Journal of Physical Activity and Health, 2016, 13, 910-918
http://dx.doi.org/10.1123/jpah.2015-0436

Human Kinetics
REVIEW

Physical Activity in People With Posttraumatic Stress Disorder: A Systematic Review of Correlates

Davy Vancampfort, Justin Richards, Brendon Stubbs, Grace Akello, Caleb Ademola Gbiri, Philip B. Ward, and Simon Rosenbaum

Background: People with posttraumatic stress disorder (PTSD) are more likely than the general population to be physically inactive. The present review systematically evaluated correlates of physical activity across the socioecological model for people with PTSD. **Methods:** Two independent reviewers searched Embase, PubMed, PsycARTICLES, and CINAHL from inception until June 2015, combining the medical subject heading "posttraumatic stress disorder" or "PTSD," with "physical activity" or "exercise." Data were extracted by the same independent researchers and summarized according to the socioecological model. **Results:** Eight papers involving 1368 (994 men) participants (age range = 18–70 years) were eligible and enabled evaluation of 21 correlates. The only correlate ($n \geq 4$) consistently associated with lower physical activity participation in people with PTSD was symptoms of hyperarousal. No consistent facilitators were identified. **Conclusions:** Hyperarousal symptoms are associated with lower physical activity participation among people with PTSD and should be considered in the design and delivery of individualized exercise programs targeting this population. The role of social, environmental, and policy factors on physical activity participation among people with PTSD is unknown and should be addressed by future research.

Keywords: exercise, hyperarousal, fear, sleep

People with posttraumatic stress disorder (PTSD) experience an excess mortality rate 2 to 3 times higher than the general population.[1,2] Previous research demonstrated that the presence and severity of PTSD are associated with the presence and severity of cardiovascular diseases (CVD)[3] and predict mortality independent of age, gender, and other conventional risk factors.[3] The pathophysiology underlying the association between PTSD and increased risk for CVD is complex and yet to be fully elucidated.[4] Emerging evidence suggests that both share common pathophysiological features, including hypothalamic-pituitary-adrenal (HPA) and sympathoadrenomedullary dysfunction,[5] inflammation,[6] and common genetic links and epigenetic interactions.[7] In addition, cumulative long-term effects of poor health behaviors place people with PTSD at greater risk of cardiometabolic diseases.[8] People with PTSD are more likely than the general population to have unhealthy lifestyle behaviors, including high rates of sedentary behavior,[9] smoking,[10] alcohol and substance abuse,[11] and unhealthy eating habits (ie, diets high in saturated fats and refined sugars[12] and low in fruit[13]). In a recent review, Hall et al[14] found that the current literature regarding physical activity in people with PTSD is inconsistent, with more or less one-half of the identified studies reporting a significant negative association between PTSD and physical activity participation and the other one-half reporting no significant associations between PTSD and physical activity at all.

PTSD is characterized by symptoms of hyperarousal, reexperiencing, and avoidance.[15] PTSD symptoms are commonly treated with a combination of pharmacological and nonpharmacological therapies, including selective serotonin reuptake inhibitors,[16] off-label use of atypical antipsychotics,[17] off-label use of benzodiazepines,[18] and psychological therapies, including trauma-focused cognitive-behavioral therapy, eye movement desensitization and reprocessing, stress management, and group cognitive-behavioral therapy.[19] However psychotropic medication may have adverse cardiometabolic side effects.[20] Psychological treatments are generally free from side effects but some people may decline psychological therapy due to low expectations of positive outcome or perceived stigma.[21] In recent years, research has demonstrated that adequate physical activity may promote mental and physical health in people with PTSD.[22–24] Despite the increasing body of evidence demonstrating the beneficial effects associated with physical activity participation, many people with PTSD remain physically inactive.[25] Thus, there is a need for research to investigate factors that influence physical activity participation in this group,[14] which may have an integral role in reducing the burden of CVD and improve health and well-being. Specifically, research is required to explore the amount (eg, frequency, intensity, and duration) and types of physical activity (eg, structured exercise vs lifestyle physical activity) needed for the observed mental and physical health benefits in people with PTSD. However, in order for physical activity interventions to be effective in promoting mental and physical health, it is important to address barriers and promote factors that enable participation.

Understanding barriers and facilitators of participation in physical activity in people with PTSD is an essential first step toward the development and implementation of effective treatments. Behavioral theories, such as the social-ecological model,[26] are useful in attempting to understand barriers and promoting facilitators. Social-ecological

Vancampfort is with the Dept of Rehabilitation Sciences, KU Leuven, Leuven, Belgium. Richards is with the School of Public Health & Charles Perkins Centre, University of Sydney, Sydney, NSW, Australia. Stubbs is with the Institute of Psychiatry, King's College, London, United Kingdom. Akello is with the Dept of Mental Health, Gulu University, Gulu, Uganda. Gbiri is with the Dept of Physiotherapy, University of Lagos, Lagos, Nigeria. Ward and Rosenbaum are with the School of Psychiatry, University of New South Wales, Sydney, NSW, Australia. Vancampfort (davy.vancampfort@uc-kortenberg.be) is corresponding author.

