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Physical activity in female inpatients with longstanding eating disorders

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"Even when all is known, the care of a man is not yet complete, because eating alone will not keep a man well; he must also take exercise. For food and exercise, while possessing opposite qualities, yet work together to produce health."

– Hippocrates, 460 – 370 B.C

"Both excessive and defective exercise destroys the strength."

– Aristotle, 384 – 322 B.C

SUMMARY

There are more clinical opinions than empirical knowledge regarding physical activity of patients seeking treatment for longstanding eating disorders. The aim of this dissertation was therefore to examine different aspects of physical activity among inpatients with longstanding eating disorders a) compared to non-clinical controls, and b) prospective during an inpatient treatment period.

Methods: The papers were based on a two-phased study, where papers I-III reported results from phase I and paper IV consisted of data from phase I and II of the study. Phase I was a cross sectional designed study including 59 female inpatients with longstanding eating disorders and 53 non-clinical age and gender matched controls. The patients met DSM-IV criteria for anorexia nervosa, bulimia nervosa or eating disorders not otherwise specified. The data from phase I constituted the baseline data for study phase II. In phase II, 38 patients classified as excessive and non-excessive exercisers participated. Assessment methods included objectively and self-reported amounts of physical activity, exercise dependence, reasons for exercise, physical fitness, body composition, bone mineral density, and eating disorder psychopathology.

Main results: The patients underreported weekly amounts of moderate-to-vigorous physical activity by 14% (mean 55 $min \cdot w^{-1}$). Regulation of negative affects was perceived as a more important reason for exercise, and fitness/health a less important reason, in patients compared to controls. Exercise dependence score was on average higher in patients compared to controls, but the explanatory factors for exercise dependence score were similar between the two groups. Despite a higher amount of weekly moderate-to-vigorous physical activity in patients across all diagnoses compared to the controls, there were no differences in aerobic fitness between patients and

controls. Muscular strength and bone mineral density was lower in patients with AN compared to patients with BN, EDNOS and controls. Weekly amount of physical activity with high mechanical impact, but not weight bearing physical activity in general, was associated with bone mineral density in the patients. Main explanatory factors for bone mineral density in the patients were a history of AN and muscular strength. Excessive exercising patients had more severe eating disorder psychopathology compared to the non-excessive exercisers, but the relative changes in eating disorder psychopathology from admission to discharge was similar for the excessive and non-excessive exercisers. Reduction in eating disorder psychopathology was associated with reduction in exercise dependence score and reduced importance of exercise for regulation of negative affects in the excessive exercisers, but not in the non-excessive exercisers.

Discussion and conclusions: The underreporting of moderate-to-vigorous physical activity indicates a need for objective assessment of the amount of physical activity. The importance of exercise as an affect regulator, and not only a weight regulator, calls for a wider approach and understanding of the mechanism and function of physical activity in the patients with longstanding eating disorders in general, and in excessive exercising patients in particular.

Keywords: eating disorders, physical activity, exercise, affect regulation, physical fitness, bone mineral density, inpatients, females, adults, psychiatry

LIST OF PAPERS

This dissertation is based on the following papers, which will be referred to in the text by their Roman numerals:

I. Bratland-Sanda S, Sundgot-Borgen J, Rø Ø, Rosenvinge JH, Hoffart A, Martinsen EW. "I'm not physically active – I only go for walks": Physical activity in longstanding eating disorders. Int J Eat Disord 2010 43:88-92

II. Bratland-Sanda S, Martinsen EW, Rø Ø, Hoffart A, Rosenvinge JH, Sundgot-Borgen J: Exercise dependence score in patients with longstanding eating disorders and controls: the importance of affect regulation and physical activity intensity. Eur Eat Disord Rev in press.

III. Bratland-Sanda S, Sundgot-Borgen J, Rosenvinge JH, Rø Ø, Hoffart A, Martinsen EW. Physical fitness, bone mineral density and associations with physical activity in females with longstanding eating disorders and controls. J Sports Med Phys Fitness submitted.

IV. Bratland-Sanda S, Sundgot-Borgen J, Rosenvinge JH, Rø Ø, Hoffart A, Martinsen EW: Physical activity and exercise dependence during inpatient treatment of longstanding eating disorders: an exploratory study of excessive and non-excessive exercisers. Int J Eat Disord. Published online October 16th 2009. http://www3.interscience.wiley.com/cgi-bin/fulltext/122653306/PDFSTART

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Oslo 21.01.10,
Solfrid Bratland-Sanda

LIST OF ABBREVIATIONS

AN	Anorexia Nervosa
ANOVA	Analysis of variance
BN	Bulimia Nervosa
BMD	Bone mineral density
BMI	Body mass index
BW	Body weight
DSM-IV	Diagnostic and Statistical Manual, 4th ed.
ED	Eating disorders
EDE	Eating Disorders Examination interview
EDI	Eating Disorders Inventory
EDS-R	Exercise Dependence Scale – Revised
EDNOS	Eating disorders not otherwise specified
ICD-10	International Classification of Diseases, 10th ed.
LBM	Lean body mass
MET	Metabolic equivalent
MVPA	Moderate-to-vigorous physical activity
PA	Physical activity
PBS	Peak bone strain
REI	Reasons for Exercise Inventory
RM	Repetition maximum
RPE	Ratings of Perceived Exertion
SPSS	Statistical Package of the Social Sciences
VPA	Vigorous physical activity

TABLE OF CONTENTS

1 INTRODUCTION

This dissertation concerns different aspects of physical activity in patients with longstanding eating disorders compared to non-clinical controls, and changes in these variables during an inpatient treatment period. Excessive amounts of physical activity for weight and appearance related reasons are included among the weight compensatory behaviors in the criteria for the eating disorders Anorexia Nervosa and Bulimia Nervosa (1), however the evidence-based knowledge about physical activity in longstanding eating disorders is limited. Furthermore, the associations between changes in amount of, and reasons for, physical activity and eating disorder psychopathology are poorly understood. In this introduction, a description of eating disorders, physical activity and affect/emotion regulation will be provided. The main variable was amount of physical activity in terms of energy expenditure. Other variables in the dissertation were amount of physical activity in terms of mechanical loading on the skeleton, perceived importance of different reasons for exercise, exercise dependence score, aerobic fitness, muscular strength, bone mineral density, and eating disorder psychopathology.

1.1 Eating disorders

Eating disorders are severe psychiatric disorders characterized by, among other disordered eating behaviors, preoccupation with weight and shape, and use of pathological weight control methods such as dieting and purging (1). Two different diagnostic systems are used to classify eating disorders, ICD-10 by the World Health Organization and DSM-IV by the American Psychiatric

Association (1;2). In research, DSM-IV criteria are most commonly used, and these criteria will be further described in the following chapter.

1.1.1 Classification and diagnostic criteria

A diagnostic shift among patients with eating disorders over time is common, and a transdiagnostic model of eating disorders has been suggested (3;4). However, as of today the DSM-IV criteria divide patients into the three eating disorders — anorexia nervosa (AN), bulimia nervosa (BN) and eating disorders not otherwise specified (EDNOS) (1).

Anorexia nervosa (AN)

Historically, extreme fasting has been used in religious contexts, and as early as in the 17th century the first medical report on AN (anorexia meaning no appetite) was presented by the English physician Richard Morton (5). In the 1870s, AN was again described in two separate articles by the French clinician Ernest-Charles Laségue and the English physician Sir William Gull (6). They both described characteristics such as severe weight loss, amenorrhea, constipation and restlessness. The American psychiatrist Hilde Bruch published revolutionary work in the 1960s, in which she focused on the lack of self-esteem and distorted body image (7;8). The current diagnostic characteristics of AN include low body weight, intense fear of weight gain, distorted body image, and for the females amenorrhea (Box 1) (1).

A.	Refusal to maintain body weight at or above a minimally normal weight for age and height (e.g. weight loss leading to maintenance of body weight less than 85% of what expected; or failure to make expected weight gain during period of growth, leading to body weight of less than 85% of what expected).
B.	Intense fear of gaining weight or becoming fat, even when underweight.
C.	Disturbance in the way in which one's body weight or shape is experienced, undue influence of body weight or shape on self-evaluation, or denial of the seriousness of the current low body weight.
D.	In postmenarcheal females, amenorrhea, i.e. the absence of at least three consecutive menstrual cycles. (A woman is considered to have amenorrhea if her periods occur only following hormone, e.g. estrogen administration).
	Specify type: Restricting type: during the current episode of anorexia nervosa, the person has not regularly engaged in binge-eating or purging behavior (i.e. self-induced vomiting or the misuse of laxatives, diuretics or enemas). Binge-eating/purging type: during the current episode of anorexia nervosa, the person has regularly engaged in binge-eating or purging behavior (i.e. self-induced vomiting or the misuse of laxatives, diuretics or enemas).

Box 1: DSM-IV criteria for anorexia nervosa (1).

Bulimia nervosa (BN)

The term bulimia is thought to appear from the Greek terms bous and limos, meaning ox hunger. Historically, this morbid hunger followed by purging was viewed as gastric abnormalities and dysfunctions (9). BN has been reported since the 18th century, but it was not until 1979 that BN was defined as an eating disorder by the British psychiatrist Gerhard Russell (10;11). DSM-IV criteria for BN include recurrent episodes of binge eating with the use of inappropriate compensatory behaviors, with such episodes occurring on a regular basis (Box 2).

A. Recurrent episodes of binge eating. An episode of binge eating is characterized by both of the following:
   (1) eating, in a discrete period of time (e.g. within any 2-hour period), an amount of food that is definitely larger than most people would eat during a similar period of time and under similar circumstances
   (2) a sense of lack of control over eating during the episode (e.g. a feeling that one cannot stop eating or control what or how much one is eating)

B. Recurrent inappropriate compensatory behavior in order to prevent weight gain, such as self-induced vomiting; misuse of laxatives, diuretics, enemas, or other medications; fasting; or excessive exercise.

C. The binge eating and inappropriate compensatory behaviors both occur, on average, at least twice a week for 3 months.

D. Self-evaluation is unduly influenced by body shape and weight.

E. The disturbance does not occur exclusively during episodes of anorexia nervosa.

Specify type:
Purging type: during the current episode of bulimia nervosa, the person has regularly engaged in self-induced vomiting or the misuse of laxatives, diuretics or enemas.
Non-purging type: during the current episode of bulimia nervosa, the person has used other inappropriate weight compensatory behaviors such as fasting or excessive exercise, but has not regularly engaged in self-induced vomiting or the misuse of laxatives, diuretics or enemas.

Box 2: DSM-IV diagnostic criteria for bulimia nervosa (1).

Eating disorders not otherwise specified (EDNOS)

The most frequent diagnosis of eating disorders is the EDNOS (Box 3) (12). Although this category refers to a very heterogeneous group of eating disorders that do not meet the criteria for AN or BN, it is of such severity that treatment is needed (1;12). Binge Eating Disorder, which is characterized by episodes of binge eating but without the weight compensatory behavior seen in BN, is also included in EDNOS (1).

A.	For females, all of the criteria for anorexia nervosa are met except that the individual has regular menses.
B.	All of the criteria for anorexia nervosa are met except that, despite significant weight loss, the individual's current weight is in the normal range.
C.	All of the criteria for bulimia nervosa are met except that the binge-eating and inappropriate compensatory mechanisms occur at a frequency of less than twice per week or for a duration of less than three months.
D.	The regular use of inappropriate compensatory behavior by an individual of normal body weight after eating small amounts of food (e.g., self-induced vomiting after the consumption of two cookies).
E.	Repeatedly chewing and spitting out, but no swallowing, large amounts of food.
F.	Binge-eating disorder: recurrent episodes of binge-eating in the absence of the regular use of inappropriate compensatory behaviors characteristic of bulimia nervosa.

Box 3: DSM-IV criteria for eating disorders not otherwise specified (EDNOS) (1).

1.1.2 Prevalence

The prevalence of eating disorders among Norwegian females is approximately 3.0% – 4.5% (13-15). The prevalence of the different eating disorders diagnoses in Norway was 0.4% for AN, 1.2% for BN, 3.0% for EDNOS, and 3.2% for binge eating disorder (15). A recent international review concluded with a prevalence of AN of 0.1% and BN of 1.3% for young females (16). In young women, the point and lifetime prevalence was respectively 2.6% and 7.8% for all eating disorders (17). The female to male ratio for eating disorders is approximately 10:1 (1;18;19). Studies indicate that the prevalence of AN has been relatively stable for the past 25 years, whereas the prevalence of BN has increased to some extent (16). In certain subgroups of the population, such as elite athletes and homosexual men, the prevalence has been found higher than in the general population (14;20).

1.1.3 Risk and maintenance factors

The etiology of eating disorders is multifactorial, and can be divided into biological, psychological and socio-cultural factors (21). Genes, high body mass

index, gender and puberty status are among the biological factors. Psychological risk factors include personality, low self esteem, feeling loss of control, concerns about weight, shape and appearance, and mental illnesses such as depression and anxiety (17;22). Socio-cultural risk factors include bullying, traumatic experiences such as sexual abuse, and the cultural pressure to be thin (21).

Persistent negative affects seems to predict poor outcome in eating disorders (21), and according to Fairburn the most important maintenance factor for eating disorders is the over evaluation of weight, body and appearance (23). It has been stated that performing aerobic activities of vigorous intensity, and competing in sports on a high level, may increase the risk for eating disorders development and maintenance (24;25).

1.1.4 Symptoms and consequences

Symptoms of eating disorders can be divided into eating disorders specifically, and general psychological symptoms. Specific cognitive and behavioral eating disorders symptoms are preoccupation with weight, shape, appearance, food/nutrition, and exercise, rapid weight change, eating alone, and avoidance of social situations that involve eating. The general psychological symptoms include depressed mood, anxiety, and social isolation (26;27).

The eating disordered behaviors are often followed by severe medical complications, which can be fatal (28-30). AN is the third most common death cause among female teenagers in Europe, and the mortality rate among patients with AN is six times higher than that of the general population (31;32). This high mortality rate is caused both by suicide and somatic complications following the eating disorders (16;31;33). Examples of the latter are altered electrolyte and hormone levels, fluid imbalance, and heart

arrhythmias (28;29). In addition, eating disorders can affect the bone mass by accelerated reduction in the bone mineral density, and inhibit reach of peak bone mass among adolescents (34).

1.1.5 Treatment

A diversity of treatment interventions has been reported. The most promising results have been found for cognitive behavioral therapy in treatment of BN (35-37). For patients with AN, there is no consensus on what form of treatment is the most effective (38). A recent randomized controlled trial also found favorable results of cognitive behavioral therapy for patients with EDNOS (37), but there is as yet no consensus regarding a preferred treatment form for this patient group either. Other forms of therapy that have been studied in patients with eating disorders include family therapy, art therapy, interpersonal therapy and motivational interviewing (39-41). A stepped-care approach[1] to eating disorders has been suggested as beneficial for BN and EDNOS (43). For patients with severe eating disorders, inpatient treatment can be offered when outpatient treatment is insufficient (44).

The recovery rates in eating disorders vary from 30% to 75% in AN and 50% to 70% in BN (45-48). Studies on short term and long term outcome of eating disorders after treatment at the Department of Eating Disorders at Modum Bad Psychiatric Center show that 61% of the patients had improved after five years, and 39% no longer met the criteria for an eating disorder (49). However, a cluster analysis showed a subgroup of patients with no improvement five years after inpatient treatment at Modum Bad. Analyses showed that avoidant personality disorder in combination with child sexual

[1] The stepped care approach has two fundaments: the recommended treatment should be the least restrictive of those available, and the stepped care should be self-correcting (42). In eating disorders, cognitive behavioral therapy has been suggested as the recommended first step (43).

abuse was one main predictor for poor outcome in longstanding eating disorders (50). In other studies, high amounts of physical activity have been found as an important predictor for poor treatment outcome and increased risk of relapse (45;51).

1.1.6 Assessment of eating disorders

Eating disorders can be assessed through clinical and/or diagnostic interview, questionnaires, observation, and symptom check lists. Examples of existing structured clinical interview tools are Eating Disorders Examination (52) and Structured Clinical Interview for DSM disorders axis 1 (SCID-1)(53). Widely used questionnaires include the Eating Disorders Inventory (54;55), the Eating Attitudes Test (56-58) and the Eating Disorders Examination Questionnaire (59). It has been suggested that a combination of structured interview and standardized questionnaires is the preferred assessment method (60).

1.2 Physical activity

Physical activity is defined as “any movement initiated by skeletal musculature that increases energy expenditure above resting level.”(61) Exercise is defined as the planned, structured and repeated leisure-time physical activity which aims to improve or maintain physical fitness and health (61). In this dissertation, the term physical activity also includes exercise and sports.

Physical activity can be classified based on different aspects. In this dissertation classification is based on energy demands (paper I-IV) and

mechanical impact (paper III). Energy demands of physical activity are often classified into low, moderate and vigorous based on the metabolic equivalent (MET) (62). One MET is approximately 1 kcal per kg body mass per hour, and corresponds to the amount of energy required when at rest. Physical activities with MET <3 are classified as low intensity activities (e.g. yoga, pilates, stretching), 3-6 METs are moderate intensity activities (e.g. walking with a speed of approximately 5 km/h, resistance training, tai chi) whereas activities ≥6 METs are classified as vigorous (e.g. running, scuba diving, cycling >20 km/h) (62).

