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Objectively measured physical activity and depressive symptoms in adult outpatients diagnosed with major depression. Clinical perspectives

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A B S T R A C T

Physical activity (PA) is linked to reduced risk of depression, but research on the objectively measured PA in clinically diagnosed adult outpatients with major depressive disorder (MDD) is scarce. This study aimed to examine relationships of objectively measured PA with depression and mood. A total of 19 outpatients (6 males) with MDD, a mean age of 47.79 ± 11.67 years and mild-moderate depression participated in the study. To record PA, participants wore a triaxial accelerometer device on the right hip during waking hours for seven consecutive days. Depression and mood were assessed with self-reports immediately after day seven. Participants wore the accelerometers for a high number of days ($M = 6.26 \pm 1.24$ days) and hours per day (13.40 ± 2.61 h), recording light (266.01 ± 100.74 min/day) or moderate (31.19 ± 24.90 min/day) PA, and sedentary time (515.33 ± 155.71 min/day). Stepwise regression analysis yield a significant prediction ($p < .05$) with only moderate PA contributing to the prediction of depression (Beta = −0.47, $p < .05$). The model explained 22% of the variance of depression. Our findings provide valuable preliminary evidence regarding the relationship between objectively measured PA and lower depression in clinically diagnosed outpatients with MDD, suggesting moderate PA may help alleviating depressive symptoms.

1. Introduction

Group, supervised and structured physical activity (PA) is recommended for depression treatment (National Institute for Health and Care Excellence, 2009 [NICE], pp.20). The most widely used PA subset is exercise as it is "planned, structured, repetitive, and purposive" (Caspersen et al., 1985; pp.128) and linked to lower depression in patients with major depressive disorder (MDD) in clinical settings (e.g., Morres et al., 2019). However, depressed outpatients show poor compliance to exercise in pragmatic conditions, such as in exercise on referral schemes (Crone et al., 2008; Hanson et al., 2013; James et al., 2008; Tobi et al., 2017). Adjuncts or alternatives to the PA subset of exercise are thus vital, especially for adult depressed patients (18–65 years) given their lower compliance and depression relief in exercise settings compared to older (+65) adults (James et al., 2008; Silveira et al., 2013).

Various PA subsets may support depression; PA, that is defined as "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen et al., 1985; pp.126), has been linked to lower depression via various subsets without necessarily incorporating all the exercise operational prerequisites (e.g., supervised, structured, scheduled or in groups). Particularly, the PA subsets of sports, cycling, walks or long hikes show reduced risk for depression in general population (Chekroud et al., 2018; Mammen and Faulkner, 2013) and in clinically diagnosed MDD patients (Harris et al., 2006), whereas sedentary behavior shows increased risk of depression (Zhai et al., 2015). The World Health Organization (WHO) (2011) guidelines for lower risk of depression recommend various PA subsets at moderate intensity for 30 min/day ≥5times/week (≥150 min/week); these subsets are framed in community, family or daily settings and include transportation (e.g., cycling or walking), occupational (e.g., work), leisure, household chores, play, sports, or exercise.

In the likely key role of PA subsets in depression, objective PA measures are needed to rule out confounders seen in self-reports, such as recall difficulties. These confounders may influence the accurate completion of PA measures because poor concentration/memory are common depression symptoms (American Psychiatric Association, 2013; Dillon and Pizzagalli, 2018). Indeed, a meta-analysis comparing subjective to objective PA measures in samples with depressive disorders/symptoms found a less time spent in Vigorous PA (VPA), a greater time spent in total or in Light PA (LPA), and an increased sedentary time when objective measures are used (Schuch et al., 2017). Also, objective PA measures showed more depressed people not meeting PA guidelines for ≥150 min/week of Moderate PA (MPA);

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only 14% of MDD outpatients complied with PA guidelines (Schuch et al., 2017). Exploration of objective measures of PA in depression is thus vital, especially since the link of subjectively assessed PA with better mental health may not be seen in some PA subsets (house- or work-related PA) (e.g., White et al., 2017). To date, only a few studies have addressed this exploration in clinically diagnosed MDD outpatients, although this is the most prevalent depressed group.