models suggest that multiple relevant attributes influence health behavior. These include intrapersonal (demographic, biological, psychological, emotional, and cognitive), interpersonal/cultural (eg, social support), physical environment (eg, distance to the facilities, financial costs, and enjoyable scenery), and policy (laws, rules, regulations, and codes) factors.[26] Various intrapersonal, interpersonal, physical environment, and policy-related variables have demonstrated strong positive associations with physical activity in the general population[27] and in people with severe mental illness.[28–32] Correlates consistently associated with physical activity participation in the general population are male gender, a higher self-efficacy, physical activity history, current health status, and the intention to be physically active.[27] Little is known, however, about whether these factors demonstrate similar relationships with physical activity behavior among people with PTSD. A qualitative study reported that among people with PTSD a lack of time (14% before and 39% after PTSD onset) and lack of motivation (24% before and 71% after PTSD onset) negatively affected physical activity participation. Quantitative research may identify potential mediators and moderators of physical activity that can be targeted by future interventions. The present review aimed to systematically evaluate published quantitative studies of correlates of physical activity in people with PTSD. In addition to summarizing methods and results of these studies, gaps in the literature are identified and directions for future research are proposed.

Methods

Data Sources and Searches

Two independent reviewers (DV and SR) performed an electronic search of Embase, PubMed, PsycARTICLES, and CINAHL from the inception of these databases to June 2015. Keywords used were "physical activity" or "exercise" and "post traumatic stress disorder" or "PTSD" 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: (1) clinician confirmed or self-reported PTSD according to predetermined criteria, (2) studies contained quantitative research and had been published in a peer-reviewed journal, and (3) 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 identified publications.

Articles were excluded if the dependent variable was aerobic fitness, physical activity intention, self-efficacy, or other intermediate (nonbehavioral) measures because these variables are less direct indicators of actual physical activity participation. Reviews, 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 regarding the target group.

Data Collection

Two reviewers independently extracted data from the included studies using a predetermined form. The data extracted from each study included: (1) gender, (2) age, (3) ethnicity, (4) setting if applicable, (5) criteria used for the PTSD diagnosis, (6) physical activity assessment tool, and (7) study design. In accordance with previous reviews[27–32] the following categories were used to code the quality of the physical activity measure: (1) self-report with poor, unknown, or undefined reliability/validity; (2) self-report with described and acceptable reliability/validity; and (3) acceptable objective measurements. Following Warren et al,[34] 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.[35] 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: (1) demographic, (2) biological, (3) psychological/cognitive/emotional, (4) behavioral attributes/skills, (5) social/cultural factors, (6) physical environment, and (7) 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 socioecological approach aims to identify the domains that have been explored in the literature and to elucidate the multidimensional perspective of potential influences on the physical activity behavior in people with PTSD.

Coding Associations With Physical Activity

A variety of statistical techniques were used to evaluate correlates, most commonly univariate/bivariate analyses, including correlations, *t* tests, and analysis of variance. If both univariate/bivariate and multivariate tests were conducted, univariate/bivariate tests were reported for consistency across studies. The column "related to physical activity" indicated studies reporting significant associations between the variable and the physical activity measure (see Table 1). The direction of association is indicated with a "+" or "-" The column "unrelated to physical activity" indicates which studies reported nonsignificant 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 socioeconomic groups, these subgroup analyses were not included in the summary tables.

Summary Codes

As many of the identified articles did not report 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 for each variable explored in accordance with the method of Sallis et al.[36] We summarized how many studies supported an association or not and in which direction. Data were presented as percentages, which will refer to the number of associations supporting the expected association divided

Table 1 Summary of Studies of Determinants of Physical Activity in Patients with PTSD

	Related to PA		Unrelated to PA	Summary Code[b]	
Determinant variable	Study[a]	Assoc.	Study[a]	Assoc.	% Studies reporting association
Demographic					
Age (older)			24; 37; 41; 43	00	0% (0/4)
Gender (female)	44	-	41	?	50% (1/2)
Race (White)			43	0	0% (0/1)
Education (higher)			43	0	0% (0/1)
Marital status (married)			43	0	0% (0/1)
Biological					
Body mass index (higher)			41	0	0% (0/1)
Waist circumference (higher)			24	0	0% (0/1)
Fibromyalgia (presence)	37	-		-	100% (1/1)
Behavioral attributes/skills					
Smoking status (+10 cigarettes/day)			42	0	0% (0/1)
Sleep quality (better)	24; 39; 41	+	42	+	75% (3/4)
Psychological, cognitive, and emotional					
PTSD symptoms (higher)	24; 38; 41	-	37; 39	-	60% (3/5)
PTSD reexperiencing (higher)	24	-	38; 42; 43	0	25% (1/4)
PTSD avoidance (higher)	24	-	38; 42; 43	0	25% (1/4)
PTSD hyperarousal (higher)	23; 38; 42; 43	-		–	100% (4/4)
Clinical global impression (score)			37	0	0% (0/1)
Physical quality of life (better)	37	+		+	100% (1/1)
Mental quality of life (better)	37	+		+	100% (1/1)
Depression (higher)	24; 38	-	39; 41	??	50% (2/4)
Anxiety (higher)	24	-		-	100% (1/1)
Suicide ideation (present)	39	-		-	100% (1/1)
Number of traumas (n)			43	0	0% (0/1)

Note. Associations are 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 4 or more studies support an association or no association, it is coded as "00", "–", or "++" indicating that there is consistent evidence for that correlate. The "??" code indicates a variable that was investigated four or more times studied with considerable lack of consistency in the findings.