The mechanical impact of different physical activities refers to the loading on bone and ligament structures. Peak bone strain scores based on ground reaction forces as a ratio of body weight of different physical activities were classified by Groothausen et al. (63). Torstveit and Sundgot-Borgen (64) used this method to classify 46 different physical activities and sports into low, medium and high impact. Low impact refers to non-weight bearing activities or activities with low mechanical loading (i.e. ground reaction forces 0-2 x body weight). Examples of such activities are cycling, swimming, and yoga. Medium impact activities are weight bearing with medium mechanical loading, i.e. activities with elements of sprinting and turning actions with ground reaction force 2-4 x body weight (e.g. walking, running, and cross country skiing). The high impact activities include weight bearing activities where jumping, sprinting, turning actions and rapid movements are widespread, and with ground reaction force above 4 x body weight. Examples of such activities are resistance training, alpine skiing, gymnastics, and soccer. It is not necessarily a relationship between energy requirements and mechanical impacts of physical activities (Table 1) (65).

Table 1: Example of classification of certain physical activities based on energy demands (62) and mechanical impact (63;64).

	Energy demand (MET)	Mechanical impact (PBS)
Resistance training	Moderate intensity	High impact
Walking	Moderate intensity	Medium impact
Running	Vigorous intensity	Medium impact
Cycling	Moderate-to-vigorous intensity	Low impact
Yoga	Low intensity	Low impact
Soccer	Moderate-to-vigorous intensity	High impact
Gymnastics	Vigorous intensity	High impact

MET: metabolic equivalent. Low intensity (1-3 MET), moderate intensity (3-6 MET), vigorous intensity (≥6 MET). PBS: peak bone strain. Low impact (0-2 x body weight), medium impact (2-4 x body weight), high impact (≥4 x body weight).

1.2.1 Effects of physical activity and inactivity

Acute physical responses to physical activity include increased ventilation, heart rate, systolic blood pressure and body temperature, and reduction in blood lipoproteins (66). Psychologically, physical activity can have an immediate impact on mood (67). Long term effects of physical activity include enhanced heart- and lung capacity, muscle strength and endurance, metabolism, regulation of blood glucose, digestion and bone mass (66). In addition, studies have shown a beneficial effect of physical activity on stress management, concentration, well-being, self esteem and sleep (68). Physical activity has shown to be effective in prevention and/or treatment of certain somatic and mental diseases (69). Illnesses and disorders in which using physical activity has been found effective include metabolic syndrome related diseases such as hypertension, insulin resistance, type II diabetes, dyslipidemia, and obesity, osteoarthritis, osteoporosis, certain forms of cancer, depression, and anxiety (69). Physical activity can have a direct impact on pathogenesis, or indirectly by enhancing some of the illness-specific symptoms, physical fitness and/or quality of life (66;69). Parallel to these effects, physical inactivity and low physical fitness have been shown as

important predictors of morbidity and mortality, and the World Health Organization estimates that 1.9 million deaths per year worldwide are related to physical inactivity (70-73).

In 2009, a handbook of physical activities in different clinical populations was published by the Norwegian health authorities (74). Unfortunately, the evidence for use of physical activity in prevention and/or treatment of eating disorders is poor and eating disorders are therefore not included in this handbook.

Guidelines for physical activity

The Norwegian health authorities recommend at least 30 minutes daily of moderate intensity physical activity to maintain health for healthy adults (75;76). The American College of Sports Medicine and the American Heart Association recently published updated recommendations for healthy adults aged 18-65 years (68). These recommendations include at least 30 minutes 5 times per week of moderate intensity, and/or 3 times 20 minutes per week of vigorous intensity aerobic activities. In addition, two sessions of weekly strength exercises for the major skeletal muscle groups are suggested. A recent report from Norway showed that 18% of the men and 22% of the women met the recommended amount of weekly physical activity (77).

For females from the general population, weight bearing physical activity in general is sufficient for the maintenance of bone health and prevention of osteoporosis (64;78). However, physical activities with high mechanical impact is associated with higher BMD compared to activities with medium impact (63;64;79).

Adverse effects of physical activity

Still, no consensus exists for when the amount of physical activity and exercise becomes excessive. Risk of injuries increases with increased amount of physical activity (Figure 1) (80;81). It is important to note that these suggestions depend upon exercise status (i.e. exercise history and physical fitness), restitution, and nutritional status of the individual (66;82).

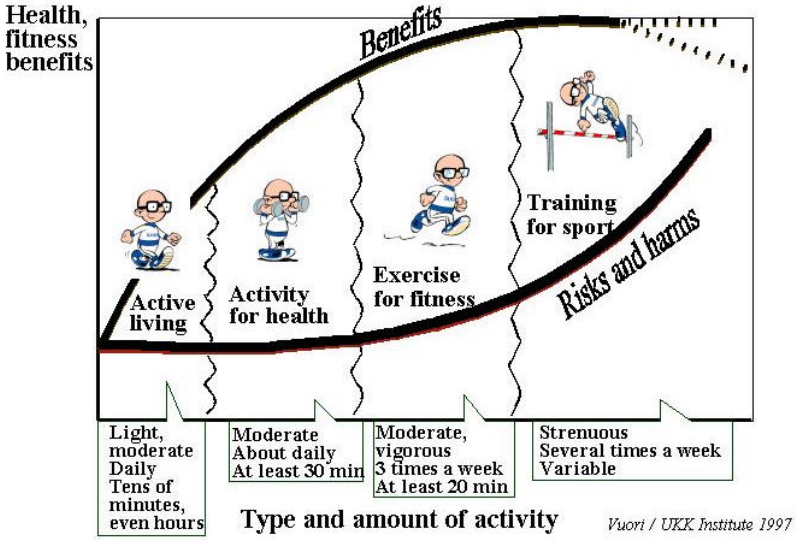

Figure 1: The association between amount of physical activity and effect on health and fitness (83).

The hazards of physical activity include increased risk of developing exercise induced asthma, especially when performing vigorous intensity physical activities in cold and dry air (84). Participation in certain physical activities and sports is also associated with increased risk of musculoskeletal injuries (85), and some studies suggest that physical activity and sport performance increases risk of developing eating disorders (24;25). The latter is not well

documented, and can at this point only be considered as speculation. Furthermore, too much physical activity with inadequate restitution can lead to overtraining syndrome (86). Symptoms of overtraining include fatigue, altered mood and performance, and overuse injuries (86). Individuals with electrolyte imbalance, e.g. low potassium levels, are at increased risk of heart failure during physical activity (87). Furthermore, the reduction in blood glucose concentration seen during performance of physical activity, while generally unproblematic for the healthy individual, can be fatal for patients with type I diabetes (88).

1.2.2 Physical activity and physical fitness

Caspersen et al. (61) define physical fitness as a set of attributes which are either health-related (i.e. muscular strength/endurance, aerobic capacity and flexibility) or skill-related (i.e. reaction time, balance and coordination). In this dissertation, only aerobic capacity and muscular strength are further described.

Aerobic capacity, also referred to as aerobic fitness and cardiorespiratory fitness, is expressed through the maximal oxygen uptake ($VO_{2\ max}$). $VO_{2\ max}$ is the ability to deliver oxygen to the skeletal muscles, and to utilize it to generate energy (89). Low aerobic capacity is associated with greater risk of mortality (70;90), and small improvements in fitness can result in significantly reduced risk of mortality (91;92). Recently, there has been an increased focus upon the possible benefits of improved muscular strength/fitness as well as the benefits of aerobic capacity. Muscular fitness consists of three dimensions: muscular strength (i.e. the ability to generate force), muscular endurance (i.e. the ability to maintain maximal voluntary contraction for a prolonged period of time), and explosive power (i.e. the ability to perform maximal contractions for a short period of time) (89). Poor

muscular fitness has been found as an independent predictor of all causes of mortality among adults (93).

Studies on physical fitness in patients with eating disorders are few and contradictory. Patients with AN have shown lower aerobic fitness (94-99) and lower muscular strength (94;100) compared to healthy controls. However, one study found higher levels of aerobic fitness among patients with AN compared to BN and controls (101). To our knowledge, physical fitness across the various eating disorder diagnoses and compared to non-clinical controls has not been examined.

1.2.3 Motives for being physically active

The motives for being physically active can vary over time and from person to person. The motives are influenced by factors such as age, BMI, mood, personality, knowledge and attitudes (102). The motives can be extrinsic, intrinsic or a combination of these. In females from both the general population and from eating disordered populations, weight control and/or regulation are perceived as very important reasons for physical activity and exercise (103;104). Other motives and reasons for physical activity and exercise are physical fitness, health, well-being, regulation of mood and affects, and socializing (105;106).

1.2.4 Physical activity in eating disorders – the two edged sword

Several studies have examined physical activity in patients diagnosed with eating disorders (24;101;107-110) (Table 2). Patients with binge eating disorder have been found less physically active than individuals from the general population (111), but the studies presented in Table 2 show various

results regarding physical activity between patients with eating disorders and controls (24;101;107-110).

Table 2: Selected studies that have examined the amount of physical activity or energy expenditure in patients with eating disorders and controls.

Study	Population (n) Age mean (SD)	Assessment	Results
Casper et al. (1991) (107)	AN (6) Yrs: 24.5 (2.8*) Controls (6) Yrs: 24.8 (2.8*)	Doubly labeled water	AN: 20.1 kcal/d^{-1}/bw^{-1} Controls: 10.5 kcal/d^{-1}/bw^{-1} AN > Controls
Pirke et al. (1991) (108)	AN (8) Yrs: 27.8 (5.2) BN (8) Yrs: 24.3 (4.7) Controls (11) Yrs: 24.5 (4.2)	PA diary	AN: 115 (52) min/day BN: 56 (44) min/day Controls: 32 (26) min/day AN > BN = controls
Davis et al. (1994) (24)	AN, BN (45) Yrs: 24.6 (4.8) Controls (51) Yrs: 21.5 (1.5)	Retrospective self report	Patients: 1791.6 (2068.7) 30 min/year Controls: 990.3 (680.7) 30 min/year Patients > Controls
Bouten et al.(1996) (109)	AN (11) Yrs: 33.6 (7.8) Controls (13) Yrs: 26.0 (4.9)	Triaxial accelerometer	AN: 1144 (318) counts/min Controls: 1085 (311) counts/min AN = controls
Sundgot-Borgen et al. (1998) (101)	AN (13) Yrs: 22.0 (4.4) BN (43) Yrs: 22.0 (2.7) Controls (17) Yrs: 24.0 (3.3)	Self report	AN: 6.6 (3.6) hours/week BN: 2.4 (2.7) hours/week Controls: 1.6 (1.4) hours/week AN > BN = Controls
Boyd et al. (2007) (110)	AN, BN, EDNOS (178) Yrs: 19.7 (11.8) Controls (722) 21.5 (7.3)	Self report (EEE-C) PA diary	Patients: 6.9 (7.2) kcal/15 minute, 13.9 days of exercise during the last 28 days Controls: 5.7 (8.2) kcal/15 minute, 12.6 days of exercise during the last 28 days Patients = controls

*Standard Error of the Mean (SEM). [a] sample consisted of females and males. AN: anorexia nervosa. BN: bulimia nervosa. EDNOS: eating disorders not otherwise specified. PA: physical activity. EEE-C: Eating and Exercise Examination – Computerized.

Across the eating disorder diagnoses, some studies have found higher amounts of physical activity and higher prevalence of excessive exercising among patients with AN compared to BN (101;112) whereas others have found no differences (113;114) (Tables 2 and 3). The assessment methods,

definition of physical activity, and eating disorder population investigated vary among the studies, and this makes comparison difficult. The results are also flawed by the lack of patients with EDNOS. The inclusion criteria used in many of the studies make generalization of the results difficult.

The patterns of physical activity behavior during inpatient treatment have been less studied. Two studies on female inpatients with AN (n=11) showed that physical activity remained stable during the hospitalization period, and that this prolonged the weight restoration time (51;115). It was therefore recommended that physical activity should be restricted during treatment.

Excessive exercise and exercise dependence

Today, there is no consensus on how to define excessive exercise. There is a wide range of definitions, and the prevalence of excessive exercisers among individuals with eating disorders varies (24;112-114;116-120) (Table 3). Excessive exercising seems to be a feature that occurs across AN, BN and EDNOS (114). Depending upon the definition used, excessive exercise seems most frequent among patients with AN (112;113;120). However, it is important to note that patients with a current BN but a previous AN were classified as AN patients in the study by Davis et al. (112). The different definitions listed in Table 3 vary in nature and number of criteria that have been added to the definition. Unfortunately, none of the criteria employed for excessive exercise has been validated. Davis et al. (112) is the only study that has taken amount, compulsiveness and persistence of the behavior into consideration. Most previous studies have focused upon younger patients with shorter duration of eating disorders compared to our sample. It is yet to be determined whether the prevalence and mechanisms of excessive exercise are similar in patients with longstanding eating disorders.

Table 3: Selected publications that have examined prevalence of excessive exercise in patients with eating disorders.

Study	Population (n) Age, mean (SD)	Definition	Prevalence
Davis et al. (1994) (24)	AN, BN (45) Yrs: 24.6 (4.8)	Degree and frequency of exercise beyond normal range for age	78%
Brewerton et al. (1995) (113)	AN (18) Yrs: N/A BN (71) Yrs: N/A	≥7 h/w exercise with motive to control weight	AN: 39% BN: 23% AN > BN
Davis et al.(1997) (112)	AN, BN (127) Yrs: 27.7 (7.8)	≥6 h/w exercise for ≥1 month, and behavior was obsessive, driven and out of control	AN: 81% BN: 57% AN > BN
Favaro et al. (2000) (116)	AN (16) Yrs: 22.3 (6.3)	≥7 h/w intensive exercise	31.2%
Solenberger (2001) (114)	AN (115) Yrs: 20.1 (7.1) BN (38) Yrs: 20.8 (7.2) EDNOS (56) Yrs: 20.0 (7.2)	≥6.7 h/w exercise	AN: 54% BN: 39% EDNOS: 46% AN=BN= EDNOS
Penas-Lledo et al. (2002) (117)	AN (63) Yrs: 18.8 (5.9) BN (61) Yrs: 20.1 (3.3)	≥ 5 x1 h/w with aim to burn calories	AN:46% BN:46% AN = BN
Holtkamp et al. (2004) (118)	AN (30) Yrs: 14.6 (1.0)	>6 h/w, exercise deprivation and exercise despite physical pain	57%
Abraham et al. (2006) (119)	AN, BN, EDNOS (212) Yrs range: 16-40	Irritation if exercise is interrupted, exercise despite injury, and regulation of body weight and shape are the motives	17%
Shroff et al.(2006) (120)	AN, BN, EDNOS (1857) Yrs: 26.3 (7.7)	>3 h/d exercise, behavior interfere with important activities, exercise deprivation, exercise at inappropriate times and places and little or no attempt to suppress the behavior; and/or exercising despite serious injury or complications.	AN: 44% BN: 21% EDNOS: 21% AN > BN = EDNOS

N/A: not available. AN: anorexia nervosa. BN: bulimia nervosa. EDNOS: eating disorders not otherwise specified. h/w: hours per week.

Exercise dependence has been suggested as maladaptive patterns of leisure time physical activity which lead to uncontrollable excessive exercise behavior with physiological and psychological symptoms (121). Diagnostic criteria for exercise dependence have been suggested based on the DSM-IV criteria for

substance dependence (1;121) (Box 4), but these criteria are not yet accepted as a diagnosis. The physiological symptoms are especially tolerance (i.e. need for continuously higher amounts of exercise) and withdrawal (i.e. physiological reactions to exercise deprivation), whereas the psychological symptoms include interference with social and occupational functioning, lack of control, continuance and intention effect (122).

Exercise dependence is manifested by three or more of the following:

1. Tolerance: need for increased amounts of exercise to achieve desired effect; diminished effect with continued use of same amount of exercise.
2. Withdrawal: characteristic withdrawal symptoms for exercise (e.g., anxiety, fatigue) or exercise is taken to relieve or avoid symptoms.
3. Intention effect: exercise is often taken in larger amounts or over a longer period than was intended.
4. Lack of control: a persistent desire or unsuccessful effort to cut down or control exercise.
5. Time: a great deal of time is spent in activities necessary to obtain exercise.
6. Reduction in other activities: social, occupational, or recreational activities are given up or reduced because of exercise.
7. Continuance: exercise is continued despite knowledge of having a persisting/recurriing physical or psychological problem that is likely to have been caused or exacerbated by the exercise (e.g., continued running despite injury).

Box 4: Proposed diagnostic criteria for exercise dependence (121;123). The criteria are based on the DSM-IV criteria for substance dependence (1).

Two separate forms of exercise dependence have been suggested – primary exercise dependence is seen in individuals without an eating disorder, and secondary exercise dependence co-occurs with eating disorders (80;124). It is, however, discussed whether the primary form of exercise dependence actually exists, and if it reflects a more harmonious passion for physical activity than the dependence observed combined with eating disorders (125-128).

Individuals with eating disorders who are exercising excessively and/or showing symptoms of exercise dependence, have more severe eating disorder psychopathology, and higher frequency of injuries, anxiety and depression compared to non-excessive exercisers (81;113;123;126;129). Efforts have therefore been made to manage this issue along with the eating disorder; supervised exercise, motivational interviewing, psycho-education and cognitive behavioral therapy have been reported as possible strategies (130-134). However, as of today there is no consensus on how excessive exercising and/or exercise dependence in eating disorders should be managed.

Physical activity as a part of treatment for eating disorders

Although the hazards of physical activity in eating disorders have received most clinical and scientific attention, a few studies have examined the effect of physical activity in treatment of eating disorders. Most documentation exists for the binge eating disorder, where patients who received physical activity had greater reduction in body weight and number of binge eating episodes, and improvement in life quality compared to patients who did not receive physical activity as part of treatment (135-137). In BN, positive effects have been found for enhancement of body composition, physical fitness and eating disorder psychopathology, and for reduction of frequency of binge eating episodes (138). Physical activity as part of treatment for AN has potential effects on body composition during the weight gain and refeeding period, bone turnover, physical fitness, and quality of life (139-144). Unfortunately, most of the studies have not been specific about type, duration and intensity of the physical activity. It is therefore difficult to make recommendations for the use of physical activity in treatment of eating disorders based on existing publications.

