

WHAT ARE THE FACTORS THAT INFLUENCE PHYSICAL ACTIVITY PARTICIPATION IN INDIVIDUALS WITH DEPRESSION? A REVIEW OF PHYSICAL ACTIVITY CORRELATES FROM 59 STUDIES

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SUMMARY

Background: The present review systematically evaluates correlates of physical activity across the socio-ecological model for people with depression.

Subjects and methods: Two independent reviewers searched Embase, PubMed, and CINAHL from their inception until May 2015, combining the medical subject heading 'depression' or 'depressive' with 'physical activity' or 'exercise'. Data were extracted by the same independent researchers and summarized according to the socio-ecological model.

Results: Fifty-nine papers involving 101,539 persons with depression were eligible and enabled us to evaluate 42 correlates. Correlates that were consistently ($n \geq 4$) associated with lower physical activity participation in depressed persons were a higher level of depressive symptoms, a higher body mass index, the presence of physical co-morbidity and a lower self-efficacy. The role of social, environmental and policy factors on physical activity participation is unknown and should be addressed in future research.

Conclusion: In persons with depression physical activity participation is a complex behavior that is influenced by many different factors. Significant correlates should be confirmed in prospective studies. Interventions to improve modifiable physical and mental health variables in people with depression should be developed and evaluated.

Key words: physical activity – exercise - depression

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INTRODUCTION

Worldwide, depression is a seriously disabling public health problem of very high prevalence (Kessler et al. 2003). Major depressive disorder has a 12-month prevalence of 6.6% and a lifetime prevalence of 16.2%, is twice as common in women as in men, and causes considerable impairment. It is currently ranked as the second leading cause of years lived with disability globally (Murray et al. 2012), and projected to be the leading cause of disability over 20 years in high-income nations (Mathers & Loncar 2006). Depressive symptoms are commonly treated with antidepressants or psychological therapies or a combination of both (Kupfer et al. 2012). However antidepressants may have adverse cardio-metabolic side effects, adherence can be poor, and there is a lag time between starting antidepressants and improvements in mood (Kupfer et al. 2012, Holt et al. 2014). Psychological treatments are generally free from side-effects but some people may not wish to receive psychological therapy due to low expectations of positive outcome or perceived stigma (Schomerus et

al. 2009). Within recent years, research has demonstrated that adequate physical activity may promote mental and physical health in persons with depression (Krogh et al. 2011, Cooney et al. 2014, Knapen et al. 2014, Rosenbaum et al. 2014). Physical activity seems to improve depressive symptoms in people with a diagnosis of depression compared with either no treatment or a control intervention (Rimer et al. 2011) whilst protecting against the development of future depressive episodes (Mammen & Faulkner 2013). Those with depressive symptoms indicative of mild-to-moderate depression and for whom physical activity participation improves function-related outcomes achieve the largest antidepressant effects (Herring et al. 2012). In addition, physical activity recommendations are also included in recent guidelines for the prevention or treatment (National Institute for Health and Clinical Excellence; De Hert et al. 2009) of an increased risk for cardiovascular diseases and diabetes in persons with depressive symptoms (De Hert et al. 2011, Vancampfort et al. 2013a). Despite the plethora of research demonstrating the beneficial effects associated with physical activity

participation, many people with depression do not meet the recommended levels of physical activity participation. Thus, there is a need for research to investigate factors that influence physical activity participation in this particular population. Indeed, there is a continuing debate about the amount (e.g., frequency, intensity, duration) and types of physical activity (e.g., structured exercise versus lifestyle physical activity) needed for the observed mental and physical health benefits in patients with depression (Dunn et al. 2005), with current recommendations not substantially different to that for general population health, nor for those with type-2 diabetes (Stanton & Reaburn 2013). Following the UK National Institute for Health and Clinical Excellence (NICE) (2009) guidelines, physical activity programs for people with persistent sub-threshold depressive symptoms or mild-to-moderate depression should consist typically of three sessions per week of moderate duration (45 minutes to 1 hour) over 10 to 14 weeks (average 12 weeks). Clearly in order for physical activity interventions to be effective in promoting mental and physical health, they must, however, adequately address the barriers to physical activity and promote factors that enable participation.

Understanding the barriers and facilitators of participation in physical activity in patients with depression is an essential first step toward the development and implementation of effective treatments. Behavioral theories such as the social-ecological model (Sallis et al. 2006) are useful in attempting to understand such barriers and promoting factors. Social-ecological models suggest that multiple relevant attributes influence health behavior. These include intrapersonal (demographic, biological, psychological, emotional and cognitive), interpersonal/ cultural (e.g., social support), physical environment (e.g., distance to the facilities, financial costs, enjoyable scenery), and policy (laws, rules, regulations, codes) factors (Sallis et al. 2006). Various intrapersonal, interpersonal, physical environment and policy related variables have demonstrated strong positive associations with physical activity in the general population (Sallis et al. 2000) and in people with severe mental illness (Stubbs et al. 2014, Vancampfort et al. 2012, 2013b, 2014). However, little is known about whether these factors demonstrate similar relationships with physical activity behavior amongst persons with depression. Qualitative studies have illustrated that in persons with depression mood, low levels of self-efficacy, negative experiences of physical activity and inactivity from close family members may all negatively affect physical activity (Azar et al. 2010, Searle et al. 2011). However, quantitative data research is required to identify more rigorously potential mediators and moderators of physical activity that can be targeted in future interventions (Baranowski et al. 2009). In order to address these shortcomings, the aim of the present review was to systematically evaluate published quantitative studies of correlates of physical

activity in persons with depression. In addition to summarizing methods and results of these studies, gaps in the literature were identified and directions for future research are proposed.