[a] Reference numbers.

[b] The percentages in parentheses refer to the number of associations supporting the expected association divided by the total number of associations for the variable.

Abbreviations: Assoc., association; PA, physical activity; PTSD, posttraumatic stress disorder.

by the total number of associations for the variable. Associations were also 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 4 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 4 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 (1) physical activity assessment tools with known and acceptable validity compared with those with unknown or nonreported psychometric properties, (2) subjective and objective physical activity assessment tools, (3) studies with a sample size below or equal to or higher than the median sample size of the identified studies, and (4) studies including patients with a formal diagnosis versus studies including patients with self-reported PTSD symptoms. The significance level was set at $P < .05$.

Results

Out of 23 potentially eligible studies, 824,[37–43] were included in this review. Reasons for exclusion are shown in Figure 1. None of the 3 research groups contacted provided additional, unpublished correlation analyses for our target group or full texts. In 2 studies[40,43] there was an overlap in correlates investigated in the same sample. In this case only the data from the largest study[44] were included.

Across all studies, a total of 1368 (994 men) people with PTSD (age range = 18–70 years) were included in the analyses. In 1 study, PTSD was assessed by self-reported symptom scales, whereas 8

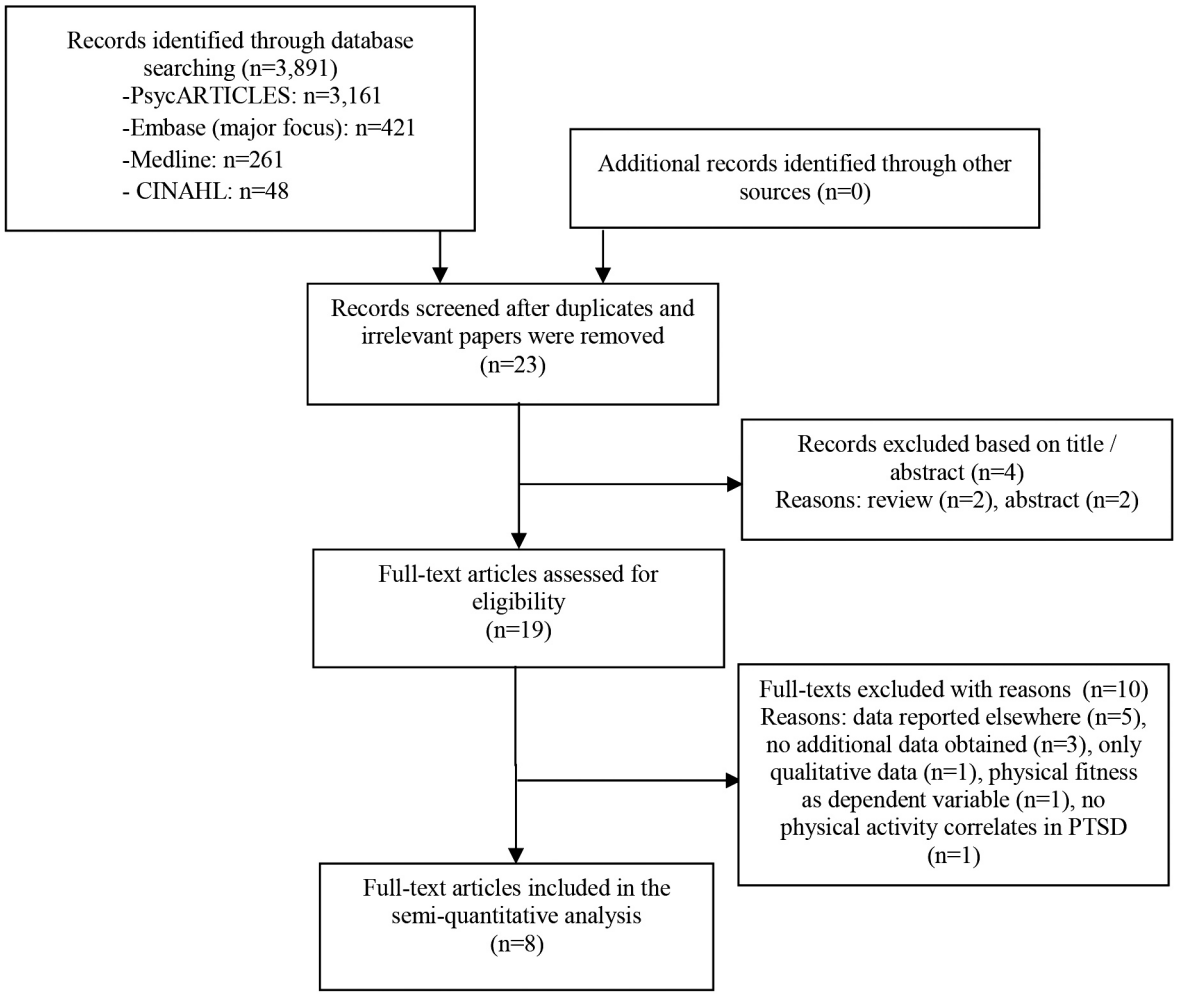

Figure 1 — Flowchart of the inclusions and exclusions.

studies involved participants with an additional physician/clinician diagnosis using a structured clinical diagnostic interview. Seven studies were based on cross-sectional data or baseline data from interventional studies, whereas only 1 study[43] had a longitudinal design.

