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Research paper

Physical exercise and body mass index as correlates of major depressive disorder in community-dwelling adults: Results from the PISMA-ep study

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ABSTRACT

Background: Major Depressive Disorder (MDD) is one of the most prevalent and disabling mental disorders. Sedentarism and obesity are recognized risk factors for MDD. Physical exercise has shown beneficial effects on mental health and there is an increasing awareness of its potential as a therapeutic and preventive tool for depression. No epidemiological studies have explored the role of physical activity and obesity as potential correlates of MDD in the Spanish population. The aim of this study was to explore whether MDD was associated with two strongly linked variables: physical exercise and body mass index.
Methods: The PISMA-ep is a cross-sectional community-based study carried out in Andalusia, southern Spain. Main outcome was current prevalence of MDD, measured through face-to-face interviews using the Mini-International Neuropsychiatric Interview (MINI). Independent variables explored were physical exercise and its intensity, Body Mass Index (BMI), BMI categories (underweight, normal weight, overweight and obesity), hip and waist circumferences, general health status measured with the SF12 questionnaire, and sociodemographic factors.
Results: Physical exercise was inversely associated with MDD, acting as a protective factor. Higher intensity of exercise strengthened this association. Four variables were independently associated with MDD in the multivariate association model: female sex, physical exercise, general health status and BMI.
Conclusion: MDD was associated with poorer health status, higher BMI and reduced physical activity. Physical exercise should be considered as a potential intervention for the treatment and prevention of MDD in clinical and public health settings.

1. Introduction

Major Depressive Disorder (MDD) is the most prevalent mood disorder worldwide and it has been a subject of public health concern for several years (Kessler et al., 2003). Along with low back pain, MDD is one of the two chronic conditions at the top ten lists of causes of Years Lived with Disability (YLDs) in every country (Vos et al., 2015). It also has a significant economic impact, frequent physical comorbidities and is linked to an increased mortality (Egede, 2007; Farmer et al., 2008; Kessler, 2012).

It is estimated that 11–15% of the world population have suffered from MDD at some point in their lives (Bromet et al., 2011). In Spain, lifetime prevalence of MDD is around 4.0% (Gabilondo et al., 2010), one of the lower rates in Europe, although prevalence seems to be higher in some areas, including Andalusia (Porras et al., 2018).

The high rates of lack of response to conventional treatments, and the side effects of psychopharmacological interventions, points out to the need of alternatives in the management of this condition. The

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implementation of exercise as both a preventive strategy in the community and a therapeutic option in the clinical practice could be a valuable tool to halt the progression of this condition which has been called the epidemic of 21st century.

A significant association between MDD and physical exercise has been found in cross-sectional and longitudinal studies (Zhai et al., 2014; Hiles et al., 2017). Physical exercise is also related to depression at the dimensional level, correlating negatively with depressive symptoms (Galper et al., 2006; Pinto-Pereira et al., 2014). Apart from contributing to the understanding of the etiopathogenesis of depression, physical exercise may be an effective strategy in the prevention and treatment of depression. Physical exercise has been associated with a reduced incidence of depression (Baumeister et al., 2017; Harvey et al., 2018) and lower depression recurrence (Baumeister et al., 2017). The antidepressant effect of exercise has also been explored in interventional studies, showing a significant reduction in depression scores, with moderate to large effect sizes (Lawlor, 2001; Stathopoulou et al., 2006; Landers and Arent, 2007;Krogh et al., 2010; Kerling et al., 2015; Kvam et al., 2016; Schuch et al., 2016). In a 2009 meta-analysis of 58 randomized trials, exercise was found to be an effective treatment for major depression, with a significant reduction in depression parameters and large effect sizes (Rethorst et al., 2009a). A recent meta-analysis found that aerobic exercise had a significant antidepressant effect in depressed patients (Morres et al., 2018). Exercise-based interventions have proven effective for both

However, the association between MDD and physical exercise has not been tested yet in the Spanish community-dwelling population. There are also no epidemiological studies that have explored the association between this mental health condition and obesity in the Spanish population.

