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THE EFFECTS OF AQUATIC HIGH-INTENSITY INTERVAL TRAINING (HIIT) ON MENTAL HEALTH PARAMETERS IN ELDERLY WOMEN WITH DEPRESSION

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ABSTRACT

The present study investigated the effects of aquatic HIIT on mental health parameters in elderly women with depression. The sample was composed of 31 elderly women randomized in non-depressed group (GND) (n=19) (61.5 ± 7anos; 29 ± 5 kg/m2) and depressed group (GD) (n=12) (58.9±6 years; 29 ± 4 kg/m2). Both groups participated in 24 sessions of aquatic HIIT. 48 hours before and after intervention, parameters of depression, anxiety, sleep and insomnia were quantified. The data were expressed as means ± standard errors of the mean (SEM), statistically analyzed by two-way analysis of variance (ANOVA), followed by Bonferroni post hoc test. The significance level was set at $p < 0.05$. During the sessions there were significant increases ($p < 00.5$) in the intensity of the exercise, reaching 8 points in the Borg's rating of perceived exertion (RPE) in both groups. There were significant reductions ($p < 00.5$) in depression (GND 54%), anxiety (GND 53% and GD 55%), sleep (GD 42%) and insomnia (GD 49%) scores post-training when compared to pre-training. We conclude that aquatic HIIT improves aspects related to mental health in non-depressed and depressed elderly women.

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INTRODUCTION

Depression is a chronic psychiatric disorder of varied prognosisthat could reduce quality of life and increase the risk of suicide (Daly *et al*., 2018; Ignacio *et al*., 2019). This disease affectsthe 4.4% of the world population and is considered a leading cause of disability, especially among women aged 55 to 74 years (Byeon, 2019; World Health Organization, 2017). By 2050, elderly people will probably exceed 2 billion (Moore *et al*., 2018). As well as the global population ages, the rates of occurrence of depression also increase, representing a serious public health problem (Byeon, 2019; Steiger& Pawlowski, 2019). However, anxiety and sleep disorders areconsiderednot only risk factors but alsosymptoms of depression. In this sense, it is estimated that 85% of depressed patients manifest anxiety symptoms, 80% suffer from insomnia and 35% from sleepiness (Lenze *et al*., 2000; Steiger& Pawlowski, 2019). It is a fact that these mental disorders aggravate the clinical picture of depressed elderly women, resulting in a barrier to healthy aging. In addition, clinically depressed elderly women are physically less active and have decreased cardiorespiratory fitness (Ignácio *et al*., 2019). In contrast, regular physical exercise can bring mental health benefits in different populations. It´s been pointed out that beneficial effects induced by physical exercise may be similar to drug treatment of some classical antidepressants (Blumenthal *et al*., 2007; Ignácio *et al*., 2019; Schuch *et al*., 2016). However, the literature is confusing regarding the exercise protocols used, mainly in the dosage of training variables such as volume and intensity. In this sense, regular practice of aquatic exercises have shown significant results in symptoms of depression, anxiety, and sleep problems in elderly and adults with different chronic pathologies (da Silva *et al*., 2018, 2019; Delevatti *et al*., 2018). According to specialized studies, water presents physical properties such as buoyancy, density, hydrostatic pressure and thermo-conductivity, which psychophysiologically alter the effects of exercises when compared to the same performed on land (Delevatti *et*

al., 2018; Nagle *et al*., 2017). Such hydrodynamic properties have clinical relevance for depressed elderly women, as they contribute to a safe, comfortable and effective environment (da Silva *et al*., 2019). Among the aquatic modalities, hydrogymnastics is characterized by functional exercises with basic multi-articular and multiplanar movements such as squatting, forward, backward, lowering, lifting, pulling, pushing, and turning (Nagle *et al*., 2017). Water aerobics exercises, when compared with gymnastics exercises for example, are safer (because water helps control movement), more cadenced (because water helps holding the movement), havelower impact (because water helps avoiding bumps and reducing body weight), andare more uniform (because water helps minimizing speed in sudden changes of direction. In relation to high intensity interval training (HIIT), it is characterised by its short duration and high intensity, close to 90% of maximum oxygen consumption (VO2max), or its equivalent of 8 to 10 points on perceived exertion scales (Nagle *et al*., 2017). On the other hand, long exercise sessions can result in an extremely stressful event and depending on the intensity can amplify the magnitude of stress (Chang *et al*., 2020; Ignacio *et al*., 2019). A cross-sectional study of 1.2 million Americans with mental health problems showed that continuous exercise sessions lasting longer than 45 minutes did not provide the same mental benefits compared to shorter exercise sessions. In addition, the authors warn that sessions longer than 90 minutes may impair the mental health of the individual (Chekroud *et al*., 2018). However, little is known about the effects of aquatic HIIT on depressed women over the age of fifty-five. Thus, this study aims to quantify the changes in psychophysiological parameters of depression, anxiety, sleep quality, sleepiness and perception of effort in elderly women, diagnosed as depressed, submitted to a program of aquatic HIIT for 12 weeks. We hypothesise that aquatic HIIT significantly alters the psychophysiological parameters of elderly women with depression.

