NIVELES DE COMPOSICIÓN CORPORAL, GASTO ENERGÉTICO, CONDICIÓN FÍSICA Y CALIDAD DE VIDA EN ADOLESCENTES CON ANOREXIA NERVIOSA: EFECTOS DE UN PROGRAMA DE PILATES

Body composition levels, energy expenditure, physical fitness and quality of life in adolescents with anorexia nervosa: effects of a Pilates program

Tesis Doctoral Internacional / International Doctoral Thesis

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AYUDAS DE INVESTIGACIÓN [RESEARCH GRANTS]

La candidata ha recibido las siguientes ayudas de investigación durante la ejecución de la presente Tesis Doctoral Internacional:

- Ayudas para Estudiantes de Programas de Doctorado de la Escuela de Doctorado de la Universidad Pablo de Olavide (EDUPO), destinadas a cubrir gastos para la mejora cualitativa en el desarrollo de sus tesis doctorales, aprobada por Resolución de 8 de Junio de 2015.
- Ayudas para Estudiantes de Programas de Doctorado de la Escuela de Doctorado de la Universidad Pablo de Olavide (EDUPO), destinadas a cubrir gastos para la mejora cualitativa en el desarrollo de sus tesis doctorales, aprobada por Resolución de 12 de Junio de 2017 (Referencia: AMC-17-1).
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- Ayudas para Estudiantes de Programas de Doctorado de la Escuela de Doctorado de la Universidad Pablo de Olavide (EDUPO), destinadas a cubrir gastos para la mejora cualitativa en el desarrollo de sus tesis doctorales, aprobada por Resolución de 14 de Julio de 2020 (Referencia: AMC-20-1).
- Ayudas para estudiantes de doctorado de la EDUPO para la realización de estancias predoctorales en universidades o centros de investigación superior de reconocido prestigio, primando aquellas dirigidas a la realización de la tesis doctoral en régimen de cotutela y a la consecución de la mención internacional al título de doctor/a, convocadas por Resolución del Vicerrector de Postgrado y Formación Permanente de 14 de Julio de 2020 (Referencia: AE-20-1).

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1. **Martínez-Sánchez SM**, Martínez-García TE, Munguía-Izquierdo D. Physical fitness and nutritional status in female adolescents with anorexia nervosa. Rev Nutr. 2020;33:e190154.
2. **Martínez-Sánchez SM**, Martínez-García TE, Munguía-Izquierdo D. Clinical and physical fitness evolution in adolescents with restrictive anorexia nervosa after 10 weeks participating in a day hospital program. Acta Medica Mediterr. 2020;36(2):927–933.
3. **Martínez-Sánchez SM**, Martínez-García TE, Munguía-Izquierdo D. Clinical, Psychopathological, Physical, and Sleep Evolution in Adolescents with Restrictive Anorexia Nervosa Participating in a Day Hospital Program. Psychiatry Investig. 2020;17(4):366-373.
4. **Martínez-Sánchez SM**, Munguía-Izquierdo D. Ejercicio físico como herramienta para el tratamiento de los trastornos de la conducta alimentaria. En: David Padilla Góngora, Remedios López Liria, José Manuel Aguilar Parra (eds.). Psicología, salud y educación. Almería, España: Editorial Universidad de Almería; 2018. p.198-208.
5. **Martínez-Sánchez SM**, Martínez-García TE, Bueno-Antequera J, Munguía-Izquierdo D. Feasibility and effect of a Pilates program on the clinical, physical and sleep parameters of adolescents with anorexia nervosa. Complement Ther Clin Pract. 2020;39:101161.
6. **Martínez-Sánchez SM**, Martínez-García C, Martínez-García TE, Munguía-Izquierdo D. Psychopathology, Body Image and Quality of Life in Female Children and Adolescents With Anorexia Nervosa: A Pilot Study on the Acceptability of a Pilates Program. Front Psychiatry. 2020;11:503274.

RESUMEN

La anorexia nerviosa se caracteriza por una restricción de la ingesta de energía que conduce a un peso corporal significativamente bajo, un miedo intenso a aumentar de peso y una alteración en la forma en que se percibe la forma del cuerpo o una falta persistente de reconocimiento de la gravedad del bajo peso corporal. Debido a la restricción energética, la anorexia nerviosa conduce a un estado de desnutrición que está asociada a severas complicaciones físicas, tales como las anomalías cardiovasculares, bioquímicas, hematológicas y neuronales junto con la pérdida de densidad ósea. Todas ellas pueden justificar la elevada tasa de mortalidad en esta enfermedad, siendo la más alta de entre todos los trastornos psiquiátricos. En los últimos 20 años, ha habido un creciente interés en la evidencia y la implementación del ejercicio como tratamiento complementario entre las personas con anorexia nerviosa. Pilates es un método de entrenamiento que combina ejercicios mente-cuerpo en el que se requiere estabilidad central, fuerza y flexibilidad, y donde se pone especial atención al control muscular, la postura y la respiración. Por consiguiente, comprender la viabilidad, la seguridad y los efectos de un programa de Pilates en esta población representa una oportunidad para la salud pública y la comunidad científica.

El objetivo general de la presente Tesis Doctoral fue analizar los niveles de composición corporal, el gasto energético, la condición física, la calidad de vida y otras variables relacionadas con la evaluación de los síntomas de los trastornos alimentarios en el tratamiento de adolescentes con anorexia nerviosa, así como estudiar la seguridad, viabilidad y el efecto de un programa de Pilates en el tratamiento de estas adolescentes.

Los principales hallazgos fueron:

(1) En adolescentes con anorexia nerviosa, mayores niveles de condición física se asoció con un mejor estado nutricional. Las pruebas de fuerza de presión manual y de ida y vuelta de 20 m pueden ser opciones como indicadores adicionales del estado de desnutrición en adolescentes anoréxicas. Las pacientes anoréxicas desnutridas mostraron peor condición física que las nutridas. De acuerdo con los datos normativos para adolescentes sanas que coinciden con el sexo y la edad, la condición física está gravemente afectada en las adolescentes anoréxicas. (2) Después de 10 semanas de seguimiento en adolescentes con anorexia nerviosa restrictiva que participaron en un programa de hospital de día, hubo una evolución positiva de los parámetros

antropométricos (peso, altura e índice de masa corporal), linfocitos sanguíneos y un aumento en la fuerza de presión manual izquierda. La fuerza de presión manual de la mano no dominante parece ser lo primero que mejora en la condición física después de la realimentación en adolescentes con anorexia nerviosa restrictiva. (3) Después de 10 semanas de seguimiento en adolescentes con anorexia nerviosa restrictiva que participaron en un programa de hospital de día, hubo una evolución positiva de la composición corporal. No se observaron cambios en la psicopatología general de los pacientes. Sin embargo, con respecto a los patrones de sueño, hubo un empeoramiento de la latencia y la eficiencia del sueño, por lo que la atención del sueño debe abordarse en los programas de tratamiento agudo para adolescentes con anorexia nerviosa restrictiva. (4) A pesar de que la elevada actividad física se incluye dentro de la psicopatología de la propia enfermedad de los trastornos de la conducta alimentaria, ya sea para controlar el peso o hacer frente al afecto negativo, se ha observado que el componente "compulsivo" es el que da una representación más precisa en el perfil del ejercicio problemático en los trastornos de la conducta alimentaria. Hay evidencia de que la participación en programas de ejercicios estructurados y supervisados (ejercicios de alta intensidad o yoga) puede ser de gran utilidad en esta población clínica, ya que reduce la psicopatología, mejora la fuerza muscular, la calidad de vida, el bienestar psicológico y facilita el cumplimiento y la adherencia al tratamiento. (5) Un programa de Pilates es seguro y factible en adolescentes con anorexia nerviosa, ya que no altera su composición corporal cuando tienen un peso controlado y estable. Pilates ayuda a aumentar los niveles plasmáticos de calcio y la eficiencia del sueño, y disminuye la folitropina plasmática, la duración del sueño y las perturbaciones nocturnas en adolescentes con anorexia nerviosa. Por lo tanto, Pilates podría ser una alternativa viable en los programas de tratamiento para lograr una mejor calidad del sueño. (6) Un programa de Pilates ayuda a mejorar la salud percibida al disminuir la psicopatología y la insatisfacción corporal, y al aumentar el bienestar físico y psicológico en niñas y adolescentes con anorexia nerviosa. Por lo que Pilates parece ser un tratamiento complementario beneficioso en niñas y adolescentes con anorexia nerviosa.

Estos hallazgos ponen de manifiesto la viabilidad y seguridad de la implantación de un programa de Pilates como herramienta complementaria en el tratamiento de adolescentes con anorexia nerviosa.

ABSTRACT

Anorexia nervosa is characterized by a restriction of energy intake that leads to a significantly low body weight, an intense fear of gaining weight and an alteration in the way the body shape is perceived or a persistent lack of recognition of the severity of low body weight. Due to energy restriction, anorexia nervosa leads to a state of undernutrition that is associated with severe physical complications, such as cardiovascular, biochemical, hematologic, and neuronal abnormalities along with loss of bone density. All of them can justify the high mortality rate in this illness, being the highest of all psychiatric disorders. In the past 20 years, there has been a growing interest in the evidence and implementation of exercise as a complementary treatment among people with anorexia nervosa. Pilates is a training method that combines mind-body exercises in which central stability, strength and flexibility are required, and where special attention is paid to muscular control, posture and breathing. Therefore, understanding the feasibility, safety, and effects of a Pilates program in this population represents an opportunity for public health and the scientific community.

The overall objective of the present Doctoral Thesis was as to analyze the levels of body composition, energy expenditure, physical fitness, quality of life and other variables related to the evaluation of the symptoms of eating disorders in the treatment of adolescents with anorexia nervosa, as well as to study the safety, feasibility and effect of a Pilates program in the treatment of these adolescents.

The main findings were:

(1) Female adolescents with anorexia nervosa showed associations between higher physical fitness levels and better nutritional status. Handgrip strength and 20-m shuttle run tests may be options for additional indicators of the state of undernutrition in anorexic female adolescents. The undernourished anorexic patients showed worse physical fitness than the nourished ones. According to normative data for healthy sex- and age-matched adolescents, physical fitness is severely impaired in anorexic female adolescents. (2) After 10 weeks of follow-up in adolescent with restrictive anorexia nervosa who participated in a day hospital program, there was a positive evolution of anthropometric parameters (weight, height and body mass index), blood lymphocytes and an increase in the left handgrip strength. The non-dominant hand grip strength seems to be the first thing that improves physical fitness after refeeding in female

adolescents with restrictive anorexia nervosa. (3) After 10 weeks of follow-up in adolescent with restrictive anorexia nervosa who participated in a day hospital program, there was a positive evolution of body composition. No changes were observed in the patients' general psychopathology. However, regarding sleep patterns, there was a worsening of sleep latency and efficiency, so sleep care should be addressed in acute treatment programs for adolescents with restrictive anorexia nervosa. (4) Despite the fact that high physical activity is included within the psychopathology of the illness itself of eating disorders, either to control weight or to cope with negative affect, it has been observed that the "compulsive" component is which gives a more accurate representation in the profile of problematic exercise in eating disorders. There is evidence that participation in structured and supervised exercise programs (high intensity exercises or yoga) can be very useful in this clinical population, since it reduces psychopathology, improves muscle strength, quality of life, and psychological well-being, and facilitates compliance and adherence to treatment. (5) A Pilates program is safe and feasible in adolescents with anorexia nervosa, since it does not alter their body composition when they have a controlled and stable weight. Pilates helps increase plasma levels of calcium and sleep efficiency and decrease plasma follitropin, sleep duration and night perturbations in female adolescents with anorexia nervosa. Therefore, Pilates could be a viable alternative in treatment programs to achieve better sleep quality. (6) A Pilates program helps to improve perceived health outcomes by decreasing psychopathology and body dissatisfaction and increasing physical and psychological well-being in female children and adolescents with anorexia nervosa, so Pilates seems to be a beneficial complementary treatment in children and adolescents with anorexia nervosa.

These findings demonstrate the feasibility and safety of implementing a Pilates program as a complementary tool in the treatment of adolescents with anorexia nervosa.

ABREVIATURAS [ABBREVIATIONS]

6RM: 6 Repeticiones Máximas.

AF: Actividad Física.

ALPHA-Fitness Battery: Assessing Levels of Physical Activity and Fitness Battery.

AN: Anorexia Nervosa. Anorexia Nerviosa.

BIA: Bioelectrical Impedance Analysis.

BMI: Body Mass Index.

BN: Bulimia Nerviosa.

CDRS: Contour Drawing Rating Scale.

CI: Confidence Intervals.

CL: Confidence Level.

CONUT: Controlling Nutritional Status.

DHP: Day Hospital Program.

DSM-5: Diagnostic and Statistical manual of Mental disorders-5.

EDI-3: Eating Disorder Inventory-3.

EDRC: Eating Disorder Risk Composite.

EDs: Eating Disorders.

EP: Ejercicio Problemático.

GPM: General Psychological Maladjustment.

HRQoL: Health-Related Quality of Life.

IMC: Índice de Masa Corporal.

METs: Metabolic equivalent.

PA: Physical Activity.

R-AN: Restrictive Anorexia Nervosa.

SD: Standard Deviation.

SWM: Sensewear Mini Armband.

TCA: Trastornos de la Conducta Alimentaria.

TCNE: Trastornos de la Conducta Alimentaria No Especificados.

TPED: Treatment Program for Eating Disorders.

INTRODUCCIÓN [INTRODUCTION]

Definition of eating disorders (EDs) and anorexia nervosa (AN)

EDs are mental disorders characterized by a pathological eating behavior and an obsession with weight control that causes a significant deterioration in both, the physical and psychosocial health of the person (1). EDs are biopsychosocial illnesses since they have a multifactorial origin due to the interaction of different biological, psychological, family and sociocultural causes (2–4).

AN and bulimia nervosa are the best known eating disorders and have a prevalence of 0.7% for AN, 4.6% for bulimia nervosa and for other specific eating disorders 11.2% (5). Although adolescence is the period when these illnesses generally appear, an increase in the prevalence rate of childhood AN has recently been worldwide observed (5–7).

AN is characterized by a restriction of energy intake leading to significantly low body weight, an intense fear of gaining weight, and a distorted body self-perception or a persistent lack of recognition of the severity of low body weight. Within AN there are two subtypes: restricting, where weight loss is mainly due to diet, fasting and/or excessive exercise; and binge-eating/purging, where the person has had recurrent episodes of binge eating or purging behaviour during the last 3 months. Within the specified EDs we find atypical AN, a diagnosis in which all of the criteria for anorexia nervosa are met, except that despite significant weight loss, the person's weight is within or above the normal range (1).

Clinical manifestations of AN

Nutritional status and body composition

Assessing nutritional status is essential in patients with AN, being evaluated through various indicators such as body composition, analytical or functional values (8). Due to energy restriction, AN leads to a state of undernutrition that is associated with severe physical complications, such as cardiovascular, biochemical, hematological, and neuronal abnormalities, along with loss of bone density, fat mass, and fat-free mass (7,9–13). All of them can justify the high mortality rate in this illness, being the highest

of all psychiatric disorders (14–16). In turn, they are related to a high comorbidity, the most frequent disorders being: depression, anxiety, obsessive compulsive disorder, substance abuse and mood disorders (7,17). Therefore, there is an urgent need for sustained medical treatment to help achieve a successful treatment result (8,11,17).

Energy expenditure and physical fitness

Restlessness and the urge for movement, generated at some point during weight loss, are commonly found patterns in AN (18,19). Thus, the evaluation of energy expenditure becomes relevant during the treatment. Denial of having the illness is also a common process that we find in this population (20). For this reason, subjective measurements can underestimate the energy expenditure actually performed, leading to a significant bias and, therefore, to the inaccuracy of the data on its extent and its role in the outcome of the treatment (21). Consequently, a concise objective assessment of energy expenditure in patients with AN is important, as it can help identify those with a higher level of energy expenditure and design specific treatment strategies (21–23).

Physical fitness is closely related to adolescents' health and it is, therefore, a crucial indicator for assessing their health (24–27). There are few studies that have evaluated the physical fitness in patients with AN (28,29), and it has been observed that in adult patients, the physical fitness is lower than the healthy controls even after weight restoration (28). For this reason, the evaluation of physical fitness in children and adolescents with AN is of great interest to determine its relationship with nutritional status and to opt for undernutrition screening tests that are simple, practical, low-cost and easily accessible for these patients. [STUDY 1].

Quality of life

Patients with AN have a reduced quality of life, compared to the healthy population and other psychiatric disorders, which continues over time (30–32). A poorer quality of life, especially psychological impairment, can contribute to feelings of hopelessness, burden, and desires to escape reality and thus represent a mechanism through which the severity and chronicity of this eating disorder foment ideation suicide (33). Moreover, it has been shown that sleep disorders are highly correlated with AN and that there are several affected areas of sleep in this population compared to the healthy population (34,35), resorting in this way to medication to solve this alteration. Accordingly, this illness

constitutes a public health problem since it usually takes a chronic and disabling course with relapses, increasing the difficulty and time of treatment with a poor quality of life, and increasing the costs of medical care (30,31).

The somatic and mental consequences of having AN for a prolonged period at an early age are important and consequently have a deleterious effect in later adult life (7). For this reason, early diagnosis and early detection of undernutrition in patients with AN could be the only way to prevent an alteration in physical development, in order to apply a refeeding protocol in hospital treatment in the shortest possible time (7,32,36).

Treatment in AN

A short stay in hospital for weight stabilization followed by day hospital treatment has been suggested to be as effective as long-term inpatient treatment for children and adolescents with AN, provided that there is continuity in therapists responsible and whether there is sufficient support from family members (37,38). For this reason, the majority of treatment guides in different countries for children and adolescents propose a more intensive care at the beginning, followed by a graduated procedure of partial hospital treatment programs and finally outpatient (39). In addition, the British guide and, consequently, the Spanish guide, advise admitting children and young people in an environment with age-appropriate facilities, which are close to their home and have the capacity to provide appropriate educational activities (40,41).

Regardless of the intervention, only about half of the patients who develop the illness achieve a full long-term recovery (7,42,43). In consequence, studies are needed that can reveal the needs, objectively measured, that exist in conventional hospital treatments in the early stages to treat children and adolescents with AN. [STUDIES 2 and 3].

Physical exercise in AN

Being physically active on a regular basis is part of a healthy lifestyle and has positive effects on physical and mental health (44–46). However, exercise can become dysfunctional in AN (47). A common and distinctive symptom known for over 100 years is excessive physical activity despite severe emaciation in these patients (48,49). It

has been confirmed that the greater physical exercise in AN, the greater the psychopathological severity, and therefore, it can be considered as an indicator of the severity of the illness (49–51). In the 1980s and 1990s, the first treatment approaches were implemented to reduce daily physical activity and compulsive exercise behavior, such as one hour of supervised bed rest after meals (52,53).

In the last 20 years, there has been a growing interest in the evidence and implementation of exercise as complementary treatment among people with AN (54,55). These patients could benefit from structured exercise sessions as long as they are in combination with supervision and nutritional assistance (55–59). Different types of exercises have been suggested as safe and beneficial. For example, individualized yoga decreased the symptomatology after two months in adolescents and was maintained one month after the intervention (60). In others studies, yoga was also able to reduce anxiety, depression and altered body image (61,62). While a light resistance exercise program showed no changes compared to conventional treatment in adolescents (63), positive effects on physical strength were found in adults hospitalized with AN (64). However, a high-intensity resistance exercise program effectively and safely improved muscular strength in adolescents with AN, as well as their ability to perform daily tasks (65), and increased skeletal muscle mass (66). [STUDY 4].

Pilates is a training method that combines mind-body exercises in which core stability, strength and flexibility are required, and where special attention is paid to muscle control, posture and breathing (67). Current scientific literature shows the positive effects of Pilates on muscle strength and function, balance, neuromuscular stimulation and cardiorespiratory capacity both in healthy and in different clinical populations (68–75). There are studies where it has also been observed that it can improve the quantity and quality of sleep (76–79). Likewise, Pilates has been shown to improve quality of life, depression, anxiety, and increase body awareness in different populations (68,74,75,79–81). There are studies where Pilates has improved positively perceived body image, thus increasing satisfaction with body self-image (82,83). However, there are no studies that have investigated the effects of Pilates in adolescents with AN. Therefore, understanding the feasibility, safety and effects of a Pilates program in this population represents an opportunity for public health and the scientific community. [STUDIES 5 and 6].

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OBJETIVOS

El objetivo general de la presente Tesis Doctoral fue analizar los niveles de composición corporal, el gasto energético, la condición física, la calidad de vida y otras variables relacionadas con la evaluación de los síntomas de los trastornos alimentarios en el tratamiento de adolescentes con anorexia nerviosa, así como estudiar la seguridad, viabilidad y el efecto de un programa de Pilates en el tratamiento de estas adolescentes.

Los objetivos específicos de la presente Tesis Doctoral Internacional fueron:

- Determinar si la condición física está relacionada con el estado nutricional en una muestra de adolescentes con anorexia nerviosa, contrastar las pacientes nutridas versus las desnutridas y comparar la condición física en estas pacientes con datos normativos de sujetos sanos estratificados por edad y género [ESTUDIO 1].
- Analizar la evolución clínica y física en adolescentes con anorexia nerviosa restrictiva tras 10 semanas de un programa de hospital diurno [ESTUDIO 2].
- Analizar la evolución clínica, psicopatológica, física y el sueño en adolescentes con anorexia nerviosa restrictiva tras 10 semanas de un programa de hospital diurno [ESTUDIO 3].
- Proporcionar una revisión de la literatura científica sobre la actividad física, el ejercicio y su aplicación en el tratamiento de los trastornos de la conducta alimentaria [ESTUDIO 4].
- Evaluar la seguridad de un programa de Pilates en adolescentes con anorexia nerviosa analizando la composición corporal y el análisis de sangre, investigar la viabilidad del programa y analizar el efecto sobre los parámetros físicos y del sueño [ESTUDIO 5].
- Examinar la aceptabilidad de un programa de Pilates en una muestra de niñas y adolescentes con anorexia nerviosa mediante la evaluación del estado psicopatológico, las alteraciones en la percepción de la imagen corporal y la calidad de vida relacionada con la salud después de 10 semanas [ESTUDIO 6].

AIMS

The overall objective of the present Doctoral Thesis was as to analyze the levels of body composition, energy expenditure, physical fitness, quality of life and other variables related to the evaluation of the symptoms of eating disorders in the treatment of adolescents with anorexia nervosa, as well as to study the safety, feasibility and effect of a Pilates program in the treatment of these adolescents.

The specific objectives of the present International Doctoral Thesis were:

- To determine whether physical fitness is related to nutritional status in a sample of female adolescents with anorexia nervosa, to contrast the nourished versus undernourished patients and to compare the physical fitness in these patients with normative data of healthy subjects stratified by age and gender [STUDY 1].
- To analyze the clinical and physical fitness evolution of adolescents with restrictive anorexia nervosa after 10 weeks of a daytime hospital program [STUDY 2].
- To analyze the clinical, psychopathological, physical, and sleep-related evolution of adolescents with restrictive anorexia nervosa after 10 weeks of a daytime hospital program [STUDY 3].
- To provide a review of the scientific literature on physical activity, exercise and its application in the treatment of eating disorders [STUDY 4].
- To evaluate the safety of a Pilates program in female adolescents with anorexia nervosa by analyzing body composition and blood analysis, to investigate the feasibility of the program, and to analyze the effect on the physical and sleep parameters [STUDY 5].
- To examine the acceptability of a Pilates program in a sample of female children and adolescents with anorexia nervosa by evaluating the psychopathological status, alterations in the perception of body image and health-related quality of life after 10 weeks [STUDY 6].

MATERIAL Y MÉTODOS [MATERIAL AND METHODS]

La sección de material y métodos de la presente Tesis se resume en la siguiente tabla que incluye la información metodológica más relevante de los trabajos que la componen.

Table 1. Summary table of the main methodology used in the current Thesis.

	Paper	Type	Participants	Intervention	Main outcomes	Methods
1	Physical fitness and nutritional status in female adolescents with anorexia nervosa.	CS	15 ♀ adolescents with AN.	No.	Nutritional status (body mass index z-score, fat mass, fat free mass, albumin, lymphocyte and cholesterol), physical fitness.	Bioelectrical impedance, Anthropometry, Blood samples, ALPHA-Fitness Battery.
2	Clinical and physical fitness evolution in adolescents with restrictive anorexia nervosa after 10 weeks participating in a day hospital program.	LS	14 ♀ adolescents with restrictive AN.	Day hospital program for the treatment of eating disorders. 10 weeks.	Anthropometric parameters (weight, height and body mass index), blood parameters, physical fitness.	Anthropometry, Blood samples, ALPHA-Fitness Battery.
3	Clinical, Psychopathological, Physical, and Sleep Evolution in Adolescents with Restrictive Anorexia Nervosa Participating in a Day Hospital Program.	LS	14 ♀ adolescents with restrictive AN.	Day hospital program for the treatment of eating disorders. 10 weeks.	Body composition, psychiatric symptoms of AN, body image disturbance, physical activity, sleep.	Bioelectrical impedance, Anthropometry, Eating Disorder Inventory-3, Contour Drawing Rating Scale, Multisensory-activity monitor.
4	Ejercicio físico como herramienta para el tratamiento de los trastornos de la conducta alimentaria.	LR	No.	No.	Eating disorders, exercise, treatment.	Evidence-base.
5	Feasibility and effect of a Pilates program on the clinical, physical and sleep parameters of adolescents with anorexia nervosa.	LS	12 ♀ adolescents with AN.	10 weeks, 3 times per week, 60 minutes of Pilates program.	Body composition, blood parameters, sedentary time, physical activity, sleep, physical fitness.	Bioelectrical impedance, Anthropometry, Blood samples, Multisensory-activity monitor, ALPHA-Fitness Battery.

Table 1. (cont.).

	Paper	Type	Participants	Intervention	Main outcomes	Methods
6	Psychopathology, Body Image and Quality of Life in Female Children and Adolescents With Anorexia Nervosa: A Pilot Study on the Acceptability of a Pilates Program.	LS	12 ♀ adolescents with AN.	10 weeks, 3 times per week, 60 minutes of Pilates program.	Anthropometric parameters (weight, height and body mass index), psychiatric symptoms of AN, body image disturbance, quality of life.	Anthropometry, Eating Disorder Inventory-3, Contour Drawing Rating Scale, KIDSCREEN-27.