SUBJECTS AND METHODS

Data sources and searches

Two independent reviewers (XX and XX) performed an electronic search of Embase, PubMed, and CINAHL from the inception of these databases to May 2015. Keywords used were ‘physical activity’ or ‘exercise’ and ‘depression’ or ‘depressive’ in the title, abstract or index term fields. Manual searches were also conducted, using reference lists from identified articles.

Eligibility criteria

Inclusion criteria were as follows: (a) presence of a defined depression status in adults (assessed by self-reported symptom scales, or a physician/clinician diagnosis by a structured clinical diagnostic interview), (b) studies contained quantitative research and had been published in a peer-reviewed journal, (c) the dependent variable was a measure of physical activity participation. Studies could use a variety of physical activity measures reflecting a range of intensities. For cohort or intervention studies, only associations with baseline data were included. Authors were contacted to provide additional data on associations of baseline characteristics if these were not available in the publication.

Articles were excluded if the dependent variable was aerobic fitness, physical activity intention, self-efficacy, or other intermediate (non-behavioral) measures because these variables are less direct indicators of actual physical activity. Also, case-reports, conference abstracts, and expert opinions were excluded. If study data were based on different diagnoses, the first or corresponding author was asked to send results from additional analyses for our target group. Studies conducted specifically in populations with specific somatic morbidities were also excluded.

Data collection

Two reviewers independently extracted data from the included studies using a predetermined form. The data extracted from each study included: (a) gender, (b) age, (c) ethnicity, (d) setting if applicable, (e) depression status, and (f) physical activity assessment tool. In accordance with previous reviews (Salli et al. 2000, Trost et al. 2002, Stubbs et al. 2014, Vancampfort et al. 2012, 2013, 2014) the following categories were used to code quality of the physical activity measure: (a) self-report with poor, unknown or undescribed reliability/validity, (b) self-report with described and acceptable reliability/validity, and (c) acceptable objective measurements. Following Warren et al. (2010), objective

measurements included motion sensors, such as accelerometers and pedometers, combined heart rate and accelerometer devices and the doubly labeled water method. The acceptability of the psychometric properties was assessed following De Von et al. (2007). Variables were classified as “related” or “not related” to physical activity based on statistical significance, and the direction of association for related variables was coded. The detailed data tables were further analyzed to create tables that summarized the state of the literature on different variables.

Selection and categorization of variables

We selected and categorized physical activity correlates into the following categories: (a) demographic, (b) biological, (c) psychological/cognitive/emotional, (d) behavioral attributes/skills, (e) social/cultural factors, (f) physical environment, and (g) policy factors. When studies based on the same sample examined the same correlates, only the most recent data and/or those based on the largest sample size were included. The socio-ecological approach aims to identify the domains which have been explored in the literature and to elucidate the multidimensional perspective of potential influences on the physical activity behavior in patients with depression.

Coding associations with physical activity

A variety of statistical techniques were used to evaluate correlates, most commonly uni-/bivariate analyses, including correlations, t-tests, and ANOVA. Sometimes, only multivariate analyses were reported, including linear regression or logistic regression. If both uni-/bivariate and multivariate tests were conducted, uni-/bivariate tests were reported for consistency across studies. The column “related to physical activity” indicates, which studies reported significant associations between the variable and the physical activity measure. Direction of association is indicated with a “+” or “-”. The column “unrelated to physical activity” indicates which studies reported non-significant associations between the variable and physical activity.

Coding of analyses

Numbers in the columns refer to the numbers in the online supplement. If analyses were conducted separately for male and female subjects, “M” or “F” is indicated. Due to the small number of studies reporting analyses specific to ethnic or socio-economic groups, these subgroup analyses were not included in the summary tables.

Summary codes

As many articles did not include correlation values, and the methodology of included studies varied considerably, a formal meta-analysis of correlates was not conducted. Summary codes were presented and

calculated in accordance with the method of Sallis et al. (2000). The summary code column contains a code to summarize the state of the literature for that variable. The percentages in parentheses refer to the number of associations supporting the expected association divided by the total number of associations for the variable. Associations were coded with: “0” (0-33% of studies supporting association); “?” (34-59% of studies supporting an association); or “+” or “-” (60-100% of studies supporting an association). When four or more studies supported an association or no association, it was coded as “00”, “-”, or “++” indicating that there is consistent evidence for that correlate. The “??” code indicated a variable that was investigated four or more times studied with considerable lack of consistency in the findings.

Statistical analyses

Fisher’s exact tests were used to examine differences in proportions of significant associations between (a) physical activity assessment tools with known and acceptable compared to unknown or not psychometric properties, (b) subjective and objective physical activity assessment tools, (c) studies with a sample size below or equal to or higher than the median sample size, and (d) studies including patients with a formal diagnosis versus studies including patients with self-reported depressive symptoms. The significance level was set at $p < 0.05$.