METHODOLOGY

Study design: A randomized clinical study with elderly women, conducted for 12 weeks, divided into a non-depressed and a depressed group. Both groups were submitted together to the interval aquatic physical exercise program. Assessments of depression, anxiety (Açıkel, 2019), sleep quality and sleepiness (Doyenart *et al*., 2021) were performed 48 hours before and after. During the sessions, exercise intensity was assessed through Borg's rating of perceived exertion (RPE) (Delevatti *et al*., 2018). This study was conducted in accordance with Resolution 466/12 of the National Health Council (CNS) and approved by the Ethics Committee of the Universidade do Extremo Sul Catarinense (CAAE: 47120815.3.0000.0119). All participants provided prior written consent.

Sample characterization: Women between 55 and 75 years of age, clinically diagnosed with major depressive disorder by a psychiatrist at the local university, participated in the study. All the participants presented a medical certificate confirming that they were suffering from depression and were undergoing pharmacological treatment, in addition to being released by the doctor to practice exercises. As an exclusion criterion, subjects that were carriers of other diseases, participants of another program or that did not have medical release to practice were excluded from the study. To characterize the corporal composition, the corporal mass (kg) was verified using an anthropometric scale (Toledo-Brazil). The height was measured using a stadiometer (cm). The body mass index (BMI) (Kg/m2) was calculated from the body mass (kg) and height (m) by the formula BMI = body mass (kg)/height (m) x height (m) (Table 1).

Randomization: Initially, 325 individuals signed up to voluntarily participation in the university extension program "LazerAtivo" at the local university. Of this original list, 52 elderly women were selected by convenience criteria, respecting the objections of inclusion and exclusion of the study to participate voluntarily in the research. The elderly women with clinical diagnosis of depression were allocated to GD (n=23) and the rest, without depression in GND (n=29). Throughout the 12 weeks of intervention (hydrogymnastics) there were drop outs and the GND reduced to (n=19) and GD to (n=12) (Figure 1).

Table 1. Characterization of the population

Variables	GND (n=19)	GD (n=12)	*P* (value)
Age (years)	61.5 ± 7	58.9±6	0.073
Height (m)	1.62 ± 7	1.58±6	0.085
Body weight (Kg)	79 ± 15	75.2±8	0.077
BMI (Kg/m^2)	29 ± 5	29 ± 4	0.081
Medical treatment(n°)			
Alprazolam	0	3	
Bupopriona	0	4	
Citalopram	0	6	
Clonazepam	0	8	
Fluoxetina	0	7	
Rivotril	0	5	
Sertralina	0	4	
Venlafaxina	0	7	

Legend: Drugs ingested by the elderly with depression; GND - group not diagnosed with depression; GD - group diagnosed with depression; Student's t-test. The significance level was $p < 0.05$.

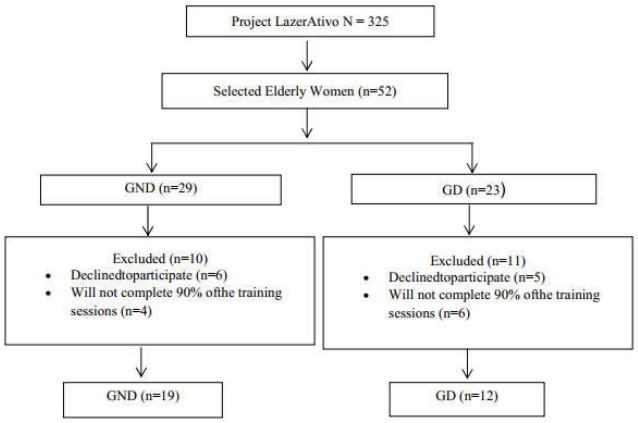

Figure 1. Flowchart. Note: Flowchart of the randomization process. GND - group not diagnosed with depression; GD - group diagnosed with depression