♀: female. CS: Cross-sectional study. LS: Longitudinal study. LR: Literature Review. AN: Anorexia Nervosa.

RESULTADOS Y DISCUSIÓN [RESULTS AND DISCUSSION]

Los resultados y discusión de los trabajos que componen la presente Tesis se presentan en la forma que han sido previamente publicados/sometidos.

ESTUDIO 1 [STUDY 1]

Physical fitness and nutritional status in female adolescents with anorexia nervosa.

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ORIGINAL

Physical fitness and nutritional status in female adolescents with anorexia nervosa

Aptidão física e estado nutricional em adolescentes do sexo feminino com anorexia nervosa

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ABSTRACT

Objective

This study aimed to determine whether physical fitness is related to nutritional status in a sample of female adolescents with anorexia nervosa, to contrast the nourished and undernourished patients, and to compare the physical fitness in these patients with normative data of healthy subjects stratified by age and gender.

Methods

Nutritional status was determined using the body mass index Z-score, fat mass, fat-free mass (bioelectrical impedance analysis), and the Controlling Nutritional Status score in 15 anorexic adolescents with 14.3±1.6 years. Physical fitness was assessed using the ALPHA-Fitness Battery (handgrip strength, standing broad jump, 4x10m shuttle run, and 20m shuttle run tests).

Results

Handgrip strength was significantly associated with all variables of nutritional status, except with the three blood components of the Controlling Nutritional Status score. The undernourished anorexic patients showed significantly worse physical fitness than the nourished anorexic patients in all tests, except in the standing broad jump and the 4x10m shuttle run tests. The physical fitness tests of the female anorexic adolescents showed scores significantly worse than those of the normative European female adolescent population.

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Conclusion

The observation of female adolescents with anorexia nervosa showed associations between higher physical fitness levels and better nutritional statuses. Handgrip strength and 20m shuttle run tests may be options of additional indicators of undernutrition in anorexic female adolescents. The undernourished anorexic patients showed worse physical fitness than the nourished ones. According to normative data for healthy sex- and age-matched adolescents, physical fitness is severely impaired in anorexic female adolescents.

Keywords: Anorexia Nervosa. Exercise test. Female adolescents. Muscle strength. Nutritional status.

RESUMO

Objetivo

Este estudo teve como objetivo determinar se a aptidão física está relacionada ao estado nutricional em uma amostra de adolescentes do sexo feminino com anorexia nervosa, contrastar pacientes nutridas versus desnutridas e comparar a aptidão física nesses pacientes com dados normativos de indivíduos saudáveis estratificados por idade e gênero.

Métodos

O estado nutricional foi determinado pelo escore Z do índice de massa corporal, massa gorda e massa livre de gordura (análise de impedância bioelétrica) e pelo escore do Estado Nutricional Controlador em 15 adolescentes anoréxicas com 14,3±1,6 anos. A aptidão física foi avaliada usando a Bateria ALPHA-Fitness (força de preensão manual, salto em distância em pé, corrida com vaivém 4x10m e corrida com vaivém de 20m).

Resultados

A força de preensão manual foi significativamente associada a todas as variáveis do estado nutricional, exceto aos três componentes sanguíneos do escore do Estado de Controle Nutricional. As pacientes anoréxicas desnutridas mostraram uma aptidão física substancialmente pior do que as pacientes anoréxicas nutridas em todos os testes, exceto nos saltos em pé em posição ampla e nos testes de corrida em 4x10m. Os testes de aptidão física dos adolescentes anoréxicos do sexo feminino apresentaram escores consideravelmente piores do que os da população adolescente europeia normativa.

Conclusão

Adolescentes do sexo feminino com anorexia nervosa apresentaram associação entre maiores níveis de aptidão física e melhor estado nutricional. Os testes de força de preensão manual e corrida de lançadeira de 20m podem ser alternativas como indicadores adicionais do estado de desnutrição em adolescentes anoréxicas. As pacientes anoréxicas desnutridas demonstraram pior condicionamento físico do que as pacientes anoréxicas nutridas. Segundo dados normativos para adolescentes saudáveis de acordo com o sexo e a idade, a aptidão física é gravemente prejudicada em adolescentes anoréxicas do sexo feminino.

Palavras-chave: *Anorexia nervosa. Teste de esforço. Adolescentes femininas. Força muscular. Estado nutricional.*

INTRODUCTION

Anorexia Nervosa (AN) is a psychiatric disorder characterized by a persistent alteration in the pattern of food intake, an intense fear of weight gain, and a disturbed body image, which in turn produces a physical and psychosocial deterioration [1]. The presence of comorbidity is common, and the prognosis can be negative if it is not diagnosed soon, with high mortality levels [1,2]. Currently, the lifetime prevalence of AN in the general population is estimated to be around 1% in female individuals and it usually appears during adolescence [2]. Anorexia nervosa constitutes a public health problem, as it may result in a prolonged clinical course and tends to become chronic.

Malnutrition, or undernutrition, is defined as a state resulting from the lack of intake or uptake of nutrition that leads to altered body composition (decreased fat free mass) and body cell mass, leading to diminished physical and mental function and impaired clinical outcome [3]. A series

of characteristic physical manifestations appear in AN patients as a consequence of undernutrition [4]. Among the most frequent are a decrease in bone mineral density, weakness of limb musculature, bradycardia, increased aortic stiffness, gastrointestinal symptoms, amenorrhea, syncope, and dizziness [2]. In addition, malnutrition can produce alterations in blood analysis as a decrease in biochemical or hematological nutritional parameters and, for this reason, screening tools have been created for the detection of hospital malnutrition [5-7]. Identifying undernutrition in AN patients is of vital importance in order to apply a refeeding protocol in the shortest time possible and reverse any negative effects [2].

Physical fitness is closely related to adolescent health [8] and decreased risk of chronic disease and premature death [9]. It is important to emphasize that the level of physical fitness in children and adolescents tends to continue into adulthood [10]; therefore, physical fitness is a crucial indicator to evaluate a person's health. Consequently, an evaluation of the level of physical fitness in children and adolescent is of great interest from the perspective of clinical and public health [8].

Anorexia nervosa is a physically debilitating disorder; however, to our knowledge, only one study has evaluated physical fitness in adult female patients with AN before and after weight restoration [11], and no such studies have been conducted on adolescents. There are also no studies that compare the physical fitness of this clinical population with normative data for healthy individuals. Consequently, the objectives of the current study were: (1) to determine whether physical fitness is related to nutritional status in a sample of female adolescents with AN and to contrast the nourished versus undernourished patients; and (2) to compare the physical fitness in these patients with normative data of healthy subjects stratified by age and gender.

METHODS

The Research Ethics Committee of the University Hospital Complex of Huelva approved this study (PI 005/16), (Identifier: NCT03667183) and followed the Declaration of Helsinki, last modified in 2013. An experienced psychiatrist followed the clinical criteria of the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) [1] and an endocrinologist was in charge of the evaluation and the medical and nutritional follow-up of the patients. All female patients between 10 and 17 years old with a clinical diagnosis of AN (n=24) from Child-Mental Health Unit of the Vázquez Díaz Hospital (Huelva, Spain) were informed about the study and fifteen subjects agreed to participate. The following inclusion criteria were followed: (1) clinical diagnosis of AN in the aforementioned hospital; (2) aged 10 to 17 years old; (3) approval of the medical team through analytical control and weight stability to perform the tests; and (4) written informed consent by the patients and their legal guardians. The following exclusion criteria were followed: (1) having other diagnoses of mental illness; and (2) consumption of narcotic toxins. All patients were assessed by the same researcher to reduce inter-examiner error.

This observational study was conducted between April 2016 and May 2017. For each participant, a visit was scheduled in which the sociodemographic data, anthropometric data, and blood chemistry work were examined. One week later, the patients underwent physical tests in a specific room conditioned for that purpose. All tests were supervised by qualified health personnel.

We used the InBody 770 (Inbody Co., LTD, Seoul, Korea) to measure weight, fat mass, and fat-free mass through Bioelectrical Impedance Analysis (BIA). In patients with AN, it has been found that multifrequency and octopolar bioelectrical impedance is a method with high reliability

and precision [12], as is the case with InBody 770. This body composition analyzer has already been validated in children and adolescents [13]. A balance with an incorporated stadiometer (Detecto 439; Detecto, USA) was used following standard procedures to measure the height to the nearest 0.1 cm with barefoot subjects. In addition, Tanner stages [14] were used to assess pubertal development in the first assessment. Body Mass Index (BMI) was calculated with the following formula: {BMI =Body Mass (kg)/Height $(m)^2$}.

After an overnight fasting of at least 9 hours, samples of venous blood were collected. We evaluated two biochemical parameters (serum albumin and total cholesterol) and one immunological parameter (total lymphocyte count) [5]. Serum albumin and total cholesterol were analyzed using the Cobas 8000/C702 analyzer (Roche Diagnostics, Mannheim, Germany), and total lymphocyte count was analyzed using the Sysmex XN modular system (Sysmex, Kobe, Japan).

Physical fitness was evaluated using the extended version of the ALPHA-Fitness Battery (Assessing Levels of Physical Activity and Fitness), which comprises 4 tests [15]. Detailed descriptions of the procedures followed in each test are available elsewhere [14]. In short, two of the tests evaluate muscular fitness, which include handgrip strength for upper body strength and standing broad jump for lower body strength.

The handgrip strength was measured using a hand dynamometer with an adjustable grip (TKK 5101 Grip D; Takey, Tokyo, Japan), and the average of the two hands was calculated.

In the standing long jump test, the participants had to jump as far as possible, pushing off vigorously and landing with their feet together. The total distance was measured from the take-off line to the back of the foot on landing. The 4x10-m shuttle run test was used to evaluate motor fitness. Participants had to run as fast as possible from the start line to the opposite end line, separated by 10 meters, and return. Finally, the 20-m shuttle run test was used to evaluate cardiorespiratory fitness. In this test, the participants had to run a distance of 20m, while keeping pace with a pre-recorded audio CD. The initial speed was 8.5km/h, increased by 0.5km/h per minute. The participants finished the test when they could not follow the audio's reference for the second time, or when the subject stopped due to fatigue. All these tests have shown a close relationship with the current and future health statuses of children and adolescents [15].

Normalized standardized values were calculated {Z-score=[mean-value] / Standard Deviation [SD]} for each physical fitness test according to gender and age [16]. In addition, a single muscular fitness Z-score was calculated as the mean of the two standardized scores from the muscular tests (handgrip strength and standing long jump), and the global physical fitness score was calculated as the mean of the four physical fitness Z-scores [17].

There is not only one indicator that can evaluate the nutritional status, so its diagnosis should take several parameters into account [18]. It has been suggested that the Z-score of the BMI is more valid than the BMI in children and adolescents [19,20], and it has been used as a measure in pediatric clinical populations [4]. Carrascosa's, *et al.* reference values [21] were used to transform the BMI into the Z-scores of the BMI according to age and gender. The fat and fat-free mass have been used as measures of body composition in patients with anorexia nervosa [22] since there is a chronic decrease in these patients' body energy reserve [23] due to unusual eating habits, restricted food consumption, and excessive physical activity. Absolute values were used as in previous studies [24,25]. Likewise, we used the Controlling Nutritional Status (CONUT) score, which includes measures of serum albumin, total cholesterol, and total lymphocyte count, and it has demonstrated high sensitivity and specificity (92.3 and 85.0, respectively) as a tool for evaluating nutritional status [5]. Scores of 0 or 1 in the

CONUT are considered normal values and values equal or greater than 2 might be taken as evidence of different levels of undernutrition. Therefore, to discriminate the existence of undernourishment, our subjects should meet at least one of the following criteria: value <-1.00 in BMI Z-score [18,19,26]; value <15th percentile in the fat and/or fat-free mass corresponding to their gender and age [27]; and/or score ≥2 in the CONUT [5].

The Statistical Package for Social Science (SPSS) was used to perform all statistical tests (IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.). Significance was set at $p<0.05$. The Shapiro-Wilk test was used to assess normality of distribution. The bivariate Spearman's correlation coefficients and linear regression analyses were used to evaluate the associations between the components of nutritional status and the physical fitness Z-scores. A model was created for each variable of the nutritional status, each of them being the dependent variable in each model, and the independent variables were the different physical tests in Z-scores that had significance in the correlation. The U Mann-Whitney test was used to evaluate the significant differences between nourished and undernourished patients. The physical fitness data obtained from the patients was compared with published normative data, where data from thousands of healthy adolescents from ten different European countries has been observed and collected. The normative data of the European adolescent female population [16] was used as a comparison to our sample and to determine possible significant differences. In addition, we calculated the percentile from the individual Z-value of each subject in each variable for which the Z-score was used, and an individual value under the 25th percentile of its gender- and age-matched norm value was defined as clinically different since it is considered low performance [28].

RESULTS

Fourteen of the fifteen subjects in the sample were diagnosed with AN-restricting subtype, and one was atypical AN, according to the DSM-V criteria [1]. The average age was 14.3 (±1.6) years, height 159.3 (±7.4) cm, and weight 46.4 (±8.8) kg. The average Tanner stage was 3.1 (± 0.9). There was no adverse effect after the tests were performed by the participants.

The simple correlation model for adolescent patients with AN revealed significant positive associations between handgrip strength and all variables of nutritional status, except with the three blood components of the CONUT (Table 1). Other significant positive correlations were also found between the fat-free mass with the 20-m shuttle run test, muscular fitness and global physical fitness, and lymphocytes with the 20-m shuttle run test and muscular fitness.

Table 1. Associations between the variables of nutritional status and physical fitness (Z-scores). *Huelva*, Spain, 2017.

Physical fitness	BMI Z-score	Fat mass	Fat-free mass	Albumin	Lymphocyte	Cholesterol
Handgrip strength	0.604*	0.529*	0.879**	-0.089	0.429	-0.170
Standing long jump	0.021	-0.171	0.432	0.213	0.379	0.038
4x10m shuttle run	0.304	0.307	0.396	-0.125	0.104	-0.002
20m shuttle run	0.079	-0.027	0.529*	0.198	0.447*	0.006
Muscular fitness[a]	0.346	0.168	0.700**	0.118	0.475*	-0.050
Global physical fitness[b]	0.364	0.268	0.718**	-0.007	0.407	-0.080

Note: *$p<0.05$; **$p<0.01$; Correlation values are Spearman correlation coefficients; [a]Mean of handgrip strength and standing long jump Z-scores; [b]Mean of the four physical fitness Z-scores.

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In the regression analysis, the independent variable "handgrip strength" explained 73.7% of the variance (R^2) in the model for fat-free mass (β=4.202, 95% Confidence Interval, 2.697-5.707, p<0.001) and it also explained 45.7% of the model for the BMI Z-score (β=0.463, 95% confidence interval, 0.160-0.765, p<0.006).

Undernourishment values (BMI Z-score, fat mass, fat-free mass, and the three blood components of the CONUT) indicated that 60% of the patients were undernourished. The variables of nutritional status and physical fitness used in the study are shown in Table 2. As far as physical fitness is concerned, there were significant differences between the groups in all the variables analyzed except for the standing broad jump and the 4x10-m shuttle run test.

The means of all the obtained scores of the ALPHA-Fitness Battery tests with the female adolescents with AN were significantly worse than the normative European female adolescent population [16] (Table 3). In addition, once we classified each participant according to their age and gender against the European reference values [16], most of the patients were below the 25th percentile in all the fitness tests studied (80% in the 4x10m shuttle run test, 73% in the 20m shuttle run test, 67% in the standing broad jump test, and 53% in the handgrip strength).

Table 2. Characteristics of the study sample by nutritional status. *Huelva*, Spain, 2017.

Variable	Nourished (n=6)	Undernourished (n=9)	*p*
Age (years)	14.9(1.5)	14.0(1.5)	0.157
Height (cm)	161.9(3.2)	157.5(9.0)	0.443
Weight (kg)	54.0(5.1)	41.4(6.9)	0.007
Nutritional status			
BMI Z-score	-0.2(0.6)	-1.1(0.7)	0.025
Fat mass (kg)	14.8(3.0)	9.6(4.3)	0.034
Fat-free mass (kg)	39.2(3.3)	31.8(4.5)	0.003
Serum Albumin (g/dL)	4.8(0.5)	4.9(0.5)	0.859
Total Lymphocytes/mL	1910.0(340.0)	1930.0(570.0)	0.906
Cholesterol (mg/dL)	174.0(33.8)	178.3(28.9)	0.860
Physical Fitness			
Upper muscular fitness (kg)	27.4(4.3)	19.1(2.4)	0.001
Lower muscular fitness (cm)	123.5(23.1)	108.0(16.5)	0.194
Motor fitness (s)[a]	14.3(1.2)	15.2(1.1)	0.175
Cardiorespiratory fitness (s)	182.7(55.5)	125.2(30.2)	0.045
Muscular fitness (upper+lower muscular fitness; Z-scores)	-0.2(0.9)	-1.3(0.5)	0.010
Global physical fitness (z-scores)[b]	-0.5(0.7)	-1.4(0.5)	0.018

Note: [a]Lower values indicate better performance; [b]Mean of the four physical fitness Z-scores; Data are shown as the Mean (Standard Deviation), unless otherwise indicated; Nutritional status differences were analyzed by the U Mann-Whitney test, with the variables of nutritional status and physical fitness as dependent variables.
BMI: Body Mass Index.

Table 3. Comparison of physical fitness with normative sample. *Huelva*, Spain, 2017.

Physical fitness	Female adolescents with AN (n=15)	European normative adolescent female sample (n=1845)	*p*
Handgrip strength (kg)	22.4(5.2)	26.1(4.8)	0.016
Standing long jump (cm)	114.2(20.2)	145.6(26.4)	0.001
4x10m shuttle run (s)[a]	14.8(1.2)	12.8(1.2)	0.001
20m shuttle run (stage)	2.2(0.8)	3.8(1.9)	0.001

Note: [a]Lower values indicate better performance; Data are shown as the mean (Standard Deviation), unless otherwise indicated.

DISCUSSION

This study is the first one examining the relation between the nutritional status of female adolescents with AN and their physical fitness. Its main findings highlight that handgrip strength was associated with all variables of nutritional status, except for the three blood components of the CONUT, explaining 74% and 46% in the regression analyzes for fat-free mass and Z-score of the Body Mass Index, respectively. Undernourished female adolescents with AN presented significantly lower upper muscular and cardiorespiratory fitness than did nourished female adolescents with AN. Adolescent patients with AN showed significantly worse physical fitness in all tests compared to that of the healthy female adolescent population matched by age.

Our results indicate that handgrip strength was positively related with three variables of nutritional status such as fat-free mass, fat mass, and BMI Z-score in our adolescent patients with AN. These findings are in line with another study conducted in healthy children and adolescents [29]. A study showed that handgrip strength was positively associated with serum levels of vitamin D [30]. It has also been observed that handgrip strength is a predictive factor for bone density in female adolescents and that having a low level of strength indicates poor health in terms of bone density [31]. It was also reported that the relation between handgrip strength and BMI allowed to discriminate between children with sarcopenic obesity and healthy children [32]. Therefore, our results and other studies suggest that the handgrip strength test can provide important health information about nutritional status in children and adolescent population.

It has been concluded that, among children and adolescents, handgrip strength can better assess malnutrition and it may be a potential marker of undernutrition in hospitalized patients [26]. Adolescent girls with low weight obtained lower levels of handgrip strength compared to girls with normal weights [33]; however, other studies found no differences in handgrip strength among female adolescents with low weight or normal weight, as well as those who are overweight [34]. This may be because low weights in this population do not necessarily mean that they suffer from undernutrition. Handgrip strength has been shown to be a functional method of nutritional assessment [35] and it might predict malnutrition in patients with Crohn's disease [36].

A high level of handgrip strength is strongly associated with better cardiovascular health [37]. The well-known strong positive correlations between fat-free mass and cardiorespiratory fitness [38] was also found in our results; however, we observed a moderate correlation between lymphocytes with cardiorespiratory fitness and muscle fitness. The muscular function responds more quickly to nutritional deprivation and nutritional repletion than the parameters of corporal composition such as muscle or corporal mass [39,40]; for this reason, it must be evaluated in patients with greater risks of undernutrition. Laboratory values are mostly delayed and costly, and largely dependent on the analytic method and the analyzing laboratory [40]. However, handgrip strength and 20m shuttle run tests are simple and non-invasive markers, which make them suitable for daily clinical practice, especially as they are easy to measure and very cost-effective [41,42]. Many hospitals and health care centers have spacious rooms where the 20-m shuttle run test could be performed, while the handgrip strength test would only require a dynamometer. In addition, these tests are quick to perform, even as they always require medical supervision. Therefore, the assessment of physical fitness, especially upper muscular fitness and cardiorespiratory fitness, seems to be a practical, simple, easily accessible, and low-cost alternative as additional indicators of undernutrition in female adolescents with AN, and thus are preferable in comparison with more expensive and complex methods.

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Undernourished anorexic patients showed worse nutritional status levels than the nourished anorexic patients in all variables, except for the blood components of the CONUT. This seems to be in line with Gómez-Candela *et al.* [43], that states that biological data in patients with AN are usually within the limits of normality, except when there are further complications. Undernourished anorexic patients showed worse physical fitness levels than nourished anorexic patients, except in the lower muscular and motor fitness. This finding is in agreement with a study in adults which reported that handgrip strength could differentiate between well-nourished and malnourished hospitalized patients and change with nutritional status [44].

By comparing each of the four physical tests of our sample of adolescents with AN and the European normative adolescent female population [16], we found that our patients were significantly worse in terms of all of the variables. Muscular fitness has been evaluated in adult female anorexic patients [11] and the values obtained were similar to those of our sample, but we must consider the age difference between the samples; thus, they should be compared with caution. A previous study concluded that muscular fitness is associated with a better state of physical health and that adolescents with better muscular performance have lower scores on the cardiovascular risk components [45]. Low levels of physical fitness in young people with a normal BMI but a high percentage of body fat seem to be partially mediated by lower skeletal muscle mass [46]. In addition, participation in organized sport is associated with greater physical fitness and better body composition among adolescents (lower BMI and body fat percentage) [47]. Likewise, we classified each patient according to age and gender in the European reference values, and we found that the majority of the patients were below the 25th percentile in all physical fitness tests. This is probably due to the consequent physiological deterioration of anorexia nervosa, with reduced muscle mass, bone mass, and connective mass when compared to the general population, which is reflected in physical fitness. Our results show that our AN population has worse physical fitness than healthy individuals of their age with an objectively measured physical disability. Thus, anorexia nervosa in female adolescents might be conceived as a physically debilitating disorder.

The current study has some limitations. First, the cross-sectional design means we cannot make cause-effect inferences. Second, there are known limitations of all nonprobability samples, such as their lower representativeness and unknown levels of sampling errors. Third, the relatively small size of our sample also limits its statistical power and the validity of the resulting data; however, as anorexia nervosa is an illness with low prevalence, it is difficult to get a large number of affected adolescents enrolled and to obtain the permission of their legal guardians. By its design, the present study does not include a prospective control group with which the data on nutritional status and physical fitness could be compared. To eliminate any selection bias, we chose to use normative data representative of larger population groups. Therefore, the references used are more representative of the population that does not suffer from eating disorders than if we had evaluated 15 adolescents who do not have this illness. This is the first preliminary study analyzing physical fitness levels in adolescents with AN. Future research initiatives should include a larger sample of adolescents with AN and perform the assessment of other anthropometric variables such as the forearm circumference. As a strength, however, our study measured all values of body and blood composition and physical fitness objectively.

CONCLUSION

Female adolescents with anorexia nervosa showed associations between higher physical fitness levels and better nutritional status. Handgrip strength and 20m shuttle run tests may be additional indicators of the state of undernutrition in anorexic female adolescents. The undernourished anorexic

patients showed worse physical fitness than the nourished ones. According to normative data for healthy sex- and age-matched adolescents, physical fitness is severely impaired in anorexic female adolescents.

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CONTRIBUTIONS

SM MARTÍNEZ-SÁNCHEZ conceived and designed the research, conducted the experiments, analyzed and interpreted the data, wrote the manuscript and revised. TE MARTÍNEZ-GARCÍA conceived and designed the research, analyzed and interpreted the data, and revised. D MUNGUÍA-IZQUIERDO conceived and designed the research, conducted the experiments, analyzed and interpreted the data and revised. All authors read and approved the final manuscript.

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ESTUDIO 2 [STUDY 2]

Clinical and physical fitness evolution in adolescents with restrictive anorexia nervosa after 10 weeks participating in a day hospital program.

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CLINICAL AND PHYSICAL FITNESS EVOLUTION IN ADOLESCENTS WITH RESTRICTIVE ANOREXIA NERVOSA AFTER 10 WEEKS PARTICIPATING IN A DAY HOSPITAL PROGRAM

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ABSTRACT

Objective*: To analyze the clinical and physical fitness evolution of adolescents with restricting-type of anorexia nervosa (AN-R) after 10 weeks of a daytime hospital program.*

Methods*: Height, weight, body mass index (BMI), blood analysis and physical fitness (ALPHA-Fitness Battery) were measured before and after 10 weeks of treatment.*

Results*: Fourteen female adolescents with AN-R (14.3 ± 1.6 years old) participated in this observational study. A significant increase was found in weight (P = 0.009), height (P = 0.003) and body mass index (P = 0.019). Concerning the blood analysis, significant decreases were observed in the mean corpuscular volume (P = 0.020), albumins (P = 0.041) and thyroxine (P = 0.008), while a significant increase was found in the lymphocytes (P = 0.026). Regarding physical fitness, a significant increase in the left handgrip strength was found (P = 0.050).*

Conclusions*: After 10 weeks of follow-up in adolescent patients with AN-R who participated in a day hospital program, there were a positive evolution of anthropometric parameters, blood values and an increase in the left handgrip strength. The non-dominant hand grip strength seems to be the first thing that improves physical fitness after refeeding in female adolescents with AN-R.*

Keywords: *restrictive anorexia nervosa, adolescents, physical fitness, handgrip strength, blood analysis.*

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Introduction

Anorexia nervosa (AN) is a psychiatric disorder that is prone to chronification and is associated with an increased mortality risk[(1)]. It usually appears during the adolescence stage, with prevalence rates of approximately 0.7% in adolescents[(2)]. Unlike the AN binge-purge subtype, the restrictive subtype of AN (AN-R) occurs when weight loss is mainly due to fasting, diet and/or excessive exercise, being more discrete and extreme cases of reduced intake, as well as more chronic energy reduction[(3)]. Differences in body composition and biological parameters have been demonstrated between the subtypes of AN[(4,5)].

