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Maximal strength training as a therapeutic approach in longstanding anorexia nervosa: a case study of a woman with osteopenia, menstrual dysfunction and compulsive exercise.

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Competing interest

The authors declare that they have no competing interests.

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Abstract

In persons with Anorexia Nervosa (AN), compulsive exercise and osteopenia are common symptoms. Although treatment of osteopenia besides weight regain is lacking, maximal strength training (MST) has been found to be effective in other populations. Such training has not been prescribed to those with AN due to uncertainty of tolerance. We therefore examined use of MST in a woman with longstanding AN, osteopenia, menstrual dysfunction, and compulsive exercise. The MST intervention consisted of four exercises: 3 sets of 5 repetitions maximum (RM), 3 times per week for 16 weeks. We examined muscle strength, bone mineral density (BMD), AN psychopathology, and compulsive exercise at baseline, posttest, and six-month follow-up. Attendance rate was 100%. The subject improved muscle strength by 20-40%. BMD in lumbar spine improved by 4% to posttest, and by 8% from baseline to 6-month follow-up. The BMD t-scores shifted from values classified as osteopenic to normal values throughout the course of the intervention, despite continuance of menstrual dysfunction and lack of weight gain. No changes in AN psychopathology or levels of compulsive exercise were detected. Perceived psychological benefits including new bodily experiences were self-reported by the subject, emphasizing the importance of close follow-up by competent instructors.

Keywords: exercise, physical activity, eating disorders, treatment, muscle strength

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1 Theoretical and Research Basis for Treatment

Anorexia nervosa (AN) ensues a state of malnutrition that is strongly associated with medical complications such as sarcopenia, myopathy, and osteoporosis (Mehler, Krantz & Sachs, 2015). The loss of fat-free mass results in reduced muscle strength and power (Bratland-Sanda, Sundgot-Borgen, Rosenvinge, et al., 2010). Osteopenia is defined as reduced bone mineral density (BDM) and a precursor to osteoporosis. This along with osteoporosis seem to be result from low energy availability and low estrogen levels, inflicting increased bone resorption without the simultaneous increase in bone formation (Mehler et al., 2015). Treatment strategy for these medical complications is aimed to restore weight through refeeding (Mehler et al., 2015). Although a weight gain of 1.1-2.2 lbs. (0.5-1.0 kg)/week until the achievement of a body mass index (BMI) of 20 is recommended (Lund et al., 2009), a recent study showed that restoring approximate BMI to 17.5 or higher through the current method of treatment is difficult (Halvorsen, Tollefsen, & Rø, 2016). Body dissatisfaction moderates the rate of weight gain in AN (Vansteelandt, Pieters, Vanderlinden, & Probst, 2010) but strength training may reduce body dissatisfaction and subsequently improve body image (SantaBarbara, Whitworth, & Ciccolo, 2017). It can therefore be hypothesized that performing strength training during treatment of AN may improve body image, reduce body dissatisfaction, and thus instigate the weight restoration process.

Common among persons with AN (Mond & Calogero, 2009), compulsive exercise has been linked to health concerns (Meyer et al., 2016). Nevertheless, several studies have shown the therapeutic benefits of adapted exercise with a psychoeducative approach to relearn

healthy exercise as part of treatment of AN (Cook et al., 2016; Young, Rhodes, Touyz, & Hay, 2015). Adapted exercise has been shown to improve physical fitness, reduce AN psychopathology such as body dissatisfaction, reduce excessiveness and compulsivity of exercise, and improve quality of life (Cook et al., 2016). Few studies have rendered psychosocial effects as wells as improved muscle strength up to 12% through low-dose strength training intervention (i.e. up to 90 repetitions with little external loading) spanning 8-12 weeks among women with AN (Chantler, Szabo, & Green, 2006; del Valle et al., 2010; Fernandez-del-Valle et al., 2014; Szabo & Green, 2002). However, these studies failed to investigate the possible effect on bone mineral density (BMD). In both healthy, young adult women and in postmenopausal women with osteopenia or osteoporosis, maximal strength training (MST, i.e. few repetitions with loading of 80-100% of 1 repetition maximum (RM) and long recovery breaks between sets) has been found to be more effective than low-dose or submaximal strength training in increasing muscle strength and BMD (ACSM, 2009; Mosti et al., 2014; Mosti, Kaehler, Stunes, Hoff, & Syversen, 2013). Improvement of BMD is of clinical importance for persons with AN, but existing treatment approaches are not adequately effective (Mehler et al., 2015). MST causes higher mechanical stress compared to submaximal strength training (Zernicke, MacKay, & Lorincz, 2006), thus there is uncertainty about the tolerance of such training among persons with AN due to increased risk of fractures.