Concerning the quality of the physical activity measure, 8 studies used unvalidated self-reports or self-reports without reported psychometric properties, and only 1 study[24] used a PA measure that has good psychometric properties. No study used objective measures. A greater number of associations were reported in the study using physical activity assessment tools with known and acceptable validity compared with the studies using tools with unknown or not acceptable psychometric properties. The proportion of significant correlates in studies with a sample size lower than or equal to the median sample size was not significantly different than those with a sample size higher than the median ($P = .21$). Table 2 presents the characteristics of the included participants, the quality of physical activity assessment, and statistical analyses performed. Table 1 summarizes the correlates of physical activity participation.

Demographic Correlates

Five demographic correlates (age, gender, ethnicity, education, and marital status) were evaluated in the literature, and none was consistently associated with physical activity participation (Table 1). There was consistent ($n \geq 4$) evidence that older age was not a barrier.

Biological Correlates

Three biological correlates (body mass index, waist circumference, and the presence of fibromyalgia) were studied. Only the presence of fibromyalgia was associated with less physical activity participation ($n = 1$) (see Table 1).

Behavioral Attributes/Skills

Two correlates (smoking status and sleep quality) were examined within the behavioral attributes and skills part of the model. Better sleep quality was associated with higher physical activity levels. Smoking status was only investigated in 1 study and was found to be unrelated to the level of physical activity (see Table 1).

Psychological, Cognitive, and Emotional Correlates

Out of 11 psychological, cognitive, and emotional variables (see Table 1), 2 consistently significant associations with physical

Table 2 Study Characteristics

First author/year	Study design	Participants	PTSD diagnosis criteria	PA instrument	Quality of PA meas.	Statistical tests
Arnson 2007[37]	Cross-sectional	55♂ with fibromyalgia; 18–60 years	DSM-IV; Clinician Administered PTSD Scale	Do you exercise often, occasionally or not at all?	A	ANOVA
Rutter 2007[38]	Cross-sectional	200 (75♂) undergraduate students; 18–23 years; 59.8% white	PTSD Checklist Civilian Version	On the average, how many times per week do you engage in physical activity, exercise, or work which increases the heart rate, causes you to breathe and sweat heavily, and is done for at least 20 minutes in duration?	A	Bivariate correlations
Davidson 2013[39]	Cross-sectional	346 (280♂) veterans in a 90 days rehabilitation program; 45.4 ± 14.3 years; 54.5% white	DSM-IV; PTSD Checklist Military Version	Over the past month, how often have you engaged in regular activities (eg, brisk walking, jogging, bicycling) long enough to work up a sweat?	A	Zero-order correlations
Vujanovic 2013[40]	Cross-sectional	81 (36♂) community recruited; 24.3 ± 10.5yrs; 89.5% white	DSM-IV; Posttraumatic Diagnostic Scale	Exercise Habits Questionnaire–Revised	A	Zero-order correlations
Talbot 2014[41]	Baseline data of a prospective cohort study	258 (230♂) veterans; 59% white	DSM-IV; Clinician Administered PTSD Scale	Which of the following statements best describes how physically active you have been during the last month (doing activities such as 15 to 20 minutes brisk walking, swimming, general conditioning, or recreational sports): 1–2/month, 3–4/month, 1–2 /week, 3–4/week, or 5+/week	A	Hierarchical multiple regression models
Babson 2015[42]	Intervention: longitudinal data	247♂ veterans in a 60–90 days rehabilitation program; 24–70 years; 60.9% white	DSM-IV; PTSD Checklist Military Version	Total number of days cycled	A	zero-order correlations
Harte 2015[43]	Baseline data intervention study	108 (63♂) community recruited; 18–62 years; 91.7% white	DSM-IV; Posttraumatic Diagnostic Scale	Exercise Habits Questionnaire–Revised	A	zero-order correlations
Rosenbaum 2014[24]	Baseline data intervention study	76 (63♂) inpatients; 47.6 ± 11.9 years	DSM-IV; PTSD Checklist Civilian Version	International Physical Activity Questionnaire- Short Form	B	Pearson's correlations

Note. A = self-report of poor or unknown reliability/validity for patients with PTSD, B = self-report with acceptable reliability/validity for patients with PTSD, and C = acceptable objective measure (pedometers, accelerometry).

Abbreviations: ♂, male; ANOVA, analysis of variance; meas., measurement; PA, physical activity; PTSD, posttraumatic stress disorder.

activity participation were reported. Although there is still some uncertainty regarding depressive symptoms, there was strong consistent evidence (n ≥ 4) that PTSD symptom severity and in particular hyperarousal as a specific symptom was a negative correlate of physical activity participation.

Social/Cultural Factors and the Physical Environment

No studies investigated the role of the social and the physical environment.

Policy Factors

No policy-level correlates were found.

Discussion

General Findings

To our knowledge, the present review is the first to investigate correlates of physical activity in people with PTSD. The most consistent correlates of lower physical activity were symptoms of hyperarousal. At the biological and behavioral level, no consistent correlates were found, and no data were available at all regarding social, physical environment, or policy level correlates. This lack of consistent correlates in these domains might be due to (1) the paucity of studied correlates and (2) differences in study design, sample characteristics, choice of assessments/correlates, and analysis methods.