A concern of the clinicians who assist these patients is the initial evaluation and their evolution of the nutritional status during the refeeding[(6)].

Although there is no consensus on treatment protocols regarding refeeding practices, the importance of adequate refeeding strategies for body weight restoration in this population is clears[(7,8)]. Restoring optimal weight in patients with AN-R is the key to avoiding serious physical complications in the hematological system, the endocrine system, the musculoskeletal system and linear growth[(9)]. Therefore, monitoring these systems during the refeeding process, especially in the early stages, is essential among these patients. Although there is no superior

treatment setting for AN (outpatient, inpatient, reduced length of inpatient followed by outpatient, or partial hospital care)[10], programs based on cognitive behavioral treatment, together with family support, seem to be effective and have been recommended in the treatment of adolescents with AN[11].

There are few data available on the different health-related physical fitness components of patients with AN[12-19] although the low weight in these patients has consequences on the musculoskeletal system[9]. As far as we know, in the last fifteen years, there has been only one study that has evaluated physical fitness in adult patients with AN before and after weight restoration[13]. However, there are no studies that have evaluated changes in physical fitness in adolescents with AN-R during refeeding.

Therefore, the objective of the present study was to analyze the clinical and physical fitness evolution of adolescents with AN-R after 10 weeks of a daytime hospital program. We hypothesized that after the hospital program it would improve the parameters evaluated in adolescents with AN-R.

Methods

Participants

This study was approved by the Research Ethics Committee of the University Hospital Complex of Huelva (PI 005/16) and registered in www.clinicaltrials.gov (Identifier: NCT03667183), and it followed the guidelines of the Declaration of Helsinki, last-modified in 2013. All female consecutive participants between 10 and 17 years old with restricting-type AN (n= 23), who were diagnosed according to the clinical criteria of the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5)[3] and who were included in the day hospital program (DHP) of the Treatment Program for Eating Disorders (TPED) were recruited from the Children's Mental Health Unit of the Vázquez Díaz Hospital (Huelva, Spain). Fourteen subjects agreed to participate, and they and their parents signed written informed forms.

The inclusion criteria were as follows:

• clinical diagnosis of restricting-type AN in the aforementioned hospital;

• aged from 10 to 17 years old;

• the medical team indicated that patients were under analytical control and had sufficient body mass stability to perform the tests;

• written informed consent of the patients and their legal guardians was provided.

The exclusion criteria were:

• having other mental health diagnoses;

• consumption of narcotic drugs. All patients were assessed by the same researcher to reduce interexaminer error.

Treatment description

The DHP of the TPED is a program that has been held at the Child-Mental Health Unit of the Vázquez Díaz Hospital (Huelva, Spain) since 2001. The multidisciplinary team is composed of eleven specialized eating disorders (EDs) health professionals (one psychiatrist, one endocrinologist, three nurses, four nursing assistants, one occupational therapist and one social worker) together with a professor and an administrative officer. The main objective of the program is to reduce the problematic food-related symptoms, such as restriction, binging and purging, of children who need intensive treatment without being totally hospitalized. The DHP characteristics of TPED are described in the Supplementary material 1.

Procedure

This observational study was carried out within a TPED day hospital framework between May 2016 and October 2017 and consisted of four visits to the hospital. In the first visit (baseline), anthropometric data and blood chemistry were examined. The second visit was the following week and they performed physical tests. The procedure was repeated 10 weeks later. The delay between admission to the hospital and baseline assessment averaged 48.7 (±11.6) days. All measurements and tests were collected and supervised by qualified personnel.

Clinical measures

Weight and height were measured barefoot and in underwear to the nearest 100 gr and 0.1 cm following standard procedures using a balance with an incorporated stadiometer (Detecto 439; Detecto, USA). In addition, Tanner stages were used to assess pubertal development[20]. Body mass index (BMI) was calculated as body mass (kg) divided by height (m) squared.

Blood analysis. Venous blood samples were obtained after an overnight fast of at least 9 hours to study the blood biochemical composition. Platelet, red blood cell (red blood cells, hemoglobin, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin concentration and red blood cell dispersion) and white blood cell (leukocytes, lymphocytes

and neutrophils) analyses were performed by using a Sysmex XN modular system (Sysmex, Kobe, Japan). Glucose, total cholesterol, triglycerides, total proteins, albumins, prealbumins, transferrin, transferrin saturation index, ferritin, urea, creatinine and creatinine kinase analyses were performed by using a Cobas 8000/C702 analyzer (Roche Diagnostics, Mannheim, Germany). Iron, sodium, potassium, calcium, phosphorus and magnesium were analyzed by using a Cobas 8000/ISE analyzer (Roche Diagnostics, Mannheim, Germany). Vitamin D analysis was performed by using a DiaSorin Liaison XL analyzer (DiaSorin, Stillwater, MN, USA), and hormones (thyrotropin, thyroxine, prolactin, follitropin, lutropin, estradiol and testosterone) were analyzed by using a Cobas 8000/602 analyzer (Roche Diagnostics, Mannheim, Germany).

Physical fitness

We used the extended version of the ALPHA-Fitness Battery (Assessing Levels of Physical Activity and Fitness), which is composed of 4 tests[21]. Detailed descriptions of the procedures followed for each test are available elsewhere[20]. Briefly, the handgrip strength test (the average score of the left and right hands) evaluates upper body strength, the standing broad jump test evaluates lower body strength, the 4x10 m shuttle run test evaluates motor fitness, and the 20 m shuttle run test evaluates cardiorespiratory fitness. Standardized values were calculated {z-score =((mean-value))/(standard deviation (SD))} for each physical fitness test according to gender and age[22]. In addition, a single muscular fitness z-score was calculated as the mean of the two standardized scores from the muscular tests (handgrip strength and standing long jump), and the global physical fitness score was calculated as the mean of the four physical fitness z-scores.

Statistical analysis

All statistical tests were performed using SPSS (SPSS, IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.). Significance was set at $P \leq 0.05$. Due to the size of the sample, we assumed a nonnormal distribution; therefore, the Wilcoxon test was used to evaluate significant differences between baseline assessment and after 10 weeks, and when there was significance, the 95% confidence intervals (CI) for the differences were calculated. Data were also assessed for practical/clinical meaningfulness using an approach based on the magnitudes the changes observed. Cohen's d statistic determined the effect size of the standardized differences in the selected variables, and Hopkins' scale (23) and a customized spreadsheet[24] were used to determine the magnitude of the effect size. A practically worthwhile difference was assumed when the difference score of the between subject standard deviation was at least 0.2. Threshold values for Cohen's effect size were trivial (0.0-0.19), small (0.20-0.59), moderate (0.60-1.19), large (1.20-1.99), and very large (≥2.00). Quantitative chances of positive/trivial/negative difference were assessed qualitatively as follows: <25% unclear, 25 to 75% possibly, >75% likely, >95% very likely, and >99.5% almost certainly. A substantial difference was set at >75%.

Results

The average age of the 14 participants was 14.3 (± 1.6) years, and the average Tanner stage was 3.1 (± 1.0). No adverse events resulting from the tests performed by the participants.

The results of the clinical evolution of the patients after 10 weeks of the hospital program that were analyzed anthropometric parameters and blood analysis are shown in Table 1. Regarding anthropometric parameters, a significant, small standardized and substantial increase was found in weight ($P = 0.009$, 95% CI: -3.57 to -0.75) and body mass index ($P = 0.019$, 95% CI: -1.27 to -0.16). Moreover, there was a significant increase in height ($P = 0.003$, 95% CI: -1.27 to -0.37). Concerning the blood analysis, significant, small standardized and substantial decreases were observed in the mean corpuscular volume ($P = 0.020$, 95% CI: 0.28–3.54), albumins ($P = 0.041$, 95% CI: 0.04–0.47) and thyroxine ($P = 0.008$, 95% CI: 0.02–0.10), while a significant, small standardized and substantial increase was found in the lymphocytes ($P = 0.026$, 95% CI: -0.59 to -0.04). There was a moderately standardized and substantial increase in the mean corpuscular hemoglobin concentration and decrease in the red blood cell dispersion. A small standardized and substantial increase in glucose and a decrease in calcium were found. In addition, small standardized increases were observed in red blood cells, leukocytes, triglycerides, transferrin, lutropin and testosterone, and small standardized decreases were observed in prealbumins, ferritin, prolactin and follitropin (Table 1).

Outcome measures		Baseline (n=14)	After 10 weeks (n=14)	Standardized differences (90% CL)	Qualitative assessment[a]	
Anthropometric parameters:	Weight (kg)	45.2(7.8)	47.4(6.5)*	**0.28(0.14)**	**Likely positive**	**82/18/0**
	Height (cm)	158.9(7.6)	159.8(7.3)*	0.10(0.05)	Almost certainly trivial	0/100/0
	Body mass index (kg/m²)	17.9(2.6)	18.6(2.1)*	**0.27(0.17)**	**Likely positive**	**76/24/0**
Blood analysis:	Platelets (10^3/μL)	269.1(69.1)	25.7(65.4)	-0.15(0.30)	Possibly trivial	3/59/39
	Red blood cells (10^6/μL)	4.4(0.3)	4.5(0.3)	**0.27(0.49)**	Unclear	60/35/6
	Hemoglobin (g/dL)	13.0(1.0)	13.2(0.9)	0.18(0.44)	Unclear	46/46/8
	Hematocrit (%)	40.7(2.9)	40.6(1.9)	0.00(0.45)	Unclear	22/56/22
	Mean corpuscular volume (fL)	92.6(4.3)	90.7(3.6)*	**-0.42(0.29)**	**Likely negative**	**0/10/90**
	Mean corpuscular hemoglobin concentration (g/dL)	31.9(0.6)	32.4(1.1)	**0.70(0.78)**	**Likely positive**	**86/11/3**
	Red blood cell dispersion (%)	12.8(0.7)	12.3(0.6)	**-0.67(0.65)**	**Likely negative**	**02/09/89**
	Leukocytes (10^3/μL)	6.0(1.8)	6.4(1.3)	**0.29(0.35)**	Possibly positive	67/32/1
	Lymphocytes (10^3/μL)	1.9(0.5)	2.2(0.6)*	**0.53(0.42)**	**Likely positive**	**91/9/0**
	Neutrophils (10^3/μL)	3.5(1.5)	3.5(1.2)	0.09(0.39)	Unclear	31/59/11
	Glucose (mg/dL)	72.3(13.4)	77.6(8.2)	**0.38(0.41)**	**Likely positive**	**78/21/1**
	Total cholesterol (mg/dL)	175.9(30.8)	169.2(23.6)	-0.18(0.40)	Unclear	6/48/46
	Triglycerides (mg/dL)	61.1(21.4)	65.1(19.6)	**0.21(0.46)**	Unclear	51/42/7
	Total proteins (g/dL)	7.4(0.7)	7.3(0.4)	-0.06(0.31)	Unclear	8/70/23
	Albumins (g/dL)	4.8(0.5)	4.6(0.3)*	**-0.50(0.34)**	**Likely negative**	**0/7/93**
	Prealbumins (mg/dL)	24.5(4.4)	24.0(4.8)	**-0.29(0.59)**	Unclear	8/31/60
	Transferrin (mg/dL)	279.5(37.8)	287.3(27.2)	**0.22(0.31)**	Possibly positive	54/44/2
	Transferrin saturation index (%)	23.4(11.3)	21.1(8.1)	-0.11(0.46)	Unclear	12/51/37
	Ferritin (ng/mL)	63.5(77.1)	40.2(28.8)	**-0.27(0.27)**	Possibly negative	0/33/66
	Iron (μg/dL)	91.9(43.9)	83.9(32.3)	-0.11(0.44)	Unclear	12/53/35
	Sodium (mmol/L)	140.9(4.2)	141.1(1.4)	0.04(0.46)	Unclear	28/54/18
	Potassium (mmol/L)	4.3(0.5)	4.3(0.3)	-0.01(0.45)	Unclear	21/56/24
	Calcium (mg/dL)	9.7(0.5)	9.5(0.4)	**-0.41(0.46)**	**Likely negative**	**2/20/78**
	Phosphorus (mg/dL)	4.2(0.4)	4.3(0.5)	0.15(0.57)	Unclear	44/41/15
	Magnesium (mg/dL)	2.0(0.2)	2.0(0.1)	0.02(0.52)	Unclear	28/49/23
	Vitamin D (ng/dL)	28.0(9.8)	27.3(8.0)	-0.02(0.20)	Likely trivial	4/89/7
	Urea (mg/dL)	28.5(7.1)	27.7(4.7)	-0.12(0.47)	Unclear	12/49/39
	Creatinine (mg/dL)	0.6(0.1)	0.6(0.1)	-0.11(0.24)	Possibly trivial	2/73/25
	Creatinine kinase (U/L)	77.6(36.0)	76.2(36.2)	-0.14(0.30)	Possibly trivial	4/60/36
	Thyrotropin (μUI/mL)	2.4(1.3)	2.3(0.8)	0.03(0.23)	Likely trivial	10/85/5
	Thyroxine (ng/dL)	1.3(0.1)	1.2(0.1)*	**-0.44(0.26)**	**Likely negative**	**0/6/94**
	Prolactin (ng/mL)	16.2(6.7)	13.8(5.8)	**-0.31(0.31)**	Possibly negative	1/27/73
	Follitropin (mUI/mL)	6.3(2.7)	5.3(1.8)	**-0.23(0.43)**	Possibly negative	5/40/55
	Lutropin (mUI/mL)	9.5(13.6)	10.3(9.6)	**0.26(0.36)**	Possibly positive	61/37/2
	Estradiol (pg/mL)	74.1(98.2)	60.3(66.0)	0.12(0.49)	Unclear	39/48/13
	Testosterone (ng/mL)	0.2(0.1)	0.2(0.1)	**0.38(0.57)**	Possibly positive	70/25/5

Table 1: Clinical evolution between baseline assessment and after 10 weeks.
*Data are shown as the mean (SD), unless otherwise indicated. Clinical evolution differences between baseline assessment and after 10 weeks were analyzed by the Wilcoxon test. *$P \leq 0.05$. CL = Confidence Level.*
[a] A substantial difference was set at >75%.

Changes in physical fitness are shown in Table 2. A significant increase in the left handgrip strength was found (P = 0.050, 95% CI: -1.61 to -0.04), and small standardized increases were found in upper body muscular fitness and cardiorespiratory fitness. The left hand was the non-dominant hand of all study participants.

Discussion

This study analyzed the clinical and physical fitness evolution of female adolescents with restricting-type AN admitted to a day hospital program for 10 weeks. The main finding, in addition to the increase in body mass, was significant increase in the left handgrip strength (non-dominant hand).

Although both at the beginning and at the end of the study the values of red blood cell distribution were found to be normal, there was a decrease in the mean corpuscular volume and red blood cell dispersion and an increase in the mean corpuscular hemoglobin concentration and red blood cells counts. These changes could be related to the greater formation of the red blood cells by the bone marrow after adequate nutritional intake in these patients[25].

Outcome measures		Baseline (n=14)	After 10 weeks (n=14)	Standardized differences (90% CL)	Qualitative assessment[a]	
ALPHA-Fitness Battery:	Right handgrip strength (kg)	22.3(4.2)	23.1(3.8)	0.19(0.27)	Possibly trivial	46/52/1
	Left handgrip strength (kg)	20.6(4.0)	21.4(3.8)*	0.19(0.15)	Possibly trivial	46/54/0
	Upper muscular fitness (kg)[b]	21.5(3.8)	22.3(3.8)	**0.20(0.18)**	Possibly trivial	48/52/0
	Lower muscular fitness (cm)	111.0(16.5)	110.5(19.5)	-0.06(0.32)	Unclear	9/70/22
	Motor fitness (s)[c]	14.9(1.2)	14.8(1.0)	-0.10(0.32)	Unclear	6/64/30
	Cardiorespiratory fitness (s)	143.9(48.5)	153.8(49.1)	**0.20(0.30)**	Possibly positive	51/47/2
	Muscular fitness (upper + lower muscular fitness; z-scores)	-1.0(0.6)	-1.0(0.6)	0.10(0.22)	Likely trivial	23/76/2
	Global physical fitness (z-scores)[d]	-1.2(0.6)	-1.1(0.5)	0.15(0.19)	Likely trivial	33/67/0

Table 2: Changes in physical fitness between baseline assessment and after 10 weeks.
*Data are shown as the mean (SD), unless otherwise indicated. Changes in physical fitness between baseline assessment and after 10 weeks were analyzed by the Wilcoxon test. *$P \leq 0.05$. CL = Confidence Level.*
[a]A substantial difference was set at >75%. [b]Mean of the right and left handgrip strength. [c]Lower values indicate better performance. [d]Mean of the four physical fitness z-scores.

In other previous studies, researchers also reported that hemoglobin and mean corpuscular volume of adolescents with AN were within normal values and that no differences were observed between these adolescents and the healthy population[26]. Concerning lymphocytes, we observed a significant increase, despite being within normal values at both baseline and after 10 weeks, which could also be explained by nutritional recovery since it has been reported that hematological alterations disappear completely and rapidly after sufficient refeeding in patients with AN[27].

However, in another study, no significant changes were observed in the lymphocyte count in anorexic adolescents after a 10-week nutritional intervention[28]. We also observed that, even within normal values, a significant decrease in albumins occurred after our study intervention. It has been previously reported that weight gain significantly increased serum albumin levels[29]. However, this decrease could be explained by the increase of body water in our patients and by the increased protein consumption for the formation of body tissue, since an increase in albumin levels in people with AN is due to low-grade dehydration[29,30]. Thus, it has been suggested that albumin and prealbumin levels should not be markers to assess the nutritional status in adolescents with a restrictive eating disorder[30].

With regard to hormonal changes, we found a significant decrease in thyroxine, but no changes in thyrotropin, after 10 weeks. A possible explanation for the decrease in thyroxine could be due to metabolic recovery, after its conversion to triiodothyronine, in which there is still no recovery of the thyroid function of the hypothalamic-pituitary axis in the early stages of refeeding[31]. No significant changes were found in thyroxine or thyrotropin in young women who were admitted for refeeding for an average of 14 weeks[32]. However, in another previous study, a significant increase in thyrotropin was observed without changes in thyroxine in adolescents with AN admitted for weight recovery for one month[33]. This diversity of hormonal results may be due to alterations of the hypothalamic-pituitary-thyroid axis and euthyroid sick syndrome, alterations of the thyroid profile that may occur in chronic weight loss but that are normalized with weight recovery[34].

Of the few studies in the scientific literature that have evaluated physical fitness before and after weight recovery in this population, there are somewhat conflicting results because only a few components of physical fitness were investigated[12].

In our study, we obtained a significant improvement in the left handgrip strength that was the non-dominant hand, while Kratz & Roessner[35], although they also obtained an increase in maximum grip strength after 10 weeks, did not observe differences in grip strength between the right and left sides. However, Alberti et al.[13] evaluated six physical fitness tests and obtained an improvement in five of them after 20 weeks of treatment. This difference may be due to the difference in time periods evaluated in the studies. In fact, nutritional rehabilitation and weight recovery are not enough to produce a complete restoration of physical fitness in patients with anorexia nervosa per se because, according to the clinical evolution analysis, a long period of weight maintenance is required to regain normal physical fitness[12,13]. Therefore, the first thing to improve in terms of physical fitness after 10 weeks of refeeding in adolescents with AN-R seems to be the left handgrip strength, or the non-dominant hand in our study. Future studies could investigate whether it could be a simple and easy alternative test, rather

than other more invasive tests, to assess the evolution of refeeding in these patients.

The main strength of this study is that it is the first study to investigate physical fitness objectively in female adolescents with AN-R before and after weight gain. In addition, our sample was homogenous and comprised drug-free, restricting-type AN patients without comorbid depression or other mental health diagnoses. A confounding variable could have been the mean time between admission and baseline assessment. During this period, patients were already in a stage of active refeeding, and this was necessary so that patients could perform the physical tests in a safe manner under medical supervision. However, this study also has some limitations. First, it is a single-arm study, and therefore, no control group was used for comparison, resulting in time as the independent variable. Second, there are known limitations of all nonprobability samples, including the unknown levels of sampling errors and their lack of representativeness. Third, the relatively small size of our sample also limits its statistical power and the validity of the data; however, because AN-R is an illness with low prevalence, it is difficult to enroll a large number of affected adolescents in an intervention study for several weeks and obtain the consent of their legal guardians. Future research should include a larger sample of adolescents and control group to thoroughly validate our results.

Conclusions

After 10 weeks of follow-up in adolescent patients with AN-R who participated in a day hospital program, there was a positive evolution of anthropometric parameters (weight, height and BMI), blood lymphocytes and an increase in the left handgrip strength. The non-dominant hand grip strength seems to be the first thing that improves physical fitness after refeeding in female adolescents with AN-R.

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Note in the article " Supplementary material 1"
https://drive.google.com/file/d/1ToKR3U9uGSqRsBGxgPnI-7ros1VgkZ0KI/view?usp=sharing

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Supplementary material

Clinical and physical fitness evolution in adolescents with restrictive anorexia nervosa after 10 weeks participating in a day hospital program

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Supplementary material 1: Description of the Day Hospital Program (DHP) of the Treatment Program for Eating Disorders (TPED)

Description of the DHP of the TPED

Descriptor	Treatment Program for Eating Disorders
In operation since	2001
Days a week	5 (Monday to Friday; from 9 am to 21 pm)
Duration of treatment	18-20 weeks generally (depending on the individual evolution of each patient)
Treatment orientations	Cognitive behavior
Group/individual treatment	Mostly group (individual sessions in parallel with the psychiatrist and the staff in charge)
Group size	8-10
Group structure	Open
Behavioral contract	Yes (patients and legal guardians)
Inclusion criteria	DSM-5 eating disorder: AN, BN and EDNOS Patients between 0 and 16 years old State of severe malnutrition and/or somatic complications Negative attitude toward the ingestion of food Failure in outpatient treatment High probability of failure due to the degree of chronicity Excessive and uncontrolled physical exercise
Exclusion criteria	Acute medical risk that requires total hospitalization Acute risk of suicide and/or very serious psychopathology that requires total hospitalization Serious abuse of substances/toxins that clearly interfere with the normalization of weight, appetite and meal
Goals of treatment	Normalization of weight or weight gain (nutritional rehabilitation through adequate caloric intake) Reeducation and normalization of eating behavior Identification and resolution of perpetuating factors Control of constants and analytics according to patient's evolution Restoration and stabilization of healthy eating patterns (e.g., promoting a more social meal) Improvement of aspects associated with ED (emotional regulation, self-esteem, interpersonal relationships, motivation, etc.) Identification of the underlying pathological processes, both psychological and family relationships.
Weight control	Individual weight measurement twice a week (Monday and

	Friday)
Eating and compensation behavior	Meal plan Supervised meals Self-monitoring (food diary) Supervised cooking Psychoeducation
Body attitude	Body awareness group Positive reinforcement Clothing control Relaxation training
Coping skills	Social skills training Health education Food education Leisure activities weekly: visits to the beach, cinema, factories, etc.
Interpersonal functioning	Group psychotherapy
Nonverbal expression	Art therapy Music therapy
Family functioning	Family therapy
Biology	Medication/medical monitoring weekly
Treatment planning	Re-evaluation of treatment plan weekly
Other	School follow-up and motivational group

Based on the descriptors proposed by Lammers, Exterkate, & De Jong (2007) to compare different DHPs for TPED.

Reference

Lammers, M. W., Exterkate, C. C., & De Jong, C. A. J. (2007). A Dutch day treatment program for anorexia and bulimia nervosa in comparison with internationally described programs. *European Eating Disorders Review : The Journal of the Eating Disorders Association*, *15*(2), 98–111. https://doi.org/10.1002/erv.767

ESTUDIO 3 [STUDY 3]

Clinical, Psychopathological, Physical, and Sleep Evolution in Adolescents with Restrictive Anorexia Nervosa Participating in a Day Hospital Program.

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Clinical, Psychopathological, Physical, and Sleep Evolution in Adolescents with Restrictive Anorexia Nervosa Participating in a Day Hospital Program

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Objective To analyze the clinical, psychopathological, physical, and sleep-related evolution of adolescents with restricting-type of anorexia nervosa (AN-R) after 10 weeks of a daytime hospital program.

Methods Body composition, physical activity and sleep were measured objectively before and after 10 weeks of treatment. In addition, psychopathology and body image disturbances were measured with a self-report questionnaire.

Results Fourteen female adolescents with AN-R (14.3±1.6 years old) participated in the study. A significant increase was found in eight of the ten variables for body composition ($p<0.05$). There were no significant changes in psychopathology, body image disturbances or physical activity. Concerning sleep, a significant, moderately standardized and substantial increase in night latency was found ($p=0.002$), and there was a significant, small standardized and substantial decrease in night efficiency ($p=0.035$).

Conclusion After 10 weeks of follow-up with adolescent patients with AN-R who attended a day hospital program, there was a positive evolution of body composition. However, with regard to sleep patterns, there was a worsening of latency and night efficiency. Therefore, sleep care should be addressed in acute treatment programs for adolescents with AN-R. **Psychiatry Investig 2020;17(4):366-373**

Key Words Restrictive anorexia nervosa, Adolescents, Sleep, Physical activity, Psychopathology.

INTRODUCTION

Anorexia nervosa (AN) is a severe psychiatric illness that is prone to pain chronification and is associated with an increased mortality risk.[1] AN occurs mainly during adolescence, with prevalence rates of approximately 1.7% in adolescents.[2] A low body weight, a fear of gaining weight and an alteration of body image are characteristics of AN. The restrictive subtype of AN (AN-R) occurs when weight loss is primarily due to diet, fasting and/or excessive exercise and, unlike the AN binge-purge subtype, includes more discrete and extreme instances of reducing intake, as well as more chronic reduction of energy.[3] Differences in body composition and psychopathology have been demonstrated between the subtypes of AN.[4] Therefore, it is necessary to differentiate the evolution of the illness between the AN subtypes to contribute to a better understanding of the symptomatology and course of AN and to find more specific treatment approaches.