Low BMD is a well-known feature in both AN and BN (101;145-147). A few studies have found associations between physical activity and BMD among

individuals with eating disorders (148-151), whereas others found no associations (149;152-154). One possible explanation for this inconsistency is that physical activity has been assessed in terms of energy expenditure, and as previously mentioned this does not necessarily influence the bone mass and structure (65). Sundgot-Borgen et al. (101) found a positive association between general weight bearing physical activity and BMD in patients with BN, but not in AN. Unfortunately, they did not distinguish between weight bearing physical activity of medium and high mechanical impact.

1.2.5 Assessment of physical activity

The assessment methods for physical activity vary from simple and cost beneficial self-report instruments to advanced methods of objective monitoring. The gold standard is doubly labeled water, which provides data on energy expenditure (155;156). The use of accelerometers, i.e. motion sensors registering movement biaxial or triaxial, has increased in recent years. Most commonly used is still self report through standardized questionnaires such as International Physical Activity Questionnaire (157-159).

1.3 Affect regulation

Affects are defined as a set of bodily based reactions that evolve to respond to life events and to motivate and guide behavior (160;161). Affects are the more acute responses to an environmental event, outer stimuli, or to the memory, while mood is a more chronic long lasting affective style or temperament (162;163). In this dissertation, affect regulation can apply to specific affect responses, or to regulation of mood in general.

There is discussion whether affects are distinct or if they occur on a continuum of positive and negative affect (164;165). Despite this discussion, Fox and Power (166) claim that there is agreement for the concept of a set of basic affects. These are fear, disgust, anger, sadness and happiness, also referred to as sad, mad, glad, and scared (163;165). Others have suggested a model with nine different affects, where two are positive (joy and excitement), one neutral (surprise) and six are negative (anger, disgust, distress, fear, dissmell (i.e. the reaction to a bad smell) and shame) (167).

Affect regulation refers to the process of increasing positive affects and decreasing negative affects (168). The regulation includes influence of the intensity and/or the duration of the affect. Primarily, suppression of negative affects has been the focus in research, but activation of positive affects has also received attention (162;163;169;170). Most research performed on affect regulation concerns the regulation mechanisms themselves, adaptation of the regulation to everyday life, and the relationship between the regulation and physical/mental health (168). Different concepts and models have been suggested for the strategies of affect regulation. Four categories (171), including management of the affects, modification of the meaning of the problem, problem-directed activation and affiliation, and six categories (172) (active mood management, seeking pleasurable activities, passive mood management, social support, direct tension reduction and withdrawal/avoidance) has been proposed.

The term “negative affect regulation” can be used in the meaning of regulation negative affects, but also as an expression of maladaptive affect regulation strategies (168;173). Some affect regulation strategies are solely negative, such as self-injurious behavior, binge eating and drug abuse. Others can be preferable to a certain extent, and maladaptive in excessive amounts. Physical activity is an example of the latter.

1.3.1 Eating disorders and affect regulation

Eating disorders have been viewed as maladaptive efforts to regulate affects. Shame, pride, anger and disgust have been viewed as important affects which contribute in the development and maintenance of eating disorders (166;174;175). It is mainly suppression and avoidance of emotions that seem important, and this can be done through bingeing, purging and/or starvation (176). The use of physical activity and exercise as an affect regulation strategy among patients with eating disorders is poorly described and understood (177).

1.3.2 Physical activity and affect regulation

Physical activity can be used both to activate positive affects and well-being, and suppress negative emotions. Studies have shown that physical activity improves affects in clinical populations with depression and anxiety (69;178), and physical activity also leads to enhanced quality of life in a variety of non-psychiatric diseases (69). The effects of physical activity in activation of positive affects and mood are also demonstrable for non-clinical populations (179;180).

Hypotheses regarding the mechanisms of physical activity as an affect regulator include biochemical, physiological and psychological hypotheses (Box 5). However, the complexity and possible associations between the various proposed mechanisms are yet to be explored (180).

Biochemical mechanisms	• Endorphin hypothesis • Monoamin hypothesis
Physiological mechanisms	• Thermogenic hypothesis • Activation of neural pathways
Psychological mechanisms	• Distraction • Cognitive restructuring (i.e. change in interpretation of bodily symptoms) • Self efficacy • Social interaction

Box 5: Proposed mechanisms for the relationship between physical activity and mental health (181).

Despite the psychological benefits of physical activity, it may worsen the mood when performed with vigorous intensity and in excessive amounts (182;183). Ekkekakis et al.(184) reported that moderate intensity physical activity was linked to pleasure, whereas vigorous intensity physical activity was associated with displeasure in studies with healthy adults and athletes. It also seemed important whether the intensity of the physical activity was self-selected or imposed. A theory of a causal chain between the intensity of the physical activity, the affective response and adherence to the activity was therefore proposed (185). A recent case report showed that vigorous physical activity was used as a self-injurious behavior to numb the negative affects in a female elite athlete (186).

2 AIMS OF THE DISSERTATION

The overall aim of this dissertation was to examine different aspects of physical activity among inpatients with longstanding eating disorders.

The specific aims were:

1. To examine (i) self reported versus objectively assessed physical activity, and (ii) reasons for exercise in patients with longstanding eating disorders and non-clinical controls (Paper I).

2. To examine (i) exercise dependence score, and (ii) associations between exercise dependence score, amount of physical activity and eating disorder psychopathology in patients with longstanding eating disorders and non-clinical controls (Paper II).

3. To examine (i) physical fitness and bone mineral density, and (ii) associated and explanatory factors for bone mineral density in patients with longstanding eating disorders and non-clinical controls (Paper III).

4. To (i) describe changes in physical activity and exercise dependence, and (ii) explore associations between changes in physical activity, reasons for exercise, exercise dependence score and eating disorder psychopathology during treatment of excessive and non-excessive exercising patients with longstanding eating disorders (Paper IV).

3 METHODS

3.1 Design and participants

This study was designed as a two-phase study (Figure 1). In phase I, inpatients with eating disorders hospitalized at the Department of Eating Disorders at Modum Bad Psychiatric Center and non-clinical age- and gender matched controls were invited to participate. Phase I also constituted the base line data for phase II. In phase II of the study, we followed the patients from admission to discharge. Papers I to III are based on data from phase I, and data from phase I and II are reported in Paper IV.

The study was approved by the Regional Committee for Medical and Health Research Ethics in Southern Norway, and by the Norwegian Social Science Data Services. All patients and controls received written information about the study, and then gave written consent to participation. For the patients, it was thoroughly explained that their decision of whether to participate or not would not influence the treatment.

3.1.1 Phase I

Sixty-five consecutive patients with admission dates between January 2006 and July 2007 were invited to participate. Inclusion criterion for the patient group was hospitalization at the Department of Eating Disorders, Modum Bad Psychiatric Centre in Vikersund, Norway. Admission criteria for treatment at this department are age ≥18 years, BMI ≥14.5 kg/m^2, meeting the DSM-IV criteria for AN, BN or EDNOS (1) and previous treatment failure. Of the 65 patients invited, 59 agreed to participate in this study. The treatment

program and the facilities at Modum Bad make it difficult to properly take care of patients with serious medical complications and/or serious risk of suicide. Therefore such patients do not receive treatment at this hospital. Only females were referred to this treatment department during the data collection, hence no males were available for participation in this study. Patients came from all parts of Norway and were aged 18-54 years at the time of admission. The hospitalization duration at Modum Bad varied from three to 26 weeks (mean and SD for the sample are shown in Table 5).

A non-clinical age- and gender-matched control group was randomly selected from subset of a base of Norwegian females originally contacted for a study by Torstveit and Sundgot-Borgen (64;187). A bureau of statistics (Ergo group) performed a random selection of subjects (n=900) from the total Norwegian female population aged 13-39 yrs in 2001. The subjects were representative of the total population in terms of age and geographical distribution, and all counties in Norway were represented. In autumn 2007, we made a random selection of 65 females who were re-contacted for our study (age range at selection time in 2007 was 19-46 yrs). Inclusion criteria were age matching the patients at group level, and sufficient Norwegian language skills to understand the information and instructions given in the data collection procedure. To ensure proper age matching, the females in the control group were selected after recruiting patients was completed. We divided the patients and controls into age groups 18-30 years, 31-40 years, and >40 years, and picked females for the control group according to the number of patients in each age group. The females were contacted by regular mail, and we were allowed to send two reminders to non-responders. Of the 65 females contacted, 56 agreed to participate. An exclusion criterion for the control group was presence of an eating disorder according to the DSM-IV criteria. A highly trained and experienced psychologist performed the structured clinical interview Eating Disorders Examination (EDE, further described in 3.3.6) to

detect possible eating disorders among the controls. This screening excluded three females due to current eating disorder (BN=1, EDNOS=2). The control group therefore consisted of 53 females (Figure 2). Compared to the total Norwegian female population aged 20-44 years (188), a higher number of the females in the control group were unmarried (n=35, 66% compared to 54%) and had education at university/college level (n=31, 58% compared to 39%).

For both patients and controls, exclusion criteria for the physical fitness tests were in accordance with recommendations from the American College of Sports Medicine (189). For further details, see Figure 2.

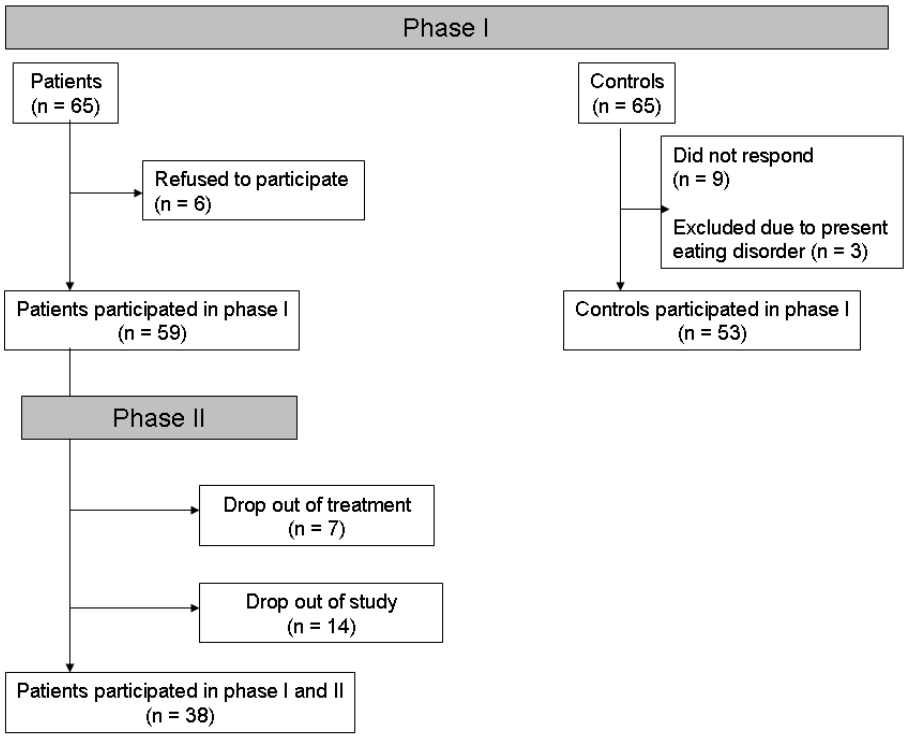

Figure 2: Flow chart of the study.

3.1.2 Phase II

This part of the study was designed as an exploratory and naturalistic follow-up study following the patients from admission to discharge in their treatment. The data collected in phase I, at admission, served as baseline data for phase II.

3.1.3 Description of the general treatment model

Eating disorders were conceptualized as inappropriate coping mechanisms to regulate emotions and affects. The treatment was multi-component with cognitive behavioral therapy as one of the concepts, and the main aims of the treatment were to reduce symptoms and severity of the eating disorders, normalize eating behavior through a minimum of four meals per day and work with the emotional difficulties (190;191). Components of the treatment were individual and group psychotherapy, psycho-education, expression therapy and physical activity sessions. Need for medication was evaluated individually. Patients with AN and sub-threshold AN (classified in the DSM-IV as EDNOS) attended the treatment for approximately 20 weeks, and the patients with BN and sub-threshold BN attended the treatment program for about 12 weeks. All patients signed a treatment contract, where they committed to participate in the treatment program, consume the prescribed amount of energy and fluid, remain abstinent from drugs and medication not prescribed from the treatment staff, and refrain from use of laxatives, diuretics, purging or other weight compensatory behaviors.

3.1.4 Description of the physical activity component of the treatment

Two weekly 60-minute group sessions with physical activity were an obligatory part of the treatment for all patients. As a general rule, patients with poor medical status (i.e. electrolyte imbalance and dehydration) and

injuries which made participation in physical activities impossible did not attend this part of treatment. No patient in our study was in a somatic or medical state that led to exclusion from the physical activity sessions. The intensity of the physical activity was mainly light to moderate, and types of activities varied from ball games (i.e. volleyball and soccer), walking and Nordic walking, strength exercises and horseback riding. The sessions were led by an experienced sports physiologist, and milieu staff was also present at these sessions. In addition, all patients attended one psycho-education lecture of 75 minutes about physical activity, led by the same sports physiologist.

3.2 Procedure of data collection

We conducted a pilot study with seven patients. In this pilot study, the assessment methods were tested, and we used the Åstrand ergometer test to assess aerobic fitness. We then discovered that the patients struggled to reach a heart rate of 120, and therefore the equation used to estimate maximum oxygen uptake gave the patients artificially high aerobic fitness. Therefore, we chose to use a maximal test instead of a sub-maximal aerobic fitness test. None of the other assessment methods were changed after the pilot study.

In phase I patient data were obtained within the first four weeks of admission. Data on physical activity, exercise dependence, reasons for exercise and eating disorder psychopathology were collected within the first two weeks of admission, and the physical fitness tests, body composition and bone mineral density measurements were obtained within the first four weeks. For the controls, all assessments were obtained within four weeks after responding to the questionnaire for each participant.

In phase II all assessments were repeated within two weeks before discharge. Objective and self reported physical activity were also obtained mid-way through treatment; therefore these data were collected three times for the patients.

3.2.1 Exclusions and drop outs

In phase I, all patients and controls completed the questionnaire with Exercise Dependence Scale, Reasons for Exercise Inventory and current and previous physical activity level. However, ten subjects (patients=9, controls=1) had incomplete Reasons for Exercise Inventory response, and 15 subjects (patients=13, controls=2) had incomplete Exercise Dependence Scale response and were therefore not included in analyses involving these instruments. No exclusion criteria were provided for the physical activity assessment. A total of 12 patients and 9 controls had either not enough days with accelerometer registrations, did not wear the accelerometer at all, or there were instrument malfunctions. Therefore 47 patients and 44 controls showed satisfactory accelerometer registrations in phase 1 (Paper I – III) (Table 4).

A total of 15 patients and 20 controls were not included in the analyses with physical fitness data due to various reasons. These reasons included withdrawal from the tests, not terminated $VO_{2\ max}$, or exclusion from tests due to somatic status. The latter included heart arrhythmia (n=1 patient), injuries (n=7 patients and 3 controls), and flu and/or cold which would have influenced the test results (n=1 patient and 5 controls). In addition, pregnancy (n=1 patient and 1 control) was an exclusion criterion for both the physical fitness tests and the DXA scanning (Table 4).

Drop out analysis showed no differences in age, BMI, eating disorder psychopathology or self reported physical activity between the patients and

controls with missing objectively monitored physical activity data, or missing data from the physical fitness tests and DXA scanning in phase I.

Table 4: Numbers of patients and controls with missing data.

MISSING DATA	PHASE I		PHASE II
	Patients (n=59)	Controls (n=53)	Patients (n=38)
PHYSICAL ACTIVITY [a]			
•Failure to achieve five registration days	7	2	2
• Did not wear the accelerometer	2	5	1
• Instrument malfunction	3	2	0
PHYSICAL FITNESS			
• Withdrawal from tests	4	8	1
•Excluded due to			
– Somatic illness/injury	9	8	9
– Pregnancy	1	1	1
• Not terminated VO2 max	1	3	1
DXA			
• Withdrawal from tests	4	19	1
• Excluded due to pregnancy	1	1	1

[a] Physical activity was obtained two times in phase II of the study (mid-way through treatment and at discharge). DXA: dual x-ray absorptiometry.

In phase II, seven patients dropped out of treatment and 14 withdrew from the study from admission to discharge. Thus, 38 of the initial 59 patients completed the study (Paper IV). Among these, eight patients had missing data from the accelerometer assessment (instrument malfunction = 3, did not wear the accelerometer = 3, and failure to achieve five days with valid recordings = 2, see Table 4). The drop out analyses showed lower mean global Eating Disorders Examination score, lower perceived importance of weight/appearance and health/fitness as reasons for exercise, and lower Exercise Dependence Scale score among drop outs compared to completers in

the patient group. No difference among the drop outs and the completers were found in age, BMI or weekly amount of physical activity assessed at admission (data from phase I).

3.3 Instruments

3.3.1 Amount of physical activity

Classification based on intensity: Objective assessment

The accelerometer MTI ActiGraph (MTI model 7164; Manufacturing Technology Inc., Fort Walton Beach, FL, USA) was worn for seven consecutive days. This instrument has been validated against doubly labeled water and indirect calorimetry (156;192;193). The ActiGraph was worn on the right hip near the spina iliaca anterior superior, and participants were told to wear it for all waking hours except when swimming and showering. The epoch length was set to 60 seconds. The accelerometers were regularly calibrated against a standard movement. The SAS based software program CSA analyzer (csa.svenssonsport.dk) was used to analyze data from the accelerometers. Night activity (12-6 am) and sequences of >10 min of consecutive zero counts, indicating that the accelerometer was not in use, were excluded from the recordings. This procedure has previously been described (194). Data were included in analyses when the participant had accumulated at least 8 hours of activity per day for at least five days. To estimate the intensity of the physical activity, the MET was used. In this study, data on moderate and vigorous physical activity were included in the analyses. Moderate-to-vigorous physical activity was calculated using definitions by Ainsworth et al. (62), and Actigraph cut off scores were obtained from Freedson et al. (193). The main physical activity variable in Paper I was minutes per week ($min \cdot w^{-1}$) of moderate-to-vigorous physical activity (MVPA). In the other papers, the

accelerometer assessed variables are mean ActiGraph counts (counts·min) (Paper III and IV), and vigorous physical activity (min·w^{-1}) (Paper II).

