HHS Public Access
Author manuscript
Eat Behav. Author manuscript; available in PMC 2018 January 01.

Published in final edited form as:
Eat Behav. 2017 January ; 24: 45–48. doi:10.1016/j.eatbeh.2016.11.005.

Measurement of fidgeting in patients with anorexia nervosa using a novel shoe-based monitor

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Abstract

Objective—To objectively assess seated non-exercise physical activity in patients with anorexia nervosa (AN) relative to healthy controls (HCs) and examine the associations between this physical activity, eating disorder pathology, and levels of anxiety and depression.

Method—Eleven inpatients with AN and 10 HCs wore a shoe-based accelerometer (SmartShoe) at three time points: a) while eating lunch, b) filling out questionnaires, and c) watching television for 1 hour.

Results—Across all three tasks, patients with AN were significantly more active than HCs, thereby engaging in a greater degree of restless or fidgeting behavior. Degree of physical activity was positively correlated with eating disorder psychopathology in the sample with AN, and a trend towards a positive association between physical activity and levels of depression and anxiety was also found in this sample. Among individuals with AN, physical activity was not significantly correlated with BMI, duration of illness, or number of days since hospital admission.

Discussion—Use of a minimally invasive, shoe-based monitor revealed patients with AN engaged in a greater degree of fidgeting relative to HCs during quiet, seated tasks and this heightened activity was related to measures of pathology. Non-exercise physical activity, including fidgeting, may warrant further clinical attention in this patient population.

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Keywords

Anorexia nervosa; physical activity; fidgeting; depression; anxiety; eating disorders

1. INTRODUCTION

Anorexia Nervosa (AN) is characterized by an intense fear of fat or weight gain, overvaluation of shape and weight, and prolonged self-starvation. Despite caloric restriction and low weight, a significant proportion of patients with AN do not display the fatigue or decline in motor activity typically observed from natural semi-starvation (Keys, Brožek, Henschel, Mickelsen, & Taylor, 1950). Patients with AN can exhibit heightened levels of activity or excessive exercise in even the most acute stages of their illness (Casper, 2006; Davis et al., 1997). Elevated levels of self-reported exercise are not only associated with heightened psychopathology and worsening mood and anxiety symptoms (Bewell-Weiss & Carter, 2010; Dalle Grave, Calugi, & Marchesini, 2008; Shroff et al., 2006; Sternheim, Danner, Adan, & Elburg, 2015), but also poor prognosis (Rigaud, Pennacchio, Bizeul, Reveillard, & Vergès, 2011).

Aside from voluntary exercise, anecdotal report suggests patients with AN also engage in a great degree of non-exercise physical activity, such as walking, standing, and fidgeting (Beumont, Arthur, Russell, & Touyz, 1994). These activities are receiving greater attention in the study of AN, as little is known about their role in weight regulation, metabolism, and psychopathology. While patients with AN have been found to spend more time on their feet after treatment, and take more steps per day than healthy controls, (El Ghoch et al., 2013; Gianini et al., 2016) clinical understanding of fidgeting is less clear. Clinicians often report elevated levels of this behavior among patients, although objective assessment using a 5-site, wire-based activity monitorhas found no significant difference in fidgeting between patients and HCs (Gianini et al., 2016).

Because of this discrepancy between clinical observation and objective assessment, we sought to further assess fidgeting among patients with AN during otherwise sedentary circumstances using a novel, shoe-based monitor which offers superior sensitivity to fidgeting relative to other activity monitors (Klein, Levine, Walsh, & Sazonov, 2014). It is possible that previous studies did not use accelerometers sensitive enough to detect fidgeting in patients with AN, or their somewhat cumbersome leads and wires may have prevented participants from acting naturally while wearing the device.

In the current study, we used a novel, shoe-based monitor called the SmartShoe (Sazonov, Fulk, Hill, Schütz, & Browning, 2011), to compare seated non-exercise physical activity between patients and HCs while eating lunch, filling out questionnaires, and watching television. We secondarily sought to determine if activity level was associated with severity of eating disorder pathology, levels of depression and anxiety, strength of eating disorder cognitions, and overall negative mood. We hypothesized that patients with AN would exhibit significantly greater levels of seated physical activity relative to HC's, and the degree to which they fidgeted would be positively correlated with pathology, negative mood, eating disorder cognitions, depression, and anxiety.