Although a recent systematic review highlighted the lack of consensus on treatment protocols with respect to refeeding practices,[5] the importance of rapid refeeding strategies for body weight restoration in this population is clear. Restoring optimal weight, especially in AN-R, is the key to avoiding serious physical complications in the bone mineral density, the musculoskeletal system and linear growth.[6] Therefore, monitoring these systems during the refeeding process is essential among these patients. There is currently no superior treatment setting for AN (outpatient, inpatient, reduced length of inpatient fol-

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lowed by outpatient, or partial hospital care).[7] However, programs based on cognitive behavioral treatment, together with family support, seem to be effective and have been recommended in the treatment of adolescents with AN.[8]

In addition to inpatient care, additional goals must be completed to facilitate a movement toward full recovery.[9] The available studies examining the changes in the psychopathology of adolescents with AN in hospital environments show contradictory results. Some studies found an improvement in general psychopathology,[10,11] while others did not find changes despite weight recovery.[12] Likewise, research on the efficacy and impact of interventions for AN should include evaluation of body image disturbance, in addition to changes in weight and medical stability.[13]

An increase in physical activity (PA) can be considered a significant factor for the onset and maintenance of the illness.[3] Since these patients are actively trying to modify the shape of their body, PA is only one of the ways to obtain the "desired ideal thinness." In addition, these patients may rely on PA as a key coping strategy in the face of negative affect of the illness.[14] However, few studies have objectively evaluated the changes in PA during nutritional recovery in patients with AN, and different results have been obtained.[15] As a consequence, a better understanding of PA in this population is justified during weight restoration efforts to improve outcomes for patients with AN-R.

Sleep disorders are highly correlated with AN and that there are multiple areas of sleep that AN effects compared to a healthy population.[16] In fact, sleep disorders in patients with AN have been considered an important clinical marker.[17] To date, the studies that have examined sleep disorders among patients with AN are mainly using polysomnographic monitoring.[18] However, studies are needed to evaluate sleep in a natural environment over a long period, and for this, actigraphs are a useful method for the assessment of sleep.[19]

Therefore, the objective of the present study was to analyze the clinical, psychopathological, physical, and sleep-related evolution of adolescents with AN-R after 10 weeks of a daytime hospital program. We hypothesized that after the hospital program it would improve the parameters evaluated in adolescents with AN-R.

METHODS

Participants

This study was approved by the Research Ethics Committee of the University Hospital Complex of Huelva (PI 005/16) and registered in www.clinicaltrials.gov (Identifier: NCT03667183), and it followed the guidelines of the Declaration of Helsinki, last-modified in 2013. All female participants between 10 and 17 years old with restricting-type AN (n=23), who were diagnosed according to the clinical criteria of the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5)[3] and who were included in the day hospital program (DHP) of the Treatment Program for Eating Disorders (TPED) were recruited from the Children's Mental Health Unit of the Vázquez Díaz Hospital (Huelva, Spain). Fourteen subjects agreed to participate, and they and their parents signed written informed forms. The inclusion criteria were as follows: 1) clinical diagnosis of restricting-type AN in the aforementioned hospital; 2) aged from 10 to 17 years old; 3) the medical team indicated that patients were under analytical control to participate; and 4) written informed consent of the patients and their legal guardians was provided. The exclusion criteria were 1) having other mental health diagnoses and 2) consumption of narcotic drugs. All patients were assessed by the same researcher to reduce interexaminer error.

Treatment description

The DHP of the TPED is a program that has been held at the Child-Mental Health Unit of the Vázquez Díaz Hospital (Huelva, Spain) since 2001. The multidisciplinary team is composed of eleven specialized eating disorders (EDs) health professionals (one psychiatrist, one endocrinologist, three nurses, four nursing assistants, one occupational therapist and one social worker) together with a professor and an administrative officer. The main objective of the program is to reduce the problematic food-related symptoms, such as restriction, binging and purging, of children who need intensive treatment without being totally hospitalized. The DHP characteristics of TPED are described in the Supplementary material.

Procedure

The study consisted of four visits to the hospital. In the first visit (baseline), anthropometric data and body composition data were examined, and patients were monitored for energy expenditure for 9 days. The day where the portable monitor was removed, they also completed different questionnaires. The procedure was repeated 10 weeks later. The delay between admission to the hospital and baseline assessment averaged 48.7 (±11.6) days. All measurements and questionnaires were collected and supervised by qualified personnel.

Clinical measures

InBody 770 (Inbody Co., LTD, Seoul, Korea) was used to measure body composition through bioelectrical impedance analysis (BIA). Multifrequency and octopolar bioelectrical impedance, such as InBody 770, has been shown to be reliable and precise in patients with AN.[20] This body composition analyzer has already been validated in children and adolescents.[21]

Height was measured barefoot and in underwear to the nearest 0.1 cm following standard procedures using a balance with an incorporated stadiometer (Detecto 439; Detecto, USA). Body mass index (BMI) was calculated as body mass (kg) divided by height (m) squared.

Psychopathology of AN

Psychiatric symptoms

The self-report questionnaire Eating Disorder Inventory-3 (EDI-3) was used to analyze psychological traits and key symptoms of the development and maintenance of EDs, including AN.[22] It is composed of 91 items with a choice of 6 answers each and organized into 12 main scales: three scales specific to EDs and nine general psychological scales that are highly relevant but not specific to EDs. The EDI-3 also provides 6 composite scores: a specific one for EDs and five indices of integrative psychological constructs. We used the Spanish adaptation of the EDI-3,[22] which has high levels of internal consistency in all the diagnostic groups (Cronbach's alpha from 0.85 to 0.95).

Body image disturbance

The Contour Drawing Rating Scale (CDRS) was used because it is one of the easy-to-administer and most popular figure drawing scales for the evaluation of body image disturbance.[23,24] This self-administered scale is composed of nine female figures viewed from the front with relatively fine increasing graduations of BMI. The person is asked to indicate which figure represents their current body shape (perceived body shape) and what figure they would like to have (ideal body shape). The discrepancy between these two classifications represents a measure of body dissatisfaction. A score of 0 was interpreted as satisfaction with body image, and a score different than 0 was interpreted as body dissatisfaction (Satisfied=0; Dissatisfied=1).[25] The use of the absolute value of the discrepancy between the current and desired body shape was used in the analyses, as it has also been used previously.[26] The validity and reliability test-retest of the CDRS have been satisfactorily analyzed in adolescents (Cronbach's alpha from 0.77 to 0.84),[24] and it has been widely used in clinical and healthy populations.[27]

Physical activity and sleep

Free-living activity behaviors were objectively measured using the multisensor monitor Sensewear Mini Armband (SWM) (BodyMedia Inc., Pittsburgh, PA, USA), previously used in adult patients with AN,[28] for a 24-hours, 9-days period, which included five weekdays and two weekend days. Sleep time and sedentary (≤1.5 METs), light (1.6−2.9 METs), moderate (3−6 METs) and vigorous (>6 METs) physical activity were recorded on a minute-by-minute basis. Sleep time variables were night sleep duration (time from sleep onset to offset), sleep latency (time from bed time to sleep start), night perturbations (number and time of perturbations after sleep onset) and sleep efficiency (percentage of time spent asleep from sleep onset to offset). Participants were told to remove the monitor only for water-based activities. Only participants who carried the monitor for at least 95% of the entire day (1,368 minutes) were included in the study. To minimize immediate reactivity to the monitor that may have altered their habitual lifestyle, we removed from the analysis the first and the last day of monitoring data.

Statistical analyses

All statistical tests were performed using SPSS (SPSS, IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. IBM Corp., Armonk, NY, USA). Significance was set at $p<0.05$. Due to the size of the sample, we assumed a non-normal distribution; therefore, the Wilcoxon test was used to evaluate significant differences between baseline assessment and after 10 weeks, and when there was significance, the 95% confidence intervals (CI) for the differences were calculated. Data were also assessed for practical/clinical meaningfulness using an approach based on the magnitudes the changes observed. Cohen's d statistic determined the effect size of the standardized differences in the selected variables, and Hopkins' scale and a customized spreadsheet were used to determine the magnitude of the effect size.[29,30] A practically worthwhile difference was assumed when the difference score of the between subject standard deviation was at least 0.2. Threshold values for Cohen's effect size were trivial (0.0−0.19), small (0.20−0.59), moderate (0.60−1.19), large (1.20−1.99), and very large (≥2.00). Quantitative chances of positive/trivial/negative difference were assessed qualitatively as follows: <25% unclear, 25% to 75% possibly, >75% likely, >95% very likely, and >99.5% almost certainly. A substantial difference was set at >75%.

RESULTS

The average age of the 14 participants was 14.3 (±1.6) years.

The results of the clinical evolution of the patients after 10 weeks of the intervention program are shown in Table 1. A significant, small standardized and substantial increase was found in weight (p=0.009, 95% CI: -3.57 to -0.75) and body mass index (p=0.019, 95% CI: -1.27 to -0.16). Significant and small standardized increases were found in total body water (p=0.014, 95% CI: -1.29 to -0.21), body fat mass (p=0.028, 95% CI: -2.26 to -0.04), soft lean mass (p=0.011, 95% CI: -1.65 to

-0.32), fat-free mass (p=0.014, 95% CI: -1.74 to -0.29) and skeletal muscle mass (p=0.010, 95% CI: -1.08 to -0.22). Moreover, there was a significant increase in height (p=0.003, 95% CI: -1.27 to -0.37) and a small standardized increase in percent body fat.

The evolution of psychopathology is shown in Table 2. In

Table 1. The evolution of body composition between baseline assessment and after 10 weeks

	Baseline (N=14)	After 10 weeks (N=14)	Standardized differences (90% CL)	Qualitative assessment†	
Weight (kg)	45.2 (7.8)	47.4 (6.5)*	0.28 (0.14)	Likely positive	82/18/0
Height (cm)	158.9 (7.6)	159.8 (7.3)*	0.10 (0.05)	Almost certainly trivial	0/100/0
Total body water (L)	24.9 (3.4)	25.6 (2.9)*	0.21 (0.12)	Possibly positive	54/46/0
Body fat mass (kg)	11.3 (4.4)	12.4 (4.3)*	0.26 (0.18)	Possibly positive	70/30/0
Soft lean mass (kg)	31.9 (4.4)	32.9 (3.7)*	0.21 (0.11)	Possibly positive	56/44/0
Fat free mass (kg)	34.0 (4.7)	35.0 (3.9)*	0.20 (0.12)	Possibly positive	53/47/0
Skeletal muscle mass (kg)	18.0 (2.8)	18.6 (2.4)*	0.22 (0.12)	Possibly positive	60/40/0
Body mass index (kg/m^2)	17.9 (2.6)	18.6 (2.1)*	0.27 (0.17)	Likely positive	76/24/0
Percent body fat (%)	24.3 (6.9)	25.7 (6.6)	0.20 (0.20)	Possibly positive	50/50/0
Bone mineral content (kg)	2.1 (0.3)	2.1 (0.2)	0.13 (0.13)	Possibly trivial	18/82/0

Data are shown as the mean (SD), unless otherwise indicated. Body composition differences between baseline assessment and after 10 weeks were analyzed by the Wilcoxon test. *p<0.05, †a substantial difference was set at >75%. CL: confidence level

Table 2. Psychopathological evolution between baseline assessment and after 10 weeks

	Baseline (N=14)	After 10 weeks (N=14)	Standardized differences (90% CL)	Qualitative assessment*	
Eating disorder inventory-3†					
Drive for thinness	42.4 (7.4)	40.9 (7.2)	-0.21 (0.24)	Possibly negative	1/48/52
Bulimia	45.9 (4.8)	44.7 (2.7)	-0.21 (0.32)	Possibly negative	2/47/51
Body dissatisfaction	42.3 (7.7)	42.7 (7.0)	0.07 (0.27)	Possibly trivial	21/74/5
Eating disorder risk composite	41.7 (6.7)	40.8 (6.4)	-0.13 (0.23)	Possibly trivial	1/69/29
Low self-esteem	44.4 (7.9)	44.0 (8.2)	-0.06 (0.27)	Unclear	6/77/18
Personal alienation	44.4 (8.3)	43.9 (8.3)	-0.05 (0.31)	Unclear	9/70/21
Interpersonal insecurity	46.6 (9.9)	46.6 (11.1)	-0.02 (0.34)	Unclear	14/67/18
Interpersonal alienation	46.4 (9.4)	47.8 (9.4)	0.14 (0.31)	Possibly trivial	38/59/4
Interoceptive deficits	44.7 (8.1)	42.6 (8.5)	-0.26 (0.39)	Possibly negative	3/37/60
Emotional dysregulation	46.9 (7.6)	46.5 (9.8)	-0.09 (0.33)	Unclear	7/65/28
Perfectionism	46.7 (5.5)	48.1 (9.4)	0.15 (0.60)	Unclear	45/40/16
Asceticism	43.4 (7.0)	42.1 (6.3)	-0.16 (0.47)	Unclear	10/46/44
Maturity fears	52.3 (5.9)	55.3 (8.5)	0.41 (0.44)	Likely positive	79/19/1
Ineffectiveness	44.1 (7.1)	43.6 (8.1)	-0.07 (0.30)	Unclear	7/71/22
Interpersonal problems	46.2 (9.4)	47.0 (10.8)	0.06 (0.27)	Unclear	19/75/6
Affective problems	45.3 (7.0)	43.9 (7.4)	-0.19 (0.31)	Possibly negative	2/49/49
Overcontrol	44.2 (5.9)	44.3 (7.8)	-0.03 (0.54)	Unclear	23/47/29
General psychological maladjustment	44.4 (6.1)	44.6 (8.6)	-0.04 (0.33)	Unclear	12/69/20
Contour drawing rating scale					
Perceived body shape	4.6 (1.3)	4.9 (1.2)	0.26 (0.33)	Possibly positive	63/36/1
Ideal body shape	4.4 (1.2)	4.6 (1.2)	0.14 (0.20)	Possibly trivial	32/68/1
Body dissatisfaction‡	0.7 (0.5)	0.6 (0.5)	-0.29 (0.63)	Unclear	10/31/59

Data are shown as the mean (SD), unless otherwise indicated. Psychological evolution differences between baseline assessment and after 10 weeks were analyzed by the Wilcoxon test. *a substantial difference was set at >75%, †all scales and composite scores of Eating Disorder Inventory-3 are shown in T-scores, ‡the greater values indicate greater body dissatisfaction. CL: confidence level

relation to EDI-3, small standardized and substantial increases were found in maturity fears, and small standardized decreases were obtained in drive for thinness, bulimia and interoceptive deficits. Regarding CDRS, there was a small standardized increase in perceived body shape and a decrease in body dissatisfaction.

Changes in physical activity and sleep are shown in Table 3. In relation to physical activity, there was a small standardized decrease in daily average METs and an increase in sedentary activity. With regard to sleep, a significant, moderately standardized and substantial increase in sleep latency was found (p=0.002, 95% CI: -16.00 to -4.10), and a significant, small standardized and substantial decrease in sleep efficiency was found (p=0.035, 95% CI: -0.04 to 5.37). In addition, small standardized and substantial increases were found in night perturbations, both in number and in duration.

DISCUSSION

This study analyzed the clinical, psychopathological, physical, and sleep evolution of female adolescents with restricting-type AN admitted to a day hospital program for 10 weeks. The main finding, in addition to the increase in body mass, was the increase in sleep latency and, consequently, the decrease in sleep efficiency.

A major finding of the current study was that the measured sleep objectively worsened after refeeding in adolescents with AN-R. We found an increase in nocturnal latency and the number and duration of night perturbations, which is because there was a decrease in sleep efficiency. It has been reported that there is an objectively measured improvement in sleep after the restoration of weight in patients with AN[31] and that sleep disorders are related to the malnutrition observed in these patients, and, after increasing weight, sleep disorders improve.[16,31] However, Pieters et al.[18] did not observe changes in the objective variables of sleep after 20 weeks of treatment in adolescents with AN, and Lehmann et al.[32] found that the duration of sleep was inversely associated with an increase in BMI. Anxiety triggered by the increase in weight and the pressure of monitoring and control of physical activity by hospital staff and parents could be one of the explanations for the increase in sleep disorders in this clinical population after 10 weeks of refeeding.[17] Therefore, it is crucial to address sleep care in acute treatment protocols in adolescents with AN-R to potentiate the treatment efficacy for the main clinical disorder, as evidenced by other psychiatric conditions.[16]

In our study we found a significant increase in eight of the ten variables of body composition, in agreement with other studies of refeeding in this population.[33,34] Contrary to our results, other study reported a decrease in total body water after weight recovery in adults with AN.[34] This discrepancy could be due to the comparison of adults with adolescents, since an increase in total body water was also reported after refeeding in adolescents with AN, and this increase was due to the in-

Table 3. Changes in physical activity and sleep between baseline assessment and after 10 weeks

	Baseline (N=14)	After 10 weeks (N=14)	Standardized differences (90% CL)	Qualitative assessment†	
Physical activity					
Energy expenditure (kcal/day)	1876.9 (248.1)	1890.7 (244.2)	0.06 (0.30)	Unclear	20/72/7
Active energy expenditure (kcal/day)	967.6 (278.8)	933.0 (339.3)	-0.14 (0.54)	Unclear	14/43/43
Steps (number/day)	7,069 (3,036)	7,137 (3,372)	0.04 (0.31)	Unclear	19/72/9
Average METs‡	1.8 (0.2)	1.7 (0.3)	-0.35 (0.39)	Possibly negative	1/25/74
Sedentary activity <1.5 METs (min/day)	783 (337)	857 (268)	0.26 (0.35)	Possibly positive	61/37/2
Light activity 1.6−2.9 METs (min/day)	545 (339)	472 (254)	-0.17 (0.34)	Possibly trivial	4/53/43
Moderate activity 3−6 METs (min/day)	75 (40)	68 (47)	-0.11 (0.37)	Unclear	8/58/34
Vigorous activity >6 METs (min/day)	19 (19)	22 (27)	0.06 (0.28)	Unclear	20/74/6
Sleep					
Night sleep duration (min/day)	491 (59)	493 (41)	0.06 (0.53)	Unclear	32/47/20
Sleep latency (min/day)	11 (6)	21 (11)*	0.97 (0.39)	Almost certainly positive	100/0/0
Night perturbations (number/day)	10 (5)	13 (4)	0.54 (0.52)	Likely positive	86/13/1
Night perturbations (min/day)	54 (33)	66 (21)	0.47 (0.37)	Likely positive	89/11/0
Sleep efficiency (%)	90.6 (5.6)	88.0 (4.6)*	-0.43 (0.38)	Likely negative	1/15/84

Data are shown as the mean (SD), unless otherwise indicated. Changes in physical activity and sleep between baseline assessment and after 10 weeks were analyzed by the Wilcoxon test. *p<0.05, †a substantial difference was set at >75%, ‡daily average. CL: confidence level, METs: metabolic equivalents

crease in intracellular water.[35] Unlike our results, there was a significant increase in bone mineral content in a study of adolescents with AN; however, no changes were found in lean tissue mass after 7 months of weight gain.[33] It is likely that this result is due to the study lengths, since no changes were found in whole body bone mineral density after a 12-week intensive nutrition therapy program with AN patients.[36]

We did not find any significant change in the psychopathology of the anorexia nervosa or in the evaluation of body dissatisfaction. These results agree with other previous studies in which no significant improvement was obtained after weight recovery in adolescents with AN.[12,37] However, Iniesta Sepúlveda et al.[10] observed a decrease in core pathological features, while Hatch et al.[11] obtained improvements in only two of the five psychopathological variables. Several studies have reported the existing gap between physical recovery and psychological change since they did not find significant associations between them,[12,34] which could explain the high rate of relapse of AN after discharge from inpatient units. One of the reasons that can explain this gap in our results may be the short evaluation period between the two assessments of our study. On the other hand, body image disturbance does not seem to change after hospitalization in these patients.[12,38] Kodama et al.[38] found, through functional magnetic resonance imaging, that there is an alteration of body image even after weight recovery in patients with AN. In our patients, we observed a small increase in perceived body image and a decrease in body dissatisfaction. Similar findings were obtained in a previous study in which ideal body image did not change after 12 weeks of nutritional recovery, though patients did obtain an increase in perceived body image.[39] It has been reported that younger adolescents with AN perceive greater coercion than older adolescents,[37] and those who have a lower weight experience less anxiety with body image than those with recovered weight.[40] Although nutritional restoration is key in the treatment of these patients, the increase in the amount of food increases anxiety and resistance to refeeding;[41] therefore, these aspects should be treated with greater emphasis especially in this clinical population in treatment programs.

Objective assessment of physical activity in adolescents with AN-R using an activity monitor revealed that there were no changes in activity after 10 weeks of refeeding, except for a small decrease in average METs and a small increase in sedentary activity. This finding contrasts with other study in which an increase in energy expenditure was found after weight recovery in adults.[42] However, it seems that this increase is not directly related to the severity of the pathology nor does it seem to cause weight loss or relapse during follow-up.[42] In a study with adolescents with AN, it was reported that physical activity tends to normalize during treatment and remains stable one year after follow-up.[15] A possible explanation for not finding changes in physical activity in our study could be due to the efforts of the clinical staff not to increase the activities in the patients, since it could compromise the nutritional recovery, which is the priority, in this clinical population.

The main strength of this study is that it is one of the very few to investigate several days of sleep and physical activity (7 full days) objectively in female adolescents with AN-R before and after weight gain. In addition, our sample was homogenous and comprised drug-free, restricting-type AN patients without comorbid depression or other mental health diagnoses. Because of rapid maturational changes, sleep characteristics in young adolescents should be interpreted with great caution. A confounding variable could have been the mean time between admission and baseline assessment. During this period, patients were already in a stage of active refeeding, and this was necessary to participate in the study safely under medical supervision. In addition, if one studies patients shortly after admission, the sleep quality may be influenced by the stress of being admitted to a hospital and/or the adaptation to a new environment.

There are some limitations to be considered regarding our study. First, it is a single-arm study, and therefore, no control group was used for comparison, resulting in time as the independent variable. Second, there are known limitations of all nonprobability samples, including the unknown levels of sampling errors and their lack of representativeness. Third, the small sample in this study may be due to the low prevalence of this illness, and it is difficult to enroll a large number of affected adolescents for ten weeks. Future research should include a randomized controlled design and a larger sample of adolescents to thoroughly validate our results.

In conclusion, after 10 weeks of follow-up in adolescent patients with AN-R who participated in a day hospital program, there was a positive evolution of body composition. No changes were observed in the patients' general psychopathology. However, regarding sleep patterns, there was a worsening of sleep latency and efficiency, so sleep care should be addressed in acute treatment programs for adolescents with AN-R.

Supplementary Materials

The online-only Data Supplement is available with this article at https://doi.org/10.30773/pi.2020.0016.

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Conflicts of Interest

The authors have no potential conflicts of interest to disclose.

Author Contributions

Conceptualization: all authors. Data curation: all authors. Formal analysis: all authors. Funding acquisition: Tomás E Martínez-García, Diego Munguía-Izquierdo. Investigation: all authors. Methodology: all authors. Project administration: Sofía M Martínez-Sánchez. Resources: Sofía M Martínez-Sánchez, Diego Munguía-Izquierdo. Software: Sofía M Martínez-Sánchez, Diego Munguía-Izquierdo. Supervision: Tomás E Martínez-García, Diego Munguía-Izquierdo. Validation: all authors. Visualization: all authors. Writing—original draft: Sofía M Martínez-Sánchez. Writing—review & editing: all authors.

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Supplementary Table 1. Description of the DHP of the TPED

Descriptor	Treatment Program for Eating Disorders
In operation since	2001
Days a week	5 (Monday to Friday; from 9 am to 21 pm)
Duration of treatment	18−20 weeks generally (depending on the individual evolution of each patient)
Treatment orientations	Cognitive behavior
Group/individual treatment	Mostly group (individual sessions in parallel with the psychiatrist and the staff in charge)
Group size	8−10
Group structure	Open
Behavioral contract	Yes (patients and legal guardians)
Inclusion criteria	DSM-5 eating disorder: AN, BN and EDNOS Patients between 0 and 16 years old State of severe malnutrition and/or somatic complications Negative attitude toward the ingestion of food Failure in outpatient treatment High probability of failure due to the degree of chronicity Excessive and uncontrolled physical exercise
Exclusion criteria	Acute medical risk that requires total hospitalization Acute risk of suicide and/or very serious psychopathology that requires total hospitalization Serious abuse of substances/toxins that clearly interfere with the normalization of weight, appetite and meal
Goals of treatment	Normalization of weight or weight gain (nutritional rehabilitation through adequate caloric intake) Reeducation and normalization of eating behavior Identification and resolution of perpetuating factors Control of constants and analytics according to patient's evolution Restoration and stabilization of healthy eating patterns (e.g., promoting a more social meal) Improvement of aspects associated with ED (emotional regulation, self-esteem, interpersonal relationships, motivation, etc.) Identification of the underlying pathological processes, both psychological and family relationships.
Weight control	Individual weight measurement twice a week (Monday and Friday)
Eating and compensation behavior	Meal plan Supervised meals Self-monitoring (food diary) Supervised cooking Psychoeducation
Body attitude	Body awareness group Positive reinforcement Clothing control Relaxation training
Coping skills	Social skills training Health education Food education Leisure activities weekly: visits to the beach, cinema, factories, etc.
Interpersonal functioning	Group psychotherapy
Nonverbal expression	Art therapy Music therapy
Family functioning	Family therapy
Biology	Medication/medical monitoring weekly
Treatment planning	Re-evaluation of treatment plan weekly
Other	School follow-up and motivational group

Based on the descriptors proposed by Lammers et al.[1] to compare different DHPs for TPED

REFERENCE

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ESTUDIO 4 [STUDY 4]

Ejercicio físico como herramienta para el tratamiento de los trastornos de la conducta alimentaria.

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EJERCICIO FÍSICO COMO HERRAMIENTA PARA EL TRATAMIENTO DE LOS TRASTORNOS DE LA CONDUCTA ALIMENTARIA

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RESUMEN

Los trastornos de la conducta alimentaria (TCA) engloban aquellas patologías en las que la obsesión por la delgadez y el miedo a la obesidad condicionan la aparición de un patrón de alimentación inadecuado y de conductas patológicas ligadas al control del peso. El ejercicio ha sido históricamente considerado como uno de los síntomas en esta enfermedad, y por ello se ha excluido como tratamiento en estos pacientes. Dentro de los TCA, podemos observar un comportamiento problemático al ejercicio (ejercicio compulsivo) y no necesariamente se da en todos los pacientes que sufren esta patología. Hay evidencia de que la participación en programas de ejercicios estructurados y supervisados (ejercicios de alta intensidad o yoga) puede ser de gran utilidad en esta población clínica, ya que reduce la psicopatología, mejora la fuerza muscular, la calidad de vida, el bienestar psicológico y facilita el cumplimiento y la adherencia al tratamiento.