Aquatic exercise protocol: Each training session lasted 50 minutes and was divided into a warm-up period (5 min), followed by the main part of training (40min) and cardiorespiratory recovery period (5min). Each main part was composed of 8 exercises with 4 minutes of stimulus, containing 4 series of 30 seconds each exercise, with 15 seconds of interval between series and with an interval between each exercise of 1 minute (Machado *et al*., 2017). Regarding the intensity, all the elderly women were encouraged to perform the exercises at the maximum speed and amplitude possible, with a RPE suggested between 8 and 10 points on the CR10 scale, classified as high intensity (Borg, 2000). The exercises involved large muscle groups with functional movement patterns (push, pull, squat, forward, backward, stoop, lift, rotate) combining the upper and lower limbs simultaneously. Both groups had identical training protocols. All selected exercises followed the guidelines of the Aquatic Exercise Association (AEA) (Netto andAlevatto, 2014) (Table 2). Classes took place in the afternoon period, in a 25m x 12.5m covered pool with depth of 1.40m and water at a temperature of approximately 26 to 28ºC.

Borg's rating of perceived exertion (RPE): The RPE is an instrument frequently used in several studies to quantify the intensity of effort of both collective and individual classes (da Silva *et al*., 2018, 2019; Delevatti *et al*., 2018; Doyenart *et al*., 2020; Silva *et al*., 2021). The 10-point RPE scale was standardized by Borg and named it CR10 (Borg, 2000). This instrument serves to classifythe subjective perception of effort on a numerical scale ranging from 0 (no effort) to 10 (maximum effort), the individual uses the scale to point out their own perception of effort (Borg, 2000). All elderly women signaled a score within the scale at the beginning and end of each exercise throughout the intervention.

Mental health parameters

Depression: The Beck Depression Inventory (BDI) (Cunha, 2001) was applied. The BDI is a self-administered questionnaire, considered by the Center for Cognitive Therapy (CCT) as a widely used instrument for the self-assessment of depression, both in the scientific field and in clinical settings (Cunha, 2001). The questionnaire includes 21 items referring to negative feelings. The total score ranges from 0 to 63 points, referring to sadness, pessimism, feeling of failure, lack of satisfaction, feeling of guilt, among others. The BDI was translated and validated for the Brazilian population, according to Cunha. (2001).

Anxiety: Regarding anxiety, the Beck Anxiety Inventory (BAI) was used (Cunha 2001). The BAI is a self-administered scale with 21 items related to somatic, affective and cognitive anxiety symptoms. Each item has four possible responses scoring the degree of intensity ranging from 0 to 3 (0 = Not at all; 1 = Slight, did not bother me much; 2 = Moderate, sometimes was not pleasant; 3 = Severe, bothered me a lot). The total score ranges from 0 to 63 points. The BAI was translated and validated for the Brazilian population by Cunha (2001).

Sleep: The latter was assessed throughthe Pittsburg Sleep Quality Index (PSQI) and sleepiness by the Epworth Sleepiness Scale Standardized for the Brazilian population (ESS-BR) (Buysse *et al*., 1989). The PSQI is a self-administered questionnaire that allows the assessment of sleep quality and sleep disorders (Buysse *et al*., 1989). The PSQI uses 19 items with a 0 to 3 point scale distributed in 7 groups (subjective sleep quality, sleep latency, sleep duration, usual sleep efficiency, sleep disturbances, use of sleep medication and daytime dysfunction); the total amount of the points can result in up to 21 points. From 0 to 4 points is considered a "good" PSQI; from 5 to 10 points configures the "bad" PSQI; and above 10 points characterizes sleep disorder. Also, the ESS-BR is a subjective method that assesses the excessive daytime sleepiness (EDS), in other words, the chances of an individual dozing in everyday situations (Bertolazi *et al*., 2009). It is organized into 8 questions with scores from 0 to 3 which, added together may generate a total of up to 24 points;EDS is considered when results areabove 10 points.