Ethical aspects regarding the use of exercise in treatment of AN are often based on clinical judgments, as no consensus has been reached addressing the benefits of exercise in treatment (Cook et al., 2016). The possible physiological and psychological benefits of MST are taken into consideration while acknowledging hazards such as inadequate recovery, injury, and deterioration of eating disorder (ED) psychopathology. There is a current lack of knowledge regarding the feasibility and adaptability of MST among persons with AN.

In existing literature, MST in cases of AN has not been examined. To address this gap in research, a feasibility and adaptability study of MST aiming to examine legitimacy of intervention within this population would prove beneficial. Due to the potential risks facing participants, ethical obligations to maintain a small sample were followed (Harriss & Atkinson, 2013). A case study was therefore considered preferable; this research design permits a more in-depth first step investigation of MST compared to large experimental studies.

The aim of the current study was to describe variability in the use of a MST protocol in the therapeutic approach in treatment of a woman with AN. Moreover, the presented case provides justification for the use of MST in treatment of AN in a clinical setting. Although this is not a psychological intervention, potential medical and therapeutic benefits are highlighted. Furthermore, incorporation of MST and more traditional psychotherapy such as enhanced cognitive behavioral therapy (CBT-E) are suggested by outcomes of the study (Draxler & Hiltunen, 2012; Karbasi, 2010).

2 Case Introduction

A woman meeting the DSM-5 criteria for AN (APA, 2013) and the International Society for Clinical Densitometry criteria for osteopenia (Leib, Lewiecki, Binkley, & Hamdy, 2004) was recruited to participate in the current study. She did not have any other Axis I or II diagnoses. She was recruited through advertisements in two non-governmental organizations for ED in Norway (www.nettros.no and www.iks.no). She was 25 years old, had just completed a master's degree, had part-time job, and maintained a 9-year history of AN. She had experience with both inpatient and outpatient treatment for AN, but was not currently

undergoing any treatment. Her body mass index (BMI) was recorded at 17.6, which falls within the underweight category.

The current study was approved by the Regional Committee for Medical and Health Research Ethics in Southern Norway (REK no. 2013/836) and registered in the ClinicalTrial.gov (NCT02142439). The woman in this case study received information about the study and provided written consent to participate. An experienced psychiatrist performed a medical screening prior to participation.

3 Presenting Complaints

The individual case volunteered to participate based off the belief that MST may be beneficial as an alternative to her current exercise behavior. She had a 9-year history of restrictive type of AN (Table 1) with no current or previous use of weight compensatory behavior other than exercise (i.e. she had never used purging or laxatives/diuretics). Her diet was restrictive with regards to both total caloric intake and choice of food. She never allowed herself to consume "unhealthy food" (i.e. snacks, candy, ice cream, and cookies) or energy dense food (i.e. nuts and avocado). Although a recorded BMI of 17.6 was maintained for a two-month period prior to intervention, this was reported as extremely demanding. She possessed a high drive for thinness, and an intense fear of becoming overweight despite a BMI classified as underweight. Despite her body dissatisfaction, an account of distorted body image was not found. In contrast to the previous DSM-IV criteria, a BMI of 17.5 or below has since been removed as an absolute criteria for AN in the DSM-5 criteria. Instead, level of AN severity is categorized based on BMI in general (APA, 2013). According to her BMI, the level of AN severity was mild (APA 2013), despite EDE clinical interview exhibiting high levels of AN psychopathology (Table 1). She had osteopenia (T-score of -1.1) in lumbar spine and

menstrual dysfunction (one menstrual cycle the past 3 months) while using oral contraceptives. Exercise was performed approximately 6 hours per week: primarily endurance training such as walking and running with moderate-to-vigorous intensity. She had some former experience with strength training, but not with MST and not on regular basis. When she was unable to conduct her scheduled exercise regime, she possessed feelings of guilt, shame, stress and anxiety. Her scores on the Compulsive Exercise Test were recorded at above suggested cut off levels indicative of compulsive exercise (Meyer et al., 2016; Taranis, Touyz, & Meyer, 2011).