Palabras clave: trastornos de la conducta alimentaria; ejercicio; actividad física; tratamiento.

ABSTRACT

Eating disorders (ED) include those pathologies in which the obsession with thinness and the fear of obesity condition the appearance of an inadequate eating pattern and pathological behaviors linked to weight control. Exercise has historically been considered as one of the symptoms in this disease, and therefore it has been excluded as treatment in these patients. Within the ED, we can observe a problematic behavior to the exercise (compulsive exercise) and not necessarily it occurs in all the patients that suffer this pathology. There is evidence that participation in structured and supervised exercise programs (high-intensity resistance training or yoga) can be very useful in this clinical population, since it reduces psychopathology, it improves muscular strength, quality of life, psychological well-being and it facilitates compliance and adherence to treatment.

Keywords: eating disorders; exercise; physical activity; treatment.

INTRODUCCIÓN

Los trastornos de la conducta alimentaria (TCA) engloban aquellas patologías en las que la obsesión por la delgadez y el miedo a la obesidad condicionan la aparición de un patrón de alimentación inadecuado y de conductas patológicas ligadas al control del peso afectando principalmente a mujeres. Estos patrones resultan dañinos para la salud, llegando incluso en muchos casos a provocar la muerte del paciente. Los trastornos más conocidos y frecuentes son la anorexia nerviosa (AN) y la bulimia nerviosa (BN) con prevalencias por encima del 0.5 y el 1%, respectivamente. En el caso de los denominados trastornos de la conducta alimentaria no especificados (TCANE), su prevalencia

sería algo superior al 3%. La AN afecta fundamentalmente a adolescentes con edades comprendidas entre los 13 y 17 años, si bien puede verse AN precoz a partir de los 7 años. La BN suele tener una aparición más tardía, normalmente a los 18-20 años, siendo excepcional su aparición antes de los 14 años (García-Camba, 2010; Gómez-Martínez et al, 2012; Santiago Fernández, Bolaños Ríos y Jáuregui Lobera, 2010).

Además de la AN, BN y TCANE, existen también otros cuadros, como los trastornos por atracones, comedores compulsivos, síndrome del comedor nocturno, vigorexia y ortorexia, que cada vez están adquiriendo una mayor relevancia por el aumento en su prevalencia (Gómez-Martínez et al, 2012).

Los TCA son patologías biopsicosociales que conllevan a una malnutrición crónica y las agudizaciones se asocian con severas complicaciones clínicas. Se caracterizan por su dificultad en el manejo de la propia patología, el tiempo prolongado de tratamiento, el riesgo de cronificación, recaídas y angustia que experimentan los pacientes. A su vez, se relacionan con limitaciones sociales, riesgo de desarrollar obesidad en el futuro, depresión, intentos de suicidio, trastornos de ansiedad, abuso de sustancias y elevada comorbilidad (Álvarez-Malé, Bautista Castaño y Serra Majem, 2015; El Ghoch, Soave, Calugi y Dalle Grave, 2013). Se ha observado que la detección precoz de pacientes que sufren AN y el ingreso hospitalario con un mayor IMC, tienen mayores probabilidades de llegar a resultados positivos en el tratamiento (Wales et al, 2016). Además, la implicación parental al principio del tratamiento de las pacientes con TCA promueve resultados clínicos eficaces y positivos (Månsson, Parling y Swenne, 2016; Noetel, Dawson, Hay y Touyz, 2017).

La actividad física (AF) es todo movimiento corporal producido por los músculos esqueléticos y exige un mayor gasto energético que estar en reposo. El ejercicio es toda aquella actividad física planificada, estructurada y repetitiva que tiene como objetivo mejorar o mantener el rendimiento, la condición física y/o la salud (Caspersen, Powell y Christenson, 1985).

ACTIVIDAD FÍSICA EN LOS TCA

El ejercicio ha sido históricamente considerado como uno de los síntomas de los TCA en sí (excesiva actividad física para perder peso), y por ello se ha excluido como tratamiento en estos pacientes. Se han propuesto varios mecanismos psicológicos para explicar los altos niveles de actividad física en los trastornos de la alimentación. En primer lugar: las ideas sobrevaloradas acerca de la forma del cuerpo y del peso en AN y BN son relativamente estables y difíciles de cambiar con el tratamiento. Es por ello que estos pacientes están tratando activamente de modificar la forma de su cuerpo y ahí, la hipótesis más obvia, es que la actividad física es sólo una de las formas de obtener la "deseada delgadez ideal". En segundo lugar: la actividad física es una manera de hacer frente al afecto negativo que conlleva la propia enfermedad en sí (nerviosismo, miedo, ansiedad, culpa, etc.)(Bardone-Cone et al, 2016), y se ha probado que los pacientes que sufren crónicamente el afecto negativo tienen un mayor impulso a ser físicamente activos (Vansteelandt, Rijmen, Pieters, Probst y Vanderlinden, 2007). Además de estos mecanismos psicológicos, los pacientes con AN podrían tener un impulso en estar físicamente activos y una incapacidad para permanecer quietos: un impulso para la actividad. Sternheim, Danner, Adan y van Elburg (2015) estudiaron a 240 mujeres con AN en los Países Bajos y encontraron que los niveles más altos de este impulso se asociaron con una mayor gravedad en la patología de AN y esta relación era independiente del afecto negativo (medido por la ansiedad). Confirmando así que los niveles elevados del impulso para la actividad en AN puede ser un indicador de la severidad de la enfermedad (en comparación con otros trastornos alimentarios). Curiosamente, no se encontró relación entre el impulso para la actividad y el IMC en este estudio, ni hubo evidencia de que la edad influyera entre la relación del mismo y la psicopatología.

Las comparaciones de la actividad física evaluada objetivamente entre grupos de sujetos con AN y controles sanos han dado resultados dispares, de tal manera que algunos estudios han encontrado que las personas con AN son más activos que los controles (El Ghoch et al, 2013; Gianini et al, 2016).

Gianini et al, (2016), encontraron que 61 mujeres con AN se volvieron más activos físicamente, en comparación con los controles, durante el día y menos activos durante la noche después de la recuperación del peso y después del alta del tratamiento. No obstante, esta investigación no encontró una asociación significativa entre la motivación para hacer ejercicio y la depresión, ansiedad o la propia patología alimentaria, en la fase aguda o tras la recuperación del peso. Sin embargo, otros estudios no han encontrado ninguna diferencia en los niveles de actividad física en comparación con la población sana (Gümmer et al, 2015; Keyes et al, 2015).

Aunque no está claro en qué medida los niveles de actividad física en los TCA difieren de los controles sanos, se ha visto que se correlaciona positivamente a una mayor psicopatología, depresión y ansiedad (Belka et al, 2017; Bratland-Sanda et al, 2010). Además se asocia con el aumento del abandono del tratamiento (El Ghoch et al, 2013; Sauchelli et al, 2015), la influencia en el resultado negativo del mismo (Stiles-Shields, DclinPsy, Lock y Le Grange, 2015), el aumento del riesgo de recaída después de la recuperación (Carter, Blackmore, Sutandar-Pinnock y Woodside, 2004) y una peor calidad de vida (Cook et al, 2014).

Bratland-Sanda et al, (2010), evaluaron la actividad física y la dependencia al ejercicio en 38 pacientes con TCA. El 29% (n=11) de los sujetos se clasificaron como participantes con un excesivo ejercicio y la reducción de la psicopatología de TCA se correlacionó con la reducción de la dependencia al ejercicio y la importancia de éste para regular los afectos negativos. En cambio, estas asociaciones no se encontraron en los participantes de TCA que no realizaban ejercicio excesivo y éstos tuvieron una reducción significativa de la AF durante el tratamiento. En los participantes con excesivo ejercicio sólo hubo una tendencia hacia la reducción de actividad física.

Otra investigación analizó el gasto energético por el método del agua doblemente marcada (patrón oro) y la calorimetría indirecta en 12 pacientes de AN y 12 controles sanos emparejados por edad (Zipfel et al, 2013). Además, se evaluaron el estado hormonal y la psicopatología de la enfermedad a través de cuestionarios. Encontraron que un subgrupo dentro de los pacientes con AN (66%) mostró un alto nivel de actividad física en comparación con los controles. Este subgrupo, tuvo un mayor gasto energético, tanto en reposo como el gasto energético diario total, y alcanzó mayores resultados en los niveles de depresión y del impulso para adelgazar en comparación con los pacientes AN que no pertenecían a este subgrupo. Davis, Guller y Smith (2016) realizaron un estudio longitudinal de tres años en una muestra de 564 niñas sanas de 10 años para ver la trayectoria del desarrollo de atracones o medidas purgantes en las mismas. Hallaron que la probabilidad de pertenecer a un grupo alimentario disfuncional (trastorno por atracón o purgante) se caracteriza por la participación en ejercicios de compensación y ayunos. Ambos comportamientos se relacionaron moderadamente entre sí, es decir, que la participación en alguno de ellos, aumenta la probabilidad de padecer el otro. El grupo que aumentó el ejercicio compensatorio a lo largo del tiempo tuvo niveles más altos depresivos y expectativas de delgadez. Lo mismo ocurrió en el grupo de niñas que ya con 10 años realizaban ayunos. Así podemos observar que dentro de los TCA existe un comportamiento problemático al ejercicio físico que no se dan en todos los pacientes que sufren esta patología.

El Ghoch, Calugi, Pellegrini, Chignola y Dalle Grave (2016) no encontraron que los niveles más altos de actividad física (moderada-vigorosa) después de la recuperación del peso en AN provoquen la pérdida del mismo ni la recaída durante el año de seguimiento después del alta hospitalaria. Keyes et al, (2015), tampoco encontraron diferencias significativas al evaluar objetivamente la actividad física entre grupos de AN, ansiedad y control, sin embargo, los grupos AN reportaron subjetivamente una actividad física total 57-92% mayor que los controles. Para el grupo de ansiedad, la actividad física parece estar motivada por el deseo de mejorar el estado de ánimo y para hacer frente al estrés. Las personas con TCA también realizan ejercicio para mejorar el estado de ánimo (Swenne, 2016); Sin embargo, la falta de una asociación entre la actividad física y los niveles de ansiedad en AN sugiere que esta motivación no está relacionada principalmente con la ansiedad. Puede ser que esté impulsado por las preocupaciones del cuerpo y el peso que son centrales en la patología de TCA.

En cuanto a la población masculina joven que padece TCA, Shu et al, (2015), estudiaron a 53 chicos y 704 chicas con TCA. La prevalencia de realizar ejercicio problemático, y así controlar el peso, fue similar tanto en hombres (51%) como en mujeres (47%).

EJERCICIO COMPULSIVO EN TCA

Las discrepancias observadas en la literatura para evaluar la actividad física en los TCA podría deberse en parte a la gran cantidad de definiciones proporcionadas por los investigadores en este campo: "Hiperactividad", "ejercicio excesivo" o "ejercicio compulsivo" (Sauchelli et al, 2015). Rizk, Lalanne, Berthoz, Kern y Godart, (2015), evaluaron las diferencias a través de las tasas de prevalencia del ejercicio problemático (EP) en pacientes con anorexia nerviosa, en relación con definiciones diferentes que se encuentran en la literatura científica. La prevalencia de EP en 180 mujeres con AN varió considerablemente, de 5 al 54%, de acuerdo con la definición utilizada. La definición más estricta es la que combina dos criterios cuantitativos (duración e intensidad) y un criterio cualitativo (compulsión) y es la que proporcionó la muestra más pequeña de AN con EP (n=5). Por el contrario, la definición menos rigurosa, que incluye sólo la duración, identificó al mayor número de pacientes con EP (n=97). El EP de duración y compulsión tuvieron una gran superposición de participantes, 40.2% y 70.9% respectivamente.

Se observó que los pacientes con EP tienden a tener restricciones de alimentos considerables y/o una conducta pequeña bulímica, independientemente de la definición de EP y subtipos de AN.

Como hemos mencionado, el elemento "compulsivo" del ejercicio es muy común en los TCA y no necesariamente está relacionado con la frecuencia e intensidad del ejercicio, sino que se caracteriza por la búsqueda de ejercicio de acuerdo con un horario rígido y tiene prioridad sobre otras actividades cotidianas. Es por ello, que si se impide realizar la actividad física, hay un aumento de la ansiedad y afecto negativo, que se modula mediante la reanudación del ejercicio (Swenne et al, 2016). El ejercicio compulsivo puede ser una representación más precisa del perfil del ejercicio problemático en TCA (Meyer et al, 2016; Noetel et al, 2017; Sauchelli et al, 2016).

Stiles-Shields et al, (2015), estudiaron a 201 adolescentes con AN y BN. El 66.3% de los adolescentes con BN y el 23.1% con AN presentaron ejercicio problemático y éste predijo mayor gravedad psicopatológica de forma significativa en AN, pero no en la BN. Estos resultados sugieren que el ejercicio problemático puede estar relacionado con características compulsivas de la AN y que pueden tener un mayor impacto tanto en el tratamiento de la AN como en la BN. Otros estudios obtuvieron los mismos resultados (Blachno et al, 2016; Egan et al, 2017; Noetel et al, 2016; Young et al, 2016). Blachno et al, (2016), estudiaron a 76 adolescentes con AN encontrar una posible relación entre la presencia de síntomas obsesivo-compulsivos con el nivel y características de la actividad física. El grupo que presentó un alto nivel del trastorno obsesivo-compulsivo (46%) tuvo una correlación positiva con la actividad física excesiva. Es por ello que éstos autores junto a otros (Blachno et al, 2016; Noetel et al, 2016), sugieren que la reducción de los síntomas obsesivo-compulsivo y la ansiedad podrían influir positivamente en el tratamiento de la AN para disminuir su actividad física. En esta línea, Danielsen, Ro, Romild y Bjornelv (2016) encontraron que una reducción significativa en la actitud y pensamiento del ejercicio compulsivo en pacientes con TCA durante el tratamiento, predice una disminución de la patología y el aumento del IMC en los participantes.

Paralelos a los resultados de Cunningham, Pearman y Brewerton (2016), Cook et al, (2015), y Meyer et al, (2016), Sauchelli et al, (2016), mostraron también que el ejercicio puede ser particularmente compulsivo en los individuos con BN y TCANE al estudiar a 157 pacientes con TCA y 128 controles sanos en Barcelona. Los grupos BN y TCANE tuvieron mayores puntuaciones cuando se evaluó el ejercicio compulsivo en comparación con los controles sanos. Curiosamente en este estudio, los pacientes con AN no difirieron de los controles sanos en el ejercicio compulsivo global, la única discrepancia fue que las puntuaciones del estado de ánimo con el ejercicio eran inferiores en el grupo

AN. Una de las explicaciones propuestas por los autores es que los individuos con AN tienen una conceptualización diferente de ejercicio, lo que podría reflejarse en las puntuaciones bajas de ejercicio compulsivo observados si se compara con los otros subtipos de TCA (Bratland-Sanda et al, 2010). Además, cuando la enfermedad progresa, se ha observado que los pacientes con una mayor duración de la enfermedad, y por lo tanto con una salud y condición física peor, son los que presentan menos actividad física moderada-vigorosa y tienen niveles más altos de depresión (Sauchelli et al, 2015). Es por ello, que el ejercicio compulsivo no debe abordarse por igual en todos los TCA, y las intervenciones que incorporan programas de actividad física deben adaptarse a los subtipos de diagnóstico.

Se realizó un estudio poblacional a 1497 adultos donde se encontró que los participantes con síntomas de TCA (14.6%) y el 18.6% de los deportistas obtuvieron resultados significativos de ejercicio problemático (Cunningham et al, 2016). Esto indica que no es la cantidad o intensidad de ejercicio lo que caracteriza al EP, sino la mentalidad con la que uno se dedica ha dicho ejercicio. En Reino Unido se evaluó a 417 adolescentes deportistas y no deportistas de ambos sexos (Goodwin, Haycraft y Meyer, 2016). Encontraron que los adolescentes no deportistas presentaban resultados significativamente mayores de padecer TCA. Por lo tanto, el deporte podría representar un entorno de protección en el desarrollo de trastornos de la alimentación en la adolescencia tanto en chicos como chicas, ya que podría ofrecer una mayor satisfacción al concebir cuerpos más funcionales y prestar menor atención a la forma del mismo y/o apariencia.

EJERCICIO COMO TRATAMIENTO EN LOS TCA

En los últimos años, varios autores han propuesto que la inclusión del ejercicio en el tratamiento convencional de los pacientes que padecen TCA puede ser de gran utilidad (Moola, Gairdner y Amara, 2013; Ng, Ng y Wong, 2013; Vancampfort et al, 2014). Dado que las anomalías físicas observadas en los TCA incluyen una menor densidad mineral ósea, musculatura debilitada, bradicardia, síntomas gastrointestinales, mareos, amenorrea, etc., un programa compuesto por profesionales especializados en el ejercicio saludable podría ser un complemento útil y de gran potencial en el tratamiento y mejorar los resultados (Achamrah, Coeffier y Dechelotte, 2016; Gümmer et al, 2015). Se debe considerar la concienciación sobre la condición física actual del cuerpo del paciente, el reconocimiento y la aceptación de los cambios en el peso corporal y los sentimientos y las necesidades asociadas. Expertos en TCA recomiendan la restricción del ejercicio hasta que el adolescente esté médicamente estable, con un peso suficiente y ser capaz de compensar el ejercicio con una suficiente ingesta energética (Noetel et al, 2017). Se debe realizar una reintroducción y promoción del ejercicio saludable de manera graduada y supervisada, donde el ejercicio proporciona grandes beneficios: como mejorar y aumentar la confianza social y otorgar una herramienta para una vida sana (Cook et al, 2016; Moola et al, 2013; Ng et al. 2013; Soundy et al, 2016).

Cook et al, (2016), propusieron las pautas que debe incluir un programa de ejercicio terapéutico en el tratamiento con TCA: emplear un equipo de expertos en la materia, controlar el estado médico, proteger del ejercicio relacionado con la psicopatología, crear un contrato escrito de cómo el ejercicio terapéutico se utilizará, incluir un componente psicoeducativo, centrarse en el refuerzo positivo, crear un programa de ejercicios graduadamente, comenzar con ejercicios de baja intensidad, adaptar el ejercicio a las necesidades del paciente, incluir un componente nutricional, y analizarlas sensaciones después de las sesiones de ejercicio.

En Noruega, Suecia, Dinamarca y Reino Unido interrogaron a 49 unidades de TCA sobre la actividad física en la patología (Bratland-Sanda et al, 2009). Aunque el 68% evaluaban regularmente la AF y un exceso de ésta se consideraba perjudicial, el 82% de las unidades incluyeron algún tipo de ejercicio como tratamiento. Los pacientes recibieron planes individuales o grupales de un especialista en el ejercicio o fisioterapeuta cuando eran somáticamente estables. En todas ellas se enfatizó la importancia de enseñar a los pacientes la diferencia entre el ejercicio problemático y la AF saludable.

Entre las actividades encontramos: paseos, bolos, juegos de pelota, equitación, ejercicios de fuerza, natación, gimnasia acuática, taichí, chi kung y yoga.

Los antidepresivos influyen de manera negativa en la densidad ósea de los adolescentes con TCA, mientras que el ejercicio la mejora (DiVasta et al, 2017). La actividad física fortaleció los músculos que se encuentran alrededor de los huesos esqueléticos y confiere beneficios, contrarrestando algunos de los efectos negativos de los antidepresivos. En cambio, realizar saltos dos veces al día durante 9 días no influyó en los marcadores de recambio óseo en adolescentes con AN, a pesar de haber sido bien tolerado (Martin, Bachrach y Golden, 2017). Este resultado se puede explicar por el corto periodo de tiempo de la intervención. Sin embargo, hubo una disminución del tiempo en la estabilización de los signos vitales y no se detuvo el aumento de peso.

Vander Wal, Maraldo, Vercellone y Gagne (2015) estudiaron a 44 pacientes con Síndrome del Comedor Nocturno (trastorno donde la ingesta excesiva de alimentos se produce al final de día o por la noche). Los participantes fueron asignados aleatoriamente a un grupo educativo (E, n=14), E más la terapia de relajación muscular progresiva (PMR, n=15); PMR más ejercicio (PMR Plus, n=15). Los participantes en los tres grupos evidenciaron reducciones significativas en las medidas de los síntomas del síndrome (depresión, ansiedad y estrés percibido), pero el único cambio significativo entre los grupo en el porcentaje de alimentos ingeridos después de la cena fue el grupo PMR que muestra la mayor disminución (-30.54%), seguido del grupo de PMR Plus (-20.42%) y el grupo E (-9.5%). Estos resultados apoyan el papel de la relajación muscular progresiva en el tratamiento en esta patología. Schlege, Hartmann, Fuchs y Zeeck (2015) investigaron a 36 pacientes (18 formaban el grupo de intervención y otras 18 el grupo control) de TCA donde se siguió un programa de actividad física semanal durante 3 meses. Hubo mejoras significativas en la psicopatología general de alimentación y calidad de vida.

Por todo ello, hay evidencia de que la participación en programas de ejercicios estructurados y supervisados durante el tratamiento en los TCA es seguro (no compromete el aumento del peso ni tiene un efecto negativo en la antropometría) siempre y cuando se cumplan las necesidades nutricionales (Cook et al, 2016; Moola et al, 2013; Ng et al, 2013). Además puede ayudar a reducir la psicopatología, mejorar la resistencia cardiovascular, la calidad de vida, el bienestar psicológico y facilitar el cumplimiento del tratamiento (Moola et al, 2013; Ng et al, 2013).

EJERCICIOS DE RESISTENCIA Y YOGA

Fernández del Valle y colaboradores han investigado el ejercicio de resistencia como complemento al tratamiento de las pacientes de AN. En población clínica española, del Valle MF et al, (2010), administró al grupo de intervención sesiones de resistencia a baja intensidad, 20%-30% de 6 repeticiones máximas (6RM) al comienzo y 50%-60% de 6RM al final, durante 3 meses (2 sesiones cada semana). Aunque la intervención fue bien tolerada y no tuvo ningún efecto perjudicial, no se encontró beneficios significativos a la psicoterapia convencional. Más tarde se realizó otro estudio (Fernández-del-Valle et al, 2014) en el cual la resistencia en el ejercicio de intervención fue de alta intensidad (70% de 6RM) durante 2 meses (3 sesiones cada semana) en jóvenes con AN. El grupo de intervención tuvo mejoras significativas en la fuerza muscular y en la agilidad en comparación con el grupo control. Fernández-del-Valle, Larumbe-Zabala, Graell-Berna y Pérez-Ruiz (2015) también observaron un aumento positivo en la masa muscular en AN después del programa de alta resistencia.

Fernández-del-Valle, Larumbe-Zabala, Morande-Lavin y Pérez-Ruiz (2016) siguieron evaluando, pero a mayor intensidad, el ejercicio de resistencia en este grupo clínico (70-100% de 6RM) en chicas jóvenes con AN durante 2 meses (3 sesiones cada semana). Hubo un aumento significativo del índice de masa corporal (IMC) tanto en el grupo de intervención como en el control. La ganancia de la masa muscular fue significativa en el grupo de intervención ($p=0.045$) y se correlacionó con el aumento del IMC. Mientras que el incremento del IMC en el grupo control fue debido al aumento

significativo de la masa grasa. Además, la fuerza relativa fue significativamente mayor en el grupo de intervención y se mantuvo a lo largo del tiempo (1 mes después de la intervención).

El yoga tiene el potencial de promover el autoconocimiento corporal, es decir, la capacidad de experimentar el cuerpo desde dentro, a través de la meditación, el movimiento físico y la respiración. Es por ello, que a lo largo de los últimos años, el yoga ha sido utilizado como tratamiento en los TCA ya que parece ser un elemento seguro (no hay impacto negativo en el IMC o signos vitales) y reduce la sintomatología (Klein y Cook-Cottone, 2013; Neumark-Sztainer, 2014; Vancampfort et al, 2014).

McIver, O'Halloran y McGartland, (2009), investigaron si el yoga (una sesión semanal) era beneficioso para el trastorno de atracones en una intervención de 3 meses. El grupo de yoga tuvo una reducción significativa en la sintomatología del trastorno y un aumento significativo en la actividad física. El yoga también fue estudiado en jóvenes entre 11 y 21 años con AN, BN y TCANE (Carei, Fyfe-Johnson, Breuner y Brown, 2010). Se demostró que el yoga (una sesión semanal durante 2 meses) disminuyó significativamente los síntomas generales de los TCA tras la intervención y se mantuvo en el tiempo (1 mes después). Tanto en el grupo de intervención como en el control, se mantuvo el IMC junto a una reducción de la ansiedad y la depresión. Resultados similares fueron hallados por Hall, Ofei-Tenkorang, Machan y Gordon (2016) donde obtuvieron una disminución estadísticamente significativa en la ansiedad, la depresión, y la alteración de la imagen corporal en 20 adolescentes con TCA. Recientemente, Pacanowski, Diers, Crosby y Neumark-Sztainer (2017) aplicaron una hora de yoga antes de la cena durante 5 días consecutivos en 38 pacientes adultos con TCA. El yoga redujo significativamente el ánimo negativo antes de la comida en comparación con el grupo control. Sin embargo, los resultados del ánimo negativo después de la cena no tuvieron diferencias significativas, seguramente debido al breve tiempo de intervención.

CONCLUSIÓN

A pesar de que la elevada actividad física se incluye dentro de la psicopatología de la propia enfermedad de los TCA, ya sea para controlar el peso o hacer frente al afecto negativo, se ha observado que el componente "compulsivo" es el que da una representación más precisa en el perfil del ejercicio problemático en TCA.

Hay evidencia de que la participación en programas de ejercicios estructurados y supervisados (ejercicios de alta intensidad o yoga) puede ser de gran utilidad en esta población clínica, ya que reduce la psicopatología, mejora la fuerza muscular, la calidad de vida, el bienestar psicológico y facilita el cumplimiento y la adherencia al tratamiento.

