18.3-31.8</td>
</tr>
<tr>
<td>Range</td>
<td></td>
<td></td>
<td></td>
<td>18.9-32.5</td>
</tr>
<tr>
<td>%BF</td>
<td>24.6±11</td>
<td>27.9±10.4</td>
<td>27.0±9.8</td>
<td>33.2±6.7</td>
</tr>
<tr>
<td>M±SD</td>
<td>9.3-43.3</td>
<td>11.5-43.8</td>
<td>13.4-44.7</td>
<td>22.9-51.1</td>
</tr>
<tr>
<td>Range</td>
<td></td>
<td></td>
<td></td>
<td>24.0-53.7</td>
</tr>
</tbody>
</table>

%BF: percentage body fat; § One individual with AN did not receive a DEXA-scan during winter.
§ One control participant was not assessed during summer due to a severe illness.

Note. The patient group had a significantly lower BMI compared to the control group ($F = 4.29; p = 0.05$) and a significantly lower %BF ($F = 4.28; p = 0.05$) across all seasons.
Correlations were computed for both the mean activity score (CM-AMT) across all seasons and the time spent in four intensity activities with both %BF and BMI.

In the group with individuals with AN, there was a significant negative correlation between %BF and the mean activity score (CM-AMT; \( r = -0.42, p = 0.03 \)), between %BF and time spent in low to moderate intensity activity (\( r = -0.49, p = 0.01 \)), and between BMI and time spent in low to moderate intensity activity (\( r = -0.42, p = 0.03 \)). Thus the lower the %BF, the higher the mean amount of activity and the more time individuals with AN spent in low to moderate intensity activities. In addition, the lower the BMI, the more time was spent in low to moderate intensity activities.

For the control group, there were no significant correlations between any of the physical activity variables and either %BF or BMI (\( p > 0.13 \)). The correlations of both groups are shown in Table 4.

### Seasonal Variation in Physical Activity

The mean score for physical activity and time spent in different intensities of physical activity in each of the seasons are displayed in Table 5. In terms of seasonal variation in the mean activity score (CM-AMT), no difference emerged in either group across the three seasons (\( F = 0.22, p = 0.81 \)). There was, however, a significant seasonal effect for time spent in low to moderate intensity activity (\( F = 4.69, p = 0.01 \)). The Scheffe Posthoc Test revealed a significant difference in time spent in low to moderate intensity activity between winter and summer, with increased activity during summer (\( p = 0.03 \)) in both groups. No seasonal variation was evident for time spent in the other intensities of physical activity in either group (moderate-high intensity activity: \( F = 0.48, p = 0.63 \); high intensity activity: \( F = 0.039, p = 0.96 \); very high intensity activity: \( F = 0.04, p = 0.96 \)). Finally, no significant interaction emerged between group (patient versus control) and season for the mean physical activity score (\( F = 0.45, p = 0.64 \)) or the time spent in different intensities of physical activity (low-moderate intensity activity: \( F = 1.76, p = 0.183 \); moderate-high intensity activity: \( F = 0.45, p = 0.64 \); high intensity activity: \( F = 0.039, p = 0.96 \))
Table 4  Correlations Between Physical Activity Variables and %BF and BMI in Individuals With AN and Control Participants

<table>
<thead>
<tr>
<th></th>
<th>Individuals with AN</th>
<th>Control participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%BF</td>
<td>BMI</td>
</tr>
<tr>
<td>CM-AMT</td>
<td>-.42*</td>
<td>-.16</td>
</tr>
<tr>
<td>Time (min/day) spent in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-Moderate intensity activity</td>
<td>-.49*</td>
<td>-.42*</td>
</tr>
<tr>
<td>Moderate-High intensity activity</td>
<td>-.22</td>
<td>-.04</td>
</tr>
<tr>
<td>High intensity activity</td>
<td>-.26</td>
<td>-.003</td>
</tr>
<tr>
<td>Very High intensity activity</td>
<td>-.26</td>
<td>-.02</td>
</tr>
</tbody>
</table>

%BF = percentage body fat; CM-AMT = counts per minute over active monitoring time, mean activity score
* p < 0.05.

Note. Correlations were computed across all seasons.

Table 5  Mean (±SD) Activity Scores (CM-AMT) and Times Spent in Different Intensity Activities (min/day) for Individuals With AN and Control Participants Across the Seasons

<table>
<thead>
<tr>
<th></th>
<th>Individuals with AN</th>
<th>Control participants</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Autumn</td>
<td>Winter</td>
</tr>
<tr>
<td>CM-AMT</td>
<td>836± 274</td>
<td>820± 369</td>
</tr>
<tr>
<td>Time (min/day) spent in</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low-Moderate intensity activity</td>
<td>121± 25</td>
<td>118± 22</td>
</tr>
<tr>
<td>Moderate-High intensity activity</td>
<td>74± 36</td>
<td>64± 22</td>
</tr>
<tr>
<td>High intensity activity</td>
<td>21± 20</td>
<td>25± 38</td>
</tr>
<tr>
<td>Very High intensity activity</td>
<td>7± 13</td>
<td>12± 24</td>
</tr>
</tbody>
</table>

Note. The Scheffe Post-hoc Test revealed a significant difference in time spent in low to moderate intensity activity between winter and summer in both groups with increased activity during summer (p = 0.03).

