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Physical activity in the treatment of Post-traumatic stress disorder: A systematic review and meta-analysis

Simon Rosenbaum [a,b,c,*], Davy Vancampfort [d,e], Zachary Steel [a,f], Jill Newby [g], Philip B. Ward [a,h], Brendon Stubbs [i,j]

[a] School of Psychiatry, University of New South Wales, Sydney, NSW, Australia
[b] Early Psychosis Programme, The Bondi Centre, South Eastern Sydney Local Health District, Australia
[c] Musculoskeletal Division, The George Institute for Global Health and School of Public Health, The University of Sydney, Sydney, New South Wales, Australia
[d] UPC KU Leuven, Campus Kortenberg, KU Leuven – University of Leuven, Department of Neurosciences, Kortenberg, Belgium
[e] KU Leuven–University of Leuven, Department of Rehabilitation Sciences, Leuven, Belgium
[f] St John of God Health Care Richmond Hospital North Richmond, Australia
[g] Clinical Research Unit for Anxiety and Depression, School of Psychiatry, University of New South Wales at St Vincent's Hospital, Darlinghurst, NSW, Australia
[h] Schizophrenia Research Unit, South Western Sydney Local Health District, Australia
[i] Physiotherapy Department, South London and Maudsley NHS FoundationTrust, Denmark Hill, London SE5 8AZ, United Kingdom
[j] Health Service and Population Research Department, Institute of Psychiatry, King's College London, De Crespigny Park, London SE5 8 AF, United Kingdom

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ABSTRACT

People with PTSD experience high levels of cardiovascular disease and comorbid mental health problems. Physical activity (PA) is an effective intervention in the general population. We conducted the first systematic review and meta-analysis to determine the effect of PA on PTSD. We searched major electronic databases from inception till 03/2015 for RCTs of PA interventions among people with PTSD. A random effects meta-analysis calculating hedges g was conducted. From a potential of 812 hits, four unique RCTs met the inclusion criteria ($n=200$, mean age of participants 34–52 years). The methodological quality of included trials was satisfactory, and no major adverse events were reported. PA was significantly more effective compared to control conditions at decreasing PTSD and depressive symptoms among people with PTSD. There was insufficient data to investigate the effect on anthropometric or cardiometabolic outcomes. Results suggest that PA may be a useful adjunct to usual care to improve the health of people with PTSD. Although there is a relative paucity of data, there is reason to be optimistic for including PA as an intervention for people with PTSD, particularly given the overwhelming evidence of the benefits of PA in the general population. Robust effectiveness and implementation studies are required.

Contents

* Corresponding author at: School of Psychiatry, University of New South Wales, 26 Llandaff St Bondi Junction, NSW 2022, Australia.
E-mail address: s.rosenbaum@unsw.edu.au (S. Rosenbaum).

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1. Introduction

Post-traumatic stress disorder (PTSD) typically occurs following exposure to potentially traumatic events including war, torture, physical or sexual assault or natural disasters, with an estimated lifetime prevalence of 6.8% (Kessler et al., 2005). PTSD is particularly prevalent and of increasing concern amongst certain populations including first responders (police officers, paramedics, firefighters) and veterans. For example, the estimated point-prevalence of PTSD among combat veterans is reported to be as high as 23% (Fulton et al., 2015). Associated adverse consequences of PTSD include severe impairments in psychosocial functioning (Zatzick et al., 2002), significantly increased risk of suicide and suicidal ideation (Jakupcak et al., 2009) and substance abuse and dependence (Schnurr et al., 2005).