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ESTUDIO 5 [STUDY 5]

Feasibility and effect of a Pilates program on the clinical, physical and sleep parameters of adolescents with anorexia nervosa.

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Feasibility and effect of a Pilates program on the clinical, physical and sleep parameters of adolescents with anorexia nervosa

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ABSTRACT

Background and purpose: Anorexia nervosa (AN) becomes chronic, with high physical, psychological and social morbidity and high mortality without early and effective treatment. The impact of physical exercise as a coadjutant to conventional treatment in this clinical population has been studied with favorable results. Although a Pilates program could be beneficial for patients with AN, no study has analyzed its feasibility and effects in adolescents with AN. Therefore, this study evaluated the safety of a Pilates program and investigated the feasibility and effect in adolescents with AN.

Materials and methods: In this prospective quasi-experimental study, body composition, blood analysis, sedentary time, physical activity and time of sleep, and physical fitness were measured objectively before and after a 10-week Pilates supervised program.

Results: Twelve female adolescents with AN (14.6 ± 1.7 years old) completed the program, with a session attendance rate of 96%, a persistence rate of 100%. There were significant increases in height, plasma calcium and sleep efficiency. Significant decreases in plasma follitropin, sleep duration and, duration and number of night perturbations were observed.

Conclusion: A Pilates program is safe and feasible in adolescents with AN when they have a controlled and stable weight, and such a program could be a viable alternative among treatment programs to achieve better sleep quality.

1. Introduction

Anorexia nervosa (AN) is a psychiatric illness characterized by a restriction of energy intake, an intense fear of gaining weight, and body image disturbance [1]. The consequences of the resulting malnutrition and low body weight can cause a massive deterioration in the health in these patients [2]. There is also a substantial prevalence of medical complications associated with AN, such as biochemical, hematological and hormonal alterations [2–4]. The weight loss in these patients creates an alteration in the hypothalamic-pituitary relationship, observing a correlation between plasma follitropin and the duration of the illness [5,6]. They can also present anomalies in minerals and electrolytes, such as calcium and phosphorus, being essential for the normal functioning of the organism [7,8]. Consequently, the importance of measuring blood chemistry analysis as a guide for the diagnosis and treatment of AN is supported [7]. This illness develops predominantly in adolescence and has an approximately 1% lifetime prevalence in the general population of women [2,9]. Anorexia nervosa becomes chronic, with high physical, psychological and social morbidity and high mortality without early and effective treatment [2]. Some of the physical disorders that most patients with AN tend to experience are related to sleep. Studies have shown that sleep disorders are highly correlated with AN and that there are multiple areas of sleep effects compared to in a healthy population [10,11].

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Excessive exercise is considered one of the symptoms of AN and therefore has been excluded as a treatment in these patients [12,13]. However, in recent years, the impact of physical exercise as a coadjutant to conventional treatment in this clinical population has been studied with favorable results [14,15]. Incorporating physical exercise into treatment can improve our understanding of healthy exercise and benefit even more people with AN [16]. Likewise, physical exercise could be especially effective in adolescents because they are in a phase of creating lifelong habits; therefore, this type of treatment may increase their adherence to healthy exercise in their adulthood [17].

Pilates is a physical and mental training system in which emphasis is placed on the control of the body position and movement [18,19]. Pilates can improve strength, endurance and functional capacity in different clinical and healthy populations [20–29]. In addition, it has been observed that it can improve the quantity and quality of sleep [30–34]. Although a Pilates program could be beneficial for patients with AN, since it improves sleep parameters and different physical characteristics, no study has analyzed its feasibility and effects in adolescents with AN. Therefore, the objectives of our study were: 1) to evaluate the safety of a Pilates program in female adolescents with anorexia nervosa by analyzing body composition and blood analysis; 2) to investigate the feasibility of the program; 3) to analyze the effect on the physical and sleep parameters. We hypothesized that a Pilates program in female adolescents with anorexia nervosa (1) would not be detrimental on the body composition and blood analysis, (2) it would be feasible and (3) it would improve physical and sleep parameters.

2. Materials and methods

2.1. Participants

All female participants between 10 and 17 years old with a clinical AN diagnosis (n = 24) were recruited from the Child-Mental Health Unit of the Vázquez Díaz Hospital (Huelva, Spain) and were fully informed about the entire procedure. The clinical criteria according to the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) [1] were followed by an experienced psychiatrist. Of the 15 subjects who agreed to participate and who, along with their parents, provided written informed consent, 12 completed all stages of the study (Fig. 1). The inclusion criteria were as follows: 1) clinical diagnosis of AN in the aforementioned hospital; 2) aged 10–17 years old; 3) approval by the medical team under analytical control and body mass stability; and 4) written informed consent by the patients and their legal guardians. The exclusion criteria were as follows: 1) having other mental health diagnoses; and 2) consumption of narcotic drugs. Patients with atypical AN meet all criteria for anorexia nervosa at the time of diagnosis, except that the weight of the individual, despite significant weight loss, is within the normal range [1], and as one of the inclusion criteria was that the participants had a body mass stability to be able to start with the intervention, for this reason they were included in the present study. This research was part of a Clinical Research, which was approved by the Research Ethics Committee of the University Hospital Complex of Huelva (PI 005/16) and registered in www.clinicaltrials.gov (Identifier: NCT03667183). The guidelines of the Declaration of Helsinki, last modified in 2013, were followed. All patients were assessed by the same researcher to reduce interexaminer error. A code was assigned to each participant to blind the data in the statistical management.

2.2. Procedure

This prospective, single-arm, quasi-experimental study began with a visit in the hospital for each participant in which an energy expenditure monitor was used and anthropometric data, body composition data and blood chemistry were examined (pre). Nine days later, the patients performed the physical tests and removed the portable monitor. The following week began the Pilates program. This procedure was repeated again the week after finishing the Pilates program (post).

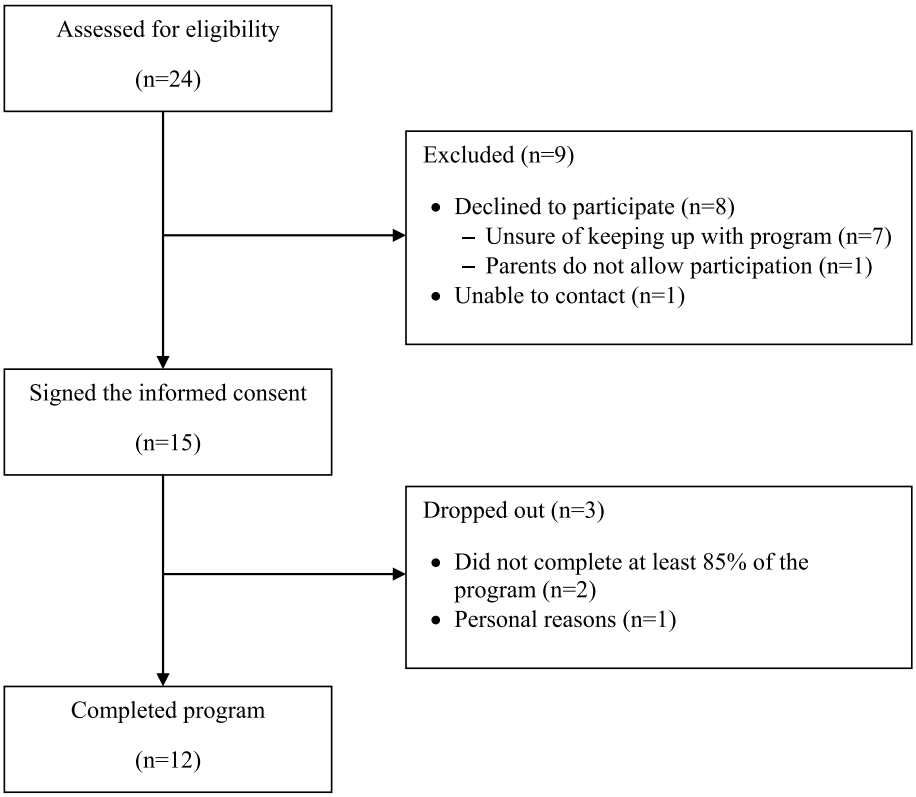

Fig. 1. Flow diagram of the study participants.

2.3. Pilates program

The Pilates program was conducted for 1 h three times a week for 10 consecutive weeks by a certified physiotherapist as the Pilates Instructor in an appropriate and spacious hospital room. The exercises were performed on mats, and the instructor demonstrated movements for participants to follow and assisted them while they performed the exercises. The Pilates program was designed to work the full range of motion and to incorporate strength, balance and coordination into different body positions (i.e., lying, sitting, kneeling and standing postures) [35]. Each training session comprised the following phases: warm-up (10 min), Pilates exercises (40 min) and cool-down period (10 min). The warm-up and cool-down always had the same instruction, and the Pilates exercises varied (6 different classes, each focusing on a basic Pilates principle). Each exercise was repeated 10 times. Subjects were instructed to perform the movements with control and precision, with attention to their breathing pattern (exhaling during flexion and inhaling during extension, for example) and to core control activation during execution [35]. The detailed protocol is explained in Supplementary material.

2.4. Measures

2.4.1. Feasibility

Feasibility measures were recruitment, attendance, persistence and dropout. The recruitment rate was defined as the number of participants divided by the number enrolled by the medical staff over the recruitment period. Persistence was defined as the number of weeks the participant attended at least one exercise session. Dropout was defined as the number of participants who did not complete their treatment. Reasons for non-attendance and dropout were recorded.

2.4.2. Clinical measures

2.4.2.1. Body composition. We used InBody 770 (Inbody Co., LTD, Seoul, Korea) to measure body composition through bioelectrical impedance analysis (BIA). Multifrequency and octopolar bioelectrical impedance has been shown to be a reliable and precise method in patients with AN [36,37], as is the case with InBody 770. This body composition analyzer has already been validated in children and adolescents [38,39]. Height was measured to the nearest 0.1 cm following standard procedures using a balance with an incorporated stadiometer (Detecto 439; Detecto, USA) with subjects in their underwear. In addition, Tanner stages [40] were used to assess pubertal development in the first assessment. Body mass index (BMI) was calculated as body mass (kg) divided by height (m) squared.

2.4.2.2. Blood analysis. Venous blood samples were obtained after an overnight fast for at least nine h to study the blood biochemical composition. Platelets, red blood cells (red blood cells, hemoglobin, hematocrit, mean corpuscular volume, mean corpuscular hemoglobin concentration and red blood cell dispersion) and white blood cells (leukocytes, lymphocytes and neutrophils) were analyzed using the Sysmex XN modular system (Sysmex, Kobe, Japan). Glucose, total cholesterol, triglycerides, total proteins, albumins, prealbumins, transferrin, transferrin saturation index, ferritin, urea, creatinine and creatinine kinase were analyzed using the Cobas 8000/C702 analyzer (Roche Diagnostics, Mannheim, Germany). Iron, sodium, potassium, calcium, phosphorus and magnesium were analyzed using the Cobas 8000/ISE analyzer (Roche Diagnostics, Mannheim, Germany). Vitamin D was analyzed using the DiaSorin Liaison XL analyzer (DiaSorin, Stillwater, MN, USA), and hormones (thyrotropin, thyroxine, follitropin, lutropin and estradiol) were analyzed using the Cobas 8000/602 analyzer (Roche Diagnostics, Mannheim, Germany).

2.4.3. Sedentary time, physical activity, and sleep time

Free-living activity behaviors were objectively measured using a multisensor monitor Sensewear Mini Armband (BodyMedia Inc., Pittsburgh, PA, USA) (SWM), previously used in adult patients with AN [41,42], for a 24-h period over 9 days, including five weekdays and two weekend days. SWM has been widely validated in different aspects of physical activity and sedentary time in children and adolescents [43–45], and has also been able to detect sleep parameters quite accurately [46]. Sleep time, sedentary time ($\leq$1.5 METs), and light (1.6–2.9 METs), moderate (3–6 METs) and vigorous (>6 METs) physical activity were recorded on a minute-by-minute basis. Sleep time variables were: night sleep duration (time from sleep onset to offset), sleep latency (time from bed time to sleep start), night perturbations (number and time of perturbations after sleep onset) and sleep efficiency (percentage of time spent asleep from sleep onset to offset). Participants were told to remove the monitor only for water-based activities. Only participants who carried the monitor for at least 95% of the entire day (1.368 min) were included in the study. To minimize immediate reactivity that may alter their habitual lifestyle, we removed from the analysis the first and the last day of monitoring.

2.4.4. Physical fitness

Physical fitness was evaluated using the extended version of the ALPHA-Fitness Battery (Assessing Levels of Physical Activity and Fitness), which comprises 4 tests [47]. Detailed descriptions of the procedures followed in each test are available elsewhere [40]. Briefly, the handgrip strength test (the average score of the left and right hands) evaluates the upper body strength, the standing broad jump test evaluates the lower body strength, the 4 × 10 m shuttle run test evaluates the motor fitness, and the 20 m shuttle run test evaluates cardiorespiratory fitness. Normalized standardized values were calculated $\{z-score = (mean - value)/standard\ deviation\ (SD)\}$ for each physical fitness test according to gender and age [48]. In addition, a single muscular fitness z-score was calculated as the mean of the two standardized scores from the muscular tests (handgrip strength and standing long jump), and the global physical fitness score was calculated as the mean of the four physical fitness z-scores.

2.5. Statistical analyses

All statistical tests were performed using the Statistical Package for the Social Sciences (SPSS, IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp.). Significance was set at $p \leq 0.05$. Due to the size of the sample, we assumed a nonnormal distribution; therefore, the Wilcoxon test was used to evaluate the significant differences between the pre and post Pilates programs and when there was significance, the 95% confidence intervals (CI) for the differences were calculated. Data were also assessed for practical/clinical meaningfulness using an approach based on the magnitudes of change. Cohen's d statistic determined the effect size of the standardized differences in the selected variables, and Hopkins' scale [49] and a customized spreadsheet [50] were used to determine the magnitude of the effect size. A practically worthwhile difference was assumed when the difference score was at least 0.2 of the between subject standard deviation. Threshold values for Cohen's effect size were trivial (0.0–0.19), small (0.20–0.59), moderate (0.60–1.19), large (1.20–1.99), and very large ($\geq$2.00). Quantitative chances of positive/trivial/-negative differences were assessed qualitatively as follows: <25%, unclear; 25%–75%, possibly; >75%, likely; >95%, very likely; and >99.5%, almost certainly [49]. A substantial difference was set at >75%.

3. Results

Fifteen of the 24 (63%) individuals enrolled by the medical staff were eligible and started the program, and 12 (80%) completed the baseline

and follow-up assessments. Three dropouts were reported (20%) who did not complete at least 85% of the sessions due to not wanting to perform the final assessments, lack of motivation and personal reasons. The remaining 12 participants had a session attendance rate of 96%, or 29 of 30 sessions (range, 26–30) and a persistence rate of 100%. Reasons for missed sessions were due to the inability to attend to studies or family vacations. Furthermore, no adverse effects or health problems were reported in the intervention.

Twelve female adolescents diagnosed with AN completed the program (eleven AN-restricting subtypes and one with atypical AN). The participants' average age was 14.6 (±1.7) years, and their average Tanner stage was 3.1 (±1.0). The results of the clinical changes during the 10 weeks of the Pilates program are shown in Table 1. No difference was found in the anthropometric and body composition variables, except for a significant increase in height ($p = 0.012$, 95% CI: −1.25 to −0.23). Concerning the blood analysis, significant, moderately standardized and substantial increases were found in calcium ($p = 0.023$, 95% CI: −0.61 to −0.16), and there were significant, moderately standardized and substantial decreases in follitropin ($p = 0.050$, 95% CI: 0.06–2.28). Moderately standardized and substantial increases were observed in red blood cell dispersion and thyroxine; small standardized and substantial increases in glucose were also found. Small standardized and substantial decreases were observed in triglycerides, prealbumins, transferrin saturation index, phosphorus, iron and lutropin. A small standardized decrease was observed in mean corpuscular volume, transferrin and thyrotropin. In addition, small standardized increases were found in red blood cells, magnesium, sodium, ferritin and vitamin D.

Changes in sedentary time, physical activity, sleep time and physical fitness variables are shown in Table 2. A significant, largely standardized and substantial decrease was observed in the duration of night perturbations ($p = 0.023$, 95% CI: 8.51–40.58), and significant, moderately standardized and substantial decreases were found in the sleep duration ($p = 0.034$, 95% CI: 5.78–69.55) and number of night perturbations ($p = 0.004$, 95% CI: 1.17–5.92). Significant, moderately standardized and substantial increases were observed in night efficiency ($p = 0.028$, 95% CI: −7.14 to −0.32). There were small standardized and substantial decreases in night latency. In addition, a small standardized increase was found in moderate physical activity. There was no difference in the physical fitness evaluated through the tests.

4. Discussion

This is the first study that analyzed the feasibility and effect of a Pilates program on the body composition, blood analysis, physical and sleep parameters of adolescents with AN. The program was well tolerated among the patients and had a high attendance range, and no adverse effect was observed during the classes or throughout the intervention. After the program, we observed maintenance of body composition and an increase in height, level of calcium in plasma and efficiency of sleep. There was also a decrease in plasma follitropin, sleep duration and number and duration of sleep disturbances.

We did not find differences in body composition after the Pilates program, in line with previous studies in adolescents [23] and adult population [24,27]. However, a small decrease was observed in the BMI percentile in healthy girls after a Pilates program and this decrease was found mainly in girls with higher weight [51]. Similar results have been found in different populations, such as the Pilates program helped to normalize the appropriate weight for each population [22,26]. It has also been observed that Pilates can increase muscle mass [21,52] and even lumbar bone mineral density [28]. In our study, Pilates did not alter the expected growth in our patients, and our results support its safety in adolescents with AN whether the patients have a controlled and stable weight.

Regarding changes in blood parameters, we found an increase in calcium after a Pilates program, although after refeeding in anorexic

Table 1
Clinical changes between pre and post.

Outcome measures	Pre (n = 12)	Post (n = 12)	Standardized differences (90% CL)	Qualitative assessment[a]	
Body Composition					
Weight (kg)	49.7 (8.0)	50.4 (7.7)	0.08 (0.21)	Likely trivial	15/83/2
Height (cm)	159.2 (7.7)	159.9 (7.1)*	0.09 (0.05)	Almost certainly trivial	0/100/0
Total body water (L)	26.2 (3.6)	26.7 (3.8)	0.11 (0.17)	Likely trivial	19/81/0
Body fat mass (kg)	14.0 (4.2)	14.0 (4.0)	0.02 (0.25)	Unclear	11/82/7
Soft lean mass (kg)	33.6 (4.6)	34.2 (4.8)	0.11 (0.16)	Likely trivial	17/83/0
Fat free mass (kg)	35.7 (4.9)	36.4 (5.1)	0.11 (0.17)	Likely trivial	17/82/0
Skeletal muscle mass (kg)	19.0 (2.9)	19.4 (3.0)	0.11 (0.16)	Likely trivial	17/82/0
Body mass index (kg/m^2)	19.6 (2.2)	19.7 (2.2)	0.03 (0.27)	Unclear	14/78/8
Percent body fat (%)	27.8 (5.6)	27.5 (5.2)	−0.02 (0.24)	Unclear	6/84/10
Bone mineral content (kg)	2.2 (0.3)	2.2 (0.3)	0.10 (0.21)	Likely trivial	20/79/1
Blood analysis					
Platelets (10^3/μL)	256.8 (59.8)	261.5 (52.7)	0.10 (0.23)	Likely trivial	22/76/2
Red blood cells (10^6/μL)	4.5 (0.2)	4.6 (0.4)	**0.21(0.41)**	Possibly positive	52/43/5
Hemoglobin (g/dL)	13.1 (0.7)	13.1 (0.6)	−0.01 (0.24)	Unclear	7/83/10
Hematocrit (%)	40.6 (1.6)	40.7 (2.5)	0.02 (0.43)	Unclear	23/58/19
Mean corpuscular volume (fL)	90.5 (3.9)	89.5 (3.4)	**−0.24(0.26)**	Possibly negative	1/39/60
Mean corpuscular hemoglobin concentration (g/dL)	32.3 (1.1)	32.2 (1.0)	−0.04 (0.50)	Unclear	20/51/29
Red blood cell dispersion (%)	12.4 (0.7)	12.9 (0.8)	**0.61(0.62)**	**Likely positive**	**87/11/2**
Leukocytes (10^3/μL)	6.5 (1.3)	6.4 (1.7)	−0.13 (0.40)	Unclear	8/54/38
Lymphocytes (10^3/μL)	2.3 (0.6)	2.3 (0.6)	0.08 (0.59)	Unclear	36/44/21
Neutrophils (10^3/μL)	3.4 (1.2)	3.4 (1.4)	−0.11 (0.53)	Unclear	15/46/39
Glucose (mg/dL)	78.1 (8.8)	83.3 (9.5)	**0.53(0.45)**	**Likely positive**	**89/10/1**
Total cholesterol (mg/dL)	171.9 (26.7)	169.3 (28.0)	−0.11 (0.21)	Likely trivial	1/76/23
Triglycerides (mg/dL)	67.2 (18.4)	58.1 (21.0)	**−0.56(0.44)**	**Likely negative**	**1/8/91**
Total proteins (g/dL)	7.3 (0.4)	7.3 (0.5)	0.06 (0.55)	Unclear	32/46/21
Albumins (g/dL)	4.6 (0.3)	4.6 (0.3)	−0.09 (0.45)	Unclear	14/53/33
Prealbumins (mg/dL)	24.0 (5.1)	22.2 (4.1)	**−0.35(0.28)**	**Likely negative**	**0/18/82**
Transferrin (mg/dL)	286.2 (28.1)	280.0 (33.7)	**−0.23(0.57)**	Unclear	10/36/53

(continued on next page)

Table 1 (*continued*)

Outcome measures	Pre (n = 12)	Post (n = 12)	Standardized differences (90% CL)	Qualitative assessment[a]	
Transferrin saturation index (%)	20.4 (7.5)	17.9 (8.5)	**−0.41(0.47)**	**Likely negative**	**2/ 20/ 78**
Ferritin (ng/mL)	32.0 (16.6)	40.9 (28.9)	**0.33(0.49)**	Possibly positive	67/ 29/4
Iron (μg/dL)	80.4 (26.9)	68.0 (29.1)	**−0.52(0.48)**	**Likely negative**	**1/ 12/ 87**
Sodium (mmol/L)	141.2 (1.1)	141.7 (1.1)	**0.42(0.77)**	Unclear	69/ 22/9
Potassium (mmol/L)	4.3 (0.3)	4.3 (0.2)	−0.05 (0.61)	Unclear	24/ 43/ 33
Calcium (mg/dL)	9.4 (0.4)	9.8 (0.4)*	**0.95(0.46)**	**Very likely positive**	**99/ 1/0**
Phosphorus (mg/dL)	4.3 (0.5)	4.1 (0.5)	**−0.43(0.45)**	**Likely negative**	**1/ 18/ 81**
Magnesium (mg/dL)	2.0 (0.1)	2.1 (0.1)	**0.36(0.50)**	Possibly positive	71/ 25/3
Vitamin D (ng/dL)	26.2 (8.7)	26.9 (6.8)	**0.25(0.27)**	Possibly positive	64/ 36/1
Urea (mg/dL)	28.6 (4.1)	29.1 (7.5)	−0.03 (0.82)	Unclear	31/ 33/ 35
Creatinine (mg/dL)	0.6 (0.1)	0.6 (0.2)	0.00 (0.41)	Unclear	20/ 60/ 20
Creatinine kinase (U/L)	86.3 (39.3)	93.7 (44.7)	0.19 (0.22)	Possibly trivial	48/ 52/0
Thyrotropin (μUI/mL)	2.4 (1.2)	2.0 (0.9)	**−0.23(0.27)**	Possibly negative	1/ 42/ 58
Thyroxine (ng/dL)	1.2 (0.1)	1.3 (0.4)	**0.62(0.82)**	**Likely positive**	**81/ 14/5**
Follitropin (mUI/mL)	5.4 (2.0)	4.3 (2.3)*	**−1.16(1.10)**	**Likely negative**	**2/5/ 93**
Lutropin (mUI/mL)	10.8 (10.0)	5.7 (3.8)	**−0.45(0.43)**	**Likely negative**	**1/ 15/ 84**
Estradiol (pg/mL)	65.4 (70.3)	89.4 (135.0)	−0.06 (0.63)	Unclear	24/ 42/ 35

Data are shown as the mean (SD), unless otherwise indicated. Clinical changes between pre and post were analyzed by the Wilcoxon test. *$p \leq 0.05$. CL: confidence level.

[a] Substantial difference was set at >75%.

patients, no changes in calcium values were found [53,54]. Electrolyte derangements of phosphorus, potassium and magnesium can occur in the medical nutritional refeeding of adolescents with eating disorders [55]. In our study, the absence of hydroelectrolytic alterations was an indispensable condition for participation, and although a decrease in plasma phosphorus was found, it was not significant and within the normal values [55], similar to magnesium and potassium in plasma. These results are similar to those of previous studies [53,54]. Although we found an increase in plasma levels of vitamin D after a Pilates program in our patients, another study found a decrease in vitamin D along with an increase in parathyroid hormone, a hormone that regulates calcium metabolism, and no changes in calcium and phosphorus after refeeding in adolescents with eating disorders [53]. Although we observed an increase in fasting glucose and a decrease in triglycerides, these findings were not significant, similar to findings in previous studies after a Pilates program [23,25,56,57]. We also did not obtain significant changes in creatine kinase, an enzyme related to muscle damage, or cholesterol, although an increase in creatinine kinase has been reported in healthy young women and a decrease in cholesterol in obese women after a Pilates program [56,57]. We suggest that the significant increase in plasma levels of calcium in our study may be due to the effect of physical activity, rather than to refeeding itself, mediated by the increase in vitamin D, which would explain the decrease in phosphorus levels and the increase in magnesium. However, this suggestion should be verified with a study appropriate to that objective.