Contrary to the hypothesis, the current study found comparable activity levels and time spent in various intensities of physical activity in those with a current or past diagnosis of AN and healthy controls. The fact that participants were assessed three
times over the course of 10 months suggests that the nonelevated level of physical activity constitutes a stable phenomenon in recovering outpatients even though the small sample size might have diminished statistical power. Nevertheless, the present sample size is comparable to other studies investigating physical activity in individuals with AN using objective assessment (e.g., Bouten et al., 1996).

While contrary to findings of increased physical activity levels in individuals with AN during the acute phase of illness (Bouten et al., 1996; Falk et al., 1985; Holtkamp et al., 2006), the present results concur with those obtained by Kaye et al. (1986) who found a normalization of increased physical activity in individuals with AN after six months of weight gain. Since participants in the current study were investigated under free-living conditions while Kaye et al. (1986) assessed their participants in hospital on a locked ward, results of nonincreased activity levels in those recovering from AN may be generalized to free-living conditions.

While the present findings suggest a normalization of overall physical activity levels in recovering individuals with AN (i.e., those with an average BMI and percent BF in the normal range), an important caveat in interpreting this result is that participants with AN were still in treatment. Since increased exercising for the purpose of weight loss is one of the predictors of early relapse (Strober, Freeman, & Morrell, 1997), the participants with AN were actively discouraged by their clinicians from engaging in excessive exercise. Thus it would be of interest to determine whether these individuals increase their engagement in physical activity once they are removed from the constraints of treatment.

Consistent with the hypothesized relationship between higher engagement in physical activity and reduced percent BF in individuals with AN, a significant negative correlation emerged between percent BF and both the mean amount of activity and time spent in low to moderate intensity activity in the group with AN. These correlations were of a medium effect size. Given the correlational nature of the findings, it cannot be determined whether higher physical activity is a cause or a consequence of reduced percent BF in the group with AN. In support of the former, prospective studies in the general population have found that increased levels of physical activity predict later reductions in percent BF (Stevens et al., 2004; Westerterp et al., 1992); however, it has also been proposed that reduced body fat may result in increased physical activity. Specifically, according to the semistarvation-induced hyperactivity (SIH) model, reduced leptin levels associated with dietary restriction and weight loss trigger elevated activity (Exner et al., 2000; Hebebrand et al., 2003; Holtkamp et al., 2006). Since leptin levels are correlated with percent BF in individuals with AN (Holtkamp et al., 2003), a reduced percent BF could be expected to be associated with lowered leptin and hence increased physical activity. Consistent with the SIH model, Holtkamp et al. (2006) found that in hospitalized adolescent AN patients, reduced leptin levels were significantly associated with increased physical activity (as measured via accelerometry and self-reported restlessness). Given these alternative interpretations, large-scale prospective research is required to further elucidate the nature of the relationship between physical activity and percent BF in individuals with AN.

The current finding of an association between elevated physical activity and reduced percent BF has implications for the definition of unhealthy exercise in individuals with an eating disorder. Dysfunctional exercise has been variously defined in terms of its quantitative features (e.g., duration, intensity, and frequency)
and/or its qualitative aspects (e.g., the amount of guilt experienced if exercise is not undertaken; Adkins & Keel, 2005). Several studies suggest that it is primarily the qualitative dimensions that are associated with eating disorder symptoms such as dysfunctional attitudes toward shape and weight (Adkins & Keel, 2005; Mond, Hay, Rodgers, & Owen, 2006). However, the current study supports the importance of the quantitative dimensions of physical activity given the association between greater time spent in low-moderate intensity activity and reduced percent BF. It thus appears that both the quantitative and qualitative components of physical activity are associated with pathology: The former may be found to be a stronger predictor of medical status while the latter is more strongly associated with attitudinal and affective disturbances.

In contrast to the group of individuals with AN, there were no significant correlations between physical activity and either percent BF or BMI in the healthy controls. This is contrary to the results obtained by Tudor-Locke and Myers (2001), who reported significantly negative correlations between physical activity and both percent BF ($r = -0.27$) and BMI ($r = -0.30$) in healthy adults. This discrepancy is partly due to the small sample size of the current study and hence the ability to detect significant relationships. For instance, the correlation between average physical activity and percent BF ($r = -0.20$) in the current study is comparable to that obtained by Tudor-Locke and Myers (2001). Sampling differences may have also contributed to discrepancies in the findings (e.g., the study by Tudor-Locke & Myers included males and females ranging from 17 to 79 years of age). For example, in an analysis of 22 different data sets, Westerterp and Goran (1997) found that after controlling for age, physical activity predicted percent BF in males only, leading them to suggest that exercise may not be an effective modality to reduce body fat in females unless accompanied by restriction of energy intake (as is likely to have been the case among the AN participants). Further research is needed to more fully understand the parameters affecting the relationship between physical activity and body composition in the general population.