In particular, Choi et al. (2019) found a protective relationship between objectively measured – but not self-reported – PA and the risk for MDD. The suggested PA level was 15 min/day of VPA or just > 60 min/day of MPA, but it was based on indirect estimations. Also, wrist-worn accelerometers were used, which are less accurate than hip-worn accelerometers (Rosenberger et al., 2013). Further, the sample age range was 40–70 years. This limits the generalizability of the findings as older depressed adults (+65) compared to adult peers show distinct differences in depression and higher completion rates and depression relief in exercise settings (Fiske et al., 2009; James et al., 2008; Silveira et al., 2013).

In Helgadóttir et al. (2015), depression predicted lower LPA but not Moderate to Vigorous PA (MVPA). The sample was mild-moderate depressed, but 13.5% ($N = 22$) was diagnosed with anxiety, 73.6% ($N = 121$) with both anxiety and depressive disorders and only 12.9% ($N = 21$) with depressive disorders. Also, the sample was about to participate in an exercise-depression trial, and included a number of community volunteers who were recruited via media calls, and not via health services. Given that community volunteers for exercise-depression trials are motivated to exercise (Blumenthal and Ong, 2009), this sample was potentially motivated towards a physically active lifestyle.

In Wielopolski et al. (2015), duration, energy expenditure and metabolic equivalents of PA were repeatedly linked to lower depression in severely MDD hospitalized inpatients. Inpatients, however, represent a small proportion in MDD because the majority is treated in primary care. To our knowledge, only Mota-Pereira et al. (2013) have objectively measured PA in referred adult outpatients with a clinical diagnosis of MDD as a primary disorder. They reported baseline MPA of 27.8 min/day and 29.48 min/day in outpatients randomly assigned into exercise and control groups, respectively, for an exercise-depression trial. These baseline means should be regarded with caution, as advanced knowledge of participation in an exercise-depression trial may have influenced their motivation towards a more active lifestyle. Also, the relationship of PA with depression was not examined at baseline.

The largely unexplored relationship of objectively measured PA with depression in MDD outpatients led to calls for relevant studies (Burton et al., 2013; Wielopolski et al., 2015). Accordingly, this preliminary study explored if objectively measured PA in adult outpatients, recruited via mental health services with a clinical diagnosis of MDD as a primary disorder, predicts lower depression and meets PA guidelines on health.

2. Method

The study was approved by the Bioethics Committee of the first author's institution (University of Thessaly, Ref: 3-2/1123, 08-June-2016) in accordance with the principles of the Declaration of Helsinki of 1975, as revised in 1989.

2.1. Participants

In line to pragmatic design properties (Hotopf, 2002), recruitment took place in a community-based Mental Health Centre via referrals by mental health professionals responsible for the treatment of eligible participants. Inclusion criteria were: (a) diagnosis of MDD as a primary disorder without psychotic features and not as a result of other mental or medical disorder or condition; (b) age 18–65 years without medical contradictions/restrictions to ambulatory PA; (c) no previous history of active alcohol/drug abuse or dependence; (d) no suicide ideation (American Psychiatric Association, 2013). From the initially eligible sample of 30 registered outpatients, 23 outpatients (77%) expressed an interest in the study and 21 presented in the Centre to receive relevant information. A total of 20 patients signed an informed consent prior to participation and received the accelerometers along with relevant instructions for a 7-day use (see below). Appointments were scheduled for returning the accelerometer upon the completion of the day 7 and for administrating self-report measures. Complete data were collected from 19 outpatients (6 males) because one participant (female) dropped out due to personal reasons. The mean age of participants was 47.79 ± 11.67 years and the mean Body Mass Index (BMI) was 26.04 ± 5.69.