A significant decrease in follitropin plasma levels was reported after the Pilates intervention in this study. It was observed that only patients with AN who had regained weight and menstruation had a significant increase in follitropin, while those who regained weight but not menstruation did not show this follitropin increase after one year of follow-up of anorexic patients [58]. Regarding the hormone lutropin, a significant increase was reported during refeeding in anorexic adolescents after 11 weeks [59], whereas in our results, we only obtained a standardized and substantial decrease. Regarding the thyroid profile, we found a standardized and substantial increase in thyroxine together with a standardized decrease in thyrotropin without being significant, in line with the findings of a previous study that also found no significant changes in young people with anorexia nervosa [60]. However, in another study, a significant increase in thyrotropin without significant changes in thyroxine was observed in adolescent patients with anorexia nervosa [54]. This disparity in the hormonal results between our study and the existing literature may be due to the heterogeneity of the subjects, alterations of the hypothalamus-pituitary axis found at the gonadal level and euthyroid sick syndrome; alterations of the thyroid profile found in systemic diseases including the chronic weight loss are usually restored with refeeding [61].

There were no changes in sedentary activity or in the physical activity measures, except for a small standardized increase in the moderate activity. In agreement with these results, Duff et al. [27] found no changes in physical activity that was objectively measured in adults with multiple sclerosis after 12 weeks of performing Pilates. However, an increase in physical activity was found in women with AN after their weight was restored and one month after discharge [62]. Guided physical exercise takes into account the practice and process of healthy exercise, which may challenge women with eating disorders to change unhealthy exercise behaviors [63]. Therefore, Pilates seems to be an example of healthy exercise for this population since it does not increase physical activity as long as it performances under specialized supervision.

One of the main findings of this study is that there was a decrease in the number and duration of sleep disturbances after the Pilates program, resulting in an increase in sleep efficiency. There are few studies that have objectively evaluated sleep in anorexic patients in the last decade [11]. Asaad Abdou et al. [10] concluded that the most common sleep problems were initial insomnia followed by awakenings in the middle of sleep. Since sleep can be a clinical marker in patients with AN [10], the results of the present study are of clinical relevance. This may mean that after 10 weeks of Pilates, our patients with AN managed to reduce their concerns, thus achieving a better quality of sleep, as measured objectively, without modifying their physical activity. On the other hand, our participants showed a decrease in the duration of sleep, and although there was a standardized and substantial decrease in sleep latency in our patients, this finding did not reach significance. A previous study found a significant decrease in sleep latency in healthy adults and an increase in the amount of sleep measured with accelerometers after a 12-week Pilates program [30]. The decrease in sleep time may be due to multiple external factors and could be associated with other causes, such as the time of the year, school work, etc., which should be confirmed in future studies.

Although we did not find any changes in the tests that evaluated physical fitness in this study, improvements in muscular strength, endurance, flexibility and balance have been reported in several populations after a Pilates program [20–29]. A Pilates program also increased cardiorespiratory parameters in healthy young people and respiratory muscle strength in patients with cystic fibrosis [64,65]. One reason why no changes in physical fitness have been found in this study

Table 2
Changes in sedentary time, physical activity, sleep and physical fitness between pre and post.

Outcome measures	Pre (n = 12)	Post (n = 12)	Standardized differences (90% CL)	Qualitative assessment[a]	
Sedentary activity					
Sedentary time (min/day, % of waking time)	442 (271),46%	496 (267),50%	0.13 (0.19)	Likely trivial	26/74/1
Physical activity					
Total physical activity <1.5 METs (min/day)	928 (284)	944 (276)	0.00 (0.44)	Unclear	22/57/21
Light activity 1.6–2.9 METs (min/day)	397 (262)	379 (296)	−0.14 (0.26)	Possibly trivial	2/64/34
Moderate activity 3–6 METs (min/day)	70 (49)	78 (31)	**0.28(0.58)**	Unclear	59/33/8
Vigorous activity >6 METs (min/day)	25 (28)	15 (14)	0.05 (0.57)	Unclear	32/46/22
Sleep					
Night sleep duration (min/day)	486 (32)	448 (44)*	**−1.18(0.79)**	**Very likely negative**	**0/2/98**
Night latency (min/day)	19 (10)	14 (6)	**−0.59(0.59)**	**Likely negative**	**2/11/87**
Night perturbations (number/day)	12.9 (3.9)	9.4 (3.7)*	**−0.81(0.44)**	**Very likely negative**	**0/1/98**
Night perturbations (min/day)	71 (22)	46 (21)*	**−1.28(0.64)**	**Very likely negative**	**0/0/99**
Night efficiency (%)	87.2 (4.9)	90.9 (3.7)*	**0.71(0.53)**	**Likely positive**	**94/5/1**
ALPHA-Fitness Battery					
Upper muscular fitness (kg)	23.2 (5.4)	23.4 (4.6)	0.06 (0.23)	Likely trivial	15/81/4
Lower muscular fitness (cm)	110.9 (23.8)	108.2 (17.9)	−0.07 (0.18)	Likely trivial	1/88/11
Motor fitness (s)[b]	14.6 (1.0)	14.5 (1.2)	−0.12 (0.61)	Unclear	18/41/40
Cardiorespiratory fitness (s)	155.8 (51.0)	164.4 (54.4)	0.16 (0.18)	Possibly trivial	34/65/0
Muscular fitness (upper + lower muscular fitness; z-scores)	−0.9 (0.9)	−0.9 (0.8)	−0.04 (0.20)	Likely trivial	3/88/9
Global physical fitness (z-scores)[c]	−1.0 (0.7)	−1.0 (0.6)	0.01 (0.24)	Unclear	9/84/7

Data are shown as the mean (SD), unless otherwise indicated. Changes in sedentary time, physical activity, sleep and physical fitness between pre and post were analyzed by the Wilcoxon test. *$p \leq 0.05$. CL: confidence level. METs: metabolic equivalents. ALPHA-Fitness Battery: Assessing Levels of Physical Activity and Fitness.
[a] Substantial difference was set at >75%.
[b] Lower values indicate better performance.
[c] Mean of the four physical fitness z-scores.

is that our participants are adolescents in a period of restoration and stabilization of their body composition, both physiologically and biochemically; according to the results, Pilates helped maintain that stabilization. Another possible reason is that we used a battery that evaluates the physical fitness globally and, therefore, was not able to observe the changes that Pilates can provide in strength and central tone.

There are some limitations to this study. First, it is a single-arm study, and therefore, no control group was used for comparison, resulting in time as the independent variable. Second, there are known limitations of all nonprobability samples, including the unknown levels of sampling errors and their lower representativeness. Third, the relatively small size of our sample also limits its statistical power and the validity of the data; however, because anorexia nervosa is a disease with low prevalence, it is difficult to enroll a large number of affected adolescents in an intervention study for several weeks and obtain the consent of their legal guardians. Future research should include a randomized controlled design and a larger sample of adolescents with anorexia nervosa adding the assessment of the social aspects and its effect on attendance and maintenance. Our study, however, had the strength that all values of body composition, blood analysis, sleep time, physical activity and physical fitness were measured objectively.

5. Conclusion

A Pilates program is safe and feasible in adolescents with AN, since it does not alter their body composition when they have a controlled and stable weight. Pilates helps increase plasma levels of calcium and sleep efficiency and decrease plasma follitropin, sleep duration and night perturbations in female adolescents with AN. Therefore, Pilates could be a viable alternative in treatment programs to achieve better sleep quality. Future studies should investigate the associations of sleep, strength and central tone, and social aspects of Pilates in this clinical population.

Ethical approval

This study was approved by the Research Ethics Committee of the University Hospital Complex of Huelva (PI 005/16), registered in www.clinicaltrials.gov (Identifier: NCT03667183) and followed the guidelines of the Declaration of Helsinki, last modified in 2013.

Informed consent

Participants received detailed information on the study and, since all the participants were minors, they and their legal guardians signed written informed consent.

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Declaration of competing interest

None.

CRediT authorship contribution statement

Sofía M. Martínez-Sánchez: Funding acquisition, Formal analysis, Writing - review & editing. **Tomás E. Martínez-García:** Funding acquisition, Formal analysis, Writing - review & editing. **Javier Bueno-Antequera:** Funding acquisition, Formal analysis, Writing - review & editing. **Diego Munguía-Izquierdo:** Funding acquisition, Formal analysis, Writing - review & editing.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.

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Supplementary material

Feasibility and effect of a Pilates program on the clinical, physical and sleep parameters of adolescents with anorexia nervosa

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Supplementary material: Pilates Mat Program

Warm-up:

- Sitting on the mat with legs crossed: lateral head mobilization, inclined head mobilization, neck flexion-extension, neck lateral-flexion, scapular elevation and depression, scapular retraction and protraction with stretched arms, scapular upward and downward rotation with stretched arms.
- Supine with knees bent and feet on the mat: awareness of breathing with the hands the last ribs, pelvis tilt, leg lifts and hip rolls(1).

Pilates exercises (1):

- Class 1, Core Control:
    1. Chest lift
    2. Pelvis curl
    3. Hamstring extension
    4. Obliques reaches
    5. Double leg stretch
    6. Side leg lifts
    7. Roll up-roll down
    8. Corkscrew 1
    9. Rolling like a ball
    10. Back support (with knees bent)
    11. Coordination
    12. Roll over
    13. Side to side

14. Gathering in
15. Basic Leg circle
16. Open leg rocker
17. Front support
18. Upper back
19. Side kick
20. Hundred

- Class 2, Axial Elongation:

1. One leg stretch
2. Hamstring extension combination
3. Chest lift with circle
4. Side two legs
5. Criss cross
6. Side to side with opening
7. Neck pull
8. Spine stretch
9. Seal
10. Spine twist
11. Intermediate Teaser
12. Back support
13. Side bend
14. Push up on knees
15. Plank to pyramid
16. Breast stroke

- Class 3, Spinal Articulation:

1. Obliques reaches
2. Roll up-roll down
3. Corkscrew 2
4. Pelvis curl
5. Roll over
6. Neck pull
7. Jack knife
8. Spine stretch
9. Spine twist
10. Saw
11. Combination
12. Twist
13. Tiger
14. Cobra
15. Push up
16. Double leg kick
17. Swan

- Class 4, Dissociation of Movement:

1. Femur arcs
2. Basic Leg circle
3. Corkscrew 1
4. Side to side
5. Side leg lifts bottom leg
6. Side kick
7. Side to side with opening
8. Intermediate Leg circle
9. Shoulder bridge
10. Corkscrew 2
11. Scissors
12. Leg pull
13. Hip circle
14. Plank to pyramid
15. Swan
16. One leg kick

- Class 5, Limb Alignment and Coordination:

1. Hamstring extension
2. One leg stretch
3. Chest lift with circle
4. Coordination
5. Criss cross
6. Hamstring extension combination
7. Double leg stretch
8. Scissors
9. Bicycle
10. Hamstring pull
11. Seal
12. Saw
13. Gathering in
14. Open leg rocker 2
15. Swimming
16. Double leg kick
17. One leg kick

- Class 6, Scapular Alignment:

1. Chest lift
2. Hamstring pull
3. Jack knife
4. Intermediate Hundred
5. Shoulder bridge
6. Rowing
7. Back support
8. Rolling like a ball

9. Hip circle
10. Combination
11. Side kick kneeling
12. Twist
13. Front support
14. Leg pull front support
15. Push up on knees
16. Push up
17. Upper back
18. Breast stroke

Cool-down: Child's pose(2) while awareness of breathing and remained quiet. It should be instructed to keep the minds and bodies of the participants as relaxed as possible.

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2. Emerson D, Hopper E. Overcoming trauma through yoga: Reclaiming your body. Berkeley, CA: North Atlantic Books; 2011.

ESTUDIO 6 [STUDY 6]

Psychopathology, Body Image and Quality of Life in Female Children and Adolescents With Anorexia Nervosa: A Pilot Study on the Acceptability of a Pilates Program.

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Psychopathology, Body Image and Quality of Life in Female Children and Adolescents With Anorexia Nervosa: A Pilot Study on the Acceptability of a Pilates Program

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Background: Anorexia nervosa (AN) is a psychiatric illness that without early effective treatment becomes chronic with high physical, psychological and social morbidity and high mortality. Pilates exercises can improve quality of life and increase body awareness in different clinical and healthy populations. The aim of this pilot study was to examine the acceptability of a Pilates program in a sample of female children and adolescents with AN by evaluating the psychopathological status, alterations in the perception of body image and health-related quality of life after 10 weeks.

Methods: A total of 12 female patients (age: 14.6 ± 1.7 years) completed the 10-week Pilates program. Psychopathology (EDI-3), body image disturbance (CDRS) and quality of life (KIDSCREEN-27) were evaluated before and after the intervention. A satisfaction questionnaire was also provided.

Results: Regarding psychopathology, although there were standardized reductions in seven parameters of those that form EDI-3, none of them reached significance. In relation to body image, significant, moderately standardized and substantial decreases were observed in the body dissatisfaction ($p = 0.046$, Cohen's $d = -0.69$). There were significant, large standardized and substantial increases in physical well-being ($p = 0.008$, Cohen's $d = 1.37$) and significant, moderately standardized and substantial decreases in autonomy and parent relation ($p = 0.021$, Cohen's $d = -0.60$). Satisfaction data was positive.

Conclusion: A Pilates program could help to improve perceived health outcomes by decreasing body dissatisfaction and increasing physical well-being in female children and adolescents with AN, so Pilates seems to be a beneficial complementary treatment in

children and adolescents with AN. These findings from our pilot study are encouraging for future research with a substantially larger sample size, representing the first phase of a longer process.

Keywords: anorexia nervosa, pilates, psychopathology, body dissatisfaction, quality of life, children, adolescents

INTRODUCTION

Anorexia nervosa (AN) is a psychiatric illness that includes in its description an intense fear of gaining weight, and a disturbance in the way in which one's body shape is experienced or a persistent lack of recognition of the seriousness of the low body weight (1). The lifetime prevalence of AN in the general population is reported to be ∼1% among women and occurs predominantly in adolescence in the peripubertal period (2). Thin ideal internalization, weight-related teasing or general concerns about weight and appearance are some of the triggers for AN in children and adolescents (3). Somatic and mental consequences of the illness at an early age probably have a deleterious effect on later adult life (4). Without early effective treatment, the illness becomes chronic with high physical, psychological and social morbidity and high mortality (2).

Body image disturbance is a robust predictor of AN, illness relapse and often persists in otherwise recovered patients (5, 6). This body image disturbance is associated with body dissatisfaction of the person based on negative thoughts about his or her own body (7). In addition, body image concerns and interoceptive processing also seem to be linked, whereby poor body awareness can aggravate body image disturbances in AN (8). Therefore, treatment and prevention programs should aim to moderate the overvaluation of "thinness" and body dissatisfaction as one of the proximal risk factors (9).

Patients with AN report poorer health-related quality of life (HRQoL) compared to both the general population and other psychiatric/somatic diseases (10). Patients who apparently obtain complete remission will still be affected in HRQoL when compared to a healthy reference group (10). Lower BMI and higher levels of organic or psychiatric comorbidities seem to be associated with a lower HRQoL than age, diagnostic subtype, duration or psychopathology of the illness or current psychiatric treatment (10).

Physical activity has been observed to have broad positive effects on children and adolescents, improving psychological functioning, body acceptance, quality of life, and physical and mental health in general (11–15). Likewise, resistance training, yoga or body awareness therapies have been found to be beneficial in adolescents with AN (16–18). Pilates is a mind-body exercise in which special attention is required to postural control, body movement and breathing (19). It has been evidenced that Pilates exercises can improve quality of life and increase body awareness in different clinical and healthy populations, including children (20–26). Moreover, Pilates can improve perceived body image positively, thereby increasing satisfaction with body self-image (27). The benefits of a Pilates program mentioned above have mainly been aimed at improving the symptomatology of people with other psychopathological diagnoses and the non-clinical population. However, its possible acceptability in children and adolescents with AN have not been studied, when it is known that they share symptoms such as body dissatisfaction and loss of quality of life, among others. Therefore, the aim of this pilot study was to examine the acceptability of a Pilates program in a sample of female children and adolescents with anorexia nervosa by evaluating the psychopathological status, alterations in the perception of body image and health-related quality of life after 10 weeks.

METHODS

Sample

All female patients between 10 and 17 years old with a clinical AN diagnosis ($n = 23$) were recruited from the Child-Mental Health Unit of the Vázquez Díaz Hospital (Huelva, Spain). The clinical criteria according to the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) (1) were followed by an experienced psychiatrist. The inclusion criteria were: (1) clinical diagnosis of AN in the aforementioned hospital; (2) aged from 10 to 17 years old; (3) the medical team gave the approval under analytical control and body mass stability; and (4) written informed consent by the patients and their legal guardians. The exclusion criteria were (1) any psychiatric diagnosis (apart from AN) and (2) consumption of narcotic toxins. Fifteen eligible patients for this pilot study agreed to participate and signed written informed consent and their parents (**Figure 1**). This study was part of a Clinical Research, which was approved by the Research Ethics Committee of the University Hospital Complex of Huelva (PI 005/16), registered in www.clinicaltrials.gov (Identifier: NCT03667183) and the guidelines of the Declaration of Helsinki were followed, last modified in 2013. All patients were assessed by the same researcher to reduce interexaminer error. A code was assigned to each patient to blind the data in the statistical management.

Pilot Study Procedure

This was a small uncontrolled pilot study. For each patient, a visit was scheduled where anthropometric data and questionnaires were collected (Pre). After the Pilates program, they were asked to complete the questionnaires again (Post). The time between admission to the hospital and the approval of the medical team to enter the Pilates program was 118.7 (± 11.6) days on average. During that time, patients received cognitive behavioral therapy and continued in it throughout the program. All patients were informed about the voluntary character of their participation and were assured that all the data were gathered anonymously.

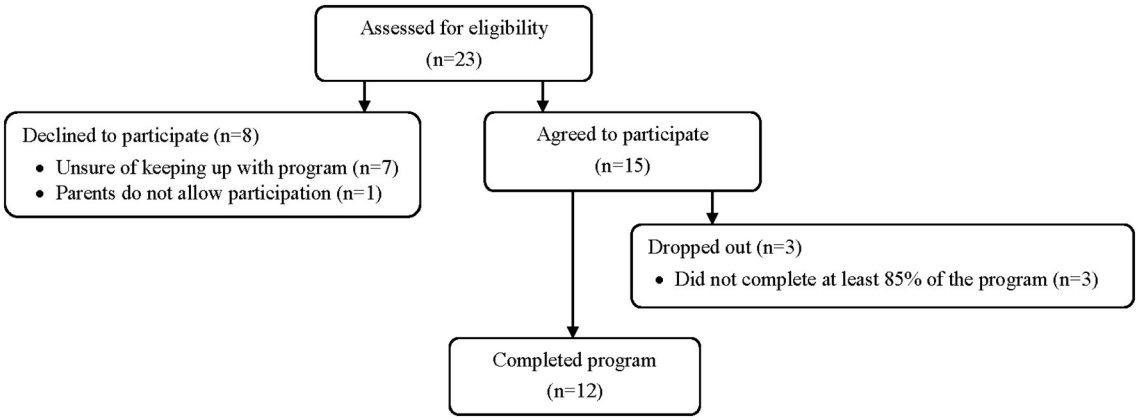

FIGURE 1 | Flow diagram of the study patients.

Pilates Program

The Pilates program was conducted in group for an hour, three times a week for 10 consecutive weeks by a certified physiotherapist as Pilates Instructor. The exercises were performed on mats and each movement was repeated 10 times. Patients were instructed to perform the movements with control and precision, with attention to their breathing pattern (exhaling during flexion and inhaling during extension, for example) and to core control activation during execution (28). The detailed protocol is explained in **Supplementary Material**.

Anthropometry

Standing height was measured to the nearest 0.1 cm following standard procedures using a balance with an incorporated stadiometer (Detecto 439; Detecto, USA), while subjects were standing barefoot. Weight was determined to the nearest 0.05 kg through bioelectrical impedance analysis (InBody 770; Inbody Co., LTD, Seoul, Korea) with the subject in their underwear. Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared.

Measures

EDI-3 (Eating Disorder Inventory-3) (29) is a self-report questionnaire that assesses the presence of eating disorders (EDs) and analyzes psychological traits and key symptoms considered relevant in the development and maintenance of eating disorders, including AN. It is composed of 91 items with a choice of six answers organized into 12 main scales: three specific scales of EDs and nine general psychological scales that are highly relevant but not specific to EDs. It also provides six composite scores: a specific one of the EDs and five indices of integrative psychological constructs. We used the Spanish version of the EDI-3 (30), which has high levels of internal consistency in all the diagnostic groups (Cronbach's alpha from 0.85 to 0.95). EDI-3 is also one of the most used tools worldwide to monitor the evolution of EDs, and it has been used as an assessment tool in young Spanish (31).

The Contour Drawing Rating Scale (CDRS) (32) is one of the most commonly used, easy-to-administer, and most popular figure drawing scales for the evaluation of body image disturbance (33). This self-administered scale is composed of nine female figures views from the front with relatively fine increasing graduations that extend from the representation of a BMI < 18.5 kg/m^2 (very low weight) up to a BMI > 30 kg/m^2 (obesity). The person is asked to indicate which figure represents their current body shape (perceived body shape) and what figure they would like to have (ideal body shape). The discrepancy between these two classifications represents a measure of body dissatisfaction. A score of 0 was interpreted as satisfaction with body image, and a score different than 0 was interpreted as body dissatisfaction (Satisfied $= 0$; Dissatisfied $= 1$) (34). The validity and reliability test-retest of the CDRS have been satisfactorily analyzed in female children and adolescents (Cronbach's alpha $= 0.77$–0.84) (33), and it has been widely used in clinical and healthy populations (35).

To evaluate the HRQoL, the Spanish version of KIDSCREEN-27 was used. KIDSCREEN-27 has been previously used in adolescents with EDs as a measure of quality of life (36). It is an internationally validated instrument, and its Spanish version obtained an acceptable reliability (Cronbach's alpha $= 0.78$–0.84) (37) and it is composed of five dimensions on the Rasch scale. Raw scores were transformed based on standard algorithms for each dimension and used to compute T-scores, with a mean of 50 and a standard deviation of 10. Higher scores indicate a higher HRQoL. A difference of half an SD (38) or a five-point difference on the dimensions are considered clinically relevant.

We also provided a satisfaction questionnaire about the Pilates program performed at Post-assessment. It included the following 3 questions: "1. Do you think Pilates has improved your posture (walk better, sit better) and flexibility?; 2. Do you think Pilates has helped you into feeling better?; 3. Do you think Pilates has made you have less back pain?" Each question had five possible Likert-scale responses rated from 1 to 5 points: "strongly disagree" (1), "disagree" (2), "neither agree nor disagree" (3), "agree" (4) or "strongly agree" (5).

Statistical Analysis

All statistical analyses were performed with SPSS 24.0 (IBM Corporation. IBM SPSS Statistics for Windows. Armonk, NY, USA). Significance was set at $p < 0.05$. The Shapiro-Wilk test was used to test for normality of distribution. The Kruskal-Wallis test was used to compare demographic data among the patients who completed the program, those dropped out, and those who declined to participate in the study. The Wilcoxon test was used to evaluate the significant differences between the Pre and Post Pilates program. Data were also assessed for practical/clinical meaningfulness using an approach based on the magnitudes of change. Cohen's d statistic determined the effect size of the standardized differences in the selected variables, and Hopkins' scale (39) and a customized spreadsheet (40) were used to determine the magnitude of the effect size. A practically worthwhile difference was assumed when the difference score was at least 0.2 of the between subject standard deviation. Threshold values for Cohen's effect size were trivial (0.0–0.19), small (0.20–0.59), moderate (0.60–1.19), large (1.20–1.99), and very large (≥2.00). Quantitative chances of positive/trivial/negative difference were assessed qualitatively as follows: <25% unclear, 25–75% possibly, >75% likely, >95% very likely, and >99.5% almost certainly. A substantial difference was set at >75%. The bivariate Spearman's correlation coefficients were used to evaluate the correlations of the difference of each parameter between the three groups of variables analyzed. A value larger than 0.7 in the correlation coefficient was considered a strong correlation (41).

RESULTS

Sample Characteristics

Of the 15 patients included in the intervention, three of them were excluded in this pilot study for not completing at least 85% of the intervention. The program was completed by 12 female children and adolescents diagnosed with AN, with an age and BMI of 14.6 (SD = 1.7) years, and 19.6 (SD = 2.2) kg/m^2, of which eleven were diagnosed with a restricting subtype and one with the atypical subtype. The demographic characteristics of the all patients are shown in **Table 1**. No differences were found in any of the variables among the patients who completed the program, those dropped out, and those who declined to participate in the study. No adverse events occurred during the study.

TABLE 1 | Demographic characteristics of all patients.

	Completed program ($n = 12$) n (%)	Dropped out ($n = 3$) n (%)	Declined ($n = 8$) n (%)
Age group			
11–12	2 (16.7)	1 (33.3)	2 (25)
13–14	6 (50)	1 (33.3)	4 (50)
15–16	3 (25)	1 (33.3)	2 (25)
17	1 (8.3)	–	–
Anorexia nervosa diagnosis			
Restricting subtype	11 (91.7)	3 (100)	7 (87.5)
Atypical	1 (8.3)	–	1 (12.5)
Father's education			
Primary	2 (16.7)	–	1 (12.5)
Secondary	8 (66.7)	2 (66.7)	6 (75)
University	2 (16.7)	1 (33.3)	1 (12.5)
Mother's education			
Secondary	8 (66.7)	2 (66.7)	7 (87.5)
University	4 (33.3)	1 (33.3)	1 (12.5)
Sibling's number			
0	1 (8.3)	–	1 (12.5)
1	10 (83.3)	2 (66.7)	5 (62.5)
2	1 (8.3)	1 (33.3)	2 (25)
Geographical area of residence			
Urban	8 (66.7)	2 (66.7)	5 (62.5)
Rural	4 (33.3)	1 (33.3)	3 (37.5)

Psychopathology and Body Image

The differences observed in the psychopathology analyzed by EDI-3 and body image disturbance are shown in **Table 2**. Regarding psychopathology, small standardized decreases were found in the post-evaluation of bulimia, body dissatisfaction, eating disorder risk composite, low self-esteem, emotional dysregulation, perfectionism and affective problems. In relation to body image, significant, moderately standardized and substantial decreases were observed in the body dissatisfaction ($p = 0.046$), forming nine patients of the total ($n = 12$) with body dissatisfaction in Pre and 5 in Post, and there was a small standardized decrease in the ideal body shape variable.

Quality of Life

Differences in quality of life are shown in **Table 3**. Significant, large standardized and substantial increases were observed in physical well-being between Pre and Post ($p = 0.008$), the difference exceeding the threshold to consider such clinically relevant changes. There were significant, moderately standardized and substantial decreases in autonomy and parent relation ($p = 0.021$). Small standardized and substantial decreases were found in peers and social support and a small standardized increase in psychological well-being.