RESULTS

Out of 266 potentially eligible studies, 59 (Moore et al. 1999, Allgöwer et al. 2001, Anderson et al. 2003, van Gool et al. 2003, Kinder et al. 2004, Perera et al. 2006, Wada et al. 2006, Knapien et al. 2007, Ball et al. 2008, Simon et al. 2008, Strine et al. 2008, Teychenne et al. 2008, Rosqvist et al. 2009, Asztalos et al. 2010, Beydoun et al. 2010, de Wit et al. 2010, Jonsdottir et al. 2010, Kerse et al. 2010, Mamplekou et al. 2010, Piwoński et al. 2010, Rethorst et al. 2010, Teychenne et al. 2010, Van Citters et al. 2010, Azar et al. 2011, Chwas-tiak et al. 2011, Demissie et al. 2011, Hamer et al. 2011, Reichert et al. 2011, Vallance et al. 2011, Azevedo et al. 2012, Barcelos-Ferreira et al. 2012, Chen et al. 2012, Giuli et al. 2012, Hendrix et al. 2012, Hennings et al. 2012, Korniloff et al. 2012, Kull et al. 2012, Mata et al. 2012, Sieverdes et al. 2012, Song et al. 2012, Wild et al. 2012, Brunet et al. 2013, De Mello et al. 2013, Garmendia et al. 2013, Hernandez et al. 2013, Icks et al. 2013, McKercher et al. 2013, Uebelacker et al. 2013, Borges et al. 2014, Dugan et al. 2014, Feng et al. 2014, Kramer et al. 2014, Loprinzi & Mahoney 2014, Lovell et al. 2014, Wassink-Vossen et al. 2014, Yu et al. 2014, Pengid 2015, Vancampfort et al. 2015) were included in this review. Reasons for exclusion are shown in Figure 1. Five of 8 contacted research groups (see acknowledgements) provided us with additional, unpublished correlation analyses for our target group or full-texts and could be included this way.

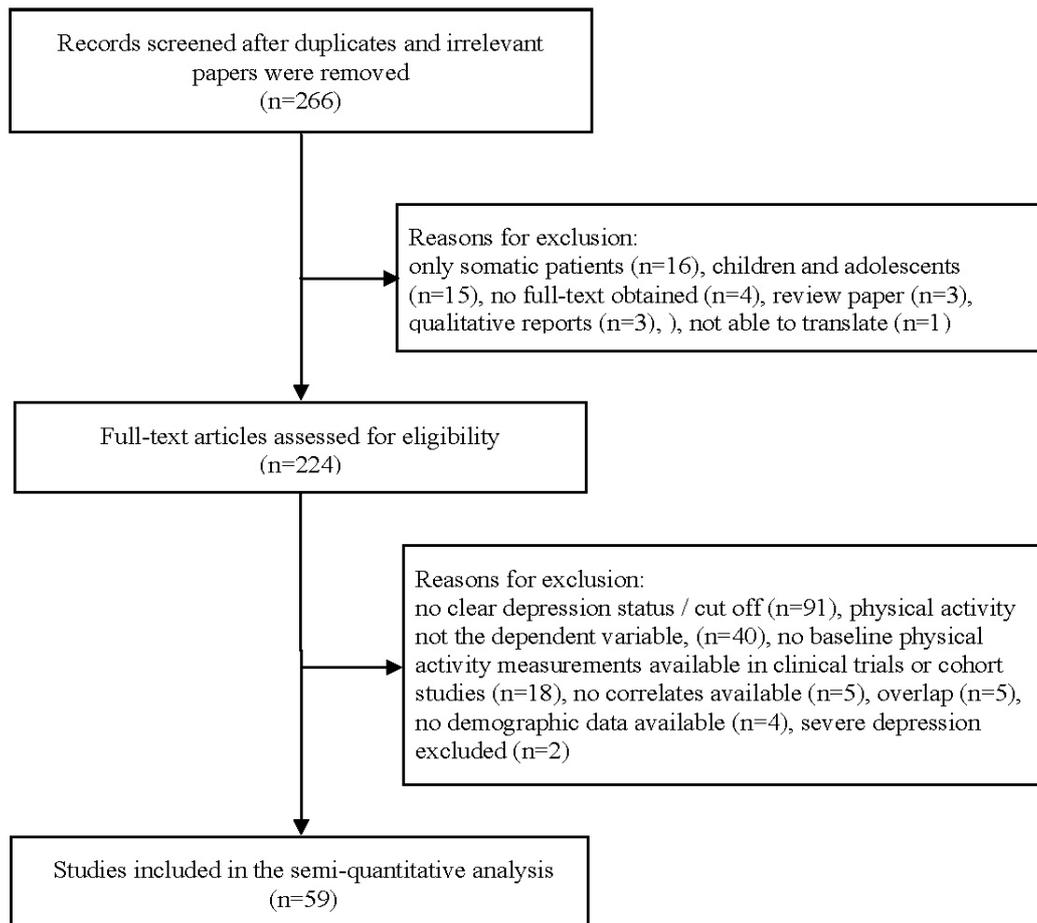


Figure 1. Flow chart of systematic review inclusion and exclusion

Across all studies, a total of 101,539 persons with depression were included in the analyses. In 45 studies depression was assessed by self-reported symptom scales, while 14 studies involved participants with a physician/clinician diagnosis using a structured clinical diagnostic interview. No significant differences in the proportion of significant associations were observed between studies using self-report assessment versus structured diagnostic interviews ($p=0.55$).

Concerning the quality of the physical activity measure, 52.5% ($n=31$) were un-validated or unreliable self-reports or self-reports without reported psychometric properties, 37.3% ($n=22$) were empirically supported self-reports, and 10.2% ($n=6$) were objective measures. Significantly ($p=0.029$) less associations were reported in studies using physical activity assessment tools with known and acceptable validity compared to studies using tools with unknown or not acceptable psychometric properties. No significant differences in the proportion of significant associations were observed between studies using subjective versus objective physical activity assessment tools ($p=0.52$). There was a lower proportion of significant correlates in studies with a sample size lower than or equal to the median sample size ($p=0.004$). Table 1 presents the characteristics of the included participants, the quality of physical activity

assessment and performed statistical analyses. Table 2 summarizes the correlates of physical activity participation in people with depression.

Demographic correlates

Nine demographic correlates were evaluated in the literature and none were consistently associated with physical activity participation (Table 1). Only ethnic minority status was associated with lower physical activity participation, but this was based on one study only.

Biological correlates

Eleven biological correlates were studied. Higher body mass index and physical comorbidity were consistently ($n \geq 4$) associated with lower levels of physical activity participation. Although limited to two studies, better physical performance was positively associated with physical activity participation.