2. METHOD

2.1 Participants

2.1.1 Patients with anorexia nervosa—Participants were 11 females between the ages of 15 and 33 who met *DSM-5* criteria for AN. Nine patients were diagnosed with restricting subtype, and 2 were diagnosed with binge/purge subtype. All patients were receiving inpatient treatment for AN at the New York State Psychiatric Institute (NYSPI). Patients had an average BMI of 17.60 kg/m^2 (±2.10 kg/m^2) upon assessment. Patients with AN were excluded from the study if they experienced psychosis, recent substance abuse, acute suicidality, or another significant medical illness.

2.1.2 Healthy Controls—Ten age-matched, female healthy controls (HC) were recruited from the community. Controls were included if they had a BMI within the normal range (18–25 kg/m^2), and if they had no current or past psychiatric diagnoses. HCs had an average BMI of 20.80 kg/m^2 (±1.20 kg/m^2) upon assessment. HCs were also compensated $50 for their participation.

All participants provided written informed consent to participate in study procedures approved by the NYSPI Institutional Review Board.

2.2 Physical Activity Measures

The SmartShoe is a sneaker fitted with pressure sensors and an accelerometer that identifies basic postures and captures acceleration in standing and static positions with a 95–98% recognition rate (Sazonov et al., 2011). SmartShoe has shown greater sensitivity to movement while seated, or “fidgeting”, relative to a 5-site activity sensor (IDEEA) apparatus (Klein et al., 2014), which was used to assess this behavior in the past (Gianini et al., 2016).

This study specifically measured non-exercise activity during three seated tasks via the SmartShoe. “Fidgeting” was operationalized as the average acceleration in meters/second^2/minute from both feet during each task. Acceleration was averaged across all three tasks and then log-transformed in order to normalize the distribution, representing overall average activity for each participant.

2.3 Psychological Measures

Before all three activities, a visual analogue scale (VAS) measuring the strength of five eating disorder cognitions was administered. The five items assessed the strength of thoughts regarding feelings of fatness, concerns about weight gain, fear of losing control over eating, nausea, and urge to eat. An average VAS score ranging from 0 to 100, with higher scores indicating greater severity, was calculated across the five items.

Prior to each activity, patients and healthy controls also completed a Profile of Mood States (POMS) assessment that is designed to measure psychological distress and momentary mood (McNair, Droppleman, & Lorr, 1992). Total Negative Mood is operationalized by the sum of Tension, Depression, Anger, Fatigue, and Confusion subscale scores (McNair et al., 1992). In the current study, Total Negative Mood disturbance scores were averaged across all three tasks to depict overall average negative mood for participants.

Patients and HCs also completed self-report assessments of depression via the Beck Depression Inventory (BDI (19)), anxiety with the Beck Anxiety Inventory (BAI (Beck, Epstein, Brown, & Steer, 1988)), and eating disturbance through the Eating Disorder Examination-Questionnaire (EDE-Q (Fairburn & Beglin, 1994)).

2.4 Study Procedure

Patients and HCs wore SmartShoes on both feet for three sequential seated activities: while eating a standardized lunch for thirty minutes, filling out questionnaires assessing mood, anxiety, and eating disturbance for thirty minutes, and watching a television sitcom for one hour. Participants completed the tasks in a study room at NYSPI and all tasks were completed in a seated position. Shoes were also not removed or tampered with between activities.

2.5 Data Analysis

ANOVA was used to compare activity levels and psychological measures between HCs and individuals with AN. Pearson's correlations were used to examine the associations between activity level and psychological measures.

3. RESULTS

Table 1 depicts demographic and physical characteristics of patients with AN and healthy controls. The average duration of illness for patients with AN was 9.80 ± 5.60 years. Patients had been on the inpatient unit for an average of 32.18 days (±24.58 days) when completing the study procedures. Ten of the eleven patients with AN wore SmartShoes for all three tasks. The remaining patient completed only the questionnaire and television viewing activities while wearing the SmartShoes due to an equipment malfunction.