Correlations

The correlations of the differences between Pre and Post of all the analyzed variables of the three questionnaires are shown in **Table 4**. Strong significant negative correlations were observed between body dissatisfaction with physical well-being, psychological well-being with interoceptive deficits, and school environment with emotional dysregulation.

Satisfaction Questionnaire

The descriptive statistics of the satisfaction questionnaire are shown in **Table 5**, being filled by the 12 patients who completed the program. The average satisfaction was high for each question, reporting at least 75% of patients "agree" or "strongly agree" for each question. The score for the overall rating was 12.8 (SD = 1.9) out of a possible 15 indicating that, on average, these patients showed high levels of satisfaction.

TABLE 2 | Changes in the psychopathology and body image disturbance between Pre and Post.

	Pre ($n = 12$)	Post ($n = 12$)	Standardized differences (90% CL)	Qualitative assessment[a]	
Eating disorder inventory-3[b]					
Drive for thinness	41.4 (7.7)	41.0 (8.0)	−0.06 (0.30)	Unclear	7/72/21
Bulimia	44.4 (2.4)	43.8 (2.3)	**−0.24 (0.42)**	Possibly negative	4/39/57
Body dissatisfaction	41.8 (6.7)	40.6 (8.6)	**−0.23 (0.52)**	Unclear	8/37/54
Eating disorder risk composite	40.6 (6.7)	39.5 (7.8)	**−0.20 (0.40)**	Unclear	5/46/49
Low self-esteem	44.3 (6.4)	42.8 (7.4)	**−0.25 (0.49)**	Unclear	6/36/57
Personal alienation	44.8 (8.3)	45.1 (9.3)	0.02 (0.39)	Unclear	22/62/16
Interpersonal insecurity	44.9 (10.4)	46.0 (10.1)	0.11 (0.32)	Unclear	31/63/6
Interpersonal alienation	47.1 (8.6)	47.0 (8.6)	−0.01 (0.39)	Unclear	18/62/20
Interoceptive deficits	42.3 (8.8)	41.3 (11.2)	−0.17 (0.34)	Possibly trivial	4/52/45
Emotional dysregulation	48.3 (10.1)	45.1 (6.8)	**−0.27 (0.49)**	Unclear	6/35/59
Perfectionism	47.6 (9.5)	45.7 (8.4)	**−0.20 (0.40)**	Unclear	5/45/50
Asceticism	42.4 (6.6)	41.8 (8.6)	−0.13 (0.56)	Unclear	15/43/42
Maturity fears	53.7 (9.8)	53.9 (11.6)	−0.01 (0.18)	Likely trivial	3/93/5
Ineffectiveness	44.3 (7.2)	43.8 (7.8)	−0.08 (0.39)	Unclear	11/59/30
Interpersonal problems	45.7 (9.8)	46.2 (8.9)	0.07 (0.23)	Likely trivial	16/81/3
Affective problems	44.7 (6.8)	42.4 (8.6)	**−0.35 (0.48)**	Possibly negative	3/26/71
Overcontrol	44.2 (7.9)	42.8 (7.3)	−0.18 (0.32)	Possibly trivial	3/52/45
General psychological maladjustment	44.3 (7.7)	43.4 (8.6)	−0.12 (0.31)	Possibly trivial	5/63/33
Contour drawing rating scale					
Perceived body shape	5.2 (1.2)	5.2 (0.9)	0.05 (0.46)	Unclear	28/54/17
Ideal body shape	4.6 (1.2)	4.2 (1.0)	**−0.25 (0.36)**	Possibly negative	2/37/60
Body dissatisfaction[c]	0.8 (0.5)	0.4 (0.5)*	**−0.69 (0.53)**	**Likely negative**	**1/6/94**

*Data are shown as the mean (SD), unless otherwise indicated. Changes in the psychopathology and body image disturbance between Pre and Post were analyzed by the Wilcoxon test. *$p < 0.05$. CL, Confidence Level. [a]A substantial difference was set at >75%. [b]All scales and composite scores of Eating Disorder Inventory-3 are shown in T-scores. [c]The greater values indicate greater body dissatisfaction. Bold indicates a practically worthwhile difference was assumed when the difference score was at least 0.2 of the between subject standard deviation.*

TABLE 3 | Changes in quality of life between Pre and Post.

	Pre ($n = 12$)	Post ($n = 12$)	Standardized differences (90% CL)	Qualitative assessment[a]	
KIDSCREEN-27					
Physical well-being	42.0 (4.2)	49.0 (8.4)*	**1.37 (0.68)**	**Very likely positive**	**99/0/0**
Psychological well-being	45.1 (6.4)	47.5 (10.5)	**0.25 (0.65)**	Unclear	56/33/12
Autonomy and parent relation	49.3 (5.0)	45.8 (3.6)*	**−0.60 (0.36)**	**Very likely negative**	**0/3/96**
Peers and social support	51.7 (8.5)	48.7 (11.0)	**−0.41 (0.47)**	**Likely negative**	**2/20/79**
School environment	50.6 (10.2)	51.6 (14.9)	−0.01 (0.43)	Unclear	20/57/23

*Data are shown as the mean (SD), unless otherwise indicated. Changes in quality of life between Pre and Post were analyzed by the Wilcoxon test. *$p < 0.05$. CL, Confidence Level. [a]A substantial difference was set at >75%. Bold indicates a practically worthwhile difference was assumed when the difference score was at least 0.2 of the between subject standard deviation.*

DISCUSSION

To the best of our knowledge, this is the first study that analyzes the acceptability of a Pilates program evaluating psychopathology, body image and quality of life in children and adolescents with AN. The main findings of this pilot study after the 10-week Pilates program were the significant and substantial increase in physical well-being, and the significant and substantial decrease in body dissatisfaction and autonomy and parent relation.

In recent years, there are few studies that can be found in the scientific literature in which alternative treatments are used in patients with AN. Although we obtained standardized reductions in seven parameters of those that form EDI-3, none of them reached significance. Similar results were found in a study in which the effect of a Yoga program during 8 weeks in young people with EDs was studied, and although the overall scores of the psychopathology decreased, they were not significant after the intervention (42). However, there was a significant decrease in two of the four components of psychopathology

TABLE 4 | Correlations of the differences between pre and post.

	Contour drawing rating scale			KIDSCREEN-27				
	Perceived body shape	Ideal body shape	Body dissatisfaction	Physical well-being	Psychological well-being	Autonomy and parent relation	Peers and social support	School environment
Eating Disorder Inventory-3								
Drive for thinness	0.123	0.189	−0.288	0.486	−0.064	0.011	0.004	0.306
Bulimia	0.000	−0.288	0.213	0.120	−0.306	−0.360	−0.605*	−0.170
Body dissatisfaction	0.604*	0.028	0.412	−0.081	−0.523	−0.323	−0.205	0.428
EDRC	0.503	0.050	0.260	0.050	−0.512	−0.433	−0.236	0.252
Low self-esteem	0.250	0.107	0.026	−0.421	−0.225	−0.530	0.484	−0.653*
Personal alienation	0.090	−0.146	0.437	−0.025	−0.251	−0.418	−0.597*	−0.237
Interpersonal insecurity	−0.008	−0.195	−0.077	−0.018	−0.471	0.523	0.208	−0.172
Interpersonal alienation	−0.092	−0.146	0.209	−0.249	−0.084	−0.388	0.050	−0.595*
Interoceptive deficits	0.137	−0.416	0.389	−0.163	−0.764**	0.039	0.118	0.140
Emotional dysregulation	−0.248	−0.223	0.077	−0.196	−0.295	−0.287	0.123	−0.760**
Perfectionism	−0.173	0.390	−0.488	0.270	0.313	−0.239	0.163	−0.204
Asceticism	0.078	−0.625*	0.478	−0.058	−0.690*	−0.073	−0.263	0.065
Maturity fears	0.069	−0.025	0.105	−0.314	−0.227	−0.439	0.493	−0.519
Ineffectiveness	0.452	0.192	0.266	−0.156	−0.429	−0.672*	−0.128	−0.280
Interpersonal problems	−0.023	−0.206	0.103	−0.354	−0.438	0.018	0.304	−0.617*
Affective problems	0.060	−0.382	0.206	−0.042	−0.504	−0.246	−0.099	−0.422
Overcontrol	0.265	−0.142	0.052	0.176	−0.452	−0.338	−0.255	0.062
GPM	0.085	−0.176	0.105	−0.068	−0.493	−0.424	0.036	−0.556
KIDSCREEN-27								
Physical well-being	0.135	0.483	−0.717**					
Psychological well-being	−0.444	0.485	−0.410					
Autonomy and parent relation	−0.406	−0.362	0.051					
Peers and social support	−0.076	0.148	−0.052					
School environment	0.354	0.096	−0.026					

*Correlation values are Spearman correlation coefficients. EDRC, Eating Disorder Risk Composite; GPM, General Psychological Maladjustment. *p < 0.05, **p < 0.01.*

TABLE 5 | Descriptive statistics of the satisfaction questionnaire.

	Strongly disagree (%)	Disagree (%)	Neither agree nor disagree (%)	Agree (%)	Strongly agree (%)	Mean (SD)
1. Do you think Pilates has improved your posture (walk better, sit better) and flexibility?	0	0	16.7	41.7	41.7	4.3 (0.8)
2. Do you think Pilates has helped you into feeling better?	0	8.3	16.7	41.7	33.3	4.0 (1.0)
3. Do you think Pilates has made you have less back pain?	0	0	8.3	25.0	66.7	4.6 (0.7)
Overall rating on the Satisfaction Questionnaire	0	2.8	13.9	36.1	47.2	12.8 (1.9)

Patients who completed the Pilates program (n = 12). Strongly disagree = 1, Disagree = 2, Neither agree nor disagree = 3, Agree = 4, Strongly agree = 5.

that was evaluated in adolescents with EDs after 12 weeks of Yoga (16). The development and evaluation of mental-body activities, in addition to aerobic exercise and massage, for patients with AN seem to be an interesting therapeutic tool that can enhance psychotherapy and contribute to the recovery process, and could even reduce eating pathology (18, 43). The small number of the sample could partially explain the absence of significant reductions in psychopathology. Future studies with a larger number of patients are necessary to analyze whether these reductions could reach significance. Nevertheless, after the results obtained in this pilot study, Pilates could be used as a complementary treatment in children and adolescents with AN

since it did not impair any of the psychopathology scores, and seemed to be well tolerated.

The biggest change and statistical consistency after our Pilates program is the decrease in body dissatisfaction. Pilates work with exercises focusing on the sensory increase of internal consciousness, and it has been suggested that this can activate multiple interoceptive channels, such as proprioception from the locomotor- and vestibular system, and also visceroception through controlled breathing (20). These favorable changes can be reflected in the development of body awareness, as previously reported in different studies where Pilates increased body awareness in healthy women (20, 27). Our inference about these results would be in line with the fact that the decrease in body dissatisfaction after the Pilates program in children and adolescents with AN could be related to the increase in body awareness, which is one of the main problems of the illness and is more difficult to treat in these patients. However, body awareness has not been an aim of this study, so future lines of research could deepen this topic.

Regarding the quality of life, an increase in physical well-being was obtained among our patients, in line with other studies where self-perceived general health improved after attending Pilates in the clinical population (24) as in the healthy population (44). Roh (26) studied this relationship and concluded that the improvement of physical self-perception obtained through Pilates in young women strengthens their psychological well-being through their perceived health status. The difference in the physical well-being dimension of the HRQoL after our Pilates intervention exceeds the threshold to determine the minimally important differences (38), indicating a clinically relevant improvement of the physical component of the HRQoL of children and adolescents with AN. The reason for these high increases in the physical well-being of patients may be due to the close relationship between body dissatisfaction and perceived physical well-being. We observed this in our study due to the strong negative association between both variables, the lower the body dissatisfaction, the greater the physical well-being. Although there was only significance in physical well-being in the current research, studies have shown that after a Pilates program, quality of life improves in clinical and healthy populations (22, 25). However, these results should be supported with specific questionnaires that accurately assess the physical well-being comparing Pilates with other types of exercises in this population. We also obtained a strong negative association between psychological well-being with interoceptive deficits and school environment with emotional dysregulation, which seems to be related to the reduced ability to recognize body and inner states in adolescents with AN (45). Therefore, this association in children and adolescents with AN is reflected in the psychological well-being and school environment, by having altered the ability to recognize their own internal states. This may have important clinical implications that would indicate the convenience of including in psychotherapy a greater emphasis on interoceptive sensations and its attention on possible "misleading" internal perceptions, given the subjectivity to interpret them according to the interests of the person. Our patients also showed a decrease in autonomy and parent relation and peers and social support. In a school setting, an increase in psychosocial adjustment was observed in healthy adolescents after the introduction of Pilates in physical education (23), and in children with juvenile idiopathic arthritis, Pilates also had a positive effect on the psychosocial impact of HRQoL (24). These results concerning the family and social environment in our pilot study could be supporting our hypothesis referred to above on the possibility that Pilates favors a greater self awareness (20, 27), since their decrease would indicate a more critical vision and/or less dependent view of the previous context when performing the Pilates program. This could be of great relevance for both the development and recovery of the illness. As in the previous discussion, future studies that prove this inference are necessary.

The clinical impacts that we can observe from this pilot study are that the inclusion of a Pilates program in hospital units for eating disorders in children and adolescents, together with conventional psychotherapy, has a good acceptance by these patients, even finding positive improvements that could help recovery from illness.

Limitations and Future Directions

There are several limitations to this pilot study. Firstly, as this is a single-arm study, time is the independent variable. The patients had been in psychotherapy for 17 weeks before entering the program and, although it is quite a long treatment time and they continued in it, without having a control group or an active control group, the improvements found may not be unequivocally attributed to the Pilates program. Secondly, the comparatively small sample size is certainly a major limitation of our study, being difficult to enroll a large number of affected children and adolescents for 10 weeks. There are known limitations of all nonprobability samples, including the unknown levels of sampling errors and their lower representativeness. Therefore, future research studying this issue within a control group design and large sample size is clearly necessary to validate and support the current results. Thirdly, although the responses to the satisfaction questionnaire were prepared according to the Likert-scale, the questions could be biased toward positive responses in retrospect. Therefore, open ended questions with several-alternatives would probably be a better way to evaluate the program. Fourthly, objective variables of physical or body changes were not evaluated in this study. Finally, specific questionnaires for associated symptoms such as depression or anxiety were not evaluated in the present pilot study. Thus, future studies should evaluate the depression and anxiety associated with AN after a Pilates program and new lines of research that analyze the possible physical changes that could be found in this population. Furthermore, it would be interesting to observe the possible differences stratified by age in studies with a large sample size. We are aware of the limitations mentioned above and the potentially confounding factors in this pilot study, and therefore the current results must be interpreted with care. However, it deserves to be pointed out that our study was intended as a pilot study and is, to the best of our knowledge, the first to analyze the acceptability of a Pilates program evaluating psychopathology, body image and quality of life in children and adolescents with AN.

After attending the Pilates program three times weekly for 10 consecutive weeks, our patients reported high levels of satisfaction and a high positive overall response. This is certainly a good beginning for future qualitative studies in this field. Therefore, more research is required to prove that Pilates could help in psychopathology and improve the quality of life in this population. We can affirm that through this pilot study it is clearly described how a more definitive study might be conducted, so this represents the first phase of a longer process.

CONCLUSION

A Pilates program could help to improve perceived health outcomes by decreasing body dissatisfaction and increasing physical well-being in female children and adolescents with AN, so Pilates seems to be a beneficial complementary treatment in children and adolescents with AN. These findings from our pilot study are encouraging for future research with a substantially larger sample size, representing the first phase of a longer process.

DATA AVAILABILITY STATEMENT

All datasets generated for this study are included in the article/**Supplementary Material**.

ETHICS STATEMENT

This pilot study was part of a Clinical Research, which was approved by the Research Ethics Committee of the University Hospital Complex of Huelva (PI 005/16) and registered in www.clinicaltrials.gov (Identifier: NCT03667183). The guidelines of the Declaration of Helsinki, last modified in 2013, were followed and, since all the patients were minors, they and their legal guardians signed written informed consent.

AUTHOR CONTRIBUTIONS

SM-S, TM-G, and DM-I: conception and design of the study. SM-S, CM-G, TM-G, and DM-I: acquisition and analysis of data and approved final version. SM-S and CM-G: manuscript draft. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpsyt.2020.503274/full#supplementary-material

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Supplementary material: Pilates Mat Program

Warm-up - 10 min:

- Sitting on the mat with legs crossed: lateral head mobilization, inclined head mobilization, neck flexion-extension, neck lateral-flexion, scapular elevation and depression, scapular retraction and protraction with stretched arms, scapular upward and downward rotation with stretched arms.
- Supine with knees bent and feet on the mat: awareness of breathing with the hands the last ribs, pelvis tilt, leg lifts and hip rolls (1).

Pilates exercises (1) – 40 min: The exercises in each class varied depending on each basic Pilates principle. Therefore, there were 6 different classes that were repeated every 2 weeks (since there were 3 classes each week).

- Class 1, Core Control
- Class 2, Axial Elongation
- Class 3, Spinal Articulation
- Class 4, Dissociation of Movement
- Class 5, Limb Alignment and Coordination
- Class 6, Scapular Alignment

Cool-down – 10 min: Child's pose (2) while awareness of breathing and remained quiet. It should be instructed to keep the minds and bodies of the participants as relaxed as possible.

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LIMITACIONES DE LA TESIS Y FUTURAS LÍNEAS DE INVESTIGACIÓN

La presente Tesis Doctoral posee varias limitaciones generales inherentes a los estudios que la componen. En primer lugar, el tamaño relativamente pequeño de la muestra limita su poder estadístico y la validez de los datos resultantes; sin embargo, al ser la anorexia nerviosa una enfermedad con baja prevalencia, es difícil inscribir a un gran número de niñas y adolescentes afectadas durante varias semanas en la investigación junto al permiso de sus tutores legales. En segundo lugar, existen limitaciones derivadas de las muestras no paramétricas, como son los niveles desconocidos de los errores de muestreo y su baja representatividad. En tercer lugar, algunos estudios son de un solo brazo, careciendo así de grupo control, y por lo tanto, resultando el tiempo la única variable independiente.

Por todo ello, las futuras líneas de investigación que indaguen sobre estos temas deberían contar con un gran tamaño en la muestra, junto a un grupo control, para solventar las limitaciones mencionadas. Sin embargo, estos han sido los primeros pasos, representando la primera fase de un proceso mayor que aún queda por estudiar en esta población clínica.

LIMITATIONS OF THE THESIS AND FUTURE LINES OF INVESTIGATION

The present Doctoral Thesis has several general limitations inherent in the studies that compose it. Firstly, the relatively small sample size limits its statistical power and the validity of the resulting data; however, since anorexia nervosa is an illness with low prevalence, it is difficult to enroll large numbers of affected children and adolescents for several weeks in the research with the permission of their legal guardians. Secondly, there are limitations derived from non-parametric samples, such as the unknown levels of sampling errors and their low representativeness. Thirdly, some studies are single-arm, thus lacking a control group, and therefore, time being the only independent variable.

For all these reasons, future lines of research that investigate these issues should have a large sample, together with a control group, to overcome the aforementioned limitations. However, these have been the first steps, representing the first phase of a larger process that still remains to be studied in this clinical population.

CONCLUSIONES

1. En adolescentes con anorexia nerviosa, mayores niveles de condición física se asoció con un mejor estado nutricional. Las pruebas de fuerza de presión manual y de ida y vuelta de 20 m pueden ser opciones como indicadores adicionales del estado de desnutrición en adolescentes anoréxicas. Las pacientes anoréxicas desnutridas mostraron peor condición física que las nutridas. De acuerdo con los datos normativos para adolescentes sanas que coinciden con el sexo y la edad, la condición física está gravemente afectada en las adolescentes anoréxicas.
2. Después de 10 semanas de seguimiento en adolescentes con anorexia nerviosa restrictiva que participaron en un programa de hospital de día, hubo una evolución positiva de los parámetros antropométricos (peso, altura e índice de masa corporal), linfocitos sanguíneos y un aumento en la fuerza de presión manual izquierda. La fuerza de presión manual de la mano no dominante parece ser lo primero que mejora en la condición física después de la realimentación en adolescentes con anorexia nerviosa restrictiva.
3. Después de 10 semanas de seguimiento en adolescentes con anorexia nerviosa restrictiva que participaron en un programa de hospital de día, hubo una evolución positiva de la composición corporal. No se observaron cambios en la psicopatología general de los pacientes. Sin embargo, con respecto a los patrones de sueño, hubo un empeoramiento de la latencia y la eficiencia del sueño, por lo que la atención del sueño debe abordarse en los programas de tratamiento agudo para adolescentes con anorexia nerviosa restrictiva.
4. A pesar de que la elevada actividad física se incluye dentro de la psicopatología de la propia enfermedad de los trastornos de la conducta alimentaria, ya sea para controlar el peso o hacer frente al afecto negativo, se ha observado que el componente “compulsivo” es el que da una representación más precisa en el perfil del ejercicio problemático en los trastornos de la conducta alimentaria. Hay evidencia de que la participación en programas de ejercicios estructurados y supervisados (ejercicios de alta intensidad o yoga) puede ser de gran utilidad en esta población clínica, ya que reduce la psicopatología, mejora la fuerza muscular, la calidad de vida, el bienestar psicológico y facilita el cumplimiento y la adherencia al tratamiento.

5. Un programa de Pilates es seguro y factible en adolescentes con anorexia nerviosa, ya que no altera su composición corporal cuando tienen un peso controlado y estable. Pilates ayuda a aumentar los niveles plasmáticos de calcio y la eficiencia del sueño, y disminuye la folitropina plasmática, la duración del sueño y las perturbaciones nocturnas en adolescentes con anorexia nerviosa. Por lo tanto, Pilates podría ser una alternativa viable en los programas de tratamiento para lograr una mejor calidad del sueño.
6. Un programa de Pilates podría ayudar a mejorar los resultados de salud percibidos al disminuir la insatisfacción corporal y aumentar el bienestar físico en niñas y adolescentes con anorexia nerviosa, por lo que Pilates parece ser un tratamiento complementario beneficioso en niños y adolescentes con anorexia nerviosa.

CONCLUSIONS

1. Female adolescents with anorexia nervosa showed associations between higher physical fitness levels and better nutritional status. Handgrip strength and 20-m shuttle run tests may be options for additional indicators of the state of undernutrition in anorexic female adolescents. The undernourished anorexic patients showed worse physical fitness than the nourished ones. According to normative data for healthy sex- and age-matched adolescents, physical fitness is severely impaired in anorexic female adolescents.
2. After 10 weeks of follow-up in adolescent with restrictive anorexia nervosa who participated in a day hospital program, there was a positive evolution of anthropometric parameters (weight, height and body mass index), blood lymphocytes and an increase in the left handgrip strength. The non-dominant hand grip strength seems to be the first thing that improves physical fitness after refeeding in female adolescents with restrictive anorexia nervosa.
3. After 10 weeks of follow-up in adolescent with restrictive anorexia nervosa who participated in a day hospital program, there was a positive evolution of body composition. No changes were observed in the patients' general psychopathology. However, regarding sleep patterns, there was a worsening of sleep latency and efficiency, so sleep care should be addressed in acute treatment programs for adolescents with restrictive anorexia nervosa.
4. Despite the fact that high physical activity is included within the psychopathology of the illness itself of eating disorders, either to control weight or to cope with negative affect, it has been observed that the "compulsive" component is which gives a more accurate representation in the profile of problematic exercise in eating disorders. There is evidence that participation in structured and supervised exercise programs (high intensity exercises or yoga) can be very useful in this clinical population, since it reduces psychopathology, improves muscle strength, quality of life, and psychological well-being, and facilitates compliance and adherence to treatment.
5. A Pilates program is safe and feasible in adolescents with anorexia nervosa, since it does not alter their body composition when they have a controlled and stable weight. Pilates helps increase plasma levels of calcium and sleep efficiency and decrease plasma follitropin, sleep duration and night perturbations

in female adolescents with anorexia nervosa. Therefore, Pilates could be a viable alternative in treatment programs to achieve better sleep quality.

6. A Pilates program could help to improve perceived health outcomes by decreasing body dissatisfaction and increasing physical well-being in female children and adolescents with anorexia nervosa, so Pilates seems to be a beneficial complementary treatment in children and adolescents with anorexia nervosa.

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Publicaciones científicas

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1. **Martínez-Sánchez SM**, Martínez-García TE, Munguía-Izquierdo D. Physical fitness and nutritional status in female adolescents with anorexia nervosa. Rev Nutr. 2020;33:e190154. Factor de impacto de la revista (2019): 0.387 (84/89) 4º Cuartil. Nutrition & Dietetics.
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1.688; SSCI (85/142) 3º Cuartil. Psychiatry; SCIE (115/155) 3º Cuartil. Psychiatry.

4. **Martínez-Sánchez SM**, Martínez-García TE, Bueno-Antequera J, Munguía-Izquierdo D. Feasibility and effect of a Pilates program on the clinical, physical and sleep parameters of adolescents with anorexia nervosa. Complement Ther Clin Pract. 2020;39:101161. Factor de impacto de la revista (2019): 1.770 (17/28) 3º Cuartil. Integrative & Complementary Medicine.
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Capítulo de libro

Martínez-Sánchez SM, Munguía-Izquierdo D. Ejercicio físico como herramienta para el tratamiento de los trastornos de la conducta alimentaria. En: David Padilla Góngora, Remedios López Liria, José Manuel Aguilar Parra (eds.). Psicología, salud y educación. Almería, España: Editorial Universidad de Almería; 2018. p.198-208. ISBN: 978-84-17261-09-2. Factor de impacto de la editorial: 10.000, Scholarly Publishers Indicators (SPI), Categoría: Ranking general (2018). Editoriales españolas (95/104) 4º Cuartil.

Aportaciones a congresos científicos

1. Munguía-Izquierdo D, Bueno-Antequera J, Oviedo-Caro MÁ, **Martínez-Sánchez SM**, París-García F. Estilo de vida activo: una potente herramienta para la salud. Simposio. XXIV Congreso Internacional INFAD y I Congreso Internacional de Salud y Ciclo Vital. Del 25 al 30 de Abril de 2017.
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