The aim of this study was to explore the association between MDD and physical exercise and obesity in a sample representative of the general adult population of southern Spain. Our findings will help to ascertain the usefulness of physical exercise as a therapeutic and preventive strategy for MDD to help health-care planning in this area.

2. Methods

The STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) guidelines were followed where applicable (STROBE Statement, 2018).

The PISMA-ep (Plan Integral de Salud Mental en Andalucía – epidemiología) is a cross-sectional study that explores the prevalence and correlates of mental disorders in Andalusia. This study was approved by the Research Ethic Committee of the University of Granada. A detailed description of the methodology of this study has been published elsewhere (Cervilla et al., 2016).

2.1. Setting and design

The PISMA-ep study uses a sample of community-dwelling adults aged 18–75, representative of the eight provinces of Andalusia, southern Spain. Andalusia is the most populous and the second largest autonomous community of Spain, with nearly 9 million inhabitants (IECA, 2018). The PISMA-ep study is an initiative the Andalusian Health Service that aims to assess the prevalence of mental disorders and its correlates for purposes of health-care planning. The main objectives of this study were: 1. Estimate the prevalence of 16 mental disorders in the area; 2. To explore the biological and psychosocial factors associated with these mental disorders, and 3. To collect a large cohort of subjects that could be the basis for future prospective studies.

2.2. Sample

Target sample size, determined as that able to calculate a 2% prevalence with ± 0.5% precision, confidence intervals of 95% and an effect size of 1.5, was estimated at 4518.

The sample was created using different levels of stratification. We ensured there was proportional representation from the eight provinces of Andalusia, and also took into account city size, dividing the municipalities in three categories: urban (over 10,000 inhabitants), intermediate (between 2001 and 10,000 inhabitants) and rural (up to 2000 inhabitants. For each size, we used a simple random method to select municipalities and street routes within each town.

Inclusion criteria for respondents were: being between 18 and 75 years old, and having lived in Andalusia for at least a year. Exclusion criteria were: illness that precluded the completion of the interview, not speaking Spanish fluently, suffering from severe cognitive impairment or intellectual disability, and usually residing in an institution.

2.3. Measures

Main outcome: Our main outcome was current (last two weeks) presence of MDD, following DSM-IV/ICD-10 criteria. This diagnosis was obtained using the Spanish version of the Mini International Neuropsychiatric Interview (MINI) (Bobes, 1998; 2006), a brief diagnostic structured interview that generates Axis I DSM-IV and ICD-10 compatible diagnoses for 16 mental disorders, including MDD. This interview consists of a screening section for each diagnostic, leading to a further set of questions in case the detection was positive (Lecrubier et al., 1997). The MINI has shown satisfactory psychometric properties, having good rates of validity and reliability when used on a community based population (Rossi et al., 2004; Kadri et al., 2005; Otsubo et al., 2005).

Physical exercise: Information on physical exercise was assessed using 3 questions about whether the participant practiced any physical activity, the setting of such activity (home labour, work or leisure), and the intensity of the activity. Intensity was classified based on the Metabolic Equivalents of Task or METs (2 METs = two times the amount of oxygen consumed at rest) as light (< 3 METs), moderate (3 – 5 METs) or vigorous (≥ 6 METs).

Anthropometric measures: Height (m) and weight (kg) of each participant were registered. Using these variables, their Body Mass Index (BMI) was calculated by the formula: weight in kilograms divided by height in square metres (kg/m^2). Hip and waist circumferences (cm) were also measured. Participants were grouped into four categories, following WHO criteria (WHO, 2018): Underweight (BMI <18.5 kg/m^2), Normal weight (BMI 18.5–24.99 kg/m^2), Overweight (BMI 25.0–29.99 kg/m^2) and Obesity (BMI ≥ 30 kg/m^2).

Physical health status: The physical component summary of the 12-Item Short Form Health Survey (SF-12), Spanish version, was used to measure general health status over the last four weeks. The SF-12 consists on a subset of 12 items of the generic SF-36 health survey that measure physical and mental health. It has shown a high correspondence with the SF-36 when the sample size is ≥ 500, and it is considered a useful alternative to the long version when making comparisons among large groups of participants (Vilagut et al., 2005). Scores were standardized to a population mean of 50 and converted into a scale ranging from 0 (worst possible health status) to 100 (best possible health status) (Alonso et al., 1998).