Knowledge about correlates of physical activity behavior helps identifying high-risk people in whom physical activity participation is reduced, in addition to those who are less likely to engage in physical activity and, therefore, require more intense and targeted interventions. Addressing barriers through tailored and integrated physical activity programs has the potential to improve long-term physical health trajectories. This is particularly pertinent given recent data indicating that many people with PTSD highly value, are preparing for, and feel ready to engage in healthier lifestyles.[44]

When looking at the current evidence on demographical correlates of physical activity participation in people with PTSD, older age and female gender, 2 demographic variables found to be consistently associated with lower physical activity participation in the general population[27,36] were not found to be associated with physical activity behavior in PTSD. Gender data were, however, conflicting and warrant more research. The current findings should be encouraging to health-care professionals, as it suggests that people with PTSD can be expected to participate in some form of physical activity across the lifespan.

More research on biological physical activity barriers is needed. It has been suggested that comorbid somatic conditions may limit mobility and/or result in more pain during physical activity in people with mental illness,[29–31] but this has not been explored sufficiently in people with PTSD. However, our review indicates that the presence of chronic somatic conditions, such as fibromyalgia, which are often comorbid among individuals who have been exposed to extreme life events,[45] are potentially important barriers that should be considered by health-care professionals and researchers when developing physical activity programs.

The presence of hyperarousal symptoms was identified as the most consistently reported barrier for physical activity participation. It is possible that the observed inverse associations between physical activity participation and hyperarousal symptoms were due to the lower likelihood of more anxious individuals to engage in physical activity. Patients with an increased trait/state anxiety, for example, might fear that engagement in physical activity will provoke physiological reactions such as hyperventilation, tachycardia, dizziness, or sweating, all reactions that can be associated with signs and symptoms of panic.[46] Alternatively, because physical activity has been demonstrated to have anxiolytic effects in anxious patients via repeated exposure to anxiety-related somatic sensations when being physically active,[46] it is possible that increased physical activity among patients with PTSD leads to decreased hyperarousal symptoms. Clinically, it could be hypothesized that exposing patients with PTSD to the physiological symptoms they fear, such as rapid heart rate, in the context of physical activity increases tolerance for such symptoms. This repeated exposure may reinforce that the feared physiological sensations may be uncomfortable, but do not pose a serious threat and consequently could facilitate habituation. Due to the current focus on correlates, however, it was not possible to determine directionality of effects.

In the same way, we were not able to explore in greater detail the directionality of effects between sleep quality and physical activity participation. A poorer sleep quality might be associated with higher fatigue and thus less physical activity engagement,[44,47] or participation in physical activity may result in improved sleep quality.[48] Clinically, the findings from the present review suggest that sleep is a behavioral factor that should be assessed and potentially targeted in physical activity interventions for patients with PTSD. For example, sleep problems could affect a patient's willingness or ability to implement physical activity behavioral interventions, while sleep improvements might encourage physical activity participation. In addition, sleep quality might influence physical activity quality, such as effort expended during physical activity or duration patients are engaged.[41] Further research is needed to assess possible sleep-physical activity behavioral linkages.

Limitations and Future Research

There are several limitations to this review that should be acknowledged. First, 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, whereas more objective devices such as accelerometers and pedometers are considered to offer more precise estimates of physical activity and remove many of the issues of recall and response bias associated with self-report measures.[34] However, a previous feasibility study[49] demonstrated that inpatients with PTSD showed poor compliance with wearing objective devices. Contributing factors to poor compliance may include a lack of motivation and fatigue.[49] Only 1 study used a validated questionnaire.[23] The International Physical Activity—Short Form[50] previously demonstrated sufficient validity in people with PTSD[49] although in this study >15% of the cases were excluded from the analyses due to erroneously high values. The authors stated that it is possible that participants may have reported physical activity based on their memory of pretrauma levels of participation, in which physical activity and regular exercise would have been required (eg, in first-responder emergency crews). One of the most important challenges in physical activity research in people with PTSD, therefore, is producing a low-cost, easy-to-use, reliable, and valid physical activity questionnaire that captures current sedentary

behaviors and physical activity participation for the entire physical activity continuum (from low to high intensity).

A second limitation of the current review is that 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 to build a body of evidence that can support or refute the potential influence of individual variables.

Third, the physical activity correlates literature on people with PTSD is still predominantly based on cross-sectional studies, precluding the ability to infer causal relationships between the hypothesized correlates and physical activity. Accordingly, to further understanding the relationship between PTSD and physical activity, we echo recent calls[14] for further longitudinal and intervention studies to confirm the relationship between PTSD and physical activity.

A fourth limitation is that the majority of the studies considered physical activity correlates at only 1 level in the social-ecological model. Future studies should attempt to analyze the role of multiple correlates of physical activity from a social-ecological perspective. For example, various physical activity correlates have been identified at different levels of the social-ecological model,[26] yet no research has examined how these correlates interact to explain physical activity behavior in PTSD.