In addition to the adverse impact on an individual's mental health and wellbeing, people with PTSD have a high prevalence of physical comorbidity including obesity, diabetes and metabolic syndrome (Boscarino, 2004; Bartoli et al., 2015; Roberts et al., 2015; Rosenbaum et al., 2015b), contributing to premature mortality. For example, it was recently demonstrated that the pooled prevalence of metabolic syndrome was 38.7%, with abdominal obesity observed in an estimated 49.3% of people with PTSD. Compared with matched general population controls, people with PTSD had an almost doubled risk of metabolic syndrome (Rosenbaum et al., 2015b). The reasons are multifactorial yet include high rates of smoking (Fu et al., 2007), poor sleep behaviours (Lamarche and De Koninck, 2007; Talbot et al., 2013) and low levels of physical activity compared to the general population (de Assis et al., 2008). Despite the known cardio-protective benefits of increased physical activity for both the general population and those experiencing mental illness (Vancampfort et al., 2015a), exercise and physical activity are yet to be acknowledged as a key component of the treatment of PTSD (Australian Centre for Post-traumatic Mental Health, 2013). Current evidence-based practice guidelines for treating PTSD include predominantly trauma-focused cognitive-behavioural therapy (CBT) and pharmacological therapy (selective serotonin reuptake inhibitors) (Australian Centre for Post-traumatic Mental Health, 2013). A 2010 Cochrane review into the effect of sports and games on PTSD highlighted the lack of available evidence for exercise as a treatment or co-treatment option (Lawrence et al., 2010), at the time finding no RCTs eligible for inclusion. Five studies were identified that evaluated exercise and or sports based interventions for PTSD, however, the generalizability of the findings was limited due to considerable methodological weaknesses, including a lack of randomization, small sample sizes, and the inclusion of interventions evaluating play-based therapy, considered a psychological intervention. Given the growing recognition of physical activity and exercise as an important component of treatment for various mental disorders (Rosenbaum et al., 2014; Vancampfort et al., 2014), the current study aimed to conduct a systematic review and meta-analysis of the evidence for both physical activity and exercise (i.e., a subset of physical activity that is planned, structured, and repetitive and has as a final or an intermediate objective (Caspersen et al., 1985) in the treatment of PTSD. The primary aim was to evaluate the impact of physical activity and exercise interventions on PTSD symptoms, while the secondary aims of this review was to determine the impact of physical activity and exercise on other important functional and psychological outcomes associated with PTSD including depression, sleep behaviour and cardiovascular risk (anthropometry).

2. Methods

2.1. Procedure

This systematic review was conducted in accordance with the MOOSE guidelines (Stroup et al., 2000) and in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standard (Moher et al., 2009). Two independent authors (SR, DV) searched Medline, PsycARTICLES, Embase and CINAHL from database inception to March 1st, 2015 for randomized controlled trials. Key words used were “physical activity”, “exercise” AND “Post-traumatic stress disorder” in the title, abstract or index term fields. Manual searches were also conducted using the reference lists from recovered articles and the Cochrane review of Lawrence et al. 2010. After the removal of duplicates, both reviewers screened the titles and abstracts of all potentially eligible articles. Both authors applied the eligibility criteria, and a list of full text articles was developed through consensus. The two reviewers then considered the full texts of these articles and the final list of included articles was reached through consensus. A third reviewer (BS) was available for mediation throughout this process.

2.2. Quality assessment

Key features of study design that impact upon methodological quality including the concealed allocation of participants to groups and the blinding of assessors are reported for all studies included in the primary analysis (see Table 1). Publication bias was tested using the Egger's regression method (Egger et al., 1997) and Begg–Mazumdar test (Begg and Mazumdar., 1994), with a p-value <0.05 suggesting the presence of bias. In addition, a funnel plot was created, in which the study-specific effect estimates are displayed in relation to the standard error in order to assess the potential presence of publication bias.

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Table 1
Description of included trials ($n=4$)

Trial	Age mean (SD)		Intervention	Diagnostic criteria	Control	Outcome(s)	Setting	Methodological quality	
	Exp	Con						Concealed allocation	Assessor blinding
Mitchell et al. (2014) N=38			12 sessions Kripalu (Hatha) yoga (1/wk for 12 weeks or 2/wk for 6-weeks)	Presence of at least one symptom in each DSM criterion cluster or meeting criteria for at least two symptom clusters	No treatment	PSS-I	Advertisement at Veteran Affairs medical Centre	No	No
Powers et al. (2015) N=17	34 (11.8)		12 sessions of moderate-intensity aerobic exercise (stationary cycling; 70% age predicted heart rate max); in addition to prolonged exposure therapy	DSM	Prolonged exposure therapy	PSS-I	Online advertising	No	Yes
Rosenbaum et al. (2015a) N=81	47.1 (11.3)	52.0 (12.7)	12 weeks of supervised, individualised combined aerobic / resistance exercise in addition to usual care	DSM	Usual-care	PCL-C	Inpatients	Yes	Yes
Kolk et al. (2014) N=64	41.5 (12.2)	44.3 (11.9)	10 weeks 1x weekly 60 min trauma-informed yoga	DSM	Supportive health education	CAPS	Community advertisement	No	Yes