4 History

Initial onset of AN was at age 16. Her lowest recorded BMI over the course of her history of AN was 12.2, registered at age 19. At that time, she was admitted to daycare treatment at a specialized eating disorders treatment unit. The initial daycare treatment (i.e. from 8.00 AM to 5.00 PM five days per week) lasted one month at the age of 19. A second admission to the treatment unit occurred at the age of 25 and lasted for 6 months. The final daycare treatment ended approximately two months before enrollment to the current intervention study. During these treatments, she received psychotherapy and nutritional counseling. The nutritional plan dictated the consumption of a total 2500-2900 kcal per day in to ensure weight gain. Although she was unable to meet this requirement for the majority of treatment, she did manage to eat approximately 2000 kcal until she reached a BMI of 17.5-17.6. She did not receive psychological treatment during the current MST intervention. From the age of 19 and up, to approximately two months prior to the current intervention, she maintained continuous outpatient treatment in addition to the two separate periods of daycare treatment. Throughout these six years, she had visited a number of therapists. Treatment periods with each individual therapist ranged from a few months to several years. Although a fluctuation in body-weight

was self-reported, AN psychopathology remained persistent during these treatments. The subject exhibited high levels of motivation for participating in this intervention.

5 Assessment

Muscle strength.

Adaptability to MST was operationalized through changes in muscle strength and power. Muscle strength was assessed through 1RM tests in lower (half squats) and upper body (bench press). Two leaders were carefully trained in testing procedures and designated to performing all pre- and posttests as described by Støren et al. (2008). The recorded 1RM pertains to the weight of the last approved repetition performed with correct technique. Muscle power was obtained by MuscleLab^{TM} (Ergotest Innovation, Porsgrunn, Norway) during the lifts at 50-70% of 1RM, and measured as the highest power (watt) obtained during these lifts.

BMD.

Dual x-ray absorptiometry (DXA, Prodigy, GE Lunar, Chalfont St. Giles, UK) was used to measure body composition and BMD. The subject was instructed to cease personal exercise a minimum of 24 hours prior to testing. She was also instructed to cease consumption of food and drink a minimum of two hours prior to pretest. BMD measurement areas were lumbar spine (L2–L4), femoral neck, total hip, and total body. DXA has been found to be an accurate assessment method for BMD, with a standard error of ±1–2% (Hangartner, Warner, Braillon, Jankowski, & Shepherd, 2013) . Osteopenia was identified by a t-score falling between −1.0 and −2.5, and osteoporosis was identified by a t-score of −2.5 or less according to the recommendations for premenopausal women (Leib et al., 2004).

AN psychopathology.

The Eating Disorders Examination 16.0 (EDE) (Fairburn, Cooper, & O'Connor, 2008) was used to diagnose AN. EDE-scores were rated through the use of a Global EDE score as well as four subscales: Restraint (EDE-R), Eating Concern (EDE-EC), Weight Concern (EDE-WC), and Shape Concern (EDE-SC). The same experienced interviewer carried out both EDE interviews. Cronbach's alpha was measured at.84, indicating a moderately high level of internal reliability. Compensatory behavior such as purging, the use of laxatives, and/or use of diuretics were assessed through the EDE interview.

Compulsive exercise.

The Compulsive Exercise Test (CET) is a 24-item survey covering various aspects of compulsive exercise (Taranis et al., 2011). All items are rated on a 6-point Likert scale from never (0) to always (5), and higher score indicates higher levels of compulsive exercise. Meyer et al. (2016) has suggested a cut-off at the total score of 15 on CET global scale indicating the definition of compulsive exercise, and this cut off was used for this current case study as well.

Energy intake and exercise.