Statistical analysis: Data were expressed as mean and mean standard deviation and statistically analyzed by two-way analysis of variance (ANOVA), followed by the Tukey post hoc test. The Kolmogorov Smirnov test was applied to check whether the data presented normal distribution. The significance level established for the statistical test is $p<0.05$. SPSS (Statistical Package for Social Sciences) version 22.0 was used as a statistical package.

RESULTS

RPE: According to Figure 2, results showed that there was a significant increase ($p < 00.5$) in the PSE at the end of all eight exercises performed during the classes in both groups, with an average intensity of 7.94 ± 1 points for GND and 8.33 ± 1 points for GD on the CR10 scale (Borg, 2000).

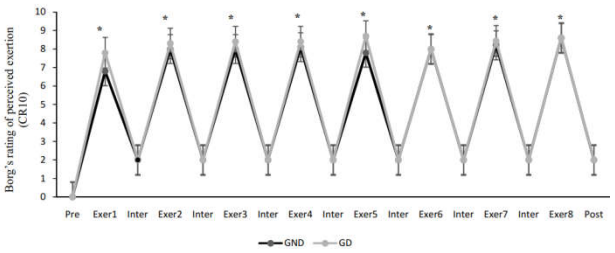

Figure 2. Borg's rating of perceived exertion. Note: Results referring to the levels of subjective effort perception on the depressed and non-depressed groups pre and post exercise. GND - group not diagnosed with depression; GD - group diagnosed with depression.The symbol (*) indicates statistic intragroup differentiation. The significance level was p < 0.05

Depression parameter: According to Figure 3, the aquatic exercise program reduced 54% the BDI depression scores of GND (3.73 ± 2.3 points) when compared with the pre-program (8.15 ± 3.8 points) ($p = 0.039$).

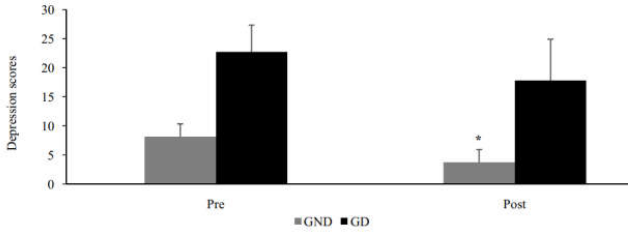

Figure 3. Beck Depression Inventory. Results referring to the levels of depression of the depressed and non-depressed groups pre and post exercise. GND - group not diagnosed with depression; GD - group diagnosed with depression. The symbol (*) indicates statistic intragroup differentiation. The significance level was p < 0.05

In relation to GD there was a reduction in the order of 21% with no statistically significant difference after intervention (pre 22.7 ± 4.6 points; post 17.8 ± 7.1) ($p = 0.074$).

Anxiety parameters: According to Figure 4 the results showed significant reductions in BAI anxiety scores in the order of 53% in GND and 55% in GD after interval aquatic exercise program when compared with pre-program. GND (pre 5.3 ± 3.8 points; after 2.5 ± 2.3 points; $p = 0.021$) and GD (pre 23.2 ± 4.6 points; after 10.5 ± 7.1 points; $p = 0.048$).

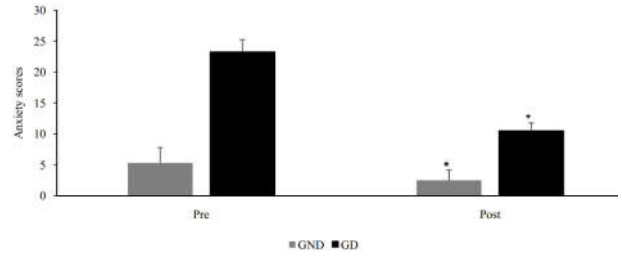

Figure 4. Beck Anxiety Inventory. Note: Results referring to anxiety levels of depressive and non-depressive groups pre and post exercise. GND - group not diagnosed with depression; GD - group diagnosed with depression. The symbol (*) indicates statistic intragroup differentiation. The significance level was p < 0.05

Sleep parameters: According to Table 2, results showed that the aquatic exercise program significantly reduced the PSQI scores for GD by 42% (9.1 ± 2.1 points) when compared with pre-training (15.8 ± 1.8 points) ($p = 0.087$). In relation to GND there was no significant difference after intervention when compared with pre-training. Similarly, ESS-BR scores decreased significantly by 49% in GD after aquatic intervention (3.1 ± 2.1 points) when compared with pre-training (6.1 ± 1.1) ($p = 0.05$). However, there was no significant difference after intervention when compared with pre-training (Table 2).