2.2. Measures

2.2.1. Physical activity

Participants were instructed to wear a small (3.8 cm × 3.7 cm × 1.8 cm), light (27 gr) triaxial accelerometer devise (Actigraph GT3X+, Actigraph LLC, Pensacola, FL) with an elastic belt on the right waist for 7 consecutive days (Corder et al., 2007) during all waking hours except when sleeping/bathing. Participants were also advised to avoid lifestyle changes for the shake of participation in the study. An epoch length of 60 s was chosen to capture PA and sedentary behavior (Trost et al., 2005). Freedson equation for adults (Freedson et al., 1998) defined PA cut points and diagnosed time spent in different PA intensities (Sedentary time: <100 cnts min^{-1}, LPA: 100–1951 cnts min^{-1}, MPA: 1952–5724 cnts min^{-1}, VPA: 5725–9498 cnts min^{-1}, Very Vigorous PA/VVPA $\geq$ 9499 cnts min^{-1}). Data from accelerometers worn for $\geq$ 3 days were considered valid (Trost et al., 2005). In line to clinical studies (e.g., Miller et al., 2013), a valid day was defined as $\geq$ 8 h of wear time. Periods of > 60 min of consecutive zero counts were considered non-wear time (Tudor-Locke et al., 2012; Ward et al., 2005). Data were analyzed with the ActiLife software version 6.5.2.

2.2.2. Depression

The primary outcome measure was depression and it was assessed with the Beck Depression Inventory-II (BDI-II) (Beck et al., 1996). The BDI-II is a widely used self-rated measure of depressive symptom severity comprising 21 items that are organized on a 4-point scale (from 0 to 3). Items measure both physical and cognitive symptoms and suicide ideation. Scoring is summed from 0 to 63, with higher scores indicating greater severity.

2.2.3. Mood

The secondary outcome measure to be related to PA was mood. The Four Dimensional Mood Scale (4DMS; Huelsman et al., 1998) was employed to assess mood. The 4DMS is a self-report questionnaire consisted of 20 items, rated on a 5-point Likert scale (1 = slightly or not at all, 5 = definitely), assessing positive energy (4 items) negative arousal (6 items), relaxation (5 items), and tiredness (5 items).

2.2.4. Statistical methods

Data were analyzed with the Statistical Package for Social Sciences (SPSS-22). Descriptive and correlation statistics were computed for all variables; *t*-test was performed to test for differences in depression as a function of gender. To examine the degree to which LPA and MPA could predict depression, regression analysis with a stepwise method was used (Field, 2005). Multicollinearity was examined with the Variance Inflation Factor (VIF) statistic; VIF values of >5 indicate critical multicollinearity levels (Kutner et al., 2005).

Table 1
Descriptive statistics of objectively measured physical activity.

Variables	*Minimum*	*Maximum*	M	SD
Valid Days	3	7	6.26	1.24
Wear time hours/valid wear days	9.59	19.10	13.40	2.61
Kcals/day	137.10	1107.10	369.50	222.93
Sedentary time min/day	321.14	870	515.33	155.71
LPA min/day	82.50	502.86	266.01	100.74
MPA min/day	.67	88.71	31.19	24.90
VPA min/day	.00	6	.40	1.39
MVPA min/day	.67	90.29	31.59	25.83
TPA min/day	102.50	524.57	297.60	110.16
Steps/day	2673.17	24,634.43	7545.02	5212.95
Counts/min	70.43	416.74	174.57	96.32

Kcals: kilocalories per day; LPA: Light Physical Activity minutes per day: M: mean; MPA: Moderate Physical Activity minutes per day; VPA: Vigorous Physical Activity minutes per day; MVPA: Moderate to Vigorous Physical Activity minutes per day; TPA: Total Physical Activity minutes per day; SD: standard deviation; Wear time hours/valid wear days: wear time in hours per valid wear days.

3. Results

3.1. Descriptive statistics and correlations

Accelerometers were worn for 13.40 h/day ± 2.61 and 6.26 days ± 1.24. Table 1 shows descriptive statistics for sedentary time, and time spent in LPA, MPA, VPA, and MVPA; however, neither VPA nor MVPA were further considered because VPA was found in only two cases at a very low rate (0.4 min/day, i.e., 24 s/day). Patients scored mild-moderate on depression; moderately to moderately low on positive energy and relaxation, and moderately for negative energy and tiredness (Table 2). Correlations displayed a statistically significant moderate negative link between MPA and depression ($r = -0.47$, $p < .05$) and a non-significant low negative link between LPA and depression. Calorie expenditure and sedentary time showed non-significant negative and positive (respectively) correlations with depression. Correlations between PA and sedentary time with mood were also non-significant (Table 2).