3.1 Physical Activity in Patients vs. Controls

Consistent with our hypothesis, patients with AN were significantly more active than HCs (Log-transformed Average Activity in patients vs. HCs : df=(1,19), F=5.93, p=0.03, partial η^2 =0.24) as measured by average activity level across all three tasks. In examining the raw data, before logarithmic transformation, patients with AN displayed an average activity of 1584.9 activity counts per minute [95% CI 446.7, 5623.4], while HCs displayed an average activity count of 933.3 counts per minute [95% CI 616.6, 1412.5]. In this original scale of measurement, patients' average activity across all tasks was therefore 1.7 times greater than that of HCs. Patients' average rate of weight gain was .33 ± .06 pounds per day, and there was no significant correlation between patients' rate of weight gain and activity level (r= −.11, p= .76). There was also no significant correlation between BMI (r= −0.15, p=0.66), duration of illness (r= −0.08, p=0.83) or number of days since hospital admission and activity level (r=−0.28, p=0.40) among patients with AN. No significant associations were found between activity level and BMI among HCs.

3.2 Relationship Between Activity Level and Psychological Measures

As expected, patients with AN reported more severe eating disorder psychopathology than HCs on the EDE-Q and endorsed stronger eating disorder cognitions, as measured by the

VAS. Patients also reported more negative affect across all three activities as determined by the POMS Total Negative Mood score and significantly higher levels of anxiety and depression relative to HCs, as operationalized by the BAI and BDI, respectively (See Table 1).

There was a significant positive correlation between physical activity and eating disorder psychopathology, as operationalized by the EDE-Q, for patients with AN (r=0.84, p= 0.01). There was no significant association between physical activity and eating disorder psychopathology in HCs. In looking at the relationship between average activity level and total BDI in patients with AN, Pearson's r was 0.58 (p=.06). Pearson's r was also 0.58 (p=.06) for the relationship between average activity level and total BAI in patients with AN. No relationship between BAI or BDI and activity level was present for HCs.

Contrary to our secondary hypothesis, in the AN sample there was no association between physical activity and the strength of eating disorder cognitions as measured by the VAS (r=0.38, p=0.24) or total negative mood (POMS-Total) (r=0.50, p=0.11). Among HCs, there were no significant associations between the POMS or VAS and physical activity.

4. DISCUSSION

Consistent with our primary hypothesis, patients with AN were more active than HCs during the seated activities of eating lunch, filling out questionnaires, and watching television. This suggests patients are engaging in a greater degree of fidgeting behavior during otherwise quiet, seated tasks. Further research should elucidate how aware patients are of this restlessness and the degree to which it contributes to caloric expenditure.

The significant positive correlation between physical activity and eating disorder psychopathology in patients with AN also supports our secondary hypothesis that these variables would be associated with each other. One potential explanation for this finding is that heightened restlessness may be a function of a patient's worsening eating disorder symptoms or eating, shape, and weight concerns. It is plausible that more severe psychopathology may lead patients to fidget in an effort to compensate for eating or to alter one's shape.

Although not significant, the positive association between physical activity and levels of depression and anxiety was in the direction we predicted(p=.06). While our small sample size may have precluded our power to detect a significant effect these results are consistent with a larger body of evidence that suggests psychomotor restlessness is often observed in agitated major depression or anxiety disorders (Angst, Gamma, Benazzi, Ajdacic, & Rössler, 2009; Garriga et al., 2016). Prevalent mood and anxiety symptoms, which are exacerbated by low weight and malnourishment from AN (Gauthier et al., 2014; Pollice, Kaye, Greeno, & Weltzin, 1997), may contribute to the heightened restlessness we observed. Future monitoring of patients with depression and anxiety disorders during these three tasks is necessary to elucidate whether fidgeting is specific to AN or enmeshed in comorbid illness presentations.

We found no significant association between BMI, duration of illness, or rate of weight gain, and activity level. Similarly, the absence of an association between physical activity and the strength of eating disorder cognitions, as measured by the VAS, failed to support our secondary hypothesis. For this small sample, severity of momentary eating disorder cognitions was independent of amount of fidgeting during the three seated activities. This lack of relationship may suggest non-exercise physical activity is not driven by the strength of one's momentary and potentially transient eating disorder cognitions, as captured by the VAS, but rather by entrenched pathology of the disorder as a whole, as measured by the EDE-Q.