Classification based on intensity: Self report (Paper I)

During the same seven days when using the Actigraph, the participants completed a diary for physical activities with duration >10 min per session with moderate-to-vigorous intensity. The participants recorded a) type, b) frequency, c) duration and d) intensity of the physical activities. The types of physical activities reported were walking, Nordic walking, jogging/running, cycling (including both indoor and outdoor cycling), resistance training, aerobics (including aerobics, dancing and step aerobics), horseback riding, cross country skiing and ball games (including basketball, soccer, handball and volleyball). The duration was reported in minutes per session, and intensity was rated using Borg's rating of perceived exertion (RPE) scale (195). This is a one-item scale ranging from 6 (no exertion) to 20 (maximum exertion). This scale has been found valid in healthy females (196). The self-reported MVPA (min·w^{-1}) was calculated by adding the total of reported minutes/week of all physical activity sessions rated ≥12 on Borg's RPE.

In addition, participants were asked if they considered themselves as physically active, if they had previously participated in competitive sports, and their highest level of competition. Level of competition was divided into recreational level (e.g. participation in matches and/or championships at regional level in Norway), and elite level (e.g. participation in matches at a national and/or international level, and/or participation in national and/or international championships).

Classification based on mechanical impact (Paper III)

The respondents were asked about childhood and adolescence (i.e. < 18 yrs, hereafter referred to as previous) as well as current participation in physical

activity. The information included type of activity, number of years of previous participation and minutes per week of current participation. The types of activity were classified into non-weight bearing physical activity (e.g. swimming and cycling) and weight-bearing physical activity. The weight bearing physical activity were further divided into medium (e.g. walking, running), and high impact (e.g. resistance training, dance aerobics and ball games such as soccer and handball) based on the degree of mechanical loading of the activity. Medium impact refers to physical activities with elements of sprinting and turning actions. High impact physical activity includes activities where jumping and/or rapid movements are widespread. This classification has been used previously (63;64), and was done prior to data analysis. Previous high impact physical activity was calculated as the number of years during childhood and/or adolescence with reported participation in high impact physical activity. Current low, medium and high impact physical activity refers to the total minutes per week with reported participation in the different types of physical activity. Weight bearing physical activity was the sum of minutes per week with medium and high impact physical activity.

Classification of excessive exercise (paper IV)

According to the classification suggested by Davis et al. (112), patients were defined as excessive exercisers if they met the following three criteria: ≥6 hours per week of ActiGraph-assessed MVPA upon admission, reported persistence of this amount for ≥1 month before admission, and classification as exercise dependent symptomatic. As mentioned earlier, this classification was chosen because it was the most comprehensive as it takes amount, compulsiveness and persistence of the behavior into consideration.

3.3.2 Reasons for exercise

Reasons for Exercise Inventory (REI) is a 25-item questionnaire assessing reasons for exercise (197). It has been found valid for females from the general population (105). The different reasons for exercise were rated on a 1 (not important) to 7 (extremely important) Likert scale. Items were classified into four different categories as specified by Cash et al. (105). Cronbach's alpha was considered good for all four categories among both patients and controls: Weight/appearance (α = 0.93 in patients, 0.94 in controls), Fitness/health (α = 0.89 in patients, 0.84 in controls), Mood regulation (α = 0.70 in patients, 0.78 in controls) and Socializing (α = 0.64 in patients, 0.71 in controls). As it was interesting to examine possible differences between the patients and the controls regarding importance of exercise in the regulation of negative and positive affects, we performed a factor analysis for the four items covering mood regulation in the patients. Two factors with Eigenvalue >1 emerged, the first factor explained 54.2%, and the second factor 31.2% of the variance in the patients. The two items I exercise to cope with sadness, depression and I exercise to cope with stress and anxiety loaded exclusively on the first factor. This subscale was called Negative affect regulation (α = 0.90 in both patients and controls). The two remaining items I exercise to have fun and I exercise to increase mood loaded exclusively in the second factor. These were merged into a subscale called Positive affect regulation (α = 0.63 in patients and 0.69 in controls). Hence, the mood regulation category was replaced by the two categories Negative and Positive affect regulation.

3.3.3 Exercise dependence

To examine level of exercise dependence, the Exercise Dependence Scale – Revised (EDS-R) (198;199) was used (α = 0.97 in both patients and controls). This scale is developed on the basis of proposed criteria for exercise dependence (121;123), and consists of the subscales tolerance, withdrawal,

intention effect, lack of control, time, reduction in other activities, and continuance. For further details on the EDS-R, see Symons Downs et al. (199)

3.3.4 Physical fitness

Aerobic fitness

Aerobic fitness, expressed as $VO_{2\,max}$, was measured using a Bruce protocol (200) on a treadmill (Woodway ELG 2, Woodway, Germany). The participants had a five-minute warm up with walking at light to moderate intensity; this warm up was also used to make participants adjust to the equipment. The Jäger Oxycon Champion spirometric analyzer (Erich Jäger GmBH & co, Würzburg, Germany) and the software program Vmax 29 (SensorMedics, USA) were used to measure oxygen consumption (VO_2), ventilation (V_E) and respiratory exchange ratio (RER). These instruments were calibrated before each bout of test was performed. Heart rate was monitored by Polar RS100 (Polar Electro Oy, Kempele Finland). Participants rated the intensity of the work load using Borg's rating of perceived exertion (RPE) scale. (195) Two experienced test leaders carried out the tests. VO_{2max} was terminated when 1) the VO_2 measures leveled off and participants were unable to maintain work load, 2) RER >1.05, 3) heart rate >90% of age predicted maximum (220 beats/minute minus age), and 4) Borg's RPE ≥18. $VO_{2\,max}$ was expressed as $ml \cdot kg^{-1} \cdot min^{-1}$.

Muscular strength

One repetition maximum (1RM) was tested in the following order and apparatus (Technogym, Italy): Lower body (leg press) and upper body (seated chest press). Correct technique for leg press was a) 90^{o} in the knee, and b) heels, back and glutea in touch with surface. Correct chest press technique was a) back and glutea against seat, and b) straight arms. Four experienced test leaders were carefully instructed about the standardized procedures. All

participants performed the 1RM tests after the $VO_{2\ max}$ testing with a 15 – 20 minutes break in between. The 1RM testing procedure was in accordance with previous descriptions(201): 10 x 50% of estimated 1RM, 1-minute break, 5 x 75% of estimated 1RM, 1-minute break and then 1RM tries with 3-minutes breaks between each try. No participants needed more than four tries at 1RM. The terminated 1RM was the weight (kg) of the last approved repetition with correct technique and performance. The 1RM was divided by the body weight, and was therefore expressed as 1RM/BW.

3.3.5 Body composition and bone mineral density (BMD)

Body composition and BMD (g/cm^2) was measured using dual-energy x-ray absorptiometry (DXA) (Prodigy, GE Lunar, Chalfont St. Giles, UK). The same operator performed all scanning and analyses, and participants were instructed not to eat or drink later than two hours before the test. BMD measurement areas were lumbar spine (L2 – L4), femur neck and total body. Reliability tests have previously shown a variance coefficiency from 0.57 to 1.08% depending on the measurement site (64). Body composition assessments reported are total body weight (kg), lean body mass (kg) and body fat (%).

3.3.6 Eating disorder psychopathology

DSM-IV diagnoses were generated from the Eating Disorders Examination Interview version 12.0 (EDE), The EDE was used to assess severity of eating disorder symptoms (202), and consists of the subscales Restraint (EDE-R), Weight concern (EDE-WC), Shape concern (EDE-SC) and Eating concern (EDE-EC). The EDE interviews were conducted by psychologists and psychiatrists trained in the use of the instrument. Cronbach's α for the global EDE was 0.82 in patients and 0.91 in controls.

Respondents also completed the Eating Disorders Inventory – 2 (EDI-2) (54). This is a widely used self report measure for ED symptoms, and it consists of 11 subscales: Drive for thinness, Body dissatisfaction, Bulimia, Perfectionism, Interpersonal distrust, Fear of maturity, Ineffectiveness, Interoceptive awareness, Asceticism, Impulse regulation and Social insecurity. The global EDI-2 had high internal consistency in both patients and controls ($\alpha = 0.94$ and 0.90, respectively), and it has been validated for both patients with eating disorders and normal controls (55;203).

In addition, a structured interview upon admission revealed information about history of AN, self-injurious behavior, and number of previous treatment periods.

3.4 Statistics

SPSS version 15.0 was used for the statistical analyses. Sample size estimations based upon findings from other studies showed that with a power of 0.80 and an alpha level of 0.05, we needed 50 patients and 50 controls to detect statistically significant differences in minutes per week of moderate-to-vigorous physical activity, which was our main outcome measure. The data were reported as mean (SD) in all papers, exceptions were low, medium and high impact physical activity reported in Paper III. These data were analyzed with the non-parametric tests Kruskall-Wallis and Spearman's correlation. Due to positive skewness of the self reported and objectively assessed moderate-to-vigorous and vigorous physical activity, these data were log transformed and presented as geometric mean with 95% confidence intervals (Papers I and II). To examine differences between patients and controls, chi square and independent sample t test were used. ANOVA with Bonferroni

post hoc test and Kruskall-Wallis were used to compare patients across the different eating disorder diagnoses to controls. Correlations were obtained by Pearson's r in Papers II and IV, and with Spearman's rho in Paper III.

In Paper I, a Bland-Altman plot was constructed for the comparison of self-reported and objectively assessed MVPA. This is a preferred technique for estimating clinically acceptable levels of agreement between different methods used to assess the same variable in the same participants (204). The plot provides information about the difference between self-reported and objectively assessed MVPA for each participant, compared to their mean. In addition, intraclass correlation coefficients, ICC (1,1), were calculated to analyze the consistency of the self-reported and objectively assessed MVPA (205).

In Paper II, a backward multiple regression analysis was performed with exercise dependence score as the dependent variable. Selection of the independent variables was based on the correlation analysis. Independent variables were exercise for weight/appearance, exercise for negative affect regulation, global EDE score, exercise for positive affect regulation (controls only), and duration of illness (patients only).

In Paper III, BMD values were adjusted for body weight and lean body mass using univariate analysis of variance. A stepwise multiple regression analysis was used to examine explanatory factors for the total body BMD in the patients. The independent variables (history of AN, total body muscular strength and total body weight) were chosen on the basis of previous studies and the correlation analysis.

In Paper IV, comparisons between assessments at admission and discharge were performed by paired samples t test. Changes in amount of physical

activity (counts·min), total exercise dependence score, EDE global and subscales scores and EDI total and subscales scores were analyzed by general linear model repeated measures ANOVA, where excessive or non-excessive exercisers were used as a between-subject factor. Interaction effects of length of treatment (weeks) were analyzed using this as a covariate.

4 MAIN RESULTS

4.1 Description of the sample

In Papers I-III, 59 patients and 53 controls were included. The sample in Paper IV consists of the 38 patients who completed the two study phases (Table 5).

Table 5: Descriptive data for the sample.

	AN	BN	EDNOS	Patients	Controls
Paper I-III	(n=8)	(n=29)	(n=22)	(n=59)	(n=53)
Age, yrs	27.6 (9.9)	30.7 (7.3)	30.3 (8.8)	30.1 (8.5)	31.3 (8.3)
BMI, kg/m^2	15.6 (1.4) [a]	22.3 (3.5)	21.0 (3.2)	20.9 (3.8)	25.3 (4.8) [b]
ED duration, yrs	12.2 (11.5)	16.6 (8.2)	11.9 (6.3)	14.3 (8.0)	-
Paper IV	(n=4)	(n=17)	(n=17)	(n=38)	-
Excessive exercise, n (%)	2 (50)	1 (6)	8 (47)	11 (29)	-
Length of treatment, weeks	23.8 (1.3)[c]	13.8 (4.2)	16.1 (5.4)	15.6 (55)	-

AN: anorexia nervosa. BN: bulimia nervosa. EDNOS: eating disorders not otherwise specified. BMI: body mass index. [a]AN differ from BN, EDNOS and controls ($p<0.001$). [b]Controls differ from patients ($p<0.001$). [c] AN differ from BN ($p<0.001$) and EDNOS ($p<0,05$).

The frequency of patients and controls who met the Norwegian recommendations for physical activity (n=43 patients and 30 controls) was comparable to those who met the recommendations by Haskell et al. (68) (n=45 patients and 32 controls). A higher percentage of patients than controls met the recommendations for weekly physical activity, and reported previous participation in competitive sports (Figure 3). All patients classified as excessive exercisers in Paper IV had either a current or a history with AN

diagnosis, whereas 16 (64%) of the non-excessive exercisers were currently or previously diagnosed with AN ($p<0.05$).

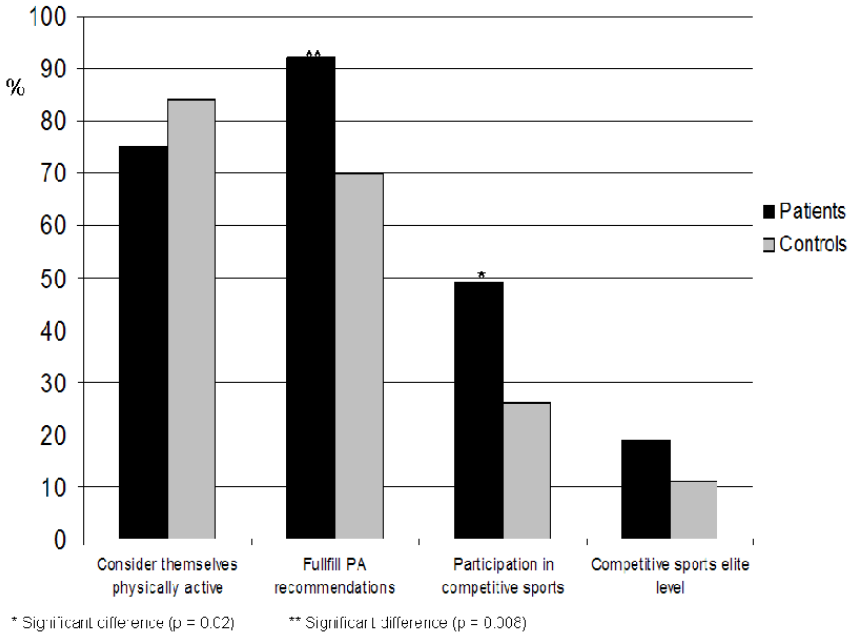

Figure 3: The graph shows percentage of patients and controls who a) reported that they considered themselves as physically active, b) met the recommendations for weekly physical activity (68) according to the objective assessment, c) reported previous participation in competitive sports in general, and d) reported previous participation in competitive sports at elite level.

4.2 Paper I

Patients across the different eating disorders had higher mean physical activity (counts·min), and more self-reported and objectively assessed MVPA ($min \cdot w^{-1}$), compared to the controls. Regulation of negative affects was considered a more important reason for exercise, and health/fitness a less important reason, among patients compared to controls. No differences

occurred in weekly physical activity, or perceived importance of different reasons for exercise, when comparing patients across the different eating disorder diagnoses. The Bland-Altman plot showed a underreporting of weekly MVPA in the patients; no such difference was found among controls.

4.3 Paper II

Total and subscales exercise dependence scores were higher among patients than controls. In the patients, weekly amount of vigorous PA was positively correlated with exercise dependence score, EDI body dissatisfaction and EDE weight concern. Vigorous physical activity was negatively correlated with age and global EDE score, and positively correlated with exercise for positive affect regulation among controls. Exercise dependence score was positively correlated with vigorous, not moderate, physical activity and exercise for negative affect regulation in both patients and controls. Correlations between exercise dependence score and EDE/EDI scores were found in patients, not in controls. A regression analysis found vigorous physical activity ($min \cdot w^{-1}$) and perceived importance of exercise for negative affect regulation to explain 78% and 54% of the variance in exercise dependence score for the patients and the controls, respectively.

4.4 Paper III

Aerobic fitness ($ml \cdot kg^{-1} \cdot min^{-1}$) did not differ among patients with different eating disorder diagnoses or controls. Patients with AN had lower muscular strength (1RM/BW) and BMD (g/cm^2) compared to BN, EDNOS and controls. No difference in fitness or BMD was found among BN, EDNOS and controls.

In the patients, total body BMD was positively associated with history of AN, body weight, muscular strength and high impact physical activity (min·w^{-1}), not weight-bearing physical activity in general or accelerometer assessed physical activity (counts·min). In a regression analysis, history of AN and muscular strength contributed significantly to explain the total body BMD.

4.5 Paper IV

According to the proposed criteria, 11 (29%) of the patients were classified as excessive exercisers. A higher number of the excessive exercising than the non-excessive exercising patients had previous inpatient treatment and reported self-injurious behavior. Furthermore, these patients had lower BMI, higher EDI and EDE scores and longer current treatment period. From admission to discharge, the excessive exercising patients reduced exercise dependence score, and there was a non-significant trend in reduction of weekly physical activity. The EDE and EDI total and subscales scores were similarly reduced in excessive and non-excessive exercisers. In the excessive exercisers the reduction in EDE score was positively associated with reduction in exercise dependence score and reduction in perceived importance of exercise as a regulator of negative affects, but not as a weight regulator. These associations were not found among non-excessive exercisers.