3.2. Preliminary analysis

Before proceeding with the main analysis the relationships between gender, age and BMI with depression were tested to examine the possibility of these variables as confounding factors. Regarding gender, independent samples *t*-test showed no significant effect, $t(17) = 0.64$, $p = .55$ (mean BDI scores 19.67 and 15.92 for males and females, respectively). Regarding age and BMI, correlation analysis showed non-significant relationships with BDI scores; for age $r = -0.16$, $p = .50$; for BMI, $r = 0.20$, $p = .40$.

Table 3
Stepwise regression analysis for depression.

	Beta	*t*	*p*	*F*	R^2 change
Significant Predictor				4.78*	.22
MPA min/day	−0.47	−2.22	.043*		
Excluded Predictors					
LPA min/day	−0.01	−0.55	.957		
VPA	−0.25	−0.88	.390		
Sedentary min/day	.29	1.41	.177		

LPA: Light Physical Activity; Min: Minutes; MPA; Moderate Physical Activity; VPA: Vigorous Physical Activity.
* $p < .05$.

3.3. Regression analysis

A regression analysis with a stepwise method (Field, 2005) examined the degree to which LPA and MPA could predict depression. Results yielded a significant prediction, $F(1, 18) = 4.78$, $p < .05$, with only MPA contributing to the prediction of depression (Beta = −0.47, t −2.19, $p < .05$). Multicollinearity diagnostics showed low VIF scores for MPA and LP; 1.00 and 1.07, respectively (Kutner et al., 2005). The model explained 22% of the variance of depression (Table 3). The regression did not change when we replaced MPA with MVPA.

4. Discussion

This study is a preliminary exploration of the relationship of objectively measured PA with depression in referred adult outpatients with a clinical diagnosis of MDD as a primary disorder. The data analysis focused on LPA and MPA because VPA was recorded for only two patients at a very low rate. We found an average MPA of 31.19 min/day (218 min/week), which significantly predicted lower depression in our mild-moderate depressed sample. Our finding is also in line with PA guidelines by the WHO (2011) recommending MPA of 30 min/day at least 5 times/week (≥150 min/week) for reduced risk of depression.

The inverse association of MPA with depression in our study concurs with the longitudinal study of Wielopolski et al. (2015). These authors found that objectively measured PA was repeatedly related with lower depression in severe MDD inpatients across three time points of hospitalization. Also, MPA but not LPA predicted lower depression in our study suggesting the importance of MPA. Similarly, guidelines recommend MPA for reduced risk of depression (WHO, 2011). Further, the PA subset of exercise at moderate intensity is recommended for depression treatment (NICE, 2009) given its large antidepressant effects among MDD patients in mental health services (Morres et al., 2019).

Our MPA seems to be 2-fold lower compared to other studies with MDD patients. First, Choi et al. (2019) found that objectively measured MPA of just > 60 min/day (or VPA 15 min/day) showed reduced risk for MDD, but this finding stemmed from indirect estimations. Also, wrist-worn accelerometers were used and patients were 40–70 years. However, waist-worn accelerometers are more accurate

Table 2
Descriptive statistics, Cronbach's alpha and correlations for the psychometric variables and physical activity.

Variables	Alpha	M	SD	LPA/day	MPA/day	TPA	Kcals/day	Sedentary/day	1	2	3	4
1.Depression	.89	17.10	8.70	−0.14	−0.47*	−0.23	−0.39	.26				
2.Positive Energy	.92	2.92	1.07	.14	.25	.19	.13	−0.28	−0.73**			
3.Relaxation	.65	2.40	0.63	.28	.28	.30	.12	0.03	−0.53*	0.58**		
4.Tiredness	.94	3.17	1.10	.12	−0.18	.07	.24	.07	0.87**	−0.64**	−0.45*	
5.Negative Energy	.89	3.16	1.08	.43	−0.17	.35	.28	−0.11	0.61**	−0.54*	−0.27	.71**

M: Mean; SD: Standard Deviation; LPA: Light Physical Activity per day; MVPA: Moderate Vigorous Physical Activity per day; TPA: Total Physical Activity; Kcals: Kilocalories per day; Positive energy, relaxation, tiredness, negative energy (*The Four Dimensional Mood Scale −4DMS)*; Depression *(BDI-II)*.
* Significant at 0.05.
** Significant at 0.01.

