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THE ROLE OF EXCESSIVE PHYSICAL ACTIVITY IN THE BONE HEALTH OF WOMEN DIAGNOSED WITH EATING DISORDERS

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ABSTRACT

Introduction and aims. There are still few studies that have evaluated the relationship between eating disorders, excessive physical activity and bone health in women with anorexia nervosa (AN) and bulimia nervosa (BN). Our study aimed to evaluate the impact of excessive physical activity on the bone health of women diagnosed with AN or BN. Materials and methods. This is a cross-sectional survey in a public specialized hospital referral service for eating disorders, involving women diagnosed with AN or BN. We measured anthropometric data to calculate the Body Mass Index. Eating behavior was measured using the Eating Disorder Examination Questionnaire. Blood samples were collected to assess the serum vitamin D levels of the participants. Physical activity status was self-reported. Bone mineral density using dual-energy X-ray absorptiometry. Results. Patients with AN had longer duration of amenorrhea and had significantly lower Body Mass Index values. Aerobic exercises were predominant in both groups (AN and BN), however women with BN presented a higher frequency of aerobic exercises and also of bodybuilding practice ($p<0.05$). In both groups, women who practiced aerobic exercise for less than 300 minutes per week had higher bone mineral density. Conclusion. The excessive practice of physical activity, especially in aerobic exercises, had a negative impact on the bone mineral density of women diagnosed with AN or BN.

Key words: Eating disorders. Bone health. Physical activity. Anorexia. Bulimia.

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RESUMO

Papel da atividade física excessiva na saúde óssea de mulheres com diagnóstico de transtornos alimentares

Introdução e objetivo. Ainda existem poucos estudos que avaliaram a relação entre transtornos alimentares, atividade física excessiva e saúde óssea em mulheres com anorexia nervosa (AN) e bulimia nervosa (BN). Nosso estudo teve como objetivo avaliar o impacto da atividade física excessiva na saúde óssea de mulheres diagnosticadas com AN ou BN. Materiais e métodos. Trata-se de um estudo transversal em um serviço de referência especializado em transtornos alimentares em um hospital público, envolvendo mulheres diagnosticadas com AN ou BN. Medimos dados antropométricos para calcular o índice de massa corporal. O comportamento alimentar foi avaliado usando o Questionário de Exame de Transtornos Alimentares. Foram coletadas amostras de sangue para avaliar os níveis séricos de vitamina D das participantes. O status de atividade física foi autorrelatado. A densidade mineral óssea foi medida usando a absorciometria por raio-X de dupla energia. Resultados. As pacientes com AN apresentaram maior duração de amenorreia e valores significativamente mais baixos de índice de massa corporal. Os exercícios aeróbicos foram predominantes em ambos os grupos (AN e BN), no entanto, as mulheres com BN apresentaram maior frequência de exercícios aeróbicos e de prática de musculação ($p<0,05$). Em ambos os grupos, mulheres que praticaram exercícios aeróbicos por menos de 300 minutos por semana apresentaram maior densidade mineral óssea. Conclusão. A prática excessiva de atividade física, especialmente em exercícios aeróbicos, teve um impacto negativo na densidade mineral óssea de mulheres diagnosticadas com AN ou BN.

Palavras-chave: Transtornos alimentares. Saúde óssea. Atividade física. Anorexia. Bulimia.

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INTRODUCTION

Severe caloric restriction and compensatory behaviors, including intense physical exercise, commonly observed in individuals with Anorexia Nervosa (AN) and Bulimia Nervosa (BN), can lead to significant dysfunctions in the hypothalamus.

These disfunctions result in reduced production of hormones essential for regulating the menstrual cycle, leading to a condition known as hypothalamic-pituitary amenorrhea (HPA).

The combination of nutritional deficiencies caused by these eating disorders and HPA, can have detrimental effects on bone health, leading to decreased bone mineral density. HPA likewise can lead to a reduction in calcium and vitamin D absorption, which contributes to frailty and increased risk of bone fractures.