4.1 Strengths and Limitations

The SmartShoe's minimally intrusive accelerometer and exceptional sensitivity make it a reliable tool for objectively measuring non-exercise physical activity in both patients and HCs.

A limitation of the present study is that activity was not measured in patients within a specified number of days following admission. Patients' activity levels may therefore have been assessed across different stages of treatment. Even though we did not find a significant association between length of time in treatment and physical activity, further investigation of a larger sample is necessary. The small number of patients and HCs assessed may further confine generalizability of results and replication with a larger sample in necessary.

To clarify the links between fidgeting and weight status, it may also be important to examine these variables in a weight-restored sample of patients with AN and patients with bulimia nervosa.

5. CONCLUSIONS

The current results offer evidence of long-suspected concerns with heightened fidgeting in patients with AN. These results add to the literature highlighting the importance of exploring the relationships between physical activity, in all its forms, and pathology in AN.

Acknowledgments

Financial support: This work was supported by the National Institute of Mental Health grants R01-MH1083795 and T32-MH096679.

References

Angst J, Gamma A, Benazzi F, Ajdacic V, Rössler W. Does psychomotor agitation in major depressive episodes indicate bipolarity? European archives of psychiatry and clinical neuroscience. 2009; 259(1):55–63. [PubMed: 18806921]

Beck AT, Epstein N, Brown G, Steer RA. An inventory for measuring clinical anxiety: psychometric properties. Journal of consulting and clinical psychology. 1988; 56(6):893. [PubMed: 3204199]

Beumont PJ, Arthur B, Russell JD, Touyz SW. Excessive physical activity in dieting disorder patients: proposals for a supervised exercise program. International Journal of Eating Disorders. 1994; 15(1): 21–36. [PubMed: 8124324]

Bewell-Weiss CV, Carter JC. Predictors of excessive exercise in anorexia nervosa. Comprehensive Psychiatry. 2010; 51(6):566–571. [PubMed: 20965301]

Casper RC. The ‘drive for activity’and “restlessness” in anorexia nervosa: potential pathways. Journal of affective disorders. 2006; 92(1):99–107. [PubMed: 16448703]

Dalle Grave R, Calugi S, Marchesini G. Compulsive exercise to control shape or weight in eating disorders: prevalence, associated features, and treatment outcome. Comprehensive Psychiatry. 2008; 49(4):346–352. doi:http://dx.doi.org/10.1016/j.comppsych.2007.12.007. [PubMed: 18555054]

Davis C, Katzman DK, Kaptein S, Kirsh C, Brewer H, Kalmbach K, Kaplan AS. The prevalence of high-level exercise in the eating disorders: etiological implications. Comprehensive Psychiatry. 1997; 38(6):321–326. [PubMed: 9406737]

El Ghoch M, Calugi S, Pellegrini M, Milanese C, Busacchi M, Battistini NC, Dalle Grave R. Measured physical activity in anorexia nervosa: Features and treatment outcome. International Journal of Eating Disorders. 2013; 46(7):709–712. [PubMed: 23712420]

Fairburn CG, Beglin SJ. Assessment of eating disorders: Interview or self-report questionnaire? International Journal of Eating Disorders. 1994; 16(4):363–370. [PubMed: 7866415]

Garriga M, Pacchiarotti I, Kasper S, Zeller SL, Allen MH, Vázquez G, Fountoulakis KN. Assessment and management of agitation in psychiatry: Expert consensus. The World Journal of Biological Psychiatry. 2016; 17(2):86–128. [PubMed: 26912127]

Gauthier C, Hassler C, Mattar L, Launay J-M, Callebert J, Steiger H, Mourier-Soleillant V. Symptoms of depression and anxiety in anorexia nervosa: Links with plasma tryptophan and serotonin metabolism. Psychoneuroendocrinology. 2014; 39:170–178. [PubMed: 24135616]

Gianini LM, Klein DA, Call C, Walsh BT, Wang Y, Wu P, Attia E. Physical activity and post-treatment weight trajectory in anorexia nervosa. International Journal of Eating Disorders. 2016; 49:482–489. [PubMed: 26712105]

Keys A, Brožek J, Henschel A, Mickelsen O, Taylor HL. The biology of human starvation. 1950; 2

Klein, DA., Levine, E., Walsh, BT., Sazonov, ES. Validation of two novel monitoring devices to measure physical activity in healthy women; Paper presented at the Engineering in Medicine and Biology Society (EMBC), 2014 36th Annual International Conference of the IEEE; 2014.