2.4. Procedure

After a public bid was launched, a local survey company specialized in the health field was tasked with the selection of the sample and the collection of the data.

After attending a one-week training course imparted by the researchers, a team of trained psychologists (5 to 10 per province, there being 8 provinces) performed the interviews. These were face-to-face and took place either in the participant's local primary health care center or in their homes, at the convenience of the participant. Data collection was conducted between 2013 and 2014, and lasted almost a year.

We carried out a pilot phase, during which we undertook 160 interviews (20 per province) and tested the suitability of the questions as well as the method of sample selection.

One in every 4 consecutive homes in the selected street routes was visited. When a home responded, we invited to participate the first person in the house that fulfilled inclusion criteria.

2.5. Quality control of data

We designated eight interviewer coordinator, who checked twice that all of the questionnaires performed in their area had been correctly completed and also reviewed the quality of the data collected.

2.6. Response rate

Homes which did not respond after four attempts on different time and day, or those whose inhabitants did not meet inclusion criteria, were replaced with the next available one in the route. Of the homes initially selected, 70.8% had to be replaced.

5496 homes were finally used for the study, of which 4507 agreed to participate in it and completed the interview, resulting in/amounting for a response rate of 83.7%. 4286 participants (95.1% of participants and 78% of those originally chosen) consented to provide a saliva sample for the DNA study. Flow chart of the recruitment process is shown in Fig. 1.

2.7. Statistical analysis

All statistical analyses were performed using the SPSS version 24.0 software. We calculated current (last two weeks) prevalence of MDD among the participants. We performed a binary logistic regression and constructed a multivariate model to explore the associations between MDD and the correlates. Crude and adjusted ORs were obtained. All tests were two-sided, with a $p < 0.05$ level of significance and 95% confidence intervals.

3. Results

3.1. Description of the sample

4507 community-based adults finally took part in the study. The gender distribution of the sample was 50.9% female and 49.1% male. Mean age was 42.8 years. Current (last two-weeks) prevalence of MDD was 6.5% (95% CI 5.7–7.2). Current prevalence of obesity was 17.4% in the total sample and 30.6% in participants with MDD. 58.8% of the total sample practiced physical exercise regularly, compared to 46.1% of participants with MDD. Vigorous exercise was practiced by 13.2% of the total sample, and by 8.8% of participants with MDD. Lifetime prevalence of chronic medical conditions was of 48.2% among the total sample (68.5% among participants with MDD, and 46.7% among participants without MDD). 40.9% of the total sample (69.5% of participants with MDD, and 39.0% of participants without MDD) were currently under pharmacological treatment. A more detailed description of the sample is presented in Table 1.

3.2. Bivariate associations for MDD

Increases in BMI were associated with higher prevalence of MDD (adjusted OR = 1.06; 95% CI: 1.04–1.09; $p < 0.001$). Considering BMI as a categorical variable, underweight (adjusted OR = 1.99; 95% CI: 1.02–3.85; $p = 0.042$) and obesity (adjusted OR = 2.23; 95% CI: 1.63–3.06; $p < 0.001$) were significantly associated with MDD. Hip (adjusted OR = 1.02; 95% CI: 1.01–1.02; $p = 0.001$) and waist (adjusted OR = 1.01; 95% CI: 1.00–1.02; $p = 0.003$) circumferences were also significantly and positively associated with MDD.

We found a statistically significant association between prevalence of MDD and the practice of physical exercise. In the bivariate analysis, physical exercise was inversely associated with prevalence of the disorder (adjusted OR = 0.63; 95% CI: 0.49–0.80; $p < 0.001$). Effect size increased with intensity of the activity performed. Thus, in participants who practised light exercise the adjusted OR for MDD was OR = 0.66 (95% CI: 0.48–0.91; $p = 0.012$), while vigorous exercise produced an adjusted OR of 0.53 (95% CI: 0.29–0.97; $p = 0.039$).

Physical health status was inversely associated with MDD (adjusted OR = 0.92; 95% CI: 0.90–0.93; $p < 0.001$).