Behavioral attributes/skills

Smoking, nicotine dependence and alcohol use disorder were the only examined within the behavioral attributes and skills part of the model. However, no significant associations were found.

Table 1. Study characteristics

First author / year	Participants	Depression status	PA instrument	Quality of PA measurement	Statistical tests
Pengid 2015	2,178; (16-30 years)	CES-D \geq 15	IPAQ, short version	B	Mann–Whitney U Test
Vancampfort 2015	96(31♂); 46 years	DSM-IV MDD	IPAQ, short version	B	Pearson correlations, Student-t test
Borges 2014	386(270♂); >60yrs	GDS-15 \geq 5	IPAQ, long version	B	Multivariate logistic regression
Dugan 2014	535♀; 46 years	CES-D \geq 16	Kaiser Physical Activity Survey	A	Chi Square test
Feng 2014	117; 16-24years	SDS \geq 53	“How often do you sport and/or vigorous free play each week with 30 minutes at least per day?” was assessed by using the following options: daily, 5–6 days/week, 3–4 days/ week, 1–2 days/week, and less than once per week. Being physically active were defined as sporting at least three days per week	A	Multivariate logistic regression
Kramer 2014	56(22♂); 44.3 \pm 13.4yrs	DSM-IV MDD and dysthymic	Participants were asked whether they participated in 1 or more exercise activities within the last 4 weeks. They could name up to 3 activities, and could list both the frequency (per month) and the duration (per episode). A physical exercise index reflecting the weekly amount of physical exercise (minutes per week) was computed.	A	Point biserial correlations
Loprinzi 2014	134; 44-48yrs	PHQ-9 \geq 10	Accelerometer	C	Multivariate logistic regression
Lovell 2014	164 students; 18-63yrs	DASS-21 \geq 5	“How many of the last 14 days have you done at least 20 min of exercise that made you breathe heavily and your heart beat fast?” and “How many days in a usual week do you accumulate 30 min or more of moderately strenuous physical activity such as walking or going to the gym?” Participants who indicated three or more days of vigorous and five or more days of moderate activity were classified as meeting the guideline.	A	Multivariate logistic regression
Wassink-Vossen 2014	295(105♂); 69 yrs	CIDI, WHO	IPAQ, long version	B	Univariate logistic regression
Yu 2014	782; 53yrs	PHQ-9 \geq 10	IPAQ, long version	B	Multivariate logistic regression
Brunes 2013	3,689(1773♂); 477(196♂); 19-40yrs; 1508(727♂); 41-60yrs; 1704(850♂)>60yrs	HADS-D $>$ 8	Items from IPAQ: 12 month recall	B	Chi Square test
De Mello 2013	228	BDI \geq 20	yes / no and what frequency (\leq 2*week or \geq 3*week)	A	Multivariate logistic regression
Garmendia 2013	306; >65years	GDS-15 \geq 5	Adherence to a physical activity intervention	A	Multivariate logistic regression
Hernandez 2013	158(34♂); 72.7 \pm 7.4yrs	GDS-5 \geq 2	Pedometer	C	Univariate logistic regression

Table 1. Continued

First author / year	Participants	Depression status	PA instrument	Quality of PA measurement	Statistical tests
Azevedo 2012	739(522♂); 24.6%≤39yrs; 26.5%: 40-44yrs; 22%: 45-49yrs; 26.9% ≥50yrs; 88.2% Caucasian	GHQ≥4	Average number of hours per week spent in moderate (e.g., dancing, cycling, leisure swimming) and vigorous (e.g., running, hard swimming, playing squash) physical activity.”	A	Chi Square test
Bernard 2012	133(73♂) smokers; 47.6±10.4yrs	HADS-D≥10	“Are you regularly active? yes/no”	A	Student-t and Chi Square tests*
Chen 2012	506(206♂); ≥65yrs	CES-D≥10	“Have you taken part in any sport or exercise activities in the past 2 weeks?” Identify the types they had engaged in from 31 named activities). They also provided frequency and duration for each activity.	B	Chi Square test
Giuli 2012	109(61♂); ≥65yrs	GDS-15≥5	Lifestyle Questionnaire	A	Student-t and Chi Square test
Hendrix 2012	4(1♂); 78yrs	DSM-IV MDD	Accelerometer	C	Student-t test
Hennings 2012	38(16♂); 47.6±10.4yrs	DSM-IV MDD	Freiburger Fragebogen zur Koerperlichen Aktivitaet	A	Student-t test*
Icks 2013	337(107♂); 58.9±7.6yrs	CES-D≥17	Any physical exercise in the preceding month?	A	Student-t test
Korniloff 2012	179(74♂); 69±3yrs	BDI≥10	“How much physical activity do you practice during leisure-time?”	A	Student-t test
Kull 2012	344♀; 18-51yrs	BDI>9	Global Physical Activity Questionnaire	B	Binary logistic model
Mata 2012	53(38♂); 28.2±6.4yrs; 73.6% Caucasian	DSM-IV MDD	“Were you physically active since the last beep? (1) How long were you active? from 5 -120 min; (2) What kind of activity did you engage in? with options of mild activity (minimal effort; e.g., easy walking, yoga), moderate activity (not exhausting; e.g., fast walking, tennis), and strenuous activity (heart beats rapidly; e.g., running, basketball).”	A	Student-t test
McKercher 2013	173(52♂); 31.4±2.6yrs	DSM-IV MDD	Pedometer	C	Multivariate logistic regression
Uebelacker 2013	14,763♀;62.8±7.6 yrs	CES-D≥5	“How long walking outside for more than 10 min and at what speed, how long strenuous, moderate, and mild exercise?”	B	Multivariate logistic regression
Barcelos-Ferreira 2012	180; ≥60yrs	CES-D≥7	Questions from the Brazilian Association of Institutes of Market Research	A	Univariate logistic regression
Sieverdes 2012	727; 49yrs	CES-D≥10	Type, frequency, and duration of several leisure time activities (e.g., walking, running, biking, swimming, dancing, and other types of sports such as softball and racquet sports)in the preceding 3 months were assessed. Each activity was assigned a MET value.	A	Multivariate logistic regression
Song 2012	790(318♂); >20yrs	PHQ-9≥5	Accelerometer	C	Multivariate logistic regression
Wild 2012	1,262; 23.3%: 53-59yrs; 19.3%: 60-64yrs; 22.0%: 65-69yrs; 20.5%:70-74yrs; 14.8%:75-80yrs	GDS-15≥5	Light physical activity such as walking or light physical work was categorized into “less than three hours per week” and “≥three hours per week”	A	Univariate logistic regression