Finally, and in accordance with the predictions, a significant seasonal effect emerged in terms of activity levels, with participants in both the AN and control groups spending more time in low-moderate intensity activity in summer compared with winter. There was no interaction between season and group (AN versus control), thus suggesting that the same seasonal effects that are present in healthy controls extend to those recovering from AN. These results are consistent with previous studies. For example, Matthews and colleagues (2001) found a peak in leisure and household moderate intensity activities during summer. Investigations of seasonal variation in physical activity in the Southern hemisphere are rare. However, Murray and Hay (1997) found seasonal variation in physical activity in a sample of 526 females from across Australia, while Hechler, Chau, Giesecke, and Vocks (2004) found that a majority and comparable proportion of Sydney and German residents perceived seasonal changes in their physical activity. Together with the objective data on physical activity obtained in the current study, research thus suggests that even in regions of relatively stable environmental conditions (Australian Surveying and Land Information Group, 2002), seasonal effects for physical activity occur. The demonstration of seasonal changes in physical activity is of relevance to clinicians in their assessment and treatment of increased activity in individuals with eating disorders, highlighting the summer period as a time of particular concern.
Limitations

Several limitations of the study are noteworthy. First, the nonsignificant findings regarding physical activity may have been partly due to the small sample size and subsequent diminished power. Further studies with larger sample sizes are therefore needed to replicate and extend the current findings. Second, the study focused on outpatients: Longitudinal studies would be useful in terms of providing insight into how physical activity levels and their relationship to body composition variables change over the course of the eating disorder and once treatment has terminated. Third, even though reported compliance to the Tracmor was high, future studies should include measurements of energy expenditure to validate the Tracmor assessments. Fourth, albeit the control group came from a variety of faculties, it was comprised of university students only and was therefore not a representative sample of young women from the general population. In addition, students’ amount of physical activity may vary depending on their degree. Future studies that draw on a broader sample of young women are needed to reexamine the nonsignificant differences between the AN and control groups regarding physical activity levels. Fifth, the present cut-off points for obtaining different intensities of physical activity were based on the general consensus (i.e., light intensities = <3 MET, moderate intensity = 3–6 MET and high intensity >6 MET). They were based on investigations in Maastricht, The Netherlands, where healthy participants were asked to run on a treadmill at three different speeds (5km/h, 7km/h, and 9km/h) for five minutes at each speed. Between the different speed-trials, they rested for a few minutes so that differences in the Tracmor-output could be identified. The procedure for obtaining cut-off points in the current study was comparable to the procedure of Bouten et al. (1996a). However, the data have not been published yet and since there is an ongoing debate on cut-off points for physical activity future studies need to replicate the present cut-off points for physical activity.

Recommendations for Further Study

Insight into how physical activity levels and their relationship to body composition variables change over the course of an eating disorder is crucial particularly for the time point when treatment has been terminated. Longitudinal studies with a large sample of individuals suffering from AN—possibly recruited through multicenter studies—are therefore warranted. In these studies, assessment of physical activity through both validated accelerometers and self-reports to assess the quantitative and qualitative aspects of physical activity should be combined with assessment of energy expenditure and leptin levels. Hence, insight may be gained into consequences of increased physical activity levels. In addition, factors need to be identified that can predict the change in physical activity and subsequently the change in body composition over the course of the eating disorder. These factors may then be implemented into therapeutic concepts for AN.

Conclusion

The current study found comparable levels of physical activity in outpatients with AN (with a mean BMI and %BF in the normal range) to healthy controls. In addition, higher levels of physical activity were associated with lower %BF and BMI in the
group of individuals with AN. These results suggest that normalization of %BF and BMI in individuals with AN may result in decreased engagement in physical activity (as predicted by the SIH model) and/or that a higher level of physical activity results in reduced %BF and BMI. The latter interpretation highlights excessive activity as a key target in interventions aimed at restoring body weight and composition in those with AN. A treatment focus on physical activity may be particularly important during the summer period given the higher level of low-moderate intensity activity evident among individuals with AN (and controls) at this time.

Acknowledgments

Professor Pierre Beumont passed away in October 2003. He was a highly respected expert in the field of eating disorders and the current research would not have been conducted were it not for his consistent interest and support. The research was completed while the first author was in receipt of a scholarship from the German Exchange Service (DAAD), the Australia Europe Scholarship (IDP Australia), and a scholarship from the Christina Barz Stiftung. The research project was further supported through the Medical Foundation (Jenny Truman-Memorial Fund) of the University of Sydney. We wish to thank Sam Colman and Federica Barzi (Royal Prince Alfred Hospital, Sydney) for their statistical advice and Thorsten Kauder (University of Hamburg) for his advice on analyzing the Tracmor data.

References


Anorexia Nervosa and Healthy Controls