Table 2. Sleep Parameters

Parameters	GND	*P* (value)	GD	*P* (value)
PSQI (scores)				
Pre	7.5 ± 2.7		15.8 ± 1.8	
Post	6.3 ± 1.9	0.087	9.1 ± 2.3*	0.039
ESS-BR (scores)				
Pre	5.9 ± 2.1		6.1 ± 1.1	
Post	3.2 ± 2.5	0.68	3.1± 2.1*	0.05

Legend: GND - group not diagnosed with depression; GD - group diagnosed with depression; PSQI - Pittsburg Sleep Quality Index; ESS-BR - Epworth Sleepiness Scale for the Brazilian population. The symbol (*) indicates statistical intra-group difference. The level of significance was $p < 0.05$.

DISCUSSION

The diagnosis of depression often comes accompanied by anxiety and sleep disorder, these being the most common psychiatric conditions among elderly women (Lenze *et al*., 2000; Pary *et al*., 2019; Steiger& Pawlowski, 2019; Vollbehr *et al*., 2018). In contrast, we know that regular practice of physical exercise, mainly aerobic, can improve mental health in depressed elderly women in isolation or combined with pharmacological treatment (Aidar *et al*., 2018; Chekroud *et al*., 2018; da Silva *et al*., 2019; Ignácio *et al*., 2019; Mikkelsen *et al*., 2017). In this sense, our results demonstrated that a 12-week aquatic HIIT protocol was sufficient to reduce anxiety and sleep disorder scores in both groups. The first parameter evaluated in this study was the RPE using the CR10. This instrument has been used as a psychophysiological variable, which measures through physical and mental RPE the changes caused by physical exercises, in several populations including the elderly, which predict the internal workload demarcating the intensity of exercise (Bray *et al*., 2016; da Silva *et al*., 2019; Doyenart *et al*., 2020; Shaw *et al*., 2020; Tibana *et al*., 2018). It is a fact that CR10 has been used in several studies correlated with physiological domains such as anaerobic threshold, heart rate and maximal oxygen uptake volume (Shaw *et al*., 2020; Tibana *et al*., 2018). Due to its practicality and effectiveness in verifying the intensity of the exercise, the CR10 is an important tool, used by the teacher in the application of collective classes to graduate the intensity of the class (Bray *et al*., 2016; da Silva *et al*., 2019). Our results point to a psychological analysis of the perceived effort of 8 points using the CR10 scale, this represents high intensity of effort (Borg, 2000).A psychophysiological explanation for our findings is that the interval exercises were oriented to perform at the maximum possible speed and amplitude, characterizing an intense activity. According to Nagle *et al*. (2017), physiologically, this practice alters heart rate, respiratory rate, blood lactate and oxygen consumption which coincides with altered RPE (Nagle *et al*., 2017). Next, we investigated symptoms of depression using the BDI. It is a fact that depression impairs mental and physical health, aggravating health problems and shortening the life span of elderly women (Jonsson *et al*., 2016; Kurdi & Flora, 2019; Micheli *et al*., 2018; Salk *et al*., 2017; Zhang *et al*., 2018; Zis *et al*., 2017).