Therefore, AN and BN can have a significant impact on women's bone health, compromising their bone quality and strength and increasing the risk of fragility and fractures (Zipfel et al., 2015; Drabkin et al., 2017; Strock et al., 2020; Nitsch et al., 2021; Indirli et al., 2022; Hirschberg, 2023).

As mentioned, women with AN and BN may exhibit dysfunctional behaviors regarding the engagement in physical exercise, often utilizing exercise as a means of punishment or compensation.

These behaviors, combined with an inadequate nutritional intake, have a negative impact on hormone balance, thereby increasing the risk of bone complications (Lambrinoudaki, Papadimitriou, 2010; Melin et al., 2014).

Consequently, the assessment of physical exercises practices and bone health of women with AN and BN is a fundamental aspect of their care. Despite the significance of this matter, there are still few comprehensive studies examining the interplay between eating disorders, physical activity and bone health. The lack of literature on this topic is concerning, given that individuals with these disorders are potentially susceptible to developing osteopenia and other conditions related to bone health.

Furthermore, the existing research predominantly concentrates on patients with AN, leaving substantial gaps in our comprehension of the effects of BN on bone health. Therefore, our study aimed to assess the influence of excessive physical activity on the bone health of women diagnosed with AN or BN.

MATERIALS AND METHODS

Study design and patients

This is a cross-sectional study involving women diagnosed with AN or BN, who were under the care of a specialized hospital referral service for eating disorders in southeastern Brazil.

The study included premenopausal women, ages 18 to 49, who received a medical diagnosis of anorexia nervosa or bulimia nervosa. Pregnant or menopausal women, as well as those with diabetes mellitus, osteometabolic diseases, recent surgical procedures or an inability to properly complete the questionnaires were excluded. The sample size was estimated using the GPower 3.1.9.2 software.

The effect size (Cohen f2 = 0.388) was calculated from the prevalence of osteopenia in women with anorexia nervosa (AN) (45.5%) and bulimia nervosa (BN) (12.9%) (Solmi et al., 2016) (Chi2 = 26,181). A significance level of 5% and an observed power of 80% were adopted.

The calculated sample size was 44 participants. To cover any losses, this amount was increased by 10%, resulting in 48 individuals. (Figure 1).

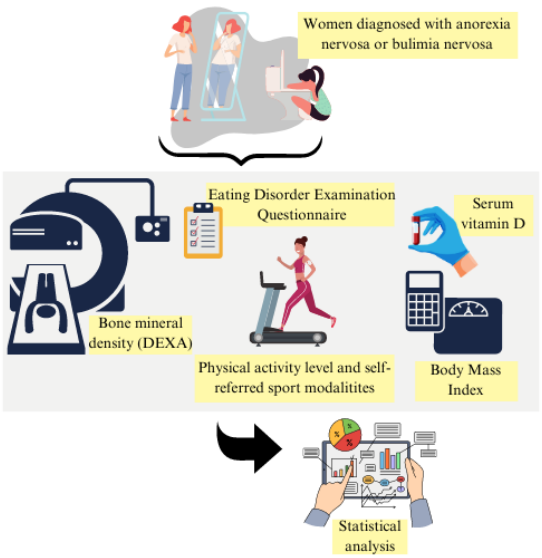

Figure 1 - Provides a comprehensive and concise summary of all the steps involved in data acquisition and analysis. DEXA: Dual-Energy X-ray Absorptiometry.

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Bone mineral density assessment

Bone mineral density (BMD) was assessed by dual-energy X-ray absorptiometry (DEXA) using a Lunar iDXA Advance device (GE Healthcare, Madison, WI, USA). BMD measurements were performed on the lumbar spine (L1-L4), total femur and femoral neck.

The cutoff values determined by the World Health Organization (WHO, 2004) were used, considering osteopenia when BMD was between -1 and -2.5 standard deviations (SD) below peak bone mass.