Energy intake (kcal/day) and habitual exercise (min/week) were prospectively assessed through a log at baseline (4-day registration of energy intake and 7-day registration of exercise). Each week in the intervention period, she was asked to report changes in energy intake, habitual exercise, and/or other compensatory behavior such as purging, the use of laxatives, and use of diuretics.

Experiences with the intervention.

A semi-structured, online questionnaire including open-ended questions with the possibility of elaborating on each answer was conducted. Instant feedback was also received from the subject for each individual training session.

Statistical analyses

The data was analyzed using the software SPSS 22.0. Data is presented by frequencies and changes are presented in percentage. A change in BMI greater than 5% was considered clinically significant (Stevens, Truesdale, McClain, & Cai, 2005). Clinical significance for changes in global EDE, EDE-R, EDE-EC, EDE-WC and EDE-SC were calculated using the Clinical Significance Spreadsheet version 1.91 beta (http://creativecommons.org/licenses/by-sa/3.0/). This calculation is based on the Reliably Change Index formula from Jacobson and Truax (1991) with the use of normative data from Fairburn (2008). The categories used to indicate change were classified as 1) Deterioration, 2) Not reliably changed, 3) Improvement and 4) Recovery.

6 Case Conceptualization

Conceptualization of the possible benefits of MST in AN was carried out with a holistic, pathophysiological, and a psychoeducative perspective. The pathophysiological perspective prioritizes the possibility for increased muscle strength and improved bone health, which may in turn result in significant health benefits in the future. According to the mechanostat theory, bone requires a certain amount of loading to adapt and increase in capability (Frost, 2003); MST may have the potential for bringing forth this adaptation in bone health.

Although MST is not classified as a psychological intervention, it includes elements of psychoeducation and interpersonal, therapeutic, and social support. Psychoeducation and

structured exercise with interpersonal and therapeutic support is important in relearning healthy exercise(Young et al., 2015). According to Cook et al. (2016), the psychoeducational component of the intervention is aimed at challenging an individual's existing attitudes towards exercise. Additionally, themes addressed through psychoeducation include promoting healthy attitudes towards exercise, recognition of compulsive exercise, body awareness, and motivation for exercise and exercise identity.

MST possesses qualities that challenge the experience and motives behind compulsive exercise in AN, identified by Kolnes and Rodriguez-Morales (2016). One of these qualities is due to the structure and modality of MST sessions. These sessions are built up by sets of exercise with recovery breaks in between that tend to last two to three minutes, depending on the training load (Garber et al., 2011). This exercise modality may help address the restlessness often experienced by persons with AN (Kolnes & Rodriguez-Morales, 2016). Additionally, heavy lifting demands concentration and total focus on the exercise; it challenges the escape function of high-intensity aerobic exercise (i.e. *"I can't walk away from my feelings, I have to run from them"*) (Bratland-Sanda, Sundgot-Borgen, Ro, et al., 2010; Kolnes & Rodriguez-Morales, 2016). Several of the MST exercises also require correct bodily posture and therefore challenge the subject into a more up-right position with focus on function and awareness, but not appearance, of the body. Increasing body awareness has the potential to improve positive body image, as found in a case study by Stewart & Williamson (2003). Lastly, the potential rapid increase in muscle strength may enhance self-efficacy, which has been linked to improved self-esteem and feelings of empowerment (ten Hoor et al., 2017).

Important aspects in the recovery process for persons with AN are self-awareness, setting boundaries, recognizing difficult feelings, self-mobilization, self-regulation, and self-caring (Pettersen, Rosenvinge, & Wynn, 2011). Based on the concept of MST, it is reasonable

to speculate that MST has a therapeutic value in addition to the expected physiological benefits.

7 Course of Treatment and Assessment of Progress

The MST was performed under supervision from an instructor with competence in clinical exercise physiology and AN psychopathology. Three MST sessions per week were carried out over a 16-week period. To ensure adequate recovery, sessions were performed with at least one day of recovery in between. Each session consisted of 10-minutes of warm-up on treadmill or cycle ergometer at low intensity (approximately 60-65% of HR_{max}). The MST exercises were performed in the following order: deadlift, squats, bench press, and pull-down. Squats and bench press were performed in a Smith machine, deadlift using an Olympic barbell, and the pull-down in a Lat PullDown (Gym2000, Vikersund, Norway). Loading was set at 5RM x 3 sets. Each repetition was performed with a maximal concentric and controlled eccentric phase, with focus on correct breathing technique. Three-minute breaks were allotted between each set and the total duration of each training session lasted 60 minutes. The instructor guided and motivated the participant during the sets, helped the subject adhere to the recovery breaks, and determined progression in loading from session to session. The loading was increased when she was able to perform more than five repetitions per set.