5 DISCUSSION

5.1 Discussion of the main findings

The higher amounts of physical activity in patients compared to controls (Paper I) are consistent with previous studies (24;101;107). Compared to other studies, the prevalence of excessive exercisers among the patients was somewhat low (Paper IV). This was expected because the used criteria were stricter than in some of the previous reports. Furthermore, the longstanding eating disorders might be an explanation, as Davis et al. (112) reported higher prevalence of excessive exercisers among patients who were in a more acute phase of the disorder than among those with longer disorder duration.

5.1.1 Underreport of MVPA

The underreporting of MVPA ($min \cdot w^{-1}$) in patients with longstanding eating disorders has to our knowledge not previously been reported. This underreporting may be deliberate due to fear of mandatory increase of the energy intake, or restrictions of the physical activity, as such adjustments were made for the energy-deficit patients. On the other hand, it is possible that the patients conceptualized and had a different understanding of the term physical activity than that of the control group. An example of the latter is the patient who told the researchers that she was not physically active – she only went for walks. When asked about her walks, she told us that she walked for about one hour every day and that she was sweating and needed to take a shower when she was finished. Despite this, she did not consider the walks as neither physical activity nor exercise. This illustrates the myth about an activity not considered as physical activity unless it is performed with

certain intensity, and the underreporting may be unintentional. Nevertheless, this discrepancy shows the importance of proper screening of physical activity.

The accelerometers are removable equipment, and it is therefore possible that the patients removed the accelerometer in order to conceal sessions of physical activity. To counteract this possibility, sequences of consecutive zero counts were recorded. It is, however, possible that the discrepancy between self-reported and actually performed moderate-to-vigorous physical activity was higher than what was found in this study.

5.1.2 The importance of negative affect regulation

Although most research on physical activity as an affect regulator have focused on enhancing positive affects and well-being, our findings showed a higher perceived importance of exercising to cope with negative affects (Paper I). Additionally, the negative affect regulation effects of physical activity were perceived as more important for the patients than for the controls. This was in contrast to exercise for weight and appearance related reasons, which was perceived equally important for patients and controls (Paper I). Negative affect regulation as a reason for exercise was also perceived as more important for the excessive compared to the non-excessive exercising patients (Paper IV). This should be seen in associations with the higher frequency of self-injurious behavior reported by the excessive exercisers. Self-injurious behavior is also considered as a strategy for regulating affects, and vigorous physical activity has been reported as a self injurious strategy in a recent case report of a Norwegian athlete (186). Furthermore, it was the main explanatory variable for exercise dependence score, along with vigorous intensity physical activity $min \cdot w^{-1}$), for both patients and controls (Paper II). It is in my opinion a paradox that blocking and down-regulation of negative affects is perceived as such an important reason for exercise among the excessive exercisers, when

previous studies have shown that excessive amounts of especially vigorous physical activity may act as an activator of such affects (180;206). One speculation could be that the vigorous physical activity temporarily reduces the negative affects, but that the patients experience a rebound with those affects when the activity session is ended.

The correlation between reduced importance of exercise for negative affect regulation and reduced eating disorder psychopathology (Paper IV) may have been influenced by reduced depressive symptoms in the patients. Furthermore, it is interesting that we did not find any indications for a symptom substitution among the excessive exercisers (i.e. no increase in depression, self-injurious behavior, binge eating episodes, purging episodes etc.) when the physical activity was reduced. It must also be taken into consideration that eating disorders are conceptualized as inappropriate coping mechanisms to regulate and tolerate emotions and affects in the treatment model at Modum Bad, and therefore changes in affect regulation strategies should be expected. Furthermore, the correlations between reduced exercise dependence score, reduced eating disorder psychopathology and reduced importance of exercising for regulation of negative affects in the excessive exercisers (Paper IV) support previous findings of associations between poor eating disorders treatment outcome and persistent negative addiction to exercise (134).

In the controls, but not among patients, exercise dependence score was also correlated with perceived importance of exercising for the regulation of positive affects (Paper II). Although positive affect regulation did not turn out to be a significant explanatory variable for exercise dependence score in the regression analysis, this correlation was an interesting finding. It may therefore be seen in relation to the concept of primary and secondary exercise

dependence; the primary exercise dependence may involve a more positive or harmonious form of dependence and engagement (128).

5.1.3 Muscular strength, high impact physical activity and bone health

Although the accelerometer-assessed physical activity (counts·min) was higher among patients across the three diagnoses compared to controls, there were no significant differences in aerobic fitness ($ml \cdot kg^{-1} \cdot min^{-1}$), and only patients with AN had lower muscular strength (1RM/BW) than the controls (Paper III). The low sample size, and hence a possible type II error, might explain the lack of difference. It is also reasonable to assume that the high amounts of physical activity were accompanied by inadequate restitution because of the poor nutrition balance (33), and that this led to overtraining in the patients.

In females from the general population, weight-bearing physical activity ($min \cdot w^{-1}$) is shown as sufficient for maintenance of BMD (g/cm^2) (64;78). We did not find associations between weight-bearing physical activity in general and BMD. For the patients with BN, this finding was in contrast to Sundgot-Borgen et al. (101). However, when dividing the weight-bearing physical activity into medium- or high-impact, we found a significant positive correlation between the high-impact physical activity and the BMD. Due to the cross-sectional design, this finding must be interpreted carefully. Nevertheless, it is in accordance with studies from populations of female elite athletes (64). Weight- bearing physical activity in general may be adequate for patients with a shorter duration and/or less severity of the eating disorders than seen in our study sample. The BMD measure site which is most sensitive to physical activity stimuli is the femur neck (207), and weight-bearing physical activity during the early stages of puberty has been shown as an important predictor of lumbar spine BMD (208;209). This can explain why

current high-impact physical activity was associated with femur neck BMD, and previous high- impact physical activity was associated with BMD in the lumbar spine. High- impact physical activities such as resistance training are also important for - muscular strength, which was one of the significant explanatory variables for total body BMD. These findings may indicate that performing high-impact physical activities, such as resistance training, may counteract some of the adverse effects of eating disorders on the BMD.

Importance of previous AN

The most important explanatory variable for total body BMD was a history of AN. This was in accordance with previous studies (146;210). The consequences of AN include impaired endocrine levels and energy deficits, and these factors are important for the BMD. Even if the patient has restored the body weight, the BMD could have been influenced. It is therefore important to take previous AN into consideration when selecting patients for BMD screening. Furthermore, all excessive exercising patients had a current or previous AN diagnosis (Paper IV). This also indicates that although excessive exercise was found across the different diagnoses, the history of AN is a common denominator.

5.2 Evaluation of the method

5.2.1 Design

Choice of method and design should be based on the aim of the study and the current state of knowledge (211;212). Cross sectional design is suitable for examination of the prevalence at the given time, and for examining correlations between variables (213). The prospective naturalistic exploratory design is appropriate for observing changes over time, and changes of different variables in relations to each other. In the field of eating disorders

and physical activity, the current knowledge seems to be too limited to make appropriate models for management and treatment of excessive physical activity and exercise behavior. Previous studies of this issue have examined management of excessive physical activity with the idea that the reasons for the excessiveness are solely related to weight, shape and appearance (133;134). Our findings revealed that it is just as important to deal with excessive physical activity and exercise as an affect regulation strategy, and that this should be included in future experimental studies.

5.2.2 Reliability and validity

The assessment methods used are common and have previously been found valid for the purposes given in the four papers (106;156;196;198;200-202;214;215). The Cronbach's alpha was considered good for the REI, EDS-R, EDE, and EDI among both patients and controls. It should be noted that Cronbach's alpha values for some of the EDI and EDE subscales were extremely high (>.9). It could therefore be argued that these tests actually do not assess all the aspects that they should.

However, neither test-retest, nor inter-rater reliability for the EDE interviews was examined. All of the controls were examined by the same psychologist, who was experienced with this structured interview. The EDE in the patients was examined upon admission and just before discharge, and different therapists conducted this interview. This may have affected the ratings on some of the questions. All of the patients were clearly within one of the three eating disorders diagnoses, and this has therefore not influenced the comparisons between the patient group as a whole and the controls, or the excessive versus the non-excessive exercisers.

The cut-off values used for identifying objectively assessed and self-reported moderate-to-vigorous physical activity were chosen based on previous studies (193;195). It must be taken into consideration that use of other cut-off values might have given different results. Likewise, the criteria for excessive exercise used in Paper IV were strict when compared to previous studies (24;113;114;116-120). When selecting the criteria, it was the aim to identify all of the actual excessive exercisers, i.e. criteria with high sensitivity, and at the same time identify all true negatives (i.e. high specificity). The used criterion of persistency of the excessive behavior is one way to increase the specificity of the assessment. However, we cannot exclude the possibility that there are false positives and/or false negatives among the excessive exercisers in our sample.

External validity

The patients were selected from inpatients at the Department of Eating Disorders, Modum Bad Psychiatric Center. As Modum Bad is a specialized hospital, the patients must have tried other treatment options before applying to the programs at this hospital. This makes the sample highly selective, and the findings cannot be generalized to the eating disorders population as a whole. Neither could they be generalized to the extremely low-weight patients (i.e. patients with BMI below 14.5) because such patients do not meet the admission criteria. However, the sample includes patients with longstanding AN, BN and EDNOS, and the distribution of the different diagnoses is comparable to what is seen in other studies (12). Similar clinical pictures regarding symptom severity are commonly seen in ordinary clinical settings as well; therefore we argue that the patient sample is representative of adult females with longstanding eating disorders in general (216;217).

Of the initial 59 patients, only 38 (64%) completed the study. Seven (12%) of the dropouts were due to early discharge from treatment, and 14 (24%)

completed the treatment but withdrew from the study. The dropout rate from treatment was quite low compared to other studies (218). Moreover, the lower mean global EDE score ($p<0.05$) among dropouts compared to study completers was in accordance with findings from Björck et al. (219), who concluded that premature termination is a complex phenomenon and not necessarily solely negative. No significant differences in age, BMI and physical activity level assessed at admission were found among patients who dropped out and who completed the study. However, with the low sample size in this study, the lack of differences could be due to a type II error. The drop outs from admission to discharge showed also mean lower EDS score ($p<0.05$) compared to the completers (Paper IV). Because more non-excessive than excessive exercisers dropped out of the study, this can have affected the results. The lack of difference found in EDS score at discharge between excessive and non-excessive exercisers might therefore be considered a potential source of bias.

Nine (14%) of the females invited to the control group did not respond and hence did not participate in the study. We did not conduct a non-participant study, hence we do not know if these females differ from the ones who did participate. Compared to results from the KAN1 study (77), the female controls in this study showed higher objectively assessed weekly physical activity level, and a higher percentage met the Norwegian health authorities' recommendations for physical activity. Furthermore, there was a tendency towards differences in marital status and education level between the controls in this study and females at similar age from the general population (188). The external validity of the results from the control group might be limited.

Nine of the 53 controls had missing data from the objective physical activity assessment. Although they did not differ on the self reported physical activity, we cannot exclude that those with missing data were more likely to

overestimate their weekly amount of physical activity than the control completers. As shown in Table 4, as many as 19 controls withdrew from the DXA scanning. Eight of these also withdrew from the physical fitness testing. One reason for this can be that the testing was located to Oslo, and some subjects therefore needed to travel a long way and to take time off work or school. The aerobic capacity of the controls tends to be higher than what has been reported in other studies (220;221), although this can be seen in relation with the higher physical activity level. Nonetheless, it is possible that the fitness testing withdrawers are in poorer physical condition compared to the other.

The missing data can have affected some of the outcome variables. It is possible that the differences in amount of weekly physical activity between patients and controls would have been even larger with a control group more representative of the general population. Moreover, the lack of differences in exercise for weight/appearance can be explained by the missing data, and hence a biased control group. However, the KAN1 study showed that almost 70% of the female participants reported weight regulation as a reason for their exercise (77). This indicates that weight regulation is an important reason for exercise among females regardless of the presence or absence of an eating disorder.

Statistical validity

When comparing different assessment methods to each other, it is common to use correlation analyses (204;222). This is not appropriate, because it does not take into consideration the variation in the sample. Thus, strong correlations do not automatically imply good agreement between the methods compared (204). The use of Bland-Altman plot and description of ICC values is therefore recommended.

Sample size was calculated with MVPA (min·w^{-1}) as the main outcome variable, and estimates showed that 50 patients and 50 controls were needed to examine differences with α of 0.05 and power of 0.8. These estimates were based on previous studies, and although only 47 patients and 44 controls had valid ActiGraph recordings this was highly statistically significant ($p<0.01$, Paper I). As type of eating disorder was not taken into consideration in the sample size estimates, the lack of difference in weekly moderate-to-vigorous physical activity among patients with AN, BN and EDNOS could be due to a type II error. The number of missing data reduces the statistical power, and some of the lacking statistical differences might therefore be due to type II error. An example of the latter is that the low sample size among excessive exercisers resulted in as little as six subjects in some of the correlation analyses in Paper IV. Consequently, a correlation of -.71, .50 and .49 between reduced amount of physical activity and reduced importance of exercise for weight/appearance, reduced eating disorder psychopathology and exercise dependence score respectively was not statistically significant. Such strong correlations are still in our opinion of clinical relevance.

5.3 Ethical considerations

Both clinical and empirical experiences suggest that physical activity plays an important role for several of the patients. It is therefore important to increase knowledge about this, in order to develop preventive and treatment strategies. This is especially important considering that the patients' somatic status requires energy balance, and that maintenance of excessive amounts of physical activity will contribute to a continued energy imbalance. On the other hand, it is not ethical to restrict all types of physical activity, because of the well known somatic and mental consequences of physical inactivity.

From the pilot study, we experienced that wearing an accelerometer can in worst case trigger the patients to increase their amount of physical activity. Therefore the staff was carefully instructed on this, and they were available for the patients to talk with if needed. Four of the initial 59 patients reported emotional discomfort with wearing the accelerometer. The reasons for this were that three patients felt that the accelerometer triggered physical activity and one patient felt she was under surveillance. None of the controls reported emotional or physical discomfort with wearing the accelerometer.

Physical fitness testing of this patient group required a thorough medical examination beforehand, especially because the tests provided were physically demanding. Therefore, the patients needed approval from medical personnel to perform the test. Our exclusion criteria were stringent and according to the recommendations from the American College of Sports Medicine (189).

As preoccupation with weight and shape is a core feature in eating disorders, the assessment of body composition in general, and the body fat percentage in particular, can be challenging to the patients. On one hand, such assessments can further contribute to the preoccupation. On the other hand, it gave the therapists and the patients an opportunity to deal with these difficulties in therapy. One patient wanted to do the DXA scanning, but refused to have the body composition assessments. This was carefully instructed to the assessor, and on request from the patient she obscured the body composition results so that they became unavailable to the researchers.

5.4 Limitations

The findings in all of the papers are influenced and limited by the small sample size (Paper I-IV), and the high number of drop-outs (Paper IV). It was

too small to detect statistically significant differences in aerobic fitness ($ml \cdot kg^{-1} \cdot min^{-1}$), muscular strength (1RM/BW) and physical activity ($counts \cdot min$ and $min \cdot w^{-1}$) across the different diagnoses. We did observe surprisingly strong correlations, which in our opinion was clinically but not statistically significant, between several of the variables (Paper II-IV). The cross sectional and the exploratory design make causal conclusions inappropriate. Only stress, anxiety and discomfort were included as negative affects by the REI; use of other questionnaires could have given additional information about the feature of negative affect regulation, physical activity and eating disorders. The reported and assessed amounts of physical activity were not necessarily representative of the preadmission patterns, and the results can only be generalized to adult female patients with longstanding eating disorders.

5.5 Clinical implications

The studies in this dissertation have indicated the complexity of physical activity in patients with eating disorders. The physical activity behavior of such a patient population is very heterogeneous, and patients who are physically inactive and would benefit from increasing amount of physical activity are undergoing the same treatment program as patients who are excessively physically active. This calls for individualizing the treatment program with respect to physical activity. First, there is a need for a proper and thorough screening of different aspects of physical activity. Quantitative aspects (e.g. frequency, duration, and intensity) as well as qualitative factors such as type, compulsivity, knowledge and attitudes, should be included in the screening. The variety of motives and reasons for exercise is also important to screen, especially but only for the importance of weight and affect regulation. Such a thorough screening is useful in a psycho-educational context, and it may contribute to patients' understanding and awareness of their physical

activity behavior. Based on our findings, we recommend that amount of physical activity should be assessed through objective methods. Furthermore, we recommend that the definition of excessive exercise used in clinical settings include the amount and dependence upon the physical activity, and that this behavior has been persistent for some time.

Consistent with previous findings (131), the excessive exercising patients had a significant weight gain during the treatment period, despite the allowance to perform a certain amount of weekly moderate-to-vigorous physical activity (Paper IV). We therefore did not find support for exclusion of physical activity as a part of treatment for these patients. However, due to the complexity of physical activity behavior, we believe it is important to include staff with special competence and education in physical activity and exercise science. This is important because physical activity, as mentioned in the introduction, is not without side effects. Because patients with eating disorders also often show severe somatic complications, staff prescribing and planning physical activity for this patient group must have competence in clinical exercise physiology (223;224). Basic training principles such as progression, variation and restitution are also essential to follow when planning physical activity for this patient group. Furthermore, there is a need to relearn how to be physically active in a way beneficial to health, as many patients with eating disorders do not have this perspective.

5.6 Scientific implications and future research

The underreporting of moderate-to-vigorous physical activity (Paper I) was assessed with accelerometers only. Although the accelerometer used has been validated against both doubly labeled water and indirect calorimetry in individuals from the general population (156;192;193), future studies should

compare accelerometer with indirect calorimetry and doubly labeled water in patients with eating disorders. This is especially important for patients with AN because this patient group previously has shown altered metabolism both at rest and during moderate intensity physical activities even when adjusting for body composition (225). In addition, future studies should undertake a thorough investigation of how patients with eating disorders conceptualize and understand the meaning of the terms physical activity and exercise, and if their understanding differs from that of individuals from the general population.