Nutritional measurement

Anthropometric data were collected, including the measurement of weight and height, to calculate the Body Mass Index (BMI), considering the cutoff points determined by the WHO (1995).

Eating behavior

To assess the severity of eating disorders, the Eating Disorder Examination Questionnaire (EDE-Q) was used in its translated and validated version for Brazil.

EDE-Q provides information on eating behavior, symptoms and concerns related to body and weight. It is a self-report questionnaire that assesses food restriction, concern about food, body shape and body weight in the last 28 days on a seven-point scale. The items that make up each subscale are ordinally classified on a severity scale from "0" to "6", in which the value "0" represents the absence of characteristic or behavior in question and the value "6" represents the presence of this behavior to an extreme degree.

Sociodemographic and clinical data

Data were collected on several variables, including age, type and duration of physical activity, menstrual status, and clinical diagnosis of the eating disorder, along with its duration. This information was obtained through interviews and by reviewing available medical records. In order to assess the participants' serum levels of vitamin D [25(OH)D], blood samples were collected. The laboratory reference values were used for analysis.

Ethical aspects

The study was approved by the Ethics Committee in Research involving human beings of the Hospital das Clínicas da Faculdade de Medicina da Universidade de São Paulo (HCFMUSP) in accordance with Declaration of Helsinki (1964) and Resolution No. 466/2012 of the National Health Council, under CAAE number (76609717.2.0000.5421). All participants spontaneously joined the study and signed the Free and Informed Consent Form.

Data analysis

The data were analyzed using the statistical program SPSS, version 20.0 (SPSS Inc., Chicago, IL, USA). All continuous variables were tested for normality of distribution by the Kolmogorov-Smirnov test. Those with normal distribution were described as arithmetic mean and standard deviation. The means were compared by Student's t-test for unpaired data. When the variance was unknown, the Welch t-test was calculated for independent samples. When the variables presented non-normal distribution, they were described as medians and interquartile ranges and compared by the nonparametric Mann-Whitney U test. The analyses that presented a p value <0.05 were considered statistically significant.

RESULTS

Initially, a total of 177 participants were recruited for our study. However, 124 were excluded due to not meeting the eligibility criteria. The final sample consisted of 53 women. Among them, 47.1% (n=25) were diagnosed with AN, with a mean age of 29.4±9.4, while 52.9% (n=28) were diagnosed with BN, with a mean age of 30.8±10.0, with no difference between the two groups ($p>0.05$). In addition, there was no difference between the time of onset or duration of the disease ($p>0.05$) (Table 1).

The participants diagnosed with AN had a significantly longer duration of amenorrhea compared to women diagnosed with BN ($p<0.05$). In addition, the AN group likewise had significantly lower BMI values, including minimum and maximum BMI levels ($p<0.05$). No statistical differences in eating behavior (EDE-Q) were observed between the two groups (Table 1).

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Regarding physical exercises, a higher frequency of aerobic exercises was observed in both groups.

However, the Welch t hypothesis test showed that women diagnosed with BN had a significantly higher frequency of aerobic exercise compared to women diagnosed with AN (t=2.02, p=0.048). Additionally, women diagnosed with BN presented a higher frequency of bodybuilding exercises compared to women diagnosed with AN (t=4.22, p<0.001) (Figure 2).

Table 1 - Clinical, nutritional, and eating behavior profile of women diagnosed with eating disorders (anorexia or bulimia) (n=53).