DSM=Diagnostic and Statistical Manual Mental Disorders; CAPS=Clinician Administered PTSD Scale; PSS-I=PTSD Symptom Scale-Interview.

2.3. Participants

Inclusion in this review was restricted to studies of adults aged at least 18 years with current, or sub-threshold diagnosis of primary PTSD as per the Diagnostic and Statistical Manual (DSM) (American Psychiatric Association, 2000) or the International Classification of Disease (ICD) (World Health Organization, 1993).

2.4. Interventions

We investigated the effect of physical activity or exercise interventions. Physical activity interventions were defined in accordance with Caspersen et al. (1985) as any interventions that use bodily movement produced by skeletal muscles and which requires energy expenditure. Exercise interventions were defined as physical activity that is planned, structured, repetitive and purposive in the sense that improvement or maintenance of physical fitness or health is an objective (Caspersen et al., 1985).

2.5. Control conditions

Usual-care or wait-list control conditions were included.

2.6. Outcome measures

The primary outcome measure was PTSD symptoms using a validated instrument. Secondary outcomes of interest were functional and psychological outcomes associated with PTSD including depression, sleep behaviour and cardiovascular risk (anthropometry).

2.7. Study design

Studies were only considered eligible for inclusion if they included a randomised controlled trial design. In order for a randomised controlled trial to be included, the experimental and comparison interventions must have had similar durations.

2.8. Exclusion criteria

Studies were excluded for the following reasons: (a) insufficient data for extraction of primary outcome data; (b) restriction to children and/or adolescents and (c) those that were trauma-exposed without meeting diagnostic criteria. In the case of multiple publications from the same study, only the most relevant paper or article was included. Trials were not excluded because of nationality, gender of the participants, or the clinical setting (inpatient, outpatient, community setting or mixed). Also no language restrictions or time restrictions were placed upon the eligibility criteria of included articles.

2.9. Statistical analyses

Random-effects meta-analyses were conducted using Comprehensive Meta-Analysis software (Version 3, Biostat, Englewood, New Jersey). Intervention effect sizes (differences between intervention and control groups) for the primary outcome measure (PTSD symptoms) at post-treatment, were calculated using Hedges' g statistic, and 95% confidence intervals (CIs) around the effect size estimate. When a posttest standard deviation was not available, an estimate was obtained using the standard deviation of the change between initial and final assessment scores (Higgins, 2011). A correlation of 0.70 for the primary outcome between pre- and post-treatment was assumed (PTSD symptoms, (Rosenbaum et al., 2015a)). Effect sizes were categorized as small (0.2), medium

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(0.5), or large (0.8 or greater) (Cohen, 1988). Statistical heterogeneity was quantified using the I^2 statistic: I^2 of more than 75% is considered to indicate considerable heterogeneity, I^2 of 50–75% is considered to indicate substantial heterogeneity, and an I^2 of less than 40% is considered to indicate limited heterogeneity (Higgins, 2011). Publication bias was calculated with Begg–Mazumdar Kendall's tau (Begg and Mazumdar, 1994) and Egger bias tests (Egger et al., 1997).

3. Results

3.1. Search results and flow of trials through the review

A total of 966 records were identified. After screening and the application of the eligibility criteria, four eligible randomized trials were identified and included in the primary meta-analysis (PTSD symptoms) (Kolk et al., 2014; Mitchell et al., 2014; Powers et al., 2015; Rosenbaum et al., 2015a). Fig. 1 presents the flow of studies through the review.