Table 1. Continued

First author / year	Participants	Depression status	PA instrument	Quality of PA measurement	Statistical tests
Azar 2011	147♀; 27.8yrs	GHQ-30≥5	IPAQ, long version	B	Wald test
Chwastiak 2011	35,582 veterans; 64yrs	ICD-9 MDD	How often do you engage in regular activities long enough to work up a sweat? Categorical responses ranged from never to more than 5 times per week.	A	Multivariate logistic regression
Demissie 2011	316♀; 31%: ≤24yrs; 27%: 25-29yrs; 29%: 30-24yrs; 13%: ≥35yrs 66% Caucasian	CES-D≥17	A structured one-week recall questionnaire for pregnant women	B	Chi Square test
Hamer 2011	210(92♂); 79.0±7.7	GDS-15≥5	Self-reported physical activity: the extent to which participants were active through exercise and sports, walking, housework, and gardening. Scores were categorized as moderate-vigorous or light-inactive levels of physical activity	A	Chi Square test
Reichert 2011	122(35♂); 69.0±6.0 yrs	GDS-15≥5	IPAQ, long version	B	Student-t test
Rethorst 2011	42(13♂); 51.4±6.8 yrs	CES-D≥17	The modified Community Health Activities Model Program for Seniors questionnaire (14 items, physical activity over the previous month)	A	Student-t test
Vallance 2011	195(87♂); 46.6±14.2yrs; 63.6% Caucasian	PHQ-9≥5	Accelerometer	C	Student-t test
Asztalos 2010	519(174♂)	SCL-90 subscore	IPAQ, long version	B	Multivariate logistic regression
Beydoun 2010	176 (62♂); 20-39years	ICD-10 MDD	A single question with responses measured on a 3-point Likert scale, which asked whether the subject was less active (score=1), about the same (score=2) or more active (score=3) than age peers.	A	Multivariate logistic regression
De Wit 2010	369(131♂); 40.6±12.2yrs;	DSM-IV MDD	IPAQ, long version	B	Multivariate logistic regression
Jonsdottir 2010	111	HADS-D≥10	Physical activity level during the last three months: mostly sedentary (group 1), light (such as gardening or walking or bicycling to work) at least two hours a week (group 2), moderate such as doing aerobics, dancing, swimming, playing football or heavy gardening) at least two hours a week (group 3), or vigorous several times a week, at least 5 hours with high intensity (group 4)	B	Chi Square test
Kerse 2010	56(25♂); 81.5yrs	GDS>4	Auckland Heart Study Physical Activity Questionnaire	A	Student-t test*
Mamp lekou 2010	246(79♂); 76±8yrs	GDS>10	IPAQ, long version	B	ANOVA
Piwoński 2010	3,800(1476♂); 50.8yrs	BDI≥10	Questions to explore lack of regular physical activity (lack of physical exercises lasting at least 30 min).	A	Chi Square test
Teychenne 2010	1,328; 35yrs	CES-D≥10	IPAQ, long version	B	Multivariate logistic regression
Van Citters 2010	30 outpatients; 1/3 older than 50yrs	DSM-IV MDD	Yale Physical Activity Scale	B	Correlation analysis*
Rosqvist 2009	131(30♂); 77.3±1.91yrs	CES-D≥16	Grimby physical activity questionnaire	B	Student-t test; Chi Square test

Table 1. Continued

First author / year	Participants	Depression status	PA instrument	Quality of PA measurement	Statistical tests
Ball 2008	1,691 ♀; 18-23yrs	CES-D \geq 10	Physical activity items assessed the frequency and duration of walking (for recreation or transport), and of moderate- and vigorous-intensity activity in the last week	A	Chi Square test
Simon 2008	743 ♀; \geq 40yrs	PHQ-9 \geq 10	Jacobs physical activity questionnaire	A	Multivariate logistic regression
Strine 2008	18,912	PHQ-8 \geq 10	Respondents were considered to be physically inactive if they did not participate in any physical activities or exercise such as running, calisthenics, golf, gardening or walking for exercise during the past month other than their regular job.	A	Multivariate logistic regression
Teychenne 2008	421 ♀; 27.8%<30yrs; 26%:30-39yrs; 22.6%:40-49yrs; 19.7%>50yrs	GHQ \geq 4	IPAQ, long version	B	Chi Square test
Knapen 2007	191(67♂); ♂=35.8 \pm 9.5yrs, ♀=32.4 \pm 10.3yrs	DSM-IV MDD and dysthymic	Baecke Physical Activity Questionnaire	B	Multivariate logistic regression ^o
Perera 2006	514; 14-19yrs	CES-D \geq 16	Details not presented.	A	Fisher's exact test
Wada 2006	3,742♂ workers; >18yrs	CES-D \geq 16		A	Multivariate logistic regression
Kinder 2004	545(177♂); 29.3yrs	DSM-III MDD	"How many times have you done sweating exercise during the past month?"	A	Chi Square test
Anderson 2003	29♀; 17-54yrs	CES-D \geq 34	"Have you been exercising regularly in the past year? If so, what types/frequency/where? (For example, going to a 1-hour exercise class 3 times per week, or regularly taking a 30 min walk twice a week in your neighborhood.) If not, say 'I have not exercised in months or years.'"	A	Multivariate logistic regression
van Gool 2003	176(56♂); >55yrs	CES-D \geq 16	Expressed in minutes per day by adding up averaged, self-reported time spent on walking, cycling, sports, and light (e.g. doing the dishes, or ironing) and heavy (e.g. cleaning windows, or vacuum cleaning) household chores	A	MANOVA
Allgöwer 2001	1,769; 18-30yrs	BDI \geq 5	Participants were asked whether they exercise for 5 or more times during past 2 weeks	A	Multivariate logistic regression
Moore 1999	146; >50yrs	DSM-IV MDD	Minnesota Leisure-Time Activity Questionnaire	B	Multivariate logistic regression