Although we did not discover significant differences in aerobic fitness among patients and controls (Paper III), this was measured at a maximum level. It is possible that differences could have been detected at sub-maximal levels of aerobic fitness; future studies should therefore address this. Other aspects of physical fitness, such as muscular endurance and flexibility, need also to be examined. The findings of muscular strength as one of the significant explanatory variables for total body BMD is promising. Controlled intervention studies should therefore properly address the possible effect of muscular strength, as well as high impact physical activities such as resistance training, on BMD in patients with longstanding eating disorders.

In this dissertation, negative affect regulation as a reason for exercise was only assessed in a general setting (Paper I, II, and IV). As previous studies have found immediate effects of physical activity on mood in persons from the general population and in patients with depression (67;206), such acute effects should be examined in patients with eating disorders as well. The REI only includes questions regarding exercise to regulate the affects of discomfort, stress and anxiety. Because shame, pride, anger and disgust have been found essential in eating disorders, it is important to examine the effect of physical activity on these affects as well. It is also interesting to examine the effect of

activities with less energy requirements, but with similar affect regulating effect as the vigorous intensity activities (i.e. climbing).

Excessive exercising and exercise dependence were shown as features which must be taken seriously (Paper II and Paper IV). Further understanding of the associations between excessive exercising and self-injurious behavior, and the link between these two behaviors and affect regulation, is necessary. Also, excessive exercising should be examined in relation to other factors and predictors of poor treatment outcome prognosis. Examples of such factors are child sexual abuse and certain personality disorders. The possible harmonious dependence of exercise in the absence of eating disorders is important to examine to enhance the knowledge of the possible differences between primary and secondary exercise dependence.

The findings of the studies in this dissertation are valid for adult female inpatients with longstanding eating disorders. It is yet not known whether the same mechanisms and factors are essential for physical activity patterns and behavior among males with eating disorders. Likewise, these factors should be explored in adolescent females and males, and in individuals who are in a more acute phase of the eating disorders.

6 Conclusions

1. Self reported and objectively assessed MVPA ($min \cdot w^{-1}$) were higher among patients compared to controls. Underreporting of MVPA was found among patients, but not among controls. Patients perceived regulation of negative affects as more important, and health/fitness as less important, reasons for exercise. No difference was found in perceived importance of exercising for weight/appearance.
2. Patients had higher exercise dependence score compared to controls. In both patients and controls, vigorous intensity physical activity ($min \cdot w^{-1}$) and perceived importance of exercise for regulation of negative affects turned out to be explanatory variables for exercise dependence score.
3. Muscular strength (1RM/BW) and BMD (g/cm^2) were lower in patients with AN compared to patients with BN or EDNOS, and controls. No significant differences were found with respect to aerobic fitness. Only high impact, and not generally weight-bearing, physical activity ($min \cdot w^{-1}$) was associated with BMD. Main explanatory variables for total body BMD in the patients were a history of AN and muscular strength.
4. The change patterns of physical activity from admission to discharge differed in excessive compared to non-excessive exercisers. Significant correlations between reductions in eating disorder psychopathology, exercise dependence score, and perceived importance for exercise for negative affect regulation was found in excessive exercisers. These correlations were not present in non-excessive exercisers.

7 REFERENCES

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ERRATA

Paper IV

Paper IV was published in April 2010 in its original form. The new reference is therefore Bratland-Sanda S, Sundgot-Borgen J, Rosenvinge JH, Rø Ø, Hoffart A, Martinsen EW: *Physical activity and exercise dependence during inpatient treatment of longstanding eating disorders: an exploratory study of excessive and non-excessive exercisers.* Int J Eat Disord 2010 43:266-73

APPENDIX 1

Approval from the Regional Committee for Medical and Health Research Ethics

UNIVERSITETET I OSLO

DET MEDISINSKE FAKULTET

KOPI

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Dato: 17.01.06
Deres ref.:
Vår ref.: S-05321

S-05321 **Fysisk aktivitet i behandling av spiseforstyrrelser**

Vi viser til brev datert 09.12.05 med vedlegg: revidert informasjonsskriv og samtykkeerklæring.

Komiteen tar svar på merknader til etterretning.

Komiteen har ingen merknader til skjema for opprettelse av forskningsbiobank.

Komiteen har følgende merknad til revidert informasjonsskriv og samtykkeerklæring:

1. Pasientinformasjonen må tilpasses biobankloven jfr. §11-14 fordi forskningsbiobank opprettes. Ansvarshavende for forskningsbiobanken må oppgis samt at den som ønsker å tilbakekalle samtykket, kan kreve det biologiske materialet destruert og innsamlede helse- og personopplysninger slettet eller utlevert. Adgangen til å tilbakekalle samtykket eller kreve destruksjon, sletting eller utlevering gjelder ikke dersom opplysningene allerede har inngått i vitenskapelige arbeider, jf biobankloven § 14 tredje ledd. (Dersom prøver skal sendes til utlandet, må pasientens tillatelse til dette innhentes, og sosial- og helsedirektoratet må søkes om tillatelse til utføring av prøver). Se også Mal for hva som bør inngå i et informasjonsskriv under Forskerportalen på http://www.etikkom.no/REK/forskerportal/infoskriv

Komiteen forutsetter at merknaden tas til etterretning, og tilrår at prosjektet gjennomføres og at forskningsbiobank opprettes. Revidert informasjonsskriv sendes komiteen til orientering.

Komiteen videresender skjema for opprettelse av forskningsbiobank og informasjonsskrivet samt komiteens vedtak til Sosial- og helsedirektoratet for endelig behandling av opprettelse av forskningsbiobanken.

Vi ønsker lykke til med prosjektet!

Med vennlig hilsen

Kristian Hagestad (sign)
Fylkeslege cand.med., spes. i samf.med
Fungerende leder

Tone Haug
Rådgiver
Sekretær

Kopi: Stipendiat Solfrid Bratland-Sanda, Norges idrettshøgskole, Pb. 4014 Ullevål Stadion, 0806 Oslo

KOPI

Sosial- og helsedirektoratet

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Deres ref:
Saksbehandler: jte
Vår ref: 06/494
Arkivkode:
Dato: 20.02.2006

Melding om opprettelse av forskningsbiobank: Fysisk aktivitet i behandling av spiseforstyrrelser

Vi viser til brev av vedrørende ovennevnte. Sosial- og helsedirektoratet er delegert å vurdere meldinger om opprettelse av forskningsbiobanker i henhold til biobankloven § 4.

Direktoratet har ingen innsigelser til at forskningsbiobanken opprettes i henhold til biobankloven.

Direktoratet forutsetter at opprettelsen av den planlagte forskningsbiobanken oppfyller nødvendige krav til godkjenning, konsesjon m.v. i henhold til annet relevant regelverk, herunder bioteknologiloven, helseregisterloven og legemiddelloven.

Meldingen om forskningsbiobanken vil bli sendt til Nasjonalt folkehelseinstitutt som har fått ansvaret for å føre et offentlig tilgjengelig register over landets biobanker, jf. biobankloven § 6.

Med vennlig hilsen

Ragnhild Castberg e.f.
seniorrådgiver

Jill Terserus
rådgiver

Kopi:
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APPENDIX 2

Approval from the Norwegian Social Science Data Services

Norsk samfunnsvitenskapelig datatjeneste AS
NORWEGIAN SOCIAL SCIENCE DATA SERVICES

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Solfrid Bratland-Sanda
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Modum Bad
3370 VIKERSUND

Vår dato: 23.01.2006 Vår ref: 13860/SM Deres dato: Deres ref:

TILRÅDING AV BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 08.12.2005. All nødvendig informasjon om prosjektet forelå i sin helhet 16.01.2006. Meldingen gjelder prosjektet:

13860	*Fysisk aktivitet i behandling av spiseforstyrrelser*
Behandlingsansvarlig	*Modum Bad, ved institusjonens øverste leder*
Daglig ansvarlig	*Solfrid Bratland-Sanda*

Personvernombudet har vurdert prosjektet, og finner at behandlingen av personopplysninger vil være regulert av § 7-27 i personopplysningsforskriften. Personvernombudet tilrår at prosjektet gjennomføres.

Personvernombudets tilråding forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, eventuelle kommentarer samt personopplysningsloven/-helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/endringsskjema. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://www.nsd.uib.no/personvern/register/

Personvernombudet vil ved prosjektets avslutning, 31.08.2008 rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Vigdis Kvalheim Siv Midthassel

Kontaktperson: Siv Midthassel tlf: 55 58 83 34

Vedlegg: Prosjektvurdering

Personvernombudet for forskning, NSD

Prosjektvurdering - Kommentar

13860

Førstegangskontakt opprettes gjennom behandlende lege eller avdelingsleder på vegne av prosjektleder, jf. telefonsamtale med prosjektleder 13.01.2006. Ombudet finner informasjonsskrivet av 16.01.2006 tilfredsstillende.

Datamaterialet anonymiseres ved prosjektslutt ved at verken direkte eller indirekte personidentifiserbare opplysninger fremgår, navneliste slettes.

Prosjektslutt er satt til 31.08.2008.

Ombudet legger til grunn at prosjektet er tilrådd av Regional komité for medisinsk forskningsetikk før datainnsamling starter og ber prosjektleder ettersende kopi av tilråding når denne foreligger. Det legges videre til grunn at opprettelse av forskningsbiobank er godkjent av Sosial- og helsedirektoratet, jf. biobankloven.

PAPER I

CE ACTIVITY

"I'm Not Physically Active - I Only Go for Walks": Physical Activity in Patients with Longstanding Eating Disorders

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ABSTRACT

Objective: To examine self reported versus objectively assessed moderate-to-vigorous physical activity (MVPA), and different reasons for exercise, in patients with longstanding eating disorders (ED) when compared with controls.

Method: Inpatient females (n = 59, mean 30.1 years) and nonclinical age matched controls (n = 53, mean 31.3 years) accepted participation in this cross sectional study. Instruments included accelerometer ActiGraph, physical activity diary, Reasons for Exercise Inventory, and Eating Disorders Examination interview.

Results: Self reported and objectively assessed MVPA were higher across all ED diagnoses when compared with controls. The patients' self reported MVPA was lower than the objectively assessed MVPA; no difference was found in controls. Regulation of negative affects, not weight/appearance, was a more important, whereas fitness/health was a less important reason for exercise in patients than controls.

Discussion: The underreporting of MVPA in some patients with ED may warrant clinical attention. © 2009 by Wiley Periodicals, Inc.

Keywords: adult; female; humans; psychiatry; exercise; sports

(Int J Eat Disord 2010; 43:88–92)

Introduction

A common clinical opinion pictures patients with eating disorders (ED) as more physically active than the general population. Empirically, the findings are inconsistent.[1–4] Among the different ED diagnoses, patients with anorexia nervosa (AN) have been found more physically active when compared with bulimia nervosa (BN),[3,5] whereas information about patients with ED not otherwise specified (EDNOS) is lacking. One possible explanation for the inconsistent findings is the use of different assessment methods for physical activity. Most common is retrospective self report which is quick and inexpensive, but it provides potentially unreliable data due to recall bias and socially desirable responding.[6] Use of prospective self report instruments such as a daily physical activity diary may improve accuracy and increase validity of the data.[7] Another method is objective monitoring through, for example, accelerometers.[8,9] Females from the general population tend to overreport amount of physical activity when comparing to objective assessment.[10] To our knowledge, no previous study has compared self-reported and objectively assessed physical activity in patients with ED.

Exercise to influence weight, shape, and appearance is important for females with and without ED.[11,12] However, whether these reasons are more important in females with ED when compared with those without ED is inconsistently shown.[4,12] In addition, regulation of negative, not positive, affects has been shown as important reasons for exercise in patients with ED.[4,13] Negative affect regulation refers to exercise to cope with affects such as anxiety and sadness, whereas positive affect regulation is defined as exercise to improve mood.[14] Whether exercise to regulate affects is more important in females with ED than non-clinical controls is yet to be examined.

Most previous studies examining physical activity and reasons for exercise have examined adolescents and young adults with relatively short

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TABLE 1. Subject characteristics, objectively assessed (ActiGraph) and self reported physical activity

	AN ($n = 7$)	BN ($n = 29$)	EDNOS ($n = 22$)	F	Patients ($n = 59$)	Controls ($n = 53$)	t
Age, years	27.6 (9.9)	30.7 (7.3)	30.3 (8.8)	0.73	30.1 (8.5)	31.3 (8.3)	0.73
BMI, kg/m^2	15.6 (1.4)	22.3 (3.5)	21.0 (3.2)	12.0[a]	20.9 (3.8)	25.3 (4.8)	4.78[a]
ED duration, years	12.2 (11.5)	16.6 (8.2)	11.9 (6.3)	2.13	14.3 (8.0)	–	
Physical activity	($n = 4$)	($n = 23$)	($n = 20$)		($n = 47$)	($n = 44$)	
ActiGraph, Counts min	675.9 (270.6)	572.9 (200.0)	658.0 (311.9)	0.85	617.4 (254.8)	515.2 (259.6)	1.98[b]
MVPA†, min w^{-1}	649.3 (342.0, 1232.6)	465.4 (385.0, 562.7)	517.3 (389.9, 686.3)	0.95	459.3 (390.3, 540.4)	283.6 (230.7, 348.8)	3.72[c]
Self report MVPA†, min w^{-1}	528.6 (180.8, 1545.2)	456.4 (386.6, 538.9)	448.3 (325.7, 617.2)	0.19	435.8 (368.8, 514.9)	311.2 (231.2, 419.0)	2.11[b]

MVPA: moderate-to-vigorous physical activity.
Data marked with † have been log transformed, and values are shown in geometric mean (95% confidence intervals).
[a] $p < 0.001$.
[b] $p < 0.05$.
[c] $p < 0.01$.

duration of ED. Extending this line of research to adult patients with longstanding ED is of interest, as the level of physical activity seems to be higher during the acute phase of the ED.[5]

The aims of this study were to compare (1) self-reported and objectively assessed amount of weekly moderate-to-vigorous physical activity (MVPA) and (2) perceived importance of different reasons for exercise in patients with longstanding ED and nonclinical controls.

Method

Participants

The sample consisted of adult females with longstanding ED ($n = 59$) and gender- and age-matched nonclinical controls ($n = 53$). The patients attended inpatient treatment at the Department of Eating Disorders, Modum Bad Psychiatric Center in Norway. Admission criteria at this department, which were also inclusion criteria for this study, were meeting the DSM-IV criteria for an ED,[15] age $\geq$ 18 years, and body mass index (BMI) $\geq$ 14.5 kg/m^2. Of 65 consecutive patients with admission date between January 2006 and July 2007, 59 accepted participation in the study. The six who declined did not differ from the participants regarding age, BMI, diagnoses, or duration of ED. The ED were diagnosed by experienced clinicians independent of the research group, using the Eating Disorders Examination (EDE) version 12.0,[16] which gave a distribution of AN = 8, BN = 29, and EDNOS = 22 (Table 1). None of the EDNOS diagnoses were binge eating disorder. A nonclinical control group was selected from a subset representative of Norwegian females, who were originally contacted for another study.[17] Inclusion criteria for controls in this study were age matching the patients and sufficient Norwegian language skills. A randomly selected sample of females meeting these criteria was contacted. From a total of 65 eligible for this study, three were excluded due to a present ED diagnosis determined by the EDE interview,[16] 9 declined to participate, leaving 53 in the control group.

Procedures and Assessment

The design was cross sectional, and all participants received written information and gave written consent to participation. The study was approved by the Regional Committee for Medical and Health Research Ethics in Southern Norway, and by the Norwegian Social Science Data Services. Patient data were obtained within the first 2 weeks of hospitalization. When accepting the treatment, the patients signed a contract in which they committed to a minimum amount of energy intake (2,000 kcal for females) and adjustment of physical activity to this intake (<4 h of moderate intensity physical activity per week). The patients were allowed to use the two first weeks of treatment to adjust to the treatment contract. This was an intermediate step offered to all patients so that they could adapt to the treatment contract, and it was independent of this study.

Objective Assessment of Physical Activity. The accelerometer *MTI ActiGraph* (MTI model 7164; Manufacturing Technology, Fort Walton Beach, FL) was worn for 7 consecutive days. This instrument has been found valid against doubly labeled water.[18,19] The ActiGraph was worn on the right hip, and participants were told to wear it for all waking hours except when swimming and showering. The epoch length was set to 60 s. The software program CSA analyzer (csa.svenssonsport.dk) was used to analyze data. Night activity (12–6 am) and sequences of >10 min of consecutive zero counts, indicating that the accelerometer was not in use, were excluded from the recordings. Data were included in the analyses when the participant had accumulated at least 8 h of activity per day for at least 5 days. A total of 47 patients and 44 controls provided valid ActiGraph recordings. Reasons for exclusion of 12 patients and 9 controls were failing to achieve a minimum of 5 days of assessment ($n = 7$ patients and 2 controls), not wearing the ActiGraph ($n = 2$ patients and 5 controls), and

TABLE 2. Reasons for exercise in patients across different ED diagnoses, and in patients when compared with controls

Reasons for Exercise Inventory Subscales	AN (n = 6)	BN (n = 25)	EDNOS (n = 19)	F	Patients (n = 50)	Controls (n = 52)	t
Fitness/health	24.2 (15.5)	28.5 (13.6)	32.5 (10.1)	1.14	29.5 (12.7)	35.2 (8.2)	−2.71[a]
Weight/appearance	30.2 (19.4)	33.5 (17.6)	35.9 (14.9)	0.29	34.0 (16.6)	31.9 (14.9)	0.68
Socializing	4.8 (3.5)	6.9 (4.4)	6.3 (2.7)	0.74	6.4 (3.7)	6.6 (3.4)	−0.30
Negative affect regulation	9.2 (2.9)	7.3 (3.3)	9.3 (3.7)	1.88	8.3 (3.5)	6.4 (3.0)	2.98[a]
Positive affect regulation	7.4 (3.9)	8.7 (2.6)	8.8 (3.0)	0.49	8.6 (2.9)	8.6 (2.8)	0.05

Note. The different categories consist of unequal numbers of items, and can, therefore, not be compared with each other.
[a] $p < 0.01$.
Values are given in mean (SD).

instrument malfunction (n = 3 patients and 2 controls). Drop out analysis showed no differences in age, BMI, self reported physical activity, diagnoses, or duration of ED. Variables used in the analyses were counts per minute, and minutes per week of MVPA. This was defined as activities >3 metabolic equivalents (METs)[20] with cut off score ≥1,952 counts per minute.[18]

Self Reported Physical Activity. During the same seven days when using the ActiGraph, the participants completed a diary for physical activities with duration ≥10 min per session and with moderate-to-vigorous intensity. The participants recorded type, frequency, duration, and intensity of the physical activities. The duration was reported in minutes per session, and intensity was rated using Borg's 6–20 rating of perceived exertion (RPE) scale.[21] The self reported MVPA was calculated by adding up reported minutes per week of all physical activity sessions rated ≥12 on Borg's RPE.