3.2. Characteristics of included Trials

Table 1 summarizes the characteristics of included trials, including participant primary diagnosis, diagnostic criteria, summary of the intervention, and control group protocol. Four trials were included, involving a total of 200 participants. Three of the four studies used blinded assessment of outcomes measures (Kolk et al., 2014; Powers et al., 2015; Rosenbaum et al., 2015a) and one of the three used concealed allocation to groups (Rosenbaum et al., 2015a). The mean age of participants in the included trials ranged from 34 to 52 years. Three of the four studies recruited participants with a DSM diagnosis of PTSD (Kolk et al., 2014; Powers et al., 2015; Rosenbaum et al., 2015a) while the third study recruited participants screening positive for PTSD on the Primary Care PTSD Screen and subsequently attended a clinical interview to establish PTSD or sub-threshold PTSD, as indicated by the presence of at least one symptom in each criterion cluster or meeting criteria for at least two symptom clusters (Mitchell et al., 2014). Study participants were recruited from inpatient settings (Rosenbaum et al., 2015a), community advertisements (Kolk et al., 2014), online advertising (Powers et al., 2015) and Veteran Affairs (Mitchell et al., 2014).

3.3. Interventions

Two of the trials utilised a yoga intervention (active yoga as opposed to chanting or laughing based) (Kolk et al., 2014; Mitchell et al., 2014), one trial investigated a combined aerobic and resistance based intervention (Rosenbaum et al., 2015a) and one trial used an aerobic (stationary cycling) intervention (Powers et al., 2015). The length of interventions ranged from 6–12 weeks, with a range of 1–2 supervised sessions per week (see Table 1). Trials were supervised by clinicians including exercise physiologists (Powers et al., 2015) as well as yoga instructors (Kolk et al., 2014; Mitchell et al., 2014; Rosenbaum et al., 2015a). Two trials assessed the effect of the physical activity interventions against usual care (Powers et al., 2015; Rosenbaum et al., 2015a), one trial used a supportive health education control (Kolk et al., 2014) and one trial used a no-treatment control condition (assessment only) (Mitchell et al., 2014).

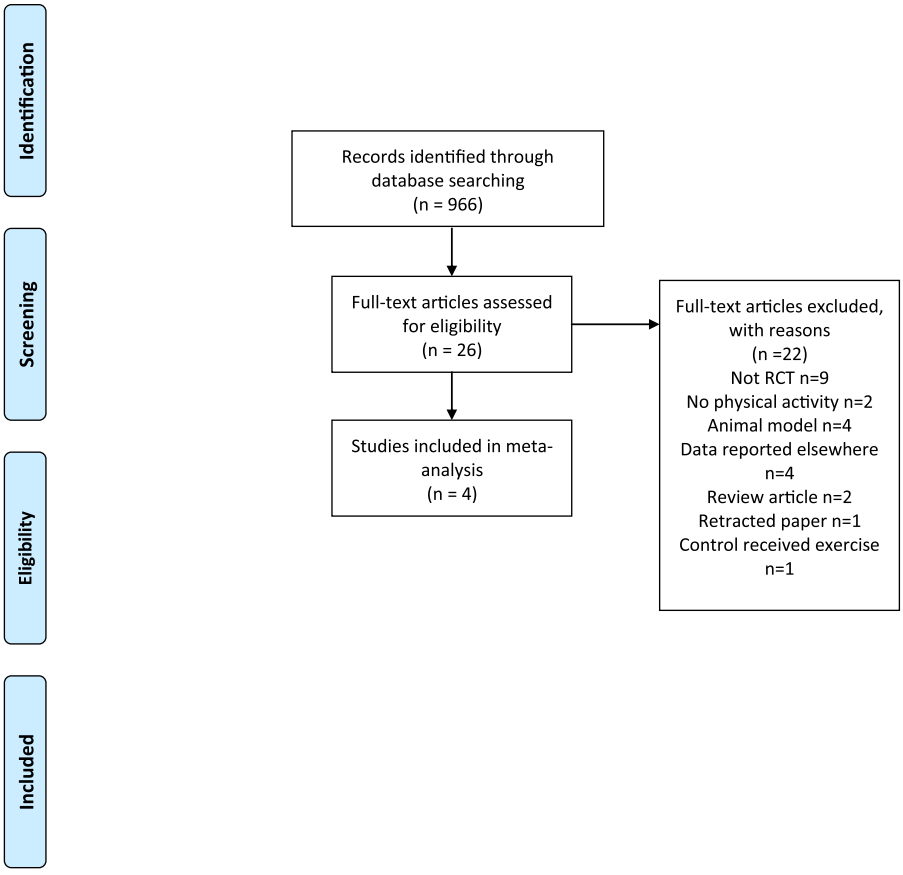

Fig. 1. PRISMA flow diagram.