McNair DM, Droppleman LF, Lorr M. Edits manual for the profile of mood states: POMS: Edits. 1992

Pollice C, Kaye WH, Greeno CG, Weltzin TE. Relationship of depression, anxiety, and obsessionality to state of illness in anorexia nervosa. International Journal of Eating Disorders. 1997; 21(4):367–376. [PubMed: 9138049]

Rigaud D, Pennacchio H, Bizeul C, Reveillard V, Vergès B. Outcome in AN adult patients: A 13-year follow-up in 484 patients. Diabetes & Metabolism. 2011; 37(4):305–311. doi:http://dx.doi.org/10.1016/j.diabet.2010.11.020. [PubMed: 21317006]

Sazonov ES, Fulk G, Hill J, Schütz Y, Browning R. Monitoring of posture allocations and activities by a shoe-based wearable sensor. Biomedical Engineering, IEEE Transactions on. 2011; 58(4):983–990.

Shroff H, Reba L, Thornton LM, Tozzi F, Klump KL, Berrettini WH, Bulik CM. Features associated with excessive exercise in women with eating disorders. International Journal of Eating Disorders. 2006; 39(6):454–461. [PubMed: 16637047]

Sternheim L, Danner U, Adan R, Elburg A. Drive for activity in patients with anorexia nervosa. International Journal of Eating Disorders. 2015; 48(1):42–45. [PubMed: 24687461]

Highlights

- Non-invasive objective measurement of fidgeting in patients with anorexia nervosa
- Patients with anorexia nervosa are more restless than healthy controls while seated
- Worsening eating disorder pathology is correlated with heightened restlessness

Table 1

Demographics and psychological measures of patients with AN and HCs

	Patients with AN N= 11	Healthy Controls N=10	Patients with AN vs. HC			
	Mean (SD)	**Mean (SD)**	**df**	**F Statistic**	***p* value**	**η^2**
Age (years)	24.50 (6)	23.10 (3.90)	1,19	0.26	0.62	0.01
White, No. (%) *	11 (100%)	9 (90%)	(1, n=21)	1.15	0.28	0.23
BMI (kg/m^2)	17.60 (2.10)	20.80 (1.20)	1,19	18.60	<.001	0.49
BAI Total	19.00 (10.70)	3.30 (2.40)	1,19	20.34	<.001	0.52
BDI Total	23.50 (12.70)	1.60 (1.80)	1,19	29.07	<.001	0.60
EDE-Q Total	3.90 (1.20)[a]	0.20 (0.20)[a]	1,16	81.39	<.001	0.84
POMS-Total Negative Mood	83.50 (41.70)	10.10 (5.40)	1,19	30.44	<.001	0.62
VAS-Eating Disorder Cognitions	43.30 (19.20)	10.40 (9.70)	1,19	24.20	<.001	0.56
Activity Level (m/s^2/min)§	1584.9 [95% CI 446.7, 5623.4]	933.3 [95% CI 616.6, 1412.5]	(1,19)	5.68	0.03	0.24

Note.

* =Chi-square test, effect size is Cramer's V;

§ = based on log-transformed values with 95% Confidence Intervals provided;

a =n=9;

AN= anorexia nervosa; BMI= Body Mass Index; HC= Healthy Control; BAI= Beck Anxiety Inventory; BDI= Beck Depression Inventory; EDE-Q= Eating Disorder Examination-Questionnaire; POMS= Profile of Mood States, Negative Mood Total represents the average for each subgroup across all three tasks; VAS= Visual Analogue Scales measuring the strength of eating disorder cognitions, averaged across all three tasks for each subgroup.