Reasons for Exercise. Reasons for Exercise Inventory (REI) is a 25 item questionnaire assessing reasons for exercise.[22] Cash et al.[23] identified four subscales, the internal consistency of these subscales in our sample was: Weight/appearance (α = 0.93 in patients, 0.94 in controls), Fitness/health (α = 0.89 in patients, 0.84 in controls), Mood regulation (α = 0.70 in patients, 0.78 in controls), and Socializing (α = 0.64 in patients, 0.71 in controls). We performed a factor analysis for the four items covering mood regulation among patients, because it was interesting to separate the statements regarding positive and negative affects. Two factors with Eigenvalue >1 emerged, the first factor explained 54.2%, and the second factor explained 31.2% of the variance. The two items *I exercise to cope with sadness, depression* and *I exercise to cope with stress and anxiety* loaded exclusively on the first factor, called Negative affect regulation (α = 0.90 in both patients and controls). The two remaining items *I exercise to have fun* and *I exercise to increase mood* loaded exclusively in the second factor. These were merged into a subscale called Positive affect regulation (α = 0.63 in patients and 0.69 in controls).

Statistics

The software SPSS version 15.0 was used for the statistical analyses, and significance level was set to 0.05. To examine differences between patients and controls, independent sample t test and chi-square tests were used. Comparisons between patients with AN, BN, and EDNOS were done by ANOVA with Bonferroni post hoc tests. Objectively assessed and self-reported MVPA (min w^{-1}) were log transformed due to positive skewness of the data, and presented as geometric mean with 95% confidence intervals. A Bland-Altman plot[24] was constructed to compare self-reported and objectively assessed MVPA. In addition, intraclass correlation coefficients, ICC (1,1),[25] were calculated to analyze the consistency of the self-reported and objectively assessed MVPA.

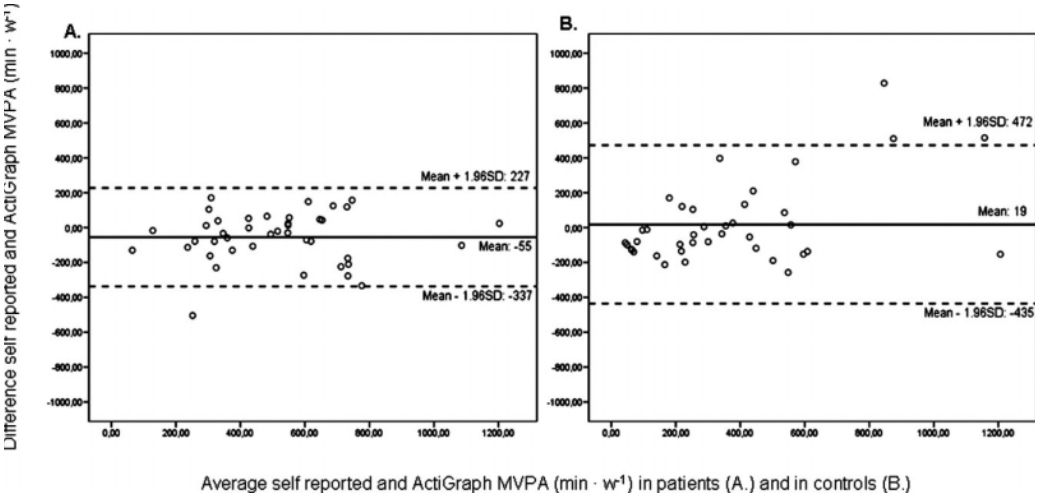
Results

No difference in mean hours per day and number of days with ActiGraph use occurred between patients and controls. Weekly amounts of objectively and self reported MVPA were higher in patients across the various ED diagnoses when compared with controls (**Table 1**). The patients' most frequently reported types of physical activities were walking (64%, n = 38), jogging/running (29%, n = 17), and Nordic walking (20%, n = 12). Among controls, walking (60%, n = 32), aerobic exercise (34%, n = 18), cycling (17%, n = 9), and resistance training (17%, n = 9) were most frequent.

Agreement Between Objectively Assessed and self-reported Physical Activity

The ICC (95% confidence interval) values of self reported and objectively assessed MVPA were 0.81 (0.67, 0.89) for patients and 0.72 (0.53, 0.84) for controls. The Bland Altman plot showed that the self reported MVPA (min w^{-1}) was 14.2% lower when compared with the objective assessments in the patients (**Fig. 1A**, $t(40) = -2.45$, $p < 0.05$); no significant difference was found in the controls (Fig. 1B, $t(30) = -0.50$, ns).

FIGURE 1 Bland-Altman plot showing difference versus average values of self reported (physical activity diary) and objectively measured (ActiGraph) moderate-to-vigorous physical activity (MVPA, min·w-1). The plots show mean difference with 95% limits of agreement (mean ± 1.96SD) in patients (n = 39) (A) and controls (n = 34) (B).



Reasons for Exercise in Patients When Compared With Controls

Patients perceived exercise for fitness/health related reasons as less important, and exercise for negative affect regulation as more important than the controls (**Table 2**). No significant differences across different ED diagnoses were found.

Discussion

In contrast to the controls, patients tended to underreport amount of weekly MVPA. Differences in reasons for exercise between patients and controls occurred for negative affect regulation and health/fitness, not weight/appearance related reasons.

Underreporting of MVPA among patients with ED has not previously been documented. A possible explanation may be deliberate underreporting due to fear of mandatory increase of energy intake or restriction of physical activity, as such efforts were made for the energy deficit patients. On the other hand, it is possible that the patients' understanding of physical activity differed from that of researchers and controls. An example of the latter was a patient participant who stated that "I am not physically active – I only go for walks," telling the researchers that she walked about 1 h daily without considering this as physical activity. Objective assessments can capture the discrepancy between self reported and actual performed physical activity, but accelerometers are removable, and we cannot exclude the possibility that they have been removed by patients to conceal physical activity sessions. Sequences of consecutive zero counts were recorded to counteract this possibility, but the actual underreporting of MVPA could be higher than what was found in this study. The Bland Altman plot is suitable for determining whether the level of agreement between the two methods is clinically acceptable, and if the methods could be used interchangeably.[24] The wide confidence intervals for the patients and controls suggest that prospective self reported amount of MVPA through a diary is not precise, and we, therefore, recommend objective assessments.

The lack of differences in MVPA among patients with AN, BN, and EDNOS should be interpreted carefully, due to the low number of patients with AN. A sample size estimate based on our results showed that valid recordings from 12 patients with AN would have given statistically significant differences between patients with AN and BN (alpha 0.05 and power 0.80). This would have been in accordance with other studies.[3,5]

The difference between patients and controls regarding exercise for negative affect regulation is consistent with previous studies.[4,13] The lack of difference in exercise for weight/appearance is consistent with the study of Boyd et al.[4] We cannot exclude

that the patients deliberately underestimated the importance of exercise for weight and shape due to the inpatient treatment setting. Also, reasons for exercise may vary over time. Therefore, weight and appearance may be more important in the acute phases of the ED,[5] and the motives may be more complex ones during the course of illness. Longitudinal studies are needed to examine this further. The possible interactive relationship between weight/shape and affect regulation motives for exercise in the patients should also be explored.

This study is limited by the small sample size, deflating statistical power when comparing patients with different ED diagnoses. The types and amount of MVPA were not necessarily representative of the pattern before admission. Our sample consists of selected patients receiving treatment at a specialized unit, and the findings can only be generalized to adult females with longstanding ED.

The practical implications are most importantly the need for more accurate physical activity assessment methods to evaluate amount of physical activity against energy intake in clinical settings, and objective methods are recommended. Although not useful for assessing amount, self report is a valuable method for capturing qualitative aspects such as type, motives, knowledge about, and attitudes towards physical activity. Such thorough screening is useful as a psycho-educative approach, which could enhance the patients' understanding and awareness of their physical activity behavior.

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PAPER II

PAPER III

PAPER IV

CE ACTIVITY

Physical Activity and Exercise Dependence During Inpatient Treatment of Longstanding Eating Disorders: An Exploratory Study of Excessive and Non-Excessive Exercisers

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ABSTRACT

Objective: To describe changes in physical activity (PA) and exercise dependence score during treatment of eating disorders (ED), and to explore correlations among changes in PA, exercise motivation, exercise dependence score and ED psychopathology in excessive and non-excessive exercisers.

Method: Thirty-eight adult females receiving inpatient treatment for anorexia nervosa, bulimia nervosa or ED not otherwise specified participated in this prospective study. Assessments included accelerometer assessed PA, Exercise Dependence Scale, Reasons for Exercise Inventory, ED Examination, and ED Inventory.

Results: Amount of PA was significantly reduced in non-excessive exercisers during treatment, in excessive exercisers there was a trend towards reduced amount of PA from admission to discharge. In excessive exercisers, reduced ED psychopathology was correlated with reduction in exercise dependence score and perceived importance of exercise to regulate negative affects, but not with importance of exercise for weight/appearance. These associations were not found in non-excessive exercisers.

Discussion: Excessive exercise is an important issue in longstanding ED, and the excessive exercising patients need help to develop alternative strategies to regulate negative affects. © 2009 by Wiley Periodicals, Inc.

Keywords: adult; female; humans; psychiatry; exercise; sports

(Int J Eat Disord 2010; 43:266–273)

Introduction

Excessive physical activity (PA) has been viewed as a common feature affecting upto 80% of patients with eating disorders (ED).[1,2] Although this feature has been shown to be most frequent in the acute phases of the ED,[1–4] it has also been reported as a persistent behavior associated with more severe psychopathology, poorer treatment outcome and higher risk of relapse.[5–10] Unfortunately previous studies are hard to interpret due to the lack of a common definition of excessive PA.[2–4,6,7] Moreover, the validity of the data may be influenced by retrospective recall biases commonly observed with self reported assessment of PA.[11]

Although excessive PA is recognized as a maladaptive behavior, adequate dosed PA might be a beneficial part of treatment for patient across the various ED diagnoses.[12] There is also good evidence for the positive effect of PA in treatment of depression and anxiety,[13] which are common comorbid conditions in ED.[14] In spite of this, development in PA behavior during ED treatment is poorly described. Blinder[15] reported an increase in weekly duration of PA parallel with weight restoration in patients with anorexia nervosa, and this increase did not interfere with the weight restoration. Similar studies have confirmed this finding[16,17] Rø et al.[18] reported no change in reported number of days with vigorous PA from admission to discharge in patients with bulimia nervosa. However, the previous studies have used self reported PA only. They

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have not explored the possible excessiveness of the PA, or made distinction between changes in PA in excessive and non-excessive exercising patients.

Exercise dependence has been suggested as a mediator between PA behavior and ED psychopathology,[19] but the development and change in exercise dependence during treatment of ED has not been studied extensively. Calogero and Pedrotty[17] found reduction in exercise compulsivity and dependence among patients who attended a supervised PA program during treatment of ED. This supports the perspective of Beumont et al.,[20] who proposed to use supervised PA as a strategy in the management of excessive PA and exercise dependence.

In clinical and scientific settings, weight, shape, and appearance have been viewed as the primary reasons for exercise in patients with ED[8,21] Recent studies, however, suggest that regulation of negative effects also might be an important reason for exercise in these patients.[22,23] To our knowledge exploration of changes in reasons and motives for exercise among excessive and non-excessive exercisers during treatment of ED has not been reported.

Further understanding of the complexity of PA behavior, and changes in this behavior during treatment of ED, is important both clinically and scientifically. A few studies have suggested use of strategies, such as psychoeducation, cognitive behavioral therapy, and motivational interviewing to manage excessive PA.[24–26] However, based on the current state of knowledge, such suggestions may be premature. According to the logic of evidence-based medicine, the level of knowledge in a research area should guide the choice of methods and design for obtaining new information. Using this principle, prospective and exploratory studies with the use of adequate assessments are justified to properly examine the changes in amount of PA, reasons for exercise, exercise dependence, and ED psychopathology. Exploring the associations between changes in these factors during treatment is important for patients with ED in general, and for excessive exercisers in particular. This may elucidate a rationale for future experimental studies, and identify variables, which must be included and controlled for, in such studies, in order to develop evidence-based treatment strategies.[27]

The aims of this study were (1) to describe changes in amount of PA, reasons for exercise, exercise dependence, and ED psychopathology during inpatient treatment of ED among patients classified as either excessive or non-excessive exercisers and (2) to explore correlations among changes in amount of PA, exercise motivation, exercise dependence score, and ED psychopathology.

Method

Participants

This sample consisted of adult females with longstanding ED receiving inpatient treatment at Department of Eating Disorders, Modum Bad Psychiatric Center in Norway. Admission criteria were meeting the DSM-IV criteria for anorexia nervosa (AN), bulimia nervosa (BN) or ED not otherwise specified (EDNOS) assessed by the Eating Disorders Examination (EDE) interview, inadequate response to previous treatment, age $\geq$18, no serious somatic complications and body mass index (BMI) above 14.5. Of the 65 consecutive patients admitted between January 2006 and July 2007, 59 were eligible. The study was approved by the Regional Committee for Medical and Health Research Ethics in Southern Norway, and by the Norwegian Social Science Data Services.

Design

This study is a prospective exploratory study. The treatment was multicomponent and lasted approximately 12 weeks for patients with BN and 20 weeks for AN. Among patients with EDNOS, patients with subthreshold AN followed the AN treatment program and the subthreshold BN patients followed the BN program. The main focus of treatment was to reduce symptoms of ED, and to normalize eating behavior through a minimum of four meals per day. The treatment also consisted of individual and group psychotherapy, psychoeducation, and art therapy sessions. More thorough description of the treatment program has been published elsewhere.[28]

PA as a Part of the Treatment. Two weekly PA group sessions (60 min) were an obligatory part of the treatment for all patients, both excessive and non-excessive exercisers. The intensity of the sessions was mainly moderate, and types of activities varied from ball games, such as volleyball and soccer, walking and Nordic walking to strength exercises, and horseback riding. The sessions were led by an experienced exercise physiologist, and milieu staff was also present in these sessions. In addition, all patients attended one psychoeducative 75 min lecture about PA led by the same exercise physiologist.

Assessments

Exercise Dependence. The Exercise Dependence Scale – Revised (EDS-R)[29] was used to examine the level of exercise dependence. The internal consistency of the EDS-R was high in our sample (α = 0.97). This scale is

based on the proposed criteria for exercise dependence, and consists of the subscales tolerance, withdrawal, intention effect, lack of control, time, reduction in other activities, and continuance. Each statement was scored on a 1–6 point Likert scale, and each subscale consisted of three statements. The scores for each subscale could therefore vary from 3 – 18. Patients with scores of ≥9 on three or more of the seven EDS-R subscales were classified as exercise dependence symptomatic (i.e., showing symptoms of exercise dependence) according to suggestions from Symons Downs et al.[29]

Amount of PA. PA was assessed objectively by the accelerometer MTI ActiGraph (MTI model 7164; Manufacturing Technology, Fort Walton Beach, FL, USA). This validated[30] instrument assesses acceleration, the amount and magnitude of the acceleration was expressed through counts per epoch. The epoch length was set to 60 s. The ActiGraph was worn on the right hip for seven consecutive days, three times during the treatment period. The participants were told to wear it for all waking hours except when swimming and showering. Data were analyzed by the SAS based software program CSA analyzer (csa.svenssonsport.dk). Night activity (12–6 am) and sequences of >10 min of consecutive zero counts, indicating that the accelerometer was not in use, were excluded from the recordings. This is a procedure previously used and described.[31] Data were included in analyses when the participant had accumulated at least 8 h of activity per day for at least five days. PA outcome variable was reported as counts per minute (counts/min).

Classification of Excessive Exercisers. According to the classification suggested by Davis et al.,[2] patients were defined as excessive exercisers if they met the following three criteria: ≥6 h per week of ActiGraph assessed moderate-to-vigorous PA (defined as >1952 counts/min[30]) upon admission, reported persistence of this amount for ≥1 month before admission, and classification as exercise dependent symptomatic.

Reasons for Exercise. The Reasons for Exercise Inventory (REI)[32] was used to assess perceived importance of different reasons for exercise. The responses were categorized into four subscales (weight/appearance, fitness/health, mood regulation, and socializing) as suggested by Cash et al.[33] Cronbach's alpha was 0.93 for weight/appearance, 0.89 for fitness/health, 0.70 for mood regulation, and 0.64 for socializing. A factor analysis of the mood regulation items was done to differentiate between regulation of negative and positive affects. Two factors (Eigenvalues > 1) emerged; the first factor explained 54.2%, and the second factor explained 31.2% of the variance. Two items loaded exclusively on the first factor, which was labeled "negative affect regulation" ($\alpha = 0.90$). The remaining two items loaded exclusively on the second factor named "positive affect regulation" ($\alpha = 0.63$). These two categories replaced the mood regulation category.