Future research should not only focus on the identified variables, but also on those that remain understudied, such as, the amount and type of social support necessary to begin and maintain physical activity behavior in people with PTSD. Future research could explore whether (1) the relationship between physical activity participation and professional support is a dynamic process in which the sources of support or need for support change over time and (2) any social barriers can be identified and addressed by involving others in the rehabilitation process. Some of these interpersonal factors have been previously examined in the general population, but not for people experiencing mental illness.[51–53] The establishment of relationships between the physical environment and physical activity levels, in turn, may prove useful from a community planning or policy perspective. To date, no policy-level correlates were identified. Correlates at this level of the social-ecological model, however, may best be explored using a qualitative approach.[54] Researchers should examine which policies are currently in place. Interviews of people with PTSD and their health-care professionals may provide further insight as to what is needed to promote 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 people with PTSD, merely documenting the relationship between environmental variables and physical activity will not meet this requirement. 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 comorbidities and physical activity service utilization as well as the economic costs and benefits of proposed policy changes.

In conclusion, the present review demonstrated that hyperarousal symptoms are the most consistent negative correlates for physical activity participation in people with PTSD identified in the literature to date. As such, these symptoms must be considered in the design and delivery of physical activity programs for people with PTSD. Because physical activity can expose people experiencing PTSD to many of the bodily sensations that are feared by individuals with PTSD (eg, increased heart rate, increased perspiration, and elevated respiration rate), physical activity can be viewed as a vehicle for interoceptive exposure, which may facilitate habituation to the feared sensations.

Acknowledgments

Vancampfort is funded by the Research Foundation—Flanders (FWO-Vlaanderen).

References

1. Boscarino JA. Posttraumatic stress disorder and mortality among US Army veterans 30 years after military service. *Ann Epidemiol*. 2006;16:248–256. PubMed doi:10.1016/j.annepidem.2005.03.009
2. Xue Y, Taub PR, Iqbal N, et al. Cardiac biomarkers, mortality, and post-traumatic stress disorder in military veterans. *Am J Cardiol*. 2012;109(8):1215–1218. PubMed doi:10.1016/j.amjcard.2011.11.063
3. Ahmadi N, Hajsadeghi F, Mirshkarlo HB, Budoff M, Yehuda R, Ebrahimi R. Post-traumatic stress disorder, coronary atherosclerosis, and mortality. *Am J Cardiol*. 2011;108(1):29–33. PubMed doi:10.1016/j.amjcard.2011.02.340
4. Farr OM, Sloan DM, Keane TM, Mantzoros CS. Stress-and PTSD-associated obesity and metabolic dysfunction: a growing problem requiring further research and novel treatments. *Metabolism*. 2014;63(12):1463–1468. PubMed doi:10.1016/j.metabol.2014.08.009
5. Dedert EA, Calhoun PS, Watkins LL, Sherwood A, Beckham JC. Posttraumatic stress disorder, cardiovascular, and metabolic disease: a review of the evidence. *Ann Behav Med*. 2010;39(1):61–78. PubMed doi:10.1007/s12160-010-9165-9
6. Eraly SA, Nievergelt CM, Maihofer AX, et al. Assessment of plasma C-reactive protein as a biomarker of posttraumatic stress disorder risk. *JAMA Psychiatry*. 2014;71(4):423–431. PubMed doi:10.1001/jamapsychiatry.2013.4374
7. Nevell L, Zhang K, Aiello AE, et al. Elevated systemic expression of ER stress related genes is associated with stress-related mental disorders in the Detroit Neighborhood Health Study. *Psychoneuroendocrinology*. 2014;43:62–70. PubMed doi:10.1016/j.psyneuen.2014.01.013
8. Rosenbaum S, Stubbs B, Ward PB, Steel Z, Lederman O, Vancampfort D. The prevalence and risk of metabolic syndrome and its components among people with posttraumatic stress disorder: a systematic review and meta-analysis. *Metabolism*. 2015;64(8):926–933. PubMed doi:10.1016/j.metabol.2015.04.009
9. Zen AL, Whooley MA, Zhao S, Cohen BE. Post-traumatic stress disorder is associated with poor health behaviors: findings from the heart and soul study. *Health Psychol*. 2012;31(2):194–201. PubMed doi:10.1037/a0025989
10. Fu SS, McFall M, Saxon AJ, et al. Post-traumatic stress disorder and smoking: a systematic review. *Nicotine Tob Res*. 2007;9(11):1071–1084. PubMed doi:10.1080/14622200701488418
11. Blanco C, Xu Y, Brady K, Pérez-Fuentes G, Okuda M, Wang S. Comorbidity of posttraumatic stress disorder with alcohol dependence among US adults: results from National Epidemiological Survey on Alcohol and Related Conditions. *Drug Alcohol Depend*. 2013;132(3):630–638. PubMed doi:10.1016/j.drugalcdep.2013.04.016
12. Carmassi C, Bertelloni CA, Massimettin G, et al. Impact of DSM-5 PTSD and gender on impaired eating behaviors in 512 Italian earthquake survivors. *Psychiatry Res*. 2015;225(1-2):64–69. PubMed doi:10.1016/j.psychres.2014.10.008
13. Godfrey KM, Lindamer LA, Mostoufi S, Afari N. Posttraumatic stress disorder and health: a preliminary study of group differences in health and health behaviors. *Ann Gen Psychiatry*. 2013;12(1):30. PubMed doi:10.1186/1744-859X-12-30