	AN (n = 25)	BN (n = 28)	p*
	Mean (SD)	Mean (SD)	
Age (Years)	29.4±9.4	30.8±10.0	0.59
Age of eating disorder onset	16.9±7.1	16.1±6.7	0.69
Illness duration (months)	149.8±107.5	176.6±123.6	0.40
Amenorrhea duration (months)	19.0±27.6	4.8±8.4	0.01
BMI (kg/m^2)	19.5±3.4	27.4±7.0	<0.001
Lowest-ever BMI (kg/m^2)	14.6±2.3	19.8±4.7	<0.001
Highest-ever BMI (kg/m^2)	22.9±3.2	30.3±7.8	<0.001
EDE-Q global score	3.9±1.4	3.9±1.7	0.92
Restrictive subscale score	3.4±2.0	3.2±2.0	0.76
Eating concern subscale score	3.4±1.4	3.7±1.8	0.48
Body shape concern subscale score	4.8±1.4	4.7±1.7	0.97
Weight concern subscale	4.0±1.6	4.2±1.9	0.69

* Student “t” Test; AN: Anorexia nervosa; BN: Bulimia nervosa; SD: Standard deviation; BMI: Body Mass Index; EDE-Q: Eating Disorder Examination Questionnair.

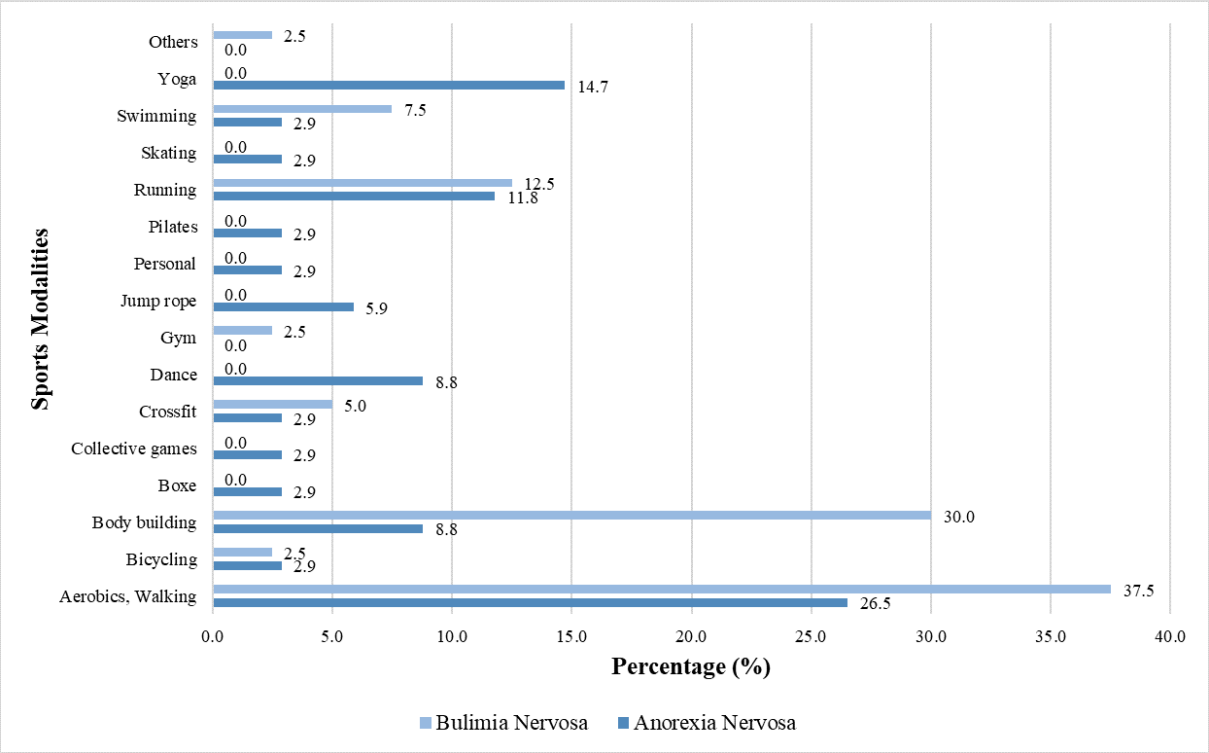

Figure 2 - Presents the types of physical exercises practiced by women diagnosed with eating disorders (anorexia or bulimia) (n=53).