(Rosenberger et al., 2013), whereas older adults (+65) show distinct differences in depression compared to adults (Fiske et al., 2009). Second, the meta-analysis of Schuch et al. (2017) found an objectively measured MPA of 64.55 min/day, but some of the reviewed studies included older adults or both adults and older adults with anxiety or various depressive disorders. This may confound results; types of depression (e.g., bipolar depression) show higher PA than MDD (Vancampfort et al., 2017). Also, Schuch et al. (2017) included baseline measures of PA from exercise-depressed trials with some participants being recruited via media calls. However, media respondents to such trials are motivated volunteers to exercise (Blumenthal and Ong, 2009), with a potential determination for physically active lifestyle. Registered patients instead, have suffered persistent symptoms including psychosocial impairment that led to a health service, and they may report failure or disappointment when the health service use reveals the disease severity and the need for systematic care (Bursztajn and Barsky, 1985; Maguire et al., 1995; Morgan, 1989).

The MPA level of our study could be representative of daily life of MDD outpatients as it seems to be comparable to studies with similar samples. The exercise-depression trial of Mota-Pereira et al. (2013) recruited severe and treatment resistant clinically diagnosed MDD outpatients via mental health services and found an objectively measured MPA average of 27.8 min/day and 29.48 min/day for the exercise and control group, respectively. These MPA levels, however, might be higher than usual as patients were at the baseline stage of participation in an exercise-depression trial and thus, potentially motivated to a physically active lifestyle. This is most likely given that features of severe treatment resistant MDD (e.g., illness duration or antidepressants) are typically regressing low PA (Vancampfort et al., 2017).

We also found low to moderate relationships between PA and mood, however, these were not significant, possibly due to the small sample size; hence, these can only be interpreted as trends. Particularly, MPA tended to be positively related with the positive and negatively related with the negative dimensions of mood. This is an encouraging finding because low mood is a cardinal symptom of depression. In contrast, LPA tended to be positively related with negative energy and tiredness, which may partly explain its inability to predict lower depression, despite its positive relation with relaxation and positive energy.

Also, LPA did not predict lower depression in our study. This involves consideration that LPA is often seen in house – or work – domain activities (see Ainsworth et al., 2011), which are linked to somatic complaints and low mood/enjoyment in MDD outpatients (Barge-Schaapveld et al., 1999). White et al. (2017) subjective measures of PA in general population are thus unsurprising; PA was related with better mental health, but house-domain PA was not related with better mental health and tended to relate with worse depression. Also, transport-to-work PA showed worse mental health. White et al. (2017) interpreted their findings via Self-Determination Theory (SDT; Ryan and Deci, 2017). They reported that enjoyable PA, but not compulsory or externally rewarded (e.g., work-related), is linked to autonomous motivation, satisfying the three psychological needs (competence, autonomy, relatedness) that contribute to wellbeing (White et al., 2017).

Indeed, subjectively measured leisure-type PA, which is typically driven by enjoyment incorporating autonomous motivation, shows reduced risk for depression in general population (Mammen and Faulkner, 2013) or in MDD patients (Harris et al., 2006). Further, only autonomous motivation is linked to the adoption or maintenance of systematic PA in depression (Vancampfort et al., 2015, 2016). However, in the latter two studies subjective, rather than objective, PA levels were recorded; also, domain-specific PA was not examined, whereas samples were not exclusively MDD. Therefore, research needs to explore the association of objectively measured and domain-specific PA with depression in MDD outpatients taking also into account the satisfaction of basic psychological needs.