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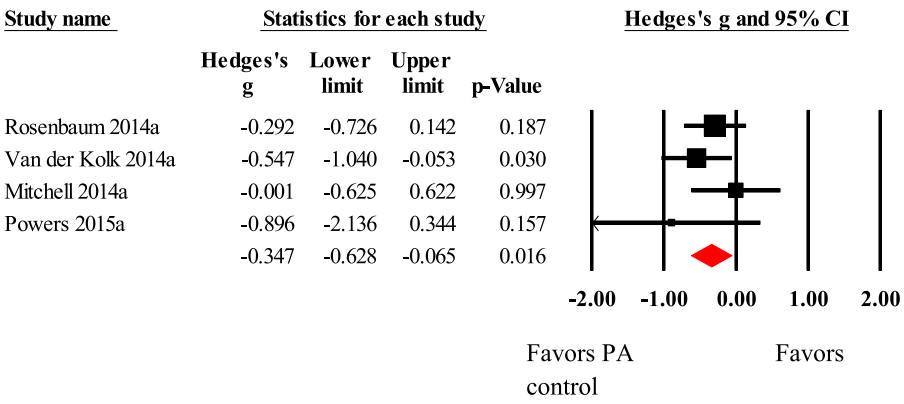

Fig. 2. The effect of exercise on PTSD symptoms.

3.4. Meta-analyses

3.4.1. The effect of physical activity on PTSD symptoms

It was possible to pool data from four RCTs (Kolk et al., 2014; Mitchell et al., 2014; Powers et al., 2015; Rosenbaum et al., 2015a) to investigate the influence of physical activity on PTSD symptoms. Results from the meta-analysis of the four trials revealed that compared control group, physical activity significantly reduced PTSD symptoms (hedges $g=-0.35$, 95% CI: -0.63 to -0.07, $p=0.02$, Fig. 2). There was no evidence of heterogeneity ($I^2=0\%$) nor any evidence of publication bias (Kendall tau=0, $p=0.5$, Eggers regression=0.8, $p=0.68$). A sensitivity analysis was conducted excluding the Powers et al. trial (which was an outlier according to the Forrest plot (Fig. 2)). This established that physical activity interventions reduced PTSD symptoms to a greater degree compared to control groups (hedges $g=-0.312$, 95% CI:$=-0.60$ to -0.023, $p=0.03$, Fig. 3). There was evidence of heterogeneity ($I^2=55\%$) yet no evidence of publication bias (Kendall tau=0.33, $p=0.7$, Eggers regression=2.9, $p=0.19$).

3.4.2. The effect of exercise on depressive symptoms

Data was available from three RCTs (Kolk et al., 2014; Mitchell et al., 2014; Rosenbaum et al., 2015a) to investigate the influence of physical activity on depressive symptoms. Physical activity interventions were significantly more effective at reducing depressive symptoms than controls (hedges $g=-0.37$, 95%CI$=-0.69$ to -0.05, $p=0.03$, Fig. 3). There was no evidence or heterogeneity ($I^2=17\%$) nor any evidence of publication bias (Kendall tau=3.0, $p=0.3$, Eggers regression=6.0, $p=0.2$).

3.4.3. The effect of exercise on anthropometric measurements

There was insufficient data to investigate the effect of physical activity interventions on anthropometric measurements with meta-analysis. Only one study reported the effect of the intervention on anthropometric measures (Rosenbaum et al., 2015a), reporting a significant mean between group reduction in waist circumference of -3.6 cm (-7.0 to -0.2), $p=0.04$ and a non-significant effect on weight -1.7 kg (-3.6 to 0.2), $p=0.08$ (Rosenbaum et al., 2015a).