14. Hall KS, Hoerster KD, Yancy WS. Post-traumatic stress disorder, physical activity, and eating behaviors. *Epidemiol Rev*. 2015;37:103–115. PubMed doi:10.1093/epirev/mxu011
15. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. 5th ed. Washington, DC: American Psychiatric Association; 2013.
16. Hoskins M, Pearce J, Bethell A, et al. Pharmacotherapy for post-traumatic stress disorder: systematic review and meta-analysis. *Br J Psychiatry*. 2015;206(2):93–100. PubMed doi:10.1192/bjp.bp.114.148551
17. Liu XH, Xie XH, Wang KY, Cui H. Efficacy and acceptability of atypical antipsychotics for the treatment of post-traumatic stress disorder: a meta-analysis of randomized, double-blind, placebo-controlled clinical trials. *Psychiatry Res*. 2014;219(3):543–549. PubMed doi:10.1016/j.psychres.2014.05.027
18. Guina J, Rossetter SR, DeRhodes BJ, Nahhas RW, Welton RS. Benzodiazepines for PTSD: a systematic review and meta-analysis. *J Psychiatr Pract*. 2015;21(4):281–303. PubMed doi:10.1097/PRA.0000000000000091
19. Bisson JI, Roberts NP, Andrew M, Cooper R, Lewis C. Psychological therapies for chronic post-traumatic stress disorder (PTSD) in adults. *Cochrane Database Syst Rev*. 2013;13:CD003388. PubMed
20. Correll CU, Detraux J, De Lepeleire J, De Hert M. Effects of antipsychotics, antidepressants and mood stabilizers on risk for physical diseases in people with schizophrenia, depression and bipolar disorder. *World Psychiatry*. 2015;14(2):119–136. PubMed doi:10.1002/wps.20204
21. Mittal D, Drummond KL, Blevins D, Curran G, Corrigan P, Sullivan G. Stigma associated with PTSD. *Psychiatr Rehabil J*. 2013;36(2):86–92. PubMed doi:10.1037/h0094976
22. Rosenbaum S, Sherrington C, Tiedemann A. Exercise augmentation compared with usual care for post-traumatic stress disorder: a randomized controlled trial. *Acta Psychiatr Scand*. 2015;131(5):350–359. PubMed doi:10.1111/acps.12371
23. Rosenbaum S, Vancampfort D, Steel Z, Newby J, Ward PB, Stubbs B. Physical activity in the treatment of posttraumatic stress disorder: a systematic review and meta-analysis. *Psychiatry Res*. 2015c;230(2):130–136. PubMed doi:10.1016/j.psychres.2015.10.017
24. Rosenbaum S, Vancampfort D, Tiedemann A, et al. Among inpatients PTSD symptom severity is negatively associated with time spent walking. *J Nerv Ment Dis*. 2014(1):15–19.
25. Rosenbaum S, Tiedemann A, Sherrington C, van der Ploeg HP. Assessing physical activity in people with posttraumatic stress disorder: feasibility and concurrent validity of the International Physical Activity Questionnaire–short form and actigraph accelerometers. *BMC Res Notes*. 2014;7:576. PubMed doi:10.1186/1756-0500-7-576
26. Sallis JF, Cervero RB, Adcher W, Henderson KA, Kraft MK, Kerr J. An ecological approach to creating active living communities. *Annu Rev Public Health*. 2006;27:297–322. PubMed doi:10.1146/annurev.publhealth.27.021405.102100
27. Bauman AE, Reis RS, Sallis JF, Wells JC, Loos RJ, Martin BW; Lancet Physical Activity Series Working Group. Correlates of physical activity: why are some people physically active and others not? *Lancet*. 2012;380(9838):258–271. PubMed doi:10.1016/S0140-6736(12)60735-1
28. Stubbs B, Eggermont A, Soundy A, Probst M, Vandenbulcke M, Vancampfort D. What are the factors associated with physical activity participation in community dwelling adults with dementia? A systematic review of physical activity correlates. *Arch Gerontol Geriatr*. 2014;59(2):195–203. PubMed doi:10.1016/j.archger.2014.06.006
29. Vancampfort D, Knapen J, Probst M, Scheewe TW, Remans S, De Hert M. A systematic review of correlates of physical activity in patients with schizophrenia. *Acta Psychiatr Scand*. 2012;125:352–362. PubMed doi:10.1111/j.1600-0447.2011.01814.x
30. Vancampfort D, Correll CU, Probst M, et al. A review of physical activity correlates in patients with bipolar disorder. *J Affect Disord*. 2013;145:285–291. PubMed doi:10.1016/j.jad.2012.07.020
31. Vancampfort D, Vanderlinden J, Stubbs B, et al. Physical activity correlates in persons with binge eating disorder: a systematic review. *Eur Eat Disord Rev*. 2014;22:1–8. PubMed doi:10.1002/erv.2255
32. Vancampfort D, De Hert M, Stubbs B, et al. A systematic review of physical activity correlates in alcohol use disorders. *Arch Psychiatr Nurs*. 2015;29:196–201. PubMed doi:10.1016/j.apnu.2014.08.006
33. de Assis MA, de Mello MF, Scorza FA, et al. Evaluation of physical activity habits in patients with posttraumatic stress disorder. *Clinics*. 2008;63(4):473–478. PubMed doi:10.1590/S1807-59322008000400010
34. Warren JM, Ekelund U, Besson H, Mezzani A, Geladas N, Vanhees L. Assessment of physical activity - a review of methodologies with reference to epidemiological research: a report of the exercise physiology section of the European Association of Cardiovascular Prevention and Rehabilitation. *Eur J Cardiovasc Prev Rehabil*. 2010;17(2):127–139. PubMed doi:10.1097/HJR.0b013e32832ed875
35. DeVon HA, Block ME, Moyle-Wright P, et al. A psychometric toolbox for testing validity and reliability. *J Nurs Scholarsh*. 2007;39:155–164. PubMed doi:10.1111/j.1547-5069.2007.00161.x
36. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc*. 2000;32(5):963–975. PubMed doi:10.1097/00005768-200005000-00014
37. Arnson Y, Amital D, Fostick L, et al. Physical activity protects male patients with post-traumatic stress disorder from developing severe fibromyalgia. *Clin Exp Rheumatol*. 2007;25(4):529–533. PubMed
38. Rutter LA, Weatherill RP, Krill SC, Orazem R, Taft CT. Posttraumatic stress disorder symptoms, depressive symptoms, exercise, and health in college students. *Psychol Trauma*. 2007;5(1):56–61. doi:10.1037/a0021996
39. Davidson CL, Babson KA, Bonn-Miller MO, Souter T, Vannoy S. The impact of exercise on suicide risk: examining pathways through depression, PTSD, and sleep in an inpatient sample of veterans. *Suicide Life Threat Behav*. 2013;43(3):279–289. PubMed doi:10.1111/sltb.12014
40. Vujanovic AA, Farris SG, Harte CB, Smits JA, Zvolensky MJ. Smoking status and exercise in relation to PTSD symptoms: a test among trauma-exposed adults. *Ment Health Phys Act*. 2013;6(2):132–138. PubMed doi:10.1016/j.mhpa.2012.12.001
41. Talbot LS, Neylan TC, Metzler TJ, Cohen BE. The mediating effect of sleep quality on the relationship between PTSD and physical activity. *J Clin Sleep Med*. 2014;10(7):795–801. PubMed
42. Babson KA, Heinz AJ, Ramirez G, et al. The interactive role of exercise and sleep on veteran recovery from symptoms of PTSD. *Ment Health Phys Act*. 2015;8:15–20. doi:10.1016/j.mhpa.2014.12.002
43. Harte CB, Vujanovic AA, Potter CM. Association between exercise and posttraumatic stress symptoms among trauma-exposed adults. *Eval Health Prof*. 2015;38(1):42–52. PubMed doi:10.1177/0163278713494774
44. Klingaman EA, Hoerster KD, Aakre JM, Viverito KM, Medoff DR, Goldberg RW. Veterans with PTSD report more weight loss barriers than veterans with no mental health disorders. *Gen Hosp Psychiatry*. 2016;39:1–7. PubMed 10.1016/j.genhosppsych.2015.11.003
45. Afari N, Ahumada SM, Wright LJ, et al. Psychological trauma and functional somatic syndromes: a systematic review and meta-analysis. *Psychosom Med*. 2014;76(1):2–11. PubMed doi:10.1097/PSY.0000000000000010
46. Knapen J, Vancampfort D, Moriën Y, Marchal Y. Exercise therapy improves both mental and physical health in patients with major