Finally, we found an average sedentary time of 8.58 h/day. This was lower by 13% and 16% than the sedentary time of the depressed subsample of Helgadóttir et al. (2015; 9.65 h/day) and the depressed samples of Schuch et al. (2017; 9.91 h/day), respectively. Also, sedentary time in our study showed positive relationships with depression and negative relationships with positive energy. Although non-statistically significant, these relationships concur with indications for the link of sedentary time with depression (Zhai et al., 2015).

Collectively, MPA of 31.19 min/day (218 min/week) predicted lower depression in our study. In line, the WHO (2011) recommends 30 min MPA at least 5 days/week (≥150 min/week) for reduced risk of depression, and various PA subsets (sports, walks, cycling or long hikes) confirm this reduced risk in MDD samples (Harris et al., 2006) or in general population (Chekroud et al., 2018; Mammen and Faulkner, 2013). Subsets of MPA are thus vital, especially since depressed outpatients are poorly complying with the widely prescribed PA subset of exercise (Crone et al., 2008; Hanson et al., 2013; James et al., 2008; Tobi et al., 2017). MPA may support depressed adults in particular, given their lower compliance and depression relief in exercise settings compared to older (+65) adults (James et al., 2008; Silveira et al., 2013).

Our preliminary study has a number of limitations. First, the size of our sample is rather small, yet considering our sampling criteria (clinical diagnosis, recruitment via health services, age range 18–65) can be seen as satisfactory. Comparable sample sizes to our study were also reported in studies with adult (18–65) clinically diagnosed MDD outpatients (Mota-Pereira et al., 2013; $N = 29$) or inpatients (Wielopolski et al., 2015; $N = 19$) referred via health services. Our study is the first to objectively measure PA in daily life for adult outpatients referred via mental health services with a clinical diagnosis of MDD as a primary disorder. Second, our sample might have performed higher than usual MPA levels resulting from increased motivation to participating in the study, and being aware that PA was recorded. Future studies may control for confounding effects of the accelerometer use on motivation to higher than usual PA levels. Third, our design did not include a healthy volunteers group, as the purpose of this field study was to explore the relationship between objectively measured PA and depression in outpatients. The inclusion of such a group however would have allowed a comparison of these patients with healthy populations. Fourth, we did not record domain specific PA, however, the scope of this preliminary study was to explore the association of intensity levels of PA with depression.

Despite the above limitations, our study has various strengths. First, the high accuracy of triaxial hip-worn accelerometers used increased the validity of our finding. Also, the considerable valid wear time of accelerometers strengthens our confidence for the findings. Second, the prediction of lower depression by MPA in our MDD patients is in line to guidelines recommending MPA for depression (NICE, 2009; WHO, 2011). Third, we incorporated important pragmatic design properties. Recruitment was achieved via a mental health service and not via media advertisements. Also, PA was recorded within the context of daily life and not within the context of an exercise-depression trial where participants might be motivated to a physically active lifestyle. Consequently, our study outcomes appear to be carrying increased external validity and potentially important translational evidence.

Replication of this study considering the above limitations and strengths is essential. Large studies with moderate or severe MDD outpatients are also essential, whereas a longitudinal design will allow bidirectional explications and causality interpretations. Accordingly, researchers will draw firmer conclusions on the association of objectively measured MPA with lower depression in adult outpatients with MDD as a primary disorder.

Conflict of interest

The authors declare no conflict of interest.

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CRediT authorship contribution statement

Ioannis D. Morres: Conceptualization, Investigation, Data curation, Writing - original draft. **Antonis Hatzigeorgiadis:** Conceptualization, Formal analysis, Writing - original draft. **Charalampos Krommidas:** Formal analysis, Data curation, Writing - review & editing. **Nikos Comoutos:** Resources, Methodology. **Eirhini Sideri:** Project administration, Writing - review & editing. **Dimitrios Ploumpidis:** Conceptualization, Writing - review & editing. **Marina Economou:** Resources, Writing - review & editing. **Athanasios Papaioannou:** Resources, Writing - review & editing. **Yannis Theodorakis:** Conceptualization, Writing - review & editing.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2019.112489.

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