3.4.4. Adverse events

All four RCTs reported that there were no major adverse events related to participation in the physical activity interventions (e.g. muscle soreness, musculoskeletal injury).

4. Discussion

The current meta-analysis is the first quantitative synthesis regarding physical activity interventions among people with PTSD. Our review identified four RCTs, all published since 2014 and found that physical activity interventions are efficacious compared to usual care or wait-list control conditions in reducing PTSD symptoms with a small to moderate effect size (Hedges $g=0.35$). Similarly, among the three trials reporting the impact of physical activity on symptoms of depression in PTSD, a significant small-moderate effect was found (hedges $g=-0.37$). Despite the fact that people with PTSD experience considerable levels of cardiometabolic abnormalities (Boscarino, 2004; Roberts et al., 2015; Rosenbaum et al., 2015b), including obesity, there was insufficient data to investigate the impact of physical activity on these factors.

Although research is still clearly in its infancy, the findings that physical activity can improve PTSD and depressive symptoms is encouraging and adds further support to the notion that physical activity has an important role in the multidisciplinary team management of people with PTSD (Rosenbaum et al., 2015a). The

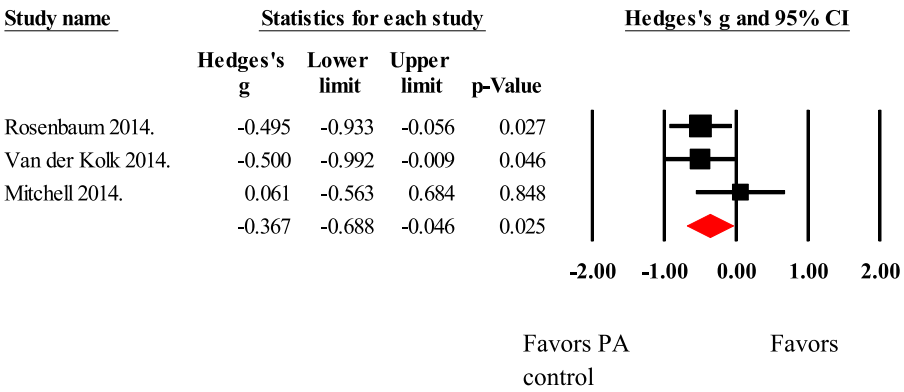

Fig. 3. The effect of exercise on depressive symptoms.

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results of this review regarding the effect on symptomology are broadly comparable to those in other meta-analyses investigating physical activity interventions in people with mental illness (Cooney et al., 2013; Jayakody et al., 2013; Rosenbaum et al., 2014). Moreover, exercise is known to improve depressive symptomology in the general population (Rebar et al., 2015) and our analysis suggests that physical activity also improves depressive symptoms among people with PTSD. Thus, the current meta-analysis builds considerably on the previous Cochrane review of sports and games for PTSD (Lawrence et al., 2010) which did not identify any RCTs at the time examining exercise interventions for PTSD. The current review provides evidence to suggest that traditional treatment for trauma (typically involving a combination of trauma focused cognitive behavioural therapy and pharmacological treatments) may benefit from the inclusion of physical activity interventions as adjunctive treatments.

Of the four included trials, two of the studies used a yoga-based intervention (Kolk et al., 2014; Mitchell et al., 2014) which were eligible for inclusion under the definition of physical activity as any bodily movement produced by skeletal muscle requiring energy expenditure (Caspersen et al., 1985). The evidence of a beneficial effect of yoga on psychiatric symptomatology is line with previous reviews investigating the effect of yoga on schizophrenia (Vancampfort et al., 2012b), anxiety (Kirkwood et al., 2005) and depression (Saeed et al., 2010). Given that yoga cannot be classified as either strictly a cardiorespiratory or resistance based activity, the results of this review demonstrate that both types of activity are likely beneficial. This is also in line with the combined aerobic and resistance based intervention of Rosenbaum et al. (Rosenbaum et al., 2015a).