Full results are shown in Table 2.

3.3. Multivariate regression model

In the multivariate regression model, physical exercise showed to be independently associated with MDD even after adjusting for potential cofounding factors such as BMI, with an OR of 0.70 (95% CI 0.51–0.96; $p = 0.026$). Other factors independently associated with MDD were BMI (OR = 1.05; 95% CI 1.02–1.07; $p < 0.001$), physical health status (OR = 0.68; 95% CI 0.61–0.75; $p < 0.001$), and female sex (OR = 1.89;

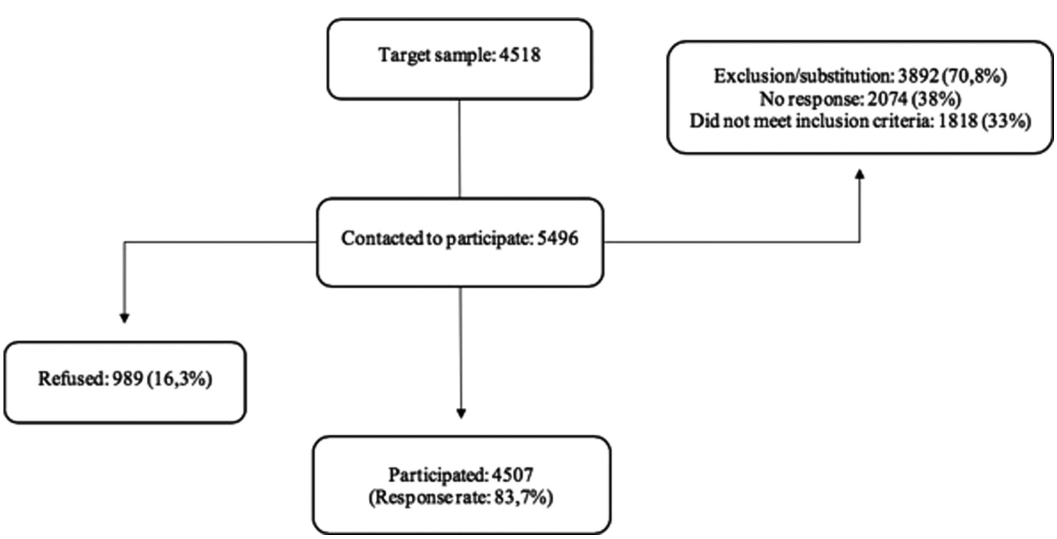

Fig. 1. Flow chart of the recruitment process.

Table 1
Description of the sample.