depression. *Disabil Rehabil*. 2015;37(16):1490–1495. PubMed doi: 10.3109/09638288.2014.972579
47. Connaughton J, Patman S, Pardoe C. Are there associations among physical activity, fatigue, sleep quality and pain in people with mental illness? A pilot study. *J Psychiatr Ment Health Nurs*. 2014;21(8):738–745. PubMed doi:10.1111/jpm.12122
48. Kredlow MA, Capozzoli MC, Hearon BA, Calkins AW, Otto MW. The effects of physical activity on sleep: a meta-analytic review. *J Behav Med*. 2015;38(3):427–449. PubMed doi:10.1007/s10865-015-9617-6
49. Rosenbaum S, Nguyen D, Lenehan T, Tiedemann A, van der Ploeg HP, Sherrington C. Exercise augmentation compared to usual care for post traumatic stress disorder: a randomised controlled trial (the REAP study: Randomised Exercise Augmentation for PTSD). *BMC Psychiatry*. 2011;22(11):115. PubMed doi:10.1186/1471-244X-11-115
50. Craig CL, Marshall AL, Sjostrom M, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*. 2003;35(8):1381–1395. PubMed doi:10.1249/01.MSS.0000078924.61453.FB
51. Richards J, Hillsdon M, Thorogood M, Foster C.. Face-to-face interventions for promoting physical activity. *Cochrane Database Syst Rev*. 2013;9:CD010392. PubMed
52. Foster C, Richards J, Thorogood M, Hillsdon M. Remote and web 2.0 interventions for promoting physical activity. *Cochrane Database Syst Rev*. 2013;9:CD010395. PubMed
53. Richards J, Thorogood M, Hillsdon M, Foster C. Face-to-face versus remote and web 2.0 interventions for promoting physical activity. *Cochrane Database Syst Rev*. 2013c;9:CD010393. PubMed
54. Petter M, Blanchard S, Kemp KR, Mazoff AS, Ferrier SN. Correlates of exercise among coronary heart disease patients: review, implications and future direction. *Eur J Cardiovasc Prev Rehabil*. 2009;16:515–526. PubMed doi:10.1097/HJR.0b013e3283299585