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When comparing the categories of physical activity, we observed that women with AN who performed aerobic physical exercises had higher serum concentrations of Vitamin D compared to women with AN who did not perform aerobic exercises ($p<0.05$).

In addition, women with AN who performed aerobic exercises had a longer time of weekly and annual physical activity ($p<0.05$).

On the other hand, women with AN who practiced anaerobic physical exercises had a longer annual time of physical activity, when compared to women with AN who did not perform this exercise modality (Table 2).

Among the group of women diagnosed with BN, we observed that women who engaged in aerobic physical exercises had a longer annual duration of physical activity compared to women with BN who did not practice aerobic exercise ($p<0.05$).

However, no other significant differences were observed between women with BN who practiced aerobic exercise or those who did not.

On the other hand, we observed that women with BN who engaged in anaerobic exercises had a longer annual duration of physical activity, as well as higher total bone mineral density and spinal bone mineral density ($p<0.05$) compared to women with BN who did not practice anaerobic exercises (Table 2).

Table 2 - Comparative analysis of variables among women diagnosed with eating disorders (anorexia or bulimia) according to the type of physical exercise practiced (Aerobic vs. Anaerobic) (n=53).

	AN (n=25)						BN (n=28)					
	Aerobic			Anaerobic			Aerobic			Anaerobic		
	Yes (n = 15)	No (n = 10)	p*	Yes (n = 8)	No (n =17)	p*	Yes (n = 19)	No (n = 9)	p*	Yes (n = 14)	No (n = 14)	p*
Age (Years)	27.2	32.6	0.15	25.4	31.2	1.37	30.6	31.3	0.85	31.0	30.6	0.93
25 (OH)D concentration (ng/mL)	21.0	16.0	0.02	22.0	18.0	0.11	25.0	22.0	0.33	24.0	24.0	0.80
Weekly physical activity (min)	824.0	132.0	0.00	812.0	422.0	0.12	911.0	340.0	0.07	1,041	414.0	0.03
Annual physical activity (min)	23,67	768.0	0.00	25,59	8,831	0.05	24,02	4,73	0.04	28,75	6,89	0.09
Locomotion duration	22.0	17.0	0.71	34.0	13.0	0.15	55.0	37.0	0.40	62.0	36.0	0.27
Compensatory exercise 28 days (day)	9.40	1.70	0.09	6.30	6.40	0.98	2.20	2.20	0.97	2.80	1.60	0.46
Compensatory exercise 3 months (day)	24.7	5.90	0.13	20.3	15.7	0.74	7.30	2.20	0.11	5.10	6.10	0.79
Total BMD (g/cm^2)	1.09	1.10	0.66	1.10	1.09	0.55	1.20	1.12	0.07	1.22	1.13	0.03
Spine BMD (g/cm^2)	1.15	1.12	0.63	1.17	1.12	0.31	1.19	1.18	0.84	1.24	1.14	0.03
Femoral neck BMD (g/cm^2)	0.93	0.99	0.19	0.98	0.94	0.94	1.08	0.97	0.08	1.09	1.00	0.15

* Student “t” Test; 25(OH)D: 25-hydroxyvitamin D, the main circulating form of vitamin D in the blood; BMD: Bone Mineral Density

Women with AN who had a longer duration of physical activity (>300 min/week) were younger, had higher serum vitamin D concentrations, longer compensatory exercise time monthly and for up to three months ($p<0.05$). Likewise, women with BN with longer weekly physical activity were younger and had longer locomotion duration (Table 3).

In order to assess the impact of the level of physical activity on BMD across the two groups, we performed a difference test, adjusting for the age and vitamin D levels. We found that women who engaged in aerobic

exercises for less than 300 minutes per week had higher BMD compared to women who practiced aerobic exercises for a longer duration or engaged in anaerobic exercises, regardless of the time spent (p<0.005). On the other hand, women who performed aerobic exercises for more than 300 minutes per week had the lowest levels of BMD when compared to all other groups (p<0.05) (Figure 3).