	Total sample (n = 4507)		Participants with MDD (n = 295)		Participants without MDD (n = 4212)	
	n (%)	Mean (SD)	*n* (%)	Mean (SD)	*n* (%)	Mean (SD)
Gender						
Male	2214 (49.1%)		93 (31.5%)		2121 (50.4%)	
Female	2293 (50.9%)		202 (68.5%)		2091 (49.6%)	
Age		42.80 (15.22)		46.64 (15.50)		42.53 (15.2)
18–30	1106 (24.5%)		55 (18.6%)		1051 (25.0%)	
31–45	1522 (33.8%)		84 (28.5%)		1438 (34.1%)	
46–60	1135 (25.2%)		92 (31.2%)		1044 (24.8%)	
61–75	744 (16.5%)		64 (21.7%)		679 (16.1%)	
Marital Status						
Married/Coupled	2747 (60.9%)		155 (52.5%)		2592 (61,5%)	
Single	1212 (26.9%)		70 (23.7%)		1142 (27.1%)	
Separated/Divorced	360 (8.0%)		45 (15.3%)		315 (7.5%)	
Widowed	188 (4.2%)		25 (8.5%)		163 (3.9%)	
Employment status						
Employed	1941 (43.1%)		68 (23.1%)		1873 (44.5%)	
Full-time student	316 (7.0%)		15 (5.1%)		301 (7.1%)	
Homemaker	442 (9.8%)		61 (20.7%)		381 (9.0%)	
Unemployed	1222 (27.1%)		102 (34.6%)		1119 (26.6%)	
Retired	504 (11.2%)		33 (11.2%)		471 (11.2%)	
Disabled	81 (1.8%)		16 (5.4%)		65 (1.5%)	
Psychiatric diagnosis						
MDD	295 (6.5%)					
Other mental disorder	710 (15.8%)				710 (16.9%)	
None	3502 (77.7%)				3502 (83.1%)	
Physical exercise						
Any physical exercise	2651 (58.8%)		136 (46.1%)		2515 (59.7%)	
Light exercise	890 (33.6%)		54 (39.7%)		836 (19.8%)	
Moderate exercise	1410 (53.2%)		70 (51.5%)		1340 (31.8%)	
Vigorous exercise	351 (13.2%)		12 (8.8%)		339 (8.0%)	
Anthropometric measures						
Height (m)		1.68 (0.09)		1.65 (0.09)		1.69 (0.09)
Weight (kg)		73.50 (15.06)		74.19 (16.20)		73.45 (14.98)
Hip circumference (cm)		102.04 (13.48)		105.54 (15.15)		101.79 (13.32)
Waist circumference (cm)		88.39 (15.33)		90.76 (17.09)		88.22 (15.19)
BMI (kg/m2)		25.93 (4.66)		27.45 (6.00)		25.83 (4.53)
BMI categories (kg/m2)						
Underweight (BMI < 18.5)	107 (2.4%)		11 (3.7%)		96 (2.3%)	
Normal Weight (BMI 18.5–24.9)	2009 (44.7%)		102 (34.7%)		1907 (45.3%)	
Overweight (BMI 25.0–29.9)	1598 (35.6%)		91 (31.0%)		1504 (35.7%)	
Obesity (BMI ≥ 30)	781 (17.4%)		90 (30.6%)		694 (16.5%)	
Physical health status (SF12)		50.00 (10.00)		45.16 (12.63)		50.32 (9.54)
Any medical condition	2174 (48.2%)		205 (68.5%)		1969 (46.7%)	
1 medical condition	1087 (24.1%)		71 (24.1%)		1016 (24.1%)	
2 medical conditions	532 (11.8%)		47 (15.9%)		485 (11.5%)	
3 or more medical conditions	555 (12.3%)		87 (29.5%)		468 (11.1%)	
Any medication	1846 (40.9%)		205 (69.5%)		1641 (39.0%)	
1 type of medication	1012 (22.5%)		68 (23.1%)		944 (22.4%)	
2 types of medication	465 (10.3%)		60 (20.3%)		405 (9.6%)	
3 or more types of medications	369 (8.2%)		77 (26.1%)		292 (6.9%)	

BMI = Body Max Index; MDD = Major Depressive Disorder; SE = Standard Error.

95% CI 1.36–2.61; $p < 0.001$). Age was not significantly associated with MDD after adjusting for covariates. Full results are shown in Table 3.

4. Discussion

4.1. Anthropometric measures and MDD

High BMI and obesity were positively associated with MDD in our study, confirming results from previous studies (Anderson et al., 2007; Mather et al., 2009; Rivera et al., 2012; Rivera et al., 2017). The relationship between depression and obesity has been long-time known. This association is often explained by means of a distortion of body image and the subsequent low self-steem (Dollar et al., 2017; Tronieri et al., 2017). Stigma and discrimination in relation to weight also play an important role in this association (Puhl and Heuer, 2010). Finally, some authors have pointed out to the biological consequences of obesity since it can be associated with a triggering of inflammatory pathways (Milaneschi et al., 2018; Ouakinin et al., 2018).

Underweight was also significantly associated with MDD in our study, albeit with a smaller effect size than obesity. Underweight is a scarcely explored factor in relation to MDD. However, eating disorders that usually present with underweight, such as anorexia nervosa, are frequently comorbid with MDD (Fernández-Aranda et al., 2007). Malnutrition may also contribute to the pathogenesis of depression (Larrieu and Layé, 2018).

4.2. Physical exercise and MDD

In our study, we found a significant negative association between physical exercise and MDD, suggesting physical exercise could be a protective factor for this mental disorder. The relationship prevailed after adjusting for BMI, suggesting a genuine association between the two factors. This effect was dependent of the intensity of exercise. This is concordant with previous literature, which showed a significant negative association between the these variables in western countries

Table 2
Bivariate associations for MDD: physical exercise, anthropometric measures and general physical health status.