According to our findings the proposed intervention model reduces the depression scores in 54% and 21% in GND and GD respectively; however, there was no statistically significant difference for GD ($p > 0.05$). Another previous study investigating depression symptoms in elderly diabetic people, also found no significant differences in BDI scores after 12 weeks of aquatic exercise with linear intensity (progression from 80% to 100% of anaerobic threshold) (Delevatti *et al*., 2018). In contrast, another study, conducted by our laboratory, demonstrated that 12 weeks of low intensity interval aquatic exercises, was sufficient to decrease 53% BDI scores in depressed older adults. Similarly, previous studies have reported decreases in BDI scores in patients of more than 50 years affected by chronic noncommunicable diseases (NCDs) after intervention with aquatic exercise (Aidar *et al*., 2018; da Silva *et al*., 2018; Dani *et al*., 2020). Based on this, it is evident that the literature is confusing and needs to advance. However, our results point to a tendency to decrease depressive symptoms which will soon be confirmed with the reduction of anxiety and sleep scores.However, aquatic intervention was effective in significantly decreasing BDI scores by 54% in GND. These findings are clinically relevant as they allow us to think that aquatic exercises can be a protective non-drug therapy for the mental health of elderly women. Anxiety symptoms were soon assessed. Anxiety is associated with ageing women and represents a risk factor for several age-related complications (Chekroud *et al*., 2018; Luo *et al*., 2020; Milligen *et al*., 2019). Our results indicate that there were significant reductions in order of 53% in BAI scores in GND and 55% in GD after intervention. Studies indicate that aquatic exercise reduces anxiety by various mechanisms, but the protocols are diverse and not very specific.A study conducted in our lab with depressed seniors demonstrates that a 12-week protocol of low-intensity interval aquatic exercise reduces BAI scores (da Silva *et al*., 2019).This is in line with other studies reporting decreases in anxiety symptoms following aquatic intervention with various protocols in elderlypeople and adults (Aidar *et al*., 2018; da Silva *et al*., 2018; Lee *et al*., 2020; Wong, 2019).We now point out that the aquatic HIIT protocol had the same outcome in depressed and non-depressed elderly women. However, we now need to compare which one (continuous low and moderate intensity x high intensity interval) presents a greater effect, leaving then a challenge for future researches. Psychophysiologically it is likely that the exercise protocol used in this study modulates serotoninergic, endocannabinoid and opioid systems associated with synaptic slowing and anxiety pathogenesis. These mechanisms may have caused a tranquilizing analgesic effect post-exercise (Cooper *et al*., 2018; Mikkelsen *et al*., 2017; Vorkapic-Ferreira *et al*., 2017). At the same time, the thermogenic property of water is able to increase the speed of heat exchange of the submerged body and cause a feeling of pleasure that may have contributed to decrease anxiety (Alberton & Kruel, 2009; Wong, 2019).

In relation to sleep quality and sleepiness we quantified the PSQI and ESS-BR scores. Sleep alterations are notable in most depressive disorders. We know that there is an association between depression, sleep disorders and aging that affect negatively physical and mental health of elderly women (Canuto *et al*., 2018; Riemann *et al*., 2020; Steiger& Pawlowski, 2019). Our results demonstrated that 12 weeks of aquatic HIIT significantly reduce PSQI scores by 42% and ESD-BR scores by 44% in GD. Our findings corroborate the results reported by Delevatti *et al*. (2018) who signaled a 17% decrease in PSQI scores after 12 weeks of aerobic aquatic exercise and progressive intensity in diabetic patients.We obtained similar results in both sleep parameters, with the difference that in this study we used an aquatic exercise protocol in depressed elderly women. A possible explanation for our findings is that pathophysiologically depression and sleep alterations are associated with a hyper activity of the hypothalamus, pituitary, adrenal (HPA) axis, induced by a chronic inflammation of the hypothalamus (associated with depressed elderly women), which results in exacerbated concentrations of plasma cortisol that inhibit the secretion of melatonin, a hormone responsible for sleep induction (Ignacio *et al*., 2019; Steiger& Pawlowski, 2019).Studies point out that the 80% of depressed individuals suffer from insomnia (Riemann *et al*., 2020; Steiger& Pawlowski, 2019). Based on that, we suggest that our aquatic protocol chronically modulated the activity of the HPA axis and the relationship between cortisol and melatonin. Added to this, acute exercise is able to activate psychological mechanisms, such as those of distraction and self-efficacy, capable of generating psychological well-being and consequently improving sleep quantitatively and qualitatively (Ebrahimi *et al*., 2017; Ignacio *et al*., 2019; Mikkelsen *et al*., 2017; Ogilvie & Patel, 2018).

CONCLUSION

We conclude that aquatic HIIT alters the PSE in a similar way in depressed and non-depressed elderly women, as well as improves psychophysiological aspects related to anxiety and sleep disorders in clinically depressed elderly women. However, regarding the specific scores of depression, the protocol adopted was only effective for non-depressed elderly women, suggesting a protective effect on mental health. These findings allow us to think that aquatic HIIT may contribute to the prevention and treatment of mental disorders associated to depression and aging. We point out as a major limitation the absence of a non-exercised group of elderly women with depression, serving as control and the lack of analysis of biochemical markers related to mental health. We recommend that future studies be conducted.

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