Whilst evidence is currently lacking demonstrating the effects of physical activity on cardiovascular disease and anthropometric measures among people with PTSD, there are promising reasons to believe it may help in this regard. For instance, in a recent meta-analysis, Naci and Ioannidis (Naci and Ioannidis, 2013) recently demonstrated that exercise is broadly as effective in as pharmacological interventions in preventing cardiovascular disease in the general population. Given the fact that cardiovascular disease appears to contribute to a significant amount of premature mortality among people with PTSD (Ahmadi et al., 2011; Xue et al., 2012), and the high prevalence of metabolic syndrome among people with PTSD (Rosenbaum et al., 2015b), the reasons to encourage physical activity are considerable. Finally, given the deleterious impact of sedentary behaviour established in the general population (Wilmot et al., 2012), increasing habitual levels of activity among people with PTSD should also be encouraged.

Unfortunately, due to the limited number of RCTs that were eligible, it is not possible to determine the optimal frequency, intensity, type and time (FITT) of physical activity for people with PTSD. However, this should follow recommendations established for the general population or those endorsed by the International Organisation of Physical Therapists in Mental Health (IOPTMH) (Vancampfort et al., 2012a) which includes aiming to undertake 150 min of moderate or 75 min vigorous physical activity per week. In addition, recommending people with PTSD engage in both resistance training and/or yoga-based exercises may be justified based on the results of this review. Furthermore, an emphasis should be placed on increasing habitual levels of physical activity in daily living, a message which may help those that find it difficult to meet physical activity guidelines (Sparling et al., 2015; Vancampfort et al., 2015b). Importantly, people with PTSD may face considerable barriers to engaging in regular physical activity that are similar to those who are experiencing other mental disorders (e.g. a lack of motivation) (Soundy et al., 2014). Trained clinicians including physiotherapists and exercise physiologists (Stanton, 2013; Stanton et al., 2014; Stubbs et al., 2014) may be best placed to deliver clinical exercise programs for people with PTSD, while clinicians should consider utilising motivational techniques such as those contained with the self-determination theory (SDT) which appear to be influential in promoting physical activity among other mental health populations (Vancampfort et al., 2013).

Whilst this meta-analysis is the first to investigate the impact of physical activity on PTSD, there are a number of important considerations and limitations. First, the review only contained four RCTs and therefore precluded investigation of whether the size of the effect of physical activity interventions is moderated by clinical characteristics of the sample, such as PTSD severity, the level of comorbidity, type of trauma, or whether the sample comprised of people who had experienced a single trauma versus multiple traumatic events. Some of the articles identified through the search strategy, although relevant were excluded from the quantitative synthesis for not meeting the inclusion criteria. These included a qualitative investigation of the impact of a surfing intervention on combat veterans (Caddick et al., 2014) and a trial investigating the role of attentional focus toward, or away from somatic arousal during exercise among people with PTSD (Fetzner and Asmundson, 2014). Second, there was some heterogeneity in terms of the outcomes used and intervention variables. Nevertheless, our pooled analysis indicated little evidence of statistical heterogeneity. Finally, data on key outcome measures, such as BMI and cardiometabolic markers was absent, thus precluding us from investigating these important factors. Future research is required to determine the optimal method of integrating physical activity programs within traditional treatment models of PTSD. Research that aims to increase and maintain adherence to physical activity interventions within clinical practice requires further investigation to maximize the potential beneficial effects.

The use of psychotropic medication was beyond the scope of this review. However, given the increased use of psychotropic medication, including antidepressants and antipsychotics (Leslie et al., 2009) and the associated cardiometabolic effects, future research should explore the relationship between physical activity and these medications. Such research may assist clinicians in the prescription of both psychotropic medication and physical activity.

In conclusion, our meta-analysis has demonstrated that physical activity shows promise as an adjunctive intervention to improve PTSD and depressive symptoms. More effectiveness and implementation studies are needed to explore the optimal method of implementation and acceptability of these interventions for people with PTSD, and how physical activity interventions compare to active control conditions. For example the investigation of how physical activity interventions can be used in conjunction with current best practice PTSD treatment including trauma-focused cognitive behavioural therapy and/or eye-movement desensitization and reprocessing is warranted. The wider beneficial effects are also likely to be broad in this population, and due to the absence of data the effects of physical activity on important factors such as cardiometabolic markers were not investigated.

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