	OR	95% CI	*p* value	OR adjusted for age and sex	95% CI	*p* value
Physical exercise						
Sedentary	1(ref)			1(ref)		
Any physical exercise	0.58*	0.46–0.73	< 0.001	0.63*	0.49–0.80	< 0.001
Light exercise	0.69*	0.50–0.95	0.023	0.66*	0.48–0.91	0.012
Moderate exercise	0.56*	0.42–0.75	< 0.001	0.62*	0.46–0.83	0.001
Vigorous exercise	0.38*	0.21–0.69	0.001	0.53*	0.29–0.97	0.039
Anthropometric measures						
Height	0.96*	0.94–0.97	< 0.001	1.00*	1.00–1.00	0.023
Weight	1.00	1.00–1.01	0.413	1.02*	1.01–1.02	0.001
Hip circumference	1.02*	1.01–1.03	< 0.001	1.02*	1.01–1.02	0.001
Waist circumference	1.01*	1.00–1.02	0.006	1.01*	1.00–1.02	0.003
BMI	1.07*	1.05–1.09	< 0.001	1.06*	1.04–1.09	< 0.001
BMI categories						
Normal Weight (BMI 18.5–24.9)	1(ref)			1(ref)		
Underweight (BMI < 18.5)	2.14*	1.11–4.12	0.023	1.99*	1.02–3.85	0.042
Overweight (BMI 25.0–29.9)	1.13	0.84–1.51	0.413	1.14	0.84–1.55	0.387
Obesity (BMI ≥ 30.0)	2.44*	1.81–3.28	< 0.001	2.23*	1.63–3.06	< 0.001
General physical health status (SF12)	0.92*	0.91–0.93	< 0.001	0.92*	0.90–0.93	< 0.001

CI = Confidence Interval; MDD = Major Depressive Disorder; OR = Odds Ratio.
* Statistically significant at $p < 0.05$.

Table 3
Multivariate association model for MDD.

	OR	95% CI	SE	*p* value
Physical exercise	0.70	0.51–0.96	0.146	0.026
BMI	1.05	1.02 –1.07	0.051	< 0.001
Female sex	1.89	1.36–2.61	0.167	< 0.001
Physical health status (SF12)	0.68	0.61–0.75	0.051	< 0.001

BMI = Body Max Index; CI = Confidence Interval; MDD = Major Depressive Disorder; OR = Odds Ratio; SE = Standard Error.

(Vallance et al., 2011; Pinto-Pereira et al., 2014; Hiles et al., 2017; Liu et al., 2017).

Evidence from longitudinal observational studies and interventional studies suggests that insufficient physical activity is a risk factor for the onset of depression (Pinto-Pereira et al., 2014; Hiles et al., 2017). The mechanisms proposed to explain this association are numerous and diverse. The effects of exercise on neural regeneration have long been pointed as one of the reasons why physical activity could reduce depressive symptoms. Some authors have found that exercise increases Brain-Derived Neurotrophic Factor (BDNF) in different areas of the brain (Russo-Neustadt et al., 2004; Winter et al., 2007). A recent study found that physical activity increased BDNF in the serum of patients with MDD (Kerling et al., 2017). However, a recent meta-analysis failed to show a significant association between physical exercise and an increase of BDNF in depressed patients (Kurebayashi and Otaki, 2018).

The immune system is also thought to be involved in this association. Inflammatory pathways are thought to play a key role in the neurobiological basis of depression. Increased plasma levels of pro-inflammatory cytokines such as tumour necrosis factor (TNF) alpha or interleukin (IL) 6 have been found in MDD patients (Dowlati et al., 2010). There seems to be a bidirectional association between MDD and inflammation by which depression would have a pro-inflammatory effect and an increased state of inflammation could induce depressive symptoms (Miller and Raison, 2016; Stewart et al., 2009). This mechanism is thought to lay behind the relationship between depression and cardiovascular diseases, which also seems to be bidirectional (Nicholson et al., 2006; Williams and Steptoe, 2007).