Table 3 - Comparison of variables in women diagnosed with eating disorders (anorexia or bulimia) based on the duration of aerobic physical activity in minutes (n=53).

	AN (n=25)			BN (n=28)		
	<300 min (n = 10)	≥ 300 min (n = 15)	p	<300 min (n = 7)	≥ 300 min (n = 21)	p
Age (Years)	33.9	26.3	0.04	38.3	28.3	0.01
25(OH)D concentration (ng/mL)	16.0	22.0	0.01	22.0	25.0	0.56
Weekly physical activity (min)	32.0	890.0	0.00	123.0	929.0	0.02
Annual physical activity (min)	480.0	23,869	0.00	1,886	23,135	0.02
Locomotion duration	14.0	24.0	0.48	15.0	60.0	0.02
Compensatory exercise 28 days (day)	1.20	9.70	0.05	2.40	2.10	0.89
Compensatory exercise 3 months (day)	2.40	27.0	0.04	6.60	5.30	0.84
Total BMD (g/cm^2)	1.11	1.08	0.39	1.18	1.18	0.97
Spine BMD (g/cm^2)	1.14	1.13	0.82	1.17	1.20	0.64
Femoral neck BMD (g/cm^2)	0.96	0.95	0.91	0.99	1.06	0.40

* Student “t” Test; 25(OH)D: 25-hydroxyvitamin D, the main circulating form of vitamin D in the blood; BMD: Bone Mineral Density.

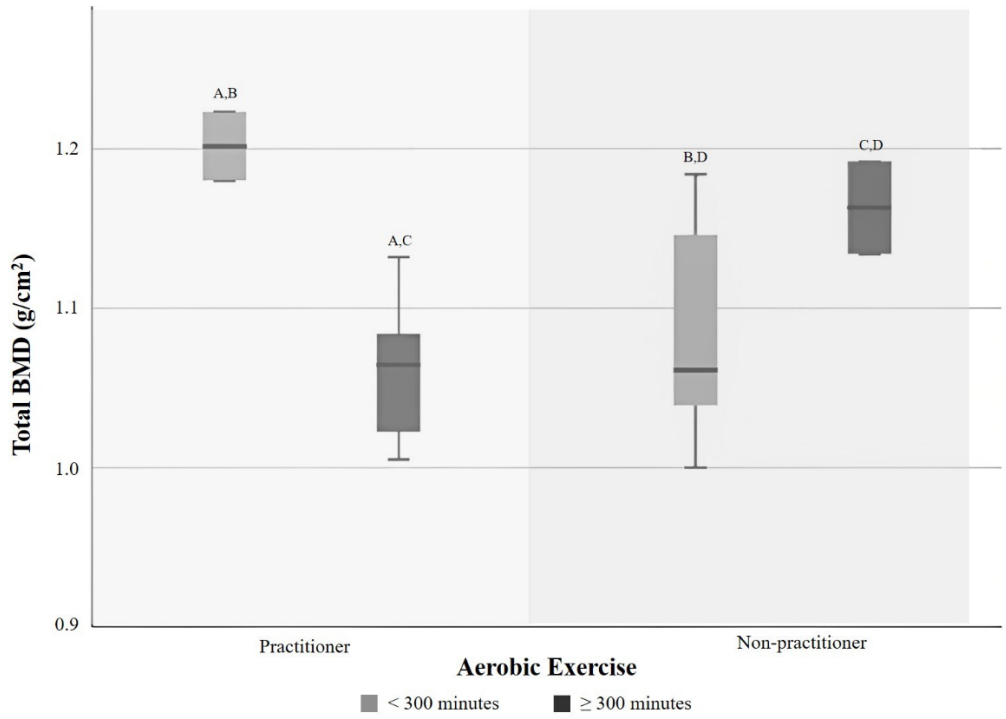

Figure 3 - Displays a comparison of the total bone mineral density (g/cm²) in women with eating disorders (anorexia or bulimia), categorized based on the duration of physical activity (aerobic and non-aerobic) in minutes (n=53). BMD: Bone Mineral Density; * Mann-Whitney U Test; A: p=0.014; B: p=0.005; C: p=0.028; D: p=0.017.