ED Psychopathology. ED psychopathology was assessed through self report and clinical interview. The self report instrument Eating Disorders Inventory – 2 (EDI)[34] consists of 11 subscales: drive for thinness, body dissatisfaction, bulimia, perfectionism, interpersonal distrust, fear of maturity, ineffectiveness, interoceptive awareness, asceticism, impulse regulation, and social insecurity. Cronbach's alpha for the EDI was 0.94. The clinical interview EDE version 12.0[35] was used to determine the DSM-IV ED diagnoses. The interviews were performed by experienced clinicians independent of the research group. Cronbach's alpha for the global EDE was 0.82.

Anamnestic Interview. From this interview, we obtained retrospective information about self injurious behavior and inpatient treatment.

Data Collection and Drop Out Analysis

Data on PA, exercise dependence, reasons for exercise, and ED psychopathology were obtained within two weeks after admission and within two weeks before discharge. Amount of PA was also assessed midway through treatment. Of the initial 59 patients, seven dropped out of treatment (AN = 3, BN = 2, EDNOS = 2). Two of these were excessive exercisers. In addition, 14 patients (AN = 1, BN = 10, EDNOS = 3) withdrew from the study between admission and discharge. None of these were excessive exercisers. Those who dropped out of the treatment or withdrew from the study had lower mean global EDE score and perceived weight/appearance and fitness/health as less important reasons for exercise at admission compared to the completers. They did not differ significantly from the completers in age, duration of illness, amount of moderate-to-vigorous PA or exercise dependence score assessed at admission. Thirty-eight patients completed the study and were included in the analyses. Among these, eight had missing data from the PA assessments (instrument malfunction $n = 3$, did not wear the accelerometer $n = 3$, and failure to achieve five days with valid recordings $n = 2$).

Statistics

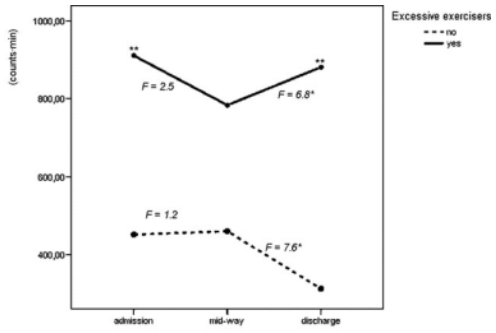
The SPSS version 15.0 was used with a significance level of 05. Chi square, Mann Whitney, and independent sample t tests were used to compare excessive and non-excessive exercisers. Changes in amount of PA, total exercise dependence score, EDE global and subscales scores, and EDI total and subscales scores were analyzed by general linear model repeated measures, where excessive or non-excessive exercisers was used as a between subject factor. Interaction effects of length of treatment (weeks)

TABLE 1. Descriptive data for patients classified as excessive (EE) and non-excessive exercisers (NEE)

	EE (n = 11)	NEE (n = 27)		Total (n = 38)
Age, mean (SD) yrs	31.8 (11.7)	30.5 (7.8)	t = 0.34	30.9 (8.9)
BMI, mean (SD) kg/m^2	19.3 (2.8)	22.5 (3.7)	t = 2.70*	21.6 (3.6)
Duration of illness, mean (SD) yrs	14.1 (10.5)	15.5 (7.0)	t = 0.43	15.1 (8.0)
Previous inpatient treatment, n (%)	6 (55)	11 (41)	χ (1) = 2.33	17 (45)
Length previous treatment, mean (SD) months	43.6 (21.7)	42.4 (39.9)	t = 0.07	42.7 (35.5)
Length current treatment, mean (SD) weeks	21.6 (2.1)	13.1 (4.5)	t = 5.99**	15.6 (5.5)
ED symptoms[a], number of episodes				
Binge, median (range)	0 (0–112)	2 (0–75)	z = 0.25	1 (0–112)
Purge, median (range)	0 (0–90)	30 (0–420)	z = 1.85	21 (0–420)
Use of laxatives, median (range)	0 (0–63)	0 (0–28)	z = 0.29	0 (0–63)
Prevalence of self injury, n (%)	7 (64)	11 (41)	χ (1) = 4.63*	17 (45)

AN: anorexia nervosa. BN: bulimia nervosa. EDNOS: eating disorders not otherwise specified.
[a] Number of episodes the past 28 days, these data are nonparametric.
* $p < .05$.
** $p < .001$.

FIGURE 1. The change in physical activity from admission to midway and discharge in patients classified as excessive (n = 10) and non-excessive exercisers (n = 20).



* p<0.05. ** Excessive differ from non-excessive at admission and discharge (p<0.01).

TABLE 2. Mean (SD) exercise dependence score (EDS-R) and reasons for exercise (REI) at admission in patients classified as excessive (EE) and non-excessive exercisers (NEE)

	EE (n = 11)	NEE (n = 24)	T value
EDS			
Total	80.5 (17.8)	49.7 (17.5)	4.77*
Withdrawal	12.6 (3.1)	8.4 (3.2)	3.60**
Continuance	10.9 (3.3)	6.9 (3.9)	2.92**
Lack of control	11.3 (4.2)	6.0 (2.6)	4.46*
Tolerance	11.5 (3.8)	7.2 (3.1)	3.50**
Reduction in other activities	12.6 (3.2)	6.2 (2.8)	5.89*
Time	11.9 (3.6)	7.7 (3.3)	3.42**
Intention effect	10.5 (3.5)	7.3 (2.8)	2.87**
REI			
Health/fitness	33.5 (11.5)	31.4 (11.2)	0.52
Weight/appearance	41.0 (13.1)	35.7 (15.1)	1.01
Social	6.9 (4.1)	7.0 (3.6)	0.07
Negative affect regulation	11.2 (2.4)	7.5 (3.4)	3.19**
Positive affect regulation	8.2 (3.1)	8.6 (3.2)	0.35

* $p < .001$.
** $p < .01$.

were analyzed using this as a covariate. Pearson's correlation was used to explore associations between changes in all of the following variables: PA (counts/min), global EDE score, total EDI score, total EDS-R score, and REI subscales negative affect regulation and weight/appearance.

Results

Eleven (29%) of the 38 patients completing the study were classified as excessive exercisers. The diagnostic distribution was AN = 2, BN = 1, and EDNOS = 8. The excessive exercisers had longer current treatment duration and lower BMI compared to the non-excessive exercisers (**Table 1**). Mean BMI increased from admission to discharge in the excessive exercisers (19.3 (2.8) kg/m^2 to 20.3 (1.7) kg/m^2, t = 4.64, $p < .01$), not in the non-excessive exercisers (22.5 (3.7) kg/m^2 to 22.5 (3.2) kg/m^2, ns).

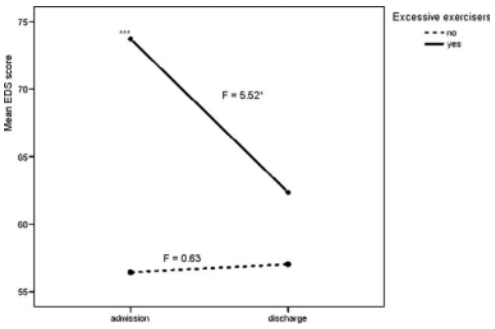
PA, Reasons for Exercise and Exercise Dependence During Treatment

Amount of PA (counts/min) was higher in excessive exercisers compared to non-excessive exercisers at admission (844 (274) versus 526 (157), $p <$ 0.001) and discharge (752 (336) versus 403 (170), $p < .01$), not midway through treatment (649 (322) versus 550 (243), ns). In the non-excessive exercisers, amount of PA was declined towards discharge (**Fig. 1**). Among excessive exercisers there was a trend towards reduction of amount of PA

during the first part of treatment, followed by a significant increase towards discharge.

Exercise dependence total and subscale scores as well as perceived importance of exercising for negative affect regulation were higher among excessive than non-excessive exercisers at admission (**Table 2**). A significant reduction was observed in exercise dependence score among excessive, but not non-excessive exercisers (**Fig. 2**). Perceived importance of exercise for health/fitness, weight/appearance, socializing, negative, and positive affect regulation did not change from admission to discharge neither in the excessive nor in the non-excessive exercisers.

FIGURE 2. The change in total exercise dependence score from admission to discharge in patients classified as excessive ($n = 11$) and non-excessive exercisers ($n = 24$).



* p<0.05. *** excessive exercisers differ from non-excessive exercisers (p<0.001)

The EDE and EDI scores were higher among the excessive exercisers compared to the non-excessive exercisers; in both groups these scores were reduced from admission to discharge (**Table 3**). Use of repeated measurements showed that the reduction in the EDI bulimia subscale, not the other EDE or EDI scores, was larger in non-excessive than excessive exercisers. No interaction effect of treatment duration and reduction in the various EDE or EDI scores was observed.

Correlations Between Changes in Amount of PA, Exercise Motivation, Exercise Dependence and ED Psychopathology

In the total sample, reduction in amount of PA was positively correlated with reduction in the total EDI score (**Table 4**). No significant correlations between changes in amount of PA, exercise motivation, exercise dependence, and ED psychopathology during treatment were found in the non-excessive exercisers. In the excessive exercisers, reduction in the global EDE score was strongly correlated with reduction in the exercise dependence

TABLE 3. Eating Disorders examination (EDE) and eating disorders inventory (EDI) score at admission and discharge in excessive (EE, $n = 11$) and non-excessive (NEE, $n = 27$) exercisers

	Admission			Discharge			Adm / Dis[a]	EE/NEE[b]
	EE	NEE	T	EE	NEE	t	F	F
EDE								
Global	5.0 (0.5)	4.3 (0.8)	−2.6*	3.6 (1.1)	2.7 (1.1)	−2.2**	46.5***	0.1
Restraint	5.1 (0.5)	3.6 (1.4)	−3.0*	3.0 (1.3)	1.7 (1.3)	−2.7**	40.1***	0.01
WC	5.2 (0.8)	4.7 (1.0)	−1.3	4.3 (1.2)	3.4 (1.5)	−1.9	16.2***	0.3
EC	4.6 (0.9)	3.9 (1.3)	−1.6	2.5 (1.5)	1.7 (1.3)	−1.5	64.7***	0.2
SC	5.2 (0.8)	5.0 (0.9)	−0.8	4.8 (1.0)	4.2 (1.3)	−1.4	13.3*	0.02
EDI								
Total score	106.7 (23.8)	84.4 (25.5)	−2.4**	89.2 (28.0)	61.1 (27.2)	−2.8*	25.7***	0.8
DT	17.5 (2.9)	15.8 (4.3)	−1.1	16.3 (4.0)	12.5 (5.9)	−1.9	11.0*	2.5
Bulimia	3.9 (5.2)	10.3 (5.8)	3.1*	2.4 (4.9)	2.3 (3.2)	−0.1	30.7***	14.6*
BD	23.5 (6.2)	19.0 (8.0)	−1.7	23.0 (6.4)	17.2 (9.2)	−1.9	1.9	0.9
Ineffectiveness	18.7 (4.3)	11.8 (6.4)	−3.2*	14.6 (6.4)	7.1 (5.4)	−3.6*	13.6*	0.07
Perfectionism	10.8 (4.0)	6.2 (4.0)	−3.0*	9.5 (3.4)	5.7 (3.9)	−2.8*	2.8	0.08
ID	6.5 (4.5)	4.6 (4.1)	−1.3	5.7 (4.5)	3.0 (3.2)	−2.0	4.1	0.6
IA	18.1 (7.5)	15.1 (6.6)	−1.2	12.9 (7.4)	9.8 (6.3)	−1.3	27.2***	0.04
Maturity fears	7.8 (5.7)	4.9 (4.7)	−1.6	4.7 (3.9)	3.5 (4.8)	−0.7	14.1*	1.7
Ascetiscism	12.3 (4.3)	6.5 (3.8)	−3.9***	11.1 (5.8)	4.9 (2.4)	−4.5***	2.6	0.4
IR	6.1 (4.0)	6.0 (5.0)	−0.1	5.6 (3.9)	4.0 (4.5)	−1.1	6.1**	2.2
SI	11.4 (4.6)	7.6 (4.0)	−2.5**	9.2 (5.5)	5.7 (4.1)	−2.1**	5.3**	0.01

Values are shown in mean (SD).

WC: weight concern. EC: eating concern. SC: shape concern. DT: drive for thinness. BD: body dissatisfaction. ID: interpersonal distrust. IA: interoceptive awareness. IR: impulse regulation. SI: social insecurity.

[a] Difference between admission and discharge for the total sample ($n = 38$).

[b] Main effect of group EE/NEE.

* $p < .01$.

** $p < .05$.

*** $p < .001$.

TABLE 4. Correlations among changes in physical activity, exercise dependence, reasons for exercise, and eating disorders psychopathology in the total sample (TOTAL) and in excessive exercisers (EE) only

TOTAL		PA	EDS	REI neg	REI w/a	EDE	EDI
PA	r	–	.12	.17	−.46	.30	.44*
	n		19	15	15	27	26
EDS	*r*		–	.60**	.27	.40	.10
	n			19	19	20	21
REI neg	*r*			–	.29	.70**	.15
	n				20	16	17
REI w/a	*r*				–	.38	.24
	n					16	17
EDE	*r*					–	.44*
	n						33
EDI	*r*						–
	n						
EE							
PA	*r*	–	.28	.49	−.71	.50	.49
	n		8	7	7	8	10
EDS	*r*		–	.72*	.36	.84*	.34
	n			8	8	7	9
REI neg	*r*			–	.32	.87*	.17
	n				8	6	8
REI w/a	*r*				–	.35	.05
	n					6	8
EDE	*r*					–	.52
	n						10
EDI	*r*						–
	n						

PA: physical activity (counts/min). EDS: exercise dependence score. REI neg: Reasons for Execise Inventory negative affect regulation. REI w/a: Reasons for Exercise Inventory weight/appearance. EDE: Eating Disorders Examination. EDI: Eating Disorders Inventory.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

score and reduced perceived importance of exercise for negative affect regulation (**Table 4**). Changes in body weight was not significantly correlated with amount of PA in the total sample (r = .32) or in the excessive exercisers only ($r = -.11$).

Discussion

The main findings of this study were that reductions in ED psychopathology were strongly correlated with reductions in both exercise dependence score and importance of exercise for negative affect regulation among excessive exercisers. Changes in these variables were not significantly correlated in non-excessive exercisers. This supports previous suggestions of excessive PA as an affect regulation strategy,[7] and is consistent with the study of Long and Hollin[26] who found poor outcome of ED treatment associated with persistent negative addiction to exercise.

As expected, and in accordance with previous studies,[5–10] excessive exercisers showed higher EDE and EDI scores, amount of PA, exercise dependence score, and importance of exercise as negative affect regulation compared to non-excessive exercisers. These findings support the seriousness of excessive PA behavior. Exercise as a regulation mechanism for negative affects is corroborated by the higher prevalence of self injurious behavior among the excessive exercisers. Self injury is also a commonly used affect regulation strategy in patients with eating disorders,[36] and vigorous PA may actually be viewed as a self injurious behavior.[37] The non-excessive exerciser had higher number of purging episodes in the past 28 days. The difference was however not statistically significant, but because of the higher number of patients with BN among the non-excessive exercisers this could be due to a Type II error.

The excessive exercisers showed no difference in mean amount of PA from admission to discharge, whereas the non-excessive exercisers reduced the amount of PA. The increase in amount of PA from midway through treatment and to discharge observed in the excessive exercisers fits well with previous studies of anorexia nervosa.[15,16] A possible explanation is fear of weight gain, as the BMI also increased significantly in these patients. Also, normalization in energy intake during the inpatient treatment could enhance the physical fitness and therefore make PA easier to perform.

Excessive exercisers had higher EDI and EDE scores at admission as well as discharge, but they experienced similar reductions in these scores as did the non-excessive exercisers. The reductions in these scores were similar to previous findings from the treatment unit.[28]

The correlation between reduced ED psychopathology and reduced amount of PA in the excessive exercisers was .50. Probably due to the low n this was not statistically significant, but it may still be of clinical interest. In the assessment of PA behavior among patients with longstanding ED, it is therefore important to consider the quantity (i.e. amount and frequency) as well as the quality (i.e. motives and compulsiveness).

Limitations

Limitations of the study are a small sample size and a substantial number of drop-outs. Our findings must therefore be interpreted with caution. Furthermore, the exploratory design makes causal conclusions inappropriate. Although objective assessment of physical activity is a more appropriate assessment method than self report, it is possible for the patients to remove the accelerometer to

conceal physical activity. The strengths of the study are the prospective design and the use of validated and appropriate assessment methods.

Implications for Clinical Practice and Future Studies

Our results have implications for the understanding of the mechanisms behind excessive PA in patients with ED. Such behavior appears to be more complex than previously assumed, and it is necessary to deal with this complexity in treatment settings as well as in future studies. Experimental studies with larger sample size should seek to further examine the role of PA as an affect regulator in ED. Moreover, such studies may be useful in the efforts to develop effective treatment strategies for excessive PA, and in providing guidelines for PA as a part of ED treatment. Clinically our findings support that excessive PA is a serious issue that must be managed in treatment of ED. We did not find any support for excluding excessive exercisers from therapist initiated and supervised PA. Previous outcome studies show promising results for including systematic PA as part of treatment for longstanding ED.[28] However, due to the complexity of the PA behavior, we recommend use of staff specialized in PA and exercise science to secure a careful implementation of adjusted PA in patients with ED.

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