She completed all 48 training sessions, and had an attendance rate of 100 %. During week 10 of the intervention, the subject was traveling and was allowed to perform training independently at a gym. In session 21, she reported some temporary pain in her lower back. She reported that the cause of this pain was unrelated to the training intervention. Due to this pain, she did not perform the dead lifts in this session. Within the next training session, the pain was gone and she was able to perform all exercises as planned. She was allowed to

continue her habitual exercise during the intervention. This was logged and reported weekly to the instructor. The exercise logs indicated that she continued with running during the first weeks of the MST intervention. After approximately three weeks, she reported that she felt the vigorous intensity running affected her performance and ability to lift heavy weights in the MST sessions. She therefore changed these sessions to moderate intensity walking and subsequently reduced the volume of the habitual exercise.

The subject's body weight increased by 2.2 lbs. (1.0 kg) from pretest to posttest, leading to a change in BMI from 17.6 to 17.9. This change in body weight is within normal day-to-day variations and is not considered clinically significant. She improved her muscle strength by 36% in upper body and 30% in legs. BMD increased by 4% in lumbar spine and right femoral neck, and by 3% in left femoral neck. Osteopenic values represented through a t-score, shifted from -1.1 to -0.8 and hence normal values from pretest to posttest respectively. No changes in reliability regarding AN psychopathology (Table 1) or compulsive exercise (CET global score of 15.3 and 15.7 at pretest and posttest) were observed. She reported positive aspects of the MST, including rapid progress and improvement in muscle strength as well as therapeutic effects of the MST including new bodily experiences. She reported feeling stronger outside of merely being stronger and that she was free and able to use her body in different ways than before. The experience of new and varied training modalities compared to endurance training was reported as positive. However, she reported feeling that the MST was not training to the same extent as endurance training. Furthermore, the subject reported that she considered close supervision by the instructor as crucial to her motivation, perceived safety, and ability to complete the training sessions.

Insert Table 1 here

8 Complicating Factors

The major complicating factor was the subject's inability to adhere to adequate energy intake and inability to cope with feelings related to the body. Given the baseline BMI of 17.6, an increase in BMI up to 20.0 would have been ideal according to treatment guidelines (Lund et al., 2009). She was encouraged to increase energy intake; a self-induced reduction in energy intake would have led to termination of the MST intervention. Challenges maintaining proper intake of energy is a primary symptom as well as a prominent clinical concern during treatment of AN (Fassino, Piero, Tomba, & bbate-Daga, 2009). The subject's weekly recordings showed normal weight fluctuations with an increase in 3.7 lbs. (1.7 kg) from baseline to week 14 as the highest variation. She never measured below her baseline body weight and BMI during the MST intervention.

Throughout the course of the intervention, it was expected that an increase in body awareness was a possibility. This is due to potential muscle soreness as well as prioritization of correct execution of each exercise. This may prove demanding for individuals who are already preoccupied with their body. She reported temporary increased focus on body weight and shape during the first weeks of the intervention. She perceived this as challenging, and noted that she may have benefited from additional therapy related to feelings and compulsivity regarding habitual exercise. Although psychological support remained available to the subject throughout the MST intervention, she did not elect to take part in therapy. Upon review of the feedback from the subject, the research team has acknowledged a potential oversight regarding a lack of further encouragement to continue psychological treatment in the subject. This oversight in protocol has been since noted as a potential source of error in success of the intervention, as well as an ethical grey area. No deterioration in EDE global or subscale scores were observed, but there remains potential for clinical improvement if MST is combined with e.g. cognitive behavioral therapy (Linardon, Fairburn, Fitzsimmons-Craft,

Wilfley, & Brennan, 2017). A case study examining CBT-E in a woman with AN showed improved BMI from 17.5 to 19.4 during 20 weeks (Karbasi, 2010) equal to the desired BMI our case. As previously mentioned, this increase in BMI is acknowledged as exceptionally challenging for individuals with AN (Halvorsen et al., 2016). The current subject possessed a relatively longstanding and persistent AN as well as a more recent failure of treatment. Although this differs to that of Karbasi (2010), symptoms and presented complaints remained constant. It is crucial for future studies to explore the potential benefits of combined psychological and strength training treatment.