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DISCUSSION

Our study stands out for its focus on a comparative analysis of the impact of physical activity on BMD in women diagnosed with the most prevalent eating disorders: AN or BN.

This research adds to the limited body of literature in this area, providing valuable insights into the bone health of these women.

The findings of our study may contribute to a more accurate diagnosis of their bone health status, enabling the development of multimodal strategies for counseling and treatment aimed at preventing further deterioration of their overall health, including the risk of falls and fractures. Our research serves as a foundation for improving the care and management of individuals with AN and BN, addressing an important aspect of their well-being.

Our findings underscore the importance of assessing physical activity levels and its impact on bone health in women diagnosed with eating disorders. It is well-established that these individuals face a higher risk of developing osteopenia and other bone-related conditions (Drabkin et al., 2017).

By gaining a deeper understanding of these factors, we can develop more targeted and effective preventive and therapeutic interventions to minimize the adverse effects of these disorders on bone health in women.

The findings of our study align with current evidence (Strock et al., 2020; Hirschberg, 2023), indicating that women with AN tend to have lower body weight and a higher frequency and duration of amenorrhea. These findings are in line with the diagnostic criteria for AN, which often includes amenorrhea, although it is not a mandatory criterion. AN is known to disrupt the hypothalamic-pituitary-gonadal axis, leading to reduced estradiol levels and triggering functional hypothalamic amenorrhea (HPA) (Hirschberg, 2023).

In contrast to women with AN, those diagnosed with BN, despite often maintaining a normal body weight, may still experience menstrual disturbances. This is because BN can also disrupt the hormonal balance in the body, leading to amenorrhea. There are several pathways through which BN can contribute to amenorrhea, including HPA by temporary starvation and potential associations with Polycystic Ovary Syndrome (Hirschberg, 2023). These factors highlight the complex relationship between eating disorders, hormonal regulation and menstrual function, reinforcing the need for comprehensive evaluation and treatment approaches for women diagnosed with BN.

Our study showed that both groups (AN and BN) had a higher frequency of engaging in aerobic exercise compared to other types of exercise. Interestingly, we noticed an even higher frequency of aerobic exercise among women diagnosed with BN compared to women with AN.

These findings may appear contradictory to previous studies, which suggested that excessive compensatory behaviors, including physical exercise, are more commonly observed in individuals with AN (Peñas-Lledó et al., 2002; Calugi et al., 2020).

However, it is important to acknowledge that the relationship between eating disorders and physical exercise is complex and multifaceted. It can vary between individuals and be influenced by several factors, including the characteristics of the sample studied.

On the other hand, previous studies have suggested that AN and BN may manifest different patterns of compensatory behavior, especially regarding physical exercises. For example, AN is often associated with more restrictive compensatory behaviors, while BN is linked to more punitive compensatory behaviors, including excessive physical exercise (Meyer et al., 2011).

However, we note that these distinctions are not always clear-cut and can vary among individuals, as we previously mentioned. Therefore, our findings should be interpreted with caution and we reinforce the need to conduct further studies to gain a deep comprehension of these differences and the complex relationship between eating disorders and physical exercises.

Our findings revealed that women with AN who engaged in aerobic exercise had higher serum levels of vitamin D.

However, we highlight that the relationship between serum vitamin D and aerobic exercise is still poorly understood and may be influenced by several factors, such as sex, body fat percentage, sun exposure and dietary intake. It is worth mentioning that only a few studies have observed a correlation between aerobic exercise and higher serum vitamin D levels, often without proper adjustment for potential confounding factors (Todd et al., 2015).