Exercise has anti-inflammatory properties that have been proven beneficial in the management of several chronic conditions that course with inflammation (Palmefors et al., 2014; Kayambu et al., 2015; Pedersen and Saltin, 2015). This decrease in inflammation and oxidative stress is mediated by changes in the neuroimmune system, such as inducing the release of IL-10 and other anti-inflammatory cytokines (Eyre and Baune, 2012; Goldhammer et al., 2005).

4.3. Implications for clinical practice

The association between MDD and physical exercise has potential implications for the prevention and treatment of this condition. Several clinical trials that investigated the use of exercise as a therapeutic tool found that physical exercise was a protective factor for depression (Lawlor, 2001; Stathopoulou et al., 2006; Landers and Arent, 2007; Rethorst et al., 2009a; Krogh et al., 2010; Kerling et al., 2015; Kvam et al., 2016; Schuch et al., 2016; Morres et al., 2018). A meta-review conducted in 2018 found that physical activity had a beneficial effect on MDD patients comparable to that achieved by antidepressants and psychotherapy (Stubbs et al., 2018). Physical exercise has also proven to be effective in reducing cardiovascular and metabolic risk in depressed patients (Kerling et al., 2015; Kahl et al., 2016). However, ascertaining the effectiveness of physical exercise as a therapeutic intervention for MDD encounters the problem of the high rate of drops-out in severely depressed subjects taking part in clinical trials (Stubbs et al., 2016).

In our study, we explored physical activity integrated as a part of daily life rather than as a specific tailored program. Although, as a therapeutic strategy, an structured program may have better results (Callaghan et al., 2011), from the public health perspective, physical activity could be beneficial even in the absence of specific programs. To such extent, general awareness and education, resulting in an indirect increase of physical activity, may be cost-effective at the population level. Exercise as a preventive strategy could be implemented by measures such as advice from general practitioners, awareness campaigns using the media and school settings, and founding of sports activities by the public administration.

Intensity of exercise influenced the power of the preventive effect on MDD. Even light exercise seems to be beneficial as evidenced from our study and from previous research (Helgadóttir et al., 2016; Meyer et al., 2016). However, a more intense exercise had a greater effect size, which has also been found in previous studies (Rahman et al., 2018; Stubbs et al., 2018).

In light of this evidence, physical exercise should be considered parallelly to psychotherapeutic and psychopharmacological treatment of MDD. It has the obvious advantage of avoiding the side effects of medication (Stubbs et al., 2018), and evidence shows it has better cost-effectiveness ratios than usual interventions (Rosenbaum and Sherrington, 2011).

5. Conclusion

In conclusion, we found that MDD was significantly associated with both obesity and underweight, as well as with increases in BMI. We also found a significant inverse association between practice of physical exercise and MDD. The effect of this association increased with the intensity of exercise. Our findings support the potential of physical exercise as a preventive and therapeutic strategy in the management of MDD.

To our knowledge, this is the first study exploring the association of physical exercise and major depression in a large Spanish community-dwelling sample. Although this association has yet to be confirmed in longitudinal studies, our results, along with the previous evidence and the biological plausibility, render exercise a more than promising therapeutic and preventive tool in the battle against MDD in the area, and support the inclusion of physical exercise as a part of the mental health policies in the area.

6. Limitations

Our findings need to be considered in light of some limitations. First, the cross-sectional design of the study precludes establishing causality. The associations found must therefore be confirmed, and their directionality set, in longitudinal studies. Additionally, our main diagnostic tool does not record lifetime prevalence of depression, nor the length of each depressive episode. Finally, a selection bias may exist due to mental patients' greater reluctance in participating.

Contributors

M. Rivera, B. Gutiérrez, and J. Cervilla conceived and designed the study. A. Porras-Segovia, E. Molina, D. López-Chaves and J. Cervilla carried out the data analysis and interpreted the data for the work. A. Porras-Segovia wrote the article with the aid of D. López-Chaves and under the supervision of M. Rivera and J. Cervilla. All authors contributed to the drafting and revisions of the manuscript. All authors read and approved the final manuscript.

Conflict of interest

All the authors confirm they have no conflict of interest

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