Note: A=self-report of poor or unknown reliability/validity for patients with depression; B=self-report with acceptable reliability/validity for patients with depressive symptoms, and C=acceptable objective measure (pedometers, accelerometry); PA=physical activity; BMI=body mass index; COPD= chronic obstructive pulmonary disease; BDI=Beck Depression Index; CES-D=Center for Epidemiologic Studies Depression Scale; CIDI=Composite Interview Diagnostic Instrument from World Health Organization; DASS-21=Depression, Anxiety, and Stress Scale; DSM-IV MDD=Diagnostic Statistical Manual edition 4 diagnosis of major depressive disorder; EDS=Edinburgh Depression Scale; GDS=Geriatric Depression Scale; GHQ=General Health Questionnaire; HADS-D=Hospital Anxiety and Depression Scale-Depression score; ICD= International Classification of Diseases; IPAQ= International Physical Activity Questionnaire; PHQ=Patient Health Questionnaire; SDS=Zung Self Rating Depression Scale; ANOVA=analysis of variance;

*additional analyzes performed by the original authors; ^oadditional analyzes performed by the current authors

Table 2. Summary of studies of determinants of physical activity in patients with depression

Determinant variable	Related to PA		Unrelated to PA		Summary code	
	Study	Ass	Study	Ass	% studies reporting ass	
<i>Demographic</i>						
Age (Older)	Chwastiak 2011; Korniloff 2012; Sieverdes 2012; Vancampfort 2015	-	Van Citters 2010; Azevedo 2012; Hennings 2012; McKercher 2013;	??	4/7 (57%)	
Age at onset	Wassink-Vossen 2014	0		0	0/1 (0%)	
Gender (Male)	Mamplekou 2010 (-); Reichert 2011 (+); Pengid 2015 (+)	?	Beydoun 2010; Van Citters 2010; Chwastiak 2011; Bernard 2012; Hennings 2012; McKercher 2013; Vancampfort 2015	00	3/9 (33.3%)	
Ethnicity (Caucasian)	Chwastiak 2011	+		+	1/1 (100%)	
Educational status (Lower)	Van Citters 2010; Vancampfort 2015	-	Bernard 2012; McKercher 2013	?	2/4(50%)	
Occupational status			Ball 2008(f); Bernard 2012; Vancampfort 2015	0	0/3 (0%)	
Living alone			Bernard 2012; Wassink-Vossen 2014; Vancampfort 2015	0	0/3 (0%)	
Being hospitalized in previous 12 months			Kerse 2010	0	0/1 (0%)	
Financial strains			Kerse 2010	0	0/1 (0%)	
<i>Biological</i>						
Physical co-morbidity (Yes)	Knapen 2007; Rosqvist 2009; Chwastiak 2011	-	Wassink-Vossen 2014	-	3/4 (75%)	
Physical performance (Better)	Kerse 2010; Wassink-Vossen 2014	+		+	2/2 (100%)	
Psychiatric co-morbidity (Yes)			Hennings 2012	0	0/1 (0%)	
Psychomotor agitation	McKercher 2013	-		-	1/1 (100%)	
Medical antecedents (Yes)			Brunes 2013	0	0/1 (0%)	
BMI (Higher)	Van Citters 2010; Chwastiak 2011; Bernard 2012; Sieverdes 2012; Wassink-Vossen 2014; Vancampfort 2015	-		-	6/6 (100%)	
Being overweight			McKercher 2013	0	0/1 (0%)	
Being obese	McKercher 2013	-		-	1/1 (100%)	
Antidepressant medication use	Wassink-Vossen 2014		Bernard 2012	?	1/2 (50%)	
Sedative medication use	Wassink-Vossen 2014		Kerse 2010	?	1/2 (50%)	
Anxiolytic medication use	Wassink-Vossen 2014; 44	-		-	2/2 (100%)	
<i>Behavioral attributes /skills</i>						
Cigarette use (number)	Chwastiak 2011; Bernard 2012	-	Van Citters 2010; Hennings 2012; Wassink-Vossen 2014	?+?	2/5 (40%)	
Alcohol misuse			Bernard 2012; Wassink-Vossen 2014	0	0/2 (0%)	
Nicotine dependence (Fagerström test)			Bernard 2012	0	0/1 (0%)	
<i>Psychological, cognitive and emotional</i>						
Depression	Moore 1999; Allgöwer 2001; Anderson 2003 (f); van Gool 2003; Kinder 2004; Perera 2006 (m); Perera 2006 (f) Wada 2006 (m); Knapen 2007; Ball 2008 (f); Simon 2008; Strine 2008; Teychenne 2008; Rosqvist 2009; Asztalos 2010; Beydoun 2010 (f); De Wit 2010; Jonsdottir 2010; Mamplekou 2010; Piwoński 2010 (m); Piwoński 2010 (f); Teychenne 2010; Van Citters 2010; Chwastiak 2011; Demissie 2011; Hamer 2011; Reichert 2011 (m); Vallance 2011; Azevedo 2012; Barcelos-Ferreira 2012; Chen 2012; Giuli 2012; Hendrix 2012; Hennings 2012; Korniloff 2012; Kull 2012 (f); Mata 2012; Sieverdes 2012; Song 2012; Wild 2012; Brunes 2013; De Mello 2013; Garmendia 2013; Hernandez 2013; McKercher 2013; Uebelacker 2013 (f); Borges 2014; Dugan 2014 (f); Loprinzi 2014; Lovell 2014 (f); Wassink-Vossen 2014; Yu 2014	-	Beydoun 2010 (m); Reichert 2011 (f); Rethorst 2011; Hennings 2012; Feng 2014; Lovell 2014(m);	-	53/59 (90%)	