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Therefore, these results should be interpreted with caution and cannot be extrapolated to broader populations.

Furthermore, our findings showed that women who engaged in excessive aerobic physical activity (more than 300 minutes per week) had lower BMD.

It is important to highlight that intense aerobic exercise, particularly when combined with an inadequate diet, can have detrimental effects on bone health, leading to compromised BMD.

The presence of low weight found in women with AN further aggravates the risk of decreased BMD (Powers, 1999).

These results show the importance of considering the potential impact of excessive aerobic exercises and insufficient nutritional intake on bone health.

On the other hand, some studies have suggested that moderate physical exercise, including aerobic exercise, may have a protective effect on bone mineral density of women diagnosed with eating disorders. However, it is crucial to highlight that this positive effect appears to be dependent on an individual's normal body weight.

For instance, Sundgot-Borgen et al., (1998) showed that patients with BN and normal body weight who engaged in regular moderate physical exercise had higher bone mass when compared to sedentary BN patients (both groups had normal bone mineral density). However, in a group of patients with AN and low body weight, regular exercise did not confer the same protective effect, and this group exhibited low BMD.

Supporting these findings, our results suggest that non-strenuous or moderate aerobic exercise (<300 min/week) is related to better BMD levels.

These results align with the previous studies aforementioned. Consequently, we suggest that moderate exercise may be beneficial for bone health, while strenuous exercise may have negative effects. Nonetheless, it is important to acknowledge that each study has its limitations and further research is needed to validate these findings.

Moreover, we highlight that other factors that can influence the relationship between exercise and BMD should be taken into account, including age, genetics, nutritional status, modality of physical exercise and history of previous diseases.

Strength and limitations

Our study has some limitations to be acknowledged. First, the cross-sectional design does not allow us to establish a cause-and-effect relationship.

Second, the study was conducted in a single center and the sample was recruited by convenience, limiting the extrapolation of results. However, this reality is not exclusive to our casuistry, as the low number of patients has been a common limitation in most studies of exercises in AN (Mathisen, 2020).

Additionally, we highlight that women could be in different stages of treatment and severity of disease, which may influence the results of BMD. To reduce this bias, we included age, diagnosis, disease duration, and amenorrhea in our analyses.

In addition, it is important to highlight that our study did not analyze serum levels of PTH (parathyroid hormone), limiting the interpretation of serum levels of vitamin D, since PTH is an important hormone that regulates vitamin D and calcium in the body.

On the other hand, it is important to highlight some strengths of our study. First, data collection was performed at a referral center for eating disorders, which helped minimize selection bias and increase sample representativeness. In addition, we performed a comparative analysis of the variables between the different diagnoses of eating disorders, which allowed us to identify possible divergences in the behaviors associated with AN or BN and its impact on bone health. It is also important to note that we use DEXA, which is considered the gold standard for the diagnosis of BMD.

This increases the reliability of our results and allows us to make more accurate comparisons with previous studies and other populations.

The findings of our study underscore the need for appropriate guidance on the regarding physical exercises in individuals with eating disorders to prevent harm to bone health. Furthermore, it emphasizes the significance of regular assessment of BMD in patients with AN or BN to promptly identify any alterations and implement preventive or therapeutic interventions.

Therefore, our study contributes to enhancing our understanding of the impact of physical exercise on the bone health of women diagnosed with eating disorders, enabling a

more personalized and safe approach to treatment.

CONCLUSION

Our findings demonstrated that the excessive engagement in physical activity, particularly aerobic exercises, has a detrimental effect on BMD of women diagnosed with AN or BN.

These results emphasize the importance of not only examining eating behaviors related to these eating disorders but also considering broader behavioral factors, such as the types of sports activities practiced, due to their negative impact on bone and overall health.

Our results underscore the importance of comprehensive assessment and interventions addressing several aspects of behavior to promote optimal bone health in women diagnosed with AN or BN.

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INTEREST CONFLICTS

The authors declare no conflicts of interest.

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