9 Access and Barriers to Care

MST must be conducted in well-equipped gym or training facility. It also requires supervision and guiding from an experienced and competent instructor. Access to care in this study was classified by free entrance to well-equipped training facilities as well as supervision and guiding executed by flexible instructors. Barriers to care included economy (hiring exercise professionals can be expensive) as well as a demanding work schedule. Another possible barrier to care is the experience of muscle soreness or motivational obstacles to perform heavy loading. Due to our case's previous experience with exercise and her motivation to complete, this barrier did not present itself in the current study.

10 Follow-Up

The intervention lasted 16 weeks, and a six-month follow up was conducted after the posttest. After the completion of the intervention, the subject continued with regular MST independently. However, from post treatment to six-month follow-up her muscle strength decreased by seven percent (Figure 1). She was unable to maintain maximal loading and

lifting weight independently, as she previously was able to under supervision. This is in accordance with previous findings (Dias, Simao, Saavedra, & Ratamess, 2017). She was therefore unable to further improve her muscle strength at the six-month follow-up. It should be noted that the subject managed to sustain a muscle strength improvement of 20% above her baseline values when performing the MST independently. This increase is considered clinically relevant and comparably higher than found in other studies on females with AN (Fernandez-Del-Valle, Larumbe-Zabala, Morande-Lavin, & Perez Ruiz, 2015; Fernandez-del-Valle et al., 2014). She had not received any other form of treatment from posttest to follow-up. No changes were observed in AN psychopathology from posttest to six-month follow-up, indicating that she still fulfilled criteria for a DSM-5 AN diagnosis. After performing additionally tests of muscle strength and BMD, a 7% decrease in both upper body and legs was presented from posttest to six-month follow-up. Despite this decrease, improvement from a baseline value to six-month follow-up was 27% in upper body and 21% in legs, determined to be significant. BMD-values in lumbar spine increased by an additional 4% from posttest to six-month follow-up, rendering total improvement in lumbar spine BMD as 8% from baseline to posttest. In femoral neck, end-results at six-month follow-up were inconsistent. Measured BMD in left femoral neck measured relatively consistent at posttest and follow-up. However, the right femoral neck BMD decreased by 2% from posttest to follow-up, yielding a total improvement of 2% from baseline to follow-up. All t-score values fell within normal range at both posttest and follow-up.

Insert Figure 1 here

11 Treatment Implications of the Case

Comprehensive findings from the current study present implications for potential future intervention studies and clinical treatment for this population. One significant finding showcased muscle strength adaptability comparable to expected ability of physically active adults (ACSM, 2009). The subject's adaptability was greater compared to subjects of other studies addressing AN (del Valle et al., 2010), which may be due to the much greater loading of external weight in the present study. Due to the modality of her habitual exercise, it is not likely that these exercises contributed to the improved muscle strength. The 4% initial increase in lumbar spine BMD from pretest to posttest, as well as overall 8% increase from pretest to six-month follow-up, is promising. This increase is comparably larger than found in other studies treating the current population through MST (Watson et al., 2017) and other alternative treatment for osteopenia/osteoporosis in individuals with AN (Jauregui-Lobera, Bolanos-Rios, & Sabate, 2016; Mehler & Mackenzie, 2008). It is worth nothing that this improvement occurred despite further weight gain and continual menstrual dysfunction. Future studies with a larger sample size would benefit from comparing effectiveness of MST to other existing treatment options for improvement of bone health in persons with AN.