Table 2. Continued

Determinant variable	Related to PA		Unrelated to PA		Summary code	
	Study	Ass	Study	Ass	% studies reporting ass	
<i>Psychological, cognitive and emotional</i>						
Depression history			Bernard 2012	0	0/1 (0%)	
Negative affect	Vancampfort 2015	-		-	1/1 (100%)	
Positive affect	Vancampfort 2015	+		+	1/1 (100%)	
Cognitive functioning (Lower)	Wassink-Vossen 2014	-		-	1/1 (100%)	
Enjoyment (More)			Azar 2011 (f)	0	0/1 (0%)	
Self-efficacy (Lower)	Knapen 2007; Van Citters 2010; Azar 2011 (f); Kramer 2014	-		-	4/4 (100%)	
Physical HRQoL (Higher)	Kerse 2010; McKercher 2013	+		+	2/2 (100%)	
Psychological HRQoL (Higher)			Kerse 2010; McKercher 2013	0	0/2 (0%)	
Lack of knowledge on the importance	Rosqvist 2009	-		-	1/1 (100%)	
Fear and negative experiences	Rosqvist 2009	-		-	1/1 (100%)	
Lack of energy/ fatigue	Rosqvist 2009	-		-	1/1 (100%)	
Self-enhancement strategies (action planning, coping planning...)	Knapen 2007; Kramer 2014	+		+	2/2 (100%)	
Sense of mastery of one's own life			Wassink-Vossen 2014	0	0/1 (0%)	
Perception of situational barriers	Kramer 2014	-		-	1/1 (100%)	
Autonomous motivation (SDT)	Vancampfort 2015	+		+	1/1 (100%)	
<i>Social and cultural</i>						
Social support			Azar 2011 (f); Wassink-Vossen 2014	0	0/2 (0%)	
<i>Physical environment</i>						
Access to facilities in the neighborhood			Azar 2011 (f)	0	0/1 (0%)	
Access to sport equipment in home			Azar 2011 (f)	0	0/1 (0%)	
<i>Policy</i>						

PA = physical activity; HRQoL = Health Related Quality of Life; SDT = self-determination theory; Ass = association; - = negative, + = positive; 0 = no relation; ? = indeterminate, f = female patients only, m = male patients only

Psychological, cognitive and emotional correlates

Out of 16 psychological, cognitive and emotional variables, 12 significant associations with physical activity participation were reported. There was overwhelming evidence that higher levels of depressive symptoms were negatively associated with physical activity participation. Lower levels of self-efficacy were also negatively associated with physical activity participation in more than 4 studies and can therefore be considered as a consistent negative correlate. There is some limited evidence that better physical health related quality of life and the use of self enhancement and self-determination strategies may be positively associated with physical activity participation.

Social/cultural factors and the physical environment

Only two studies investigated the role of the social and the physical environment. No significant associations were found.

Policy factors

No policy-level correlates were found in the literature review.

DISCUSSION

General findings and clinical implications

To the authors' best knowledge, the present review is the first to document correlates of physical activity in people with depression. The most consistent correlates of lower physical activity were the presence of (and higher levels of) symptoms of depression, a higher body mass index, the presence of physical co-morbidity and a lower self-efficacy. At behavioral, social or physical environment level, no consistent correlates were found, and no data were available at all regarding policy level correlates. We did not identify any correlates that are consistently positively associated with physical activity in people with depression. However, there is evidence that better physical performance, higher physical health

related quality of life and the use of self-enhancement and self-determination strategies are significant positive contributors to physical activity in people with depression. The lack of other consistent correlates might be due to (a) the paucity of studied correlates, and (b) differences in study design, sample characteristics, choice of assessments/correlates and analysis methods. Clearly, with the increasing prevalence of depression (Kessler et al. 2003) and the fact that physical activity can ameliorate many of these symptoms and improve the physical health of people with depression (Krogh et al. 2011, Cooney et al. 2014, Knapen et al. 2014, Rosenbaum et al. 2014), there is a need to better understand how physical activity can be successfully encouraged in people with depression.

Although the literature on physical activity correlates still is equivocal, our findings support the hypothesis that in people with depression physical activity participation is a complex behavior that is determined by many different factors. A clinical implication of this finding is that to achieve substantial physical activity behavior change, physical activity interventions should ideally target changes in different categories/dimensions and should ideally be tailored based on the individual's needs and barriers. Knowledge about correlates of physical activity behavior helps identify high-risk persons in whom physical activity is less or, even, least likely and who may therefore require intensified and targeted interventions.