A second direction for future studies includes the possibility for combining MST with additional psychological treatment of AN. Improvement in AN psychopathology or the compulsive exercise by MST was not expected, although MST is potentially linked to other psychological variables such as quality of life (Szabo & Green, 2002). Although these psychological benefits of MST were not investigated by the current study, there was no indication that exhibiting an association between MST and quality of life is impractical. Although case studies by Karbasi (2010) and Draxler & Hiltunen (2012) rendered weight gain in subjects when using CBT-E in women with AN, potential benefits of MST in combination with this form of psychological intervention is yet to be explored. Although dietary restraint is a core symptom of AN, some training modalities have exhibited an appetite suppressing

effect, contributing to a continuance of the dietary restraint (Guelfi, Donges, & Duffield, 2013). Reported difficulties with a temporary increase in focus on the body can also be considered necessary in a clinical setting. The subject reported that she experienced the need to expose herself to such feelings in order to improve AN psychopathology. Simultaneously, she reported that improvement in muscle strength made her feel stronger. This therapeutic potential warrants demand for more in-depth, future exploration in this area. This is not exclusive to merely treatment with CBT-E (Draxler & Hiltunen, 2012; Karbasi, 2010), but also with body compassion focused therapies such as mindfulness and acceptance-based CBT (Altman, Zimmaro, & Woodruff-Borden, 2017). It is important to identify if these topics can be addressed alongside MST sessions alone, or if bodily experiences procured from MST should be addressed with concurrent psychotherapy. Conducting a case study inciting MST without offering concurrent psychotherapeutic treatment may present an ethical grey area regarding potential risk to the subject. However, a previous study among persons with bulimia nervosa rendered a comparably greater reduction in eating disorder psychopathology through exercise than treatment via cognitive behavioral therapy (Sundgot-Borgen, Rosenvinge, Bahr, & Schneider, 2002). From these findings, we have determined potential risk to participants to be negligible. Moreover, alliance between patient and care provider (instructor) has been shown to play a significant role in the success of psychotherapy (Wampold, 2015). There is a need to investigate this potential further.

The therapeutic use of exercise requires a qualified and competent personnel; the current study included this important factor in addition to suggested guidelines by Cook et al (Cook et al., 2016). These guidelines also recommend inclusion of psycho-educational components, such as body awareness, when using exercise in treatment of various ED. With regards to the current MST intervention, long recovery breaks between sets provides the possibility to integrate both body awareness and exercise recovery. Additionally, the method

by which MST challenges current psychological components of exercise (i.e. distraction and escape) requires further exploration through a psychoeducative lens. Habitual exercise in cases of AN must also be taken into consideration; the current case managed to reduce exercise intensity in her existing endurance training sessions. Although the compulsivity of the exercise was persistent, this increased control in behavior is recognized as positive and hopeful for future cases.

12 Recommendations to Clinicians and Students

MST may be a promising supplement to current treatment for women with mildly severe, but longstanding AN. Adequate energy intake paired with close supervision by competent instructors, preferably clinical exercise physiologists, during exercise sessions is vital for achieving significant progress. The instructor must focus on eliciting proper lifting technique, breathing technique during lifts, and adequate recovery breaks between sets. In treatment settings, a collaborative approach emphasizing exercise physiology, nutrition, psychopathology, and preparedness towards medical complications of AN is recommended (Cook et al., 2016). Although challenging, weight gain should remain a primary goal in treatment of AN until a BMI of 20 is reached (Halvorsen et al., 2016). It is especially important to remain aware of self-inflicted dietary restraint and personal perceptions of weight and shape as core symptoms of AN. Instructors must be able to recognize potential changes in these symptoms. It is crucial to discontinue the exercise program if energy intake is inadequate, if the subject experiences adverse events such as dizziness, muscle and/or joint pain or injuries, or if there is a deterioration of the AN.

Besides direct treatment of AN, the exhibited therapeutic potential of MST is an exciting secondary outcome that warrants further investigation. Clinical trials examining the

recovery potential of MST in treatment of AN should therefore emphasize both physiological and psychological perspectives. The nature of varied or mutual feelings of trust and cohesiveness between patient and instructor may contribute to subsequent psychological effects. It is advised that the nature of this relationship should be controlled for in future studies.

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FIGURE LEGEND.

Figure 1. Changes in muscle strength, body mass index (BMI) and bone mineral density (BMD) from baseline to post-treatment (16 weeks) and six-month follow-up after post-treatment.