When looking at the current evidence on demographic correlates of physical activity participation in people with depression, we only found one study indicating that ethnic minority persons were more vulnerable for lower physical activity participation (Chwastiak et al. 2011). This may be a common theme in physical activity participation, since another physical activity correlates review in osteoarthritis also found that ethnic minorities engaged in less physical activity (Stubbs et al. 2015a, b). It may suggest the need for clinicians to engage and support those from ethnic minorities. Two well-studied demographic variables that were not found to be associated with physical activity behavior were older age and male gender. These findings should be encouraging to healthcare professionals, as it suggests that persons with depression can be expected to participate in some form of physical activity across the lifespan.

The most consistent biological correlates were a higher body mass index and the presence of physical comorbidity. It has been suggested that co-morbid conditions may limit mobility and/or result in more pain during physical activity in people with severe mental illness (Vancampfort et al. 2013, 2014), which influences the ability to engage in or sustain physical activity performance. Although the physical health status is not always amenable to improvement, it could be argued that improved treatment of co-morbid physical conditions may result in improvements in physical activity patterns. While limited to significant findings from two studies, it is however encouraging to note that better physical performance

is positively associated with physical activity. Clinicians should therefore try to identify those with depression with worse physical performance (particularly those with pain or more physical comorbidities) and attempt to provide appropriate adaptive strategies to enable them to participate. Physiotherapists and other rehabilitation professionals should oversee this process. From a tailoring perspective, physical activity programs need to take into account the limits that physical health status may place on the intensity of physical activity that people with depression can engage in without aggravating physical symptoms.

The most fundamental intrapersonal correlates to physical activity were feelings of depression and a lower self-efficacy. People with depression should be made aware that anhedonia and avolition are important barriers to participating in physical activity, but being physically active may itself be an effective coping mechanism for people with depression to deal with these debilitating symptoms. The present review indicates that action planning might enable people with depression to be more physically active. Greater support for the association between action planning and physical activity behaviour would be encouraging as action plans are easily amenable to change through intervention. Supporting people with depression in developing a plan for when and where to engage in physical activity, as well as how to overcome potential barriers should therefore be a major focus. This way, health care professionals can anticipate as well the detrimental effects of the frequently observed low self-efficacy. An individual physical activity plan taking into account mental and physical health barriers will increase the confidence of people with depression and consequently improve self-efficacy and chances of success. According to Bandura (1997) self-efficacy perceptions are derived from four principal sources of information: (a) past performances, (b) vicarious experiences (modeling), (c) verbal persuasion, and (d) the physiological state. Therefore, to increase physical activity related self-efficacy, an action plan should: (a) provide enjoyable, appropriate options that enable patients to experience success; (b) create opportunities to observe role models (e.g., friends, relatives and fellow patients) performing physical activity; (c) include verbal encouragements to participate in physical activity from influential others including staff members and physicians; and (d) reduce any anxiety associated with participation in physical activity.

Limitations and future research

There are several limitations to this review, which should be acknowledged. First of all, the diversity of physical activity measures, subject samples and analysis strategies prevented us from performing a formal meta-analysis. Measuring physical activity levels poses many challenges. Self-report questionnaires are known to require motivation to complete all of the questions, and it is often difficult to ascertain the frequency, duration and intensity of physical activity with good reliability (Warren et al. 2010). Fewer significant associations

would be expected in studies that relied on self-report measures. However, a Fisher's exact test indicated that there was no difference in the proportion of significant correlates between subjective and objective physical activity measurements. While this could be due to the relatively small number of studies using objective measures, we did find less significant correlates in studies with acceptable versus unknown/unacceptable psychometric properties, pointing to the benefits of using standardized measures. Furthermore, expectedly, sample size had a direct bearing on the likelihood of declaring a statistically significant result. This finding indicates that studies should perform adequate power analyses and enroll sufficient numbers of participants relative to the number of examined correlates, with even higher numbers required for the performance of multivariate analyses and identification of correlates that are independent of each other. Third, most correlates of physical activity were only documented in a small number of studies. Examination of the same, standardized variables in different studies is therefore necessary in order to build a body of evidence that can support or refute the potential influence of individual variables. Future studies should in particular attempt to analyze the role of multiple correlates of physical activity from a social-ecological perspective and should not only focus on the identified variables, but also on those that remain under-studied. Only two studies examined the role of influential others and of a comfortable physical environment in relation to physical activity participation. This is surprising, as these variables are known to play an important role in physical activity behavior in the general population (Sallis et al 2000, Trost et al. 2002). Future research should determine the amount and type of social support necessary to begin and maintain physical activity behavior in persons with depression. To date, no policy-level correlates were identified. Correlates at this level of the social-ecological model may be explored however best initially using a qualitative approach (Petter et al. 2009). Researchers should examine, which policies are currently in place. Interviews of people with depression and their healthcare professionals may provide further insight as to what is needed to stimulate an active lifestyle. Future studies should also evaluate environmental modifications, which can provide an opportunity to examine changes in physical activity levels occurring in conjunction with changes in the physical environment. If the purpose of this kind of physical activity research is to inform and motivate policy changes that will improve the mental and physical health of persons with depression, merely documenting the relationship between environmental variables and physical activity is likely insufficient. At some point, environmental and policy change research will need to include assessments of broader health outcomes, such as changes in the prevalence of chronic co-morbidities, physical activity service utilization, as well as the economic costs and benefits of proposed policy changes.

CONCLUSIONS

The present review demonstrates that higher levels of depressive symptoms, a higher body mass index, the presence of physical co-morbidities and a lower self-efficacy are the most consistent correlates of physical activity participation in people with depression. Better physical performance and self enhancement strategies may positively contribute to physical activity in people with depression. Since depression causes a profound amount of burden to people across the world and physical activity has proven benefits, there is an urgent need for evidence-based interventions.

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