Exploring Resistance Training as a Potential Standalone Treatment for Anxious Adults Who Screen Positive for Posttraumatic Stress Disorder

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ABSTRACT

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Introduction: Posttraumatic stress disorder (PTSD) is a disabling psychological disorder that affects about 7% of adults in the United States. PTSD and its symptoms have consistently been shown to have an inverse relationship with exercise participation. The strongest reported associations have been between high intensity exercise, and the hyperarousal and avoidance symptom clusters. Importantly, resistance training (i.e., weight lifting) is thought to have beneficial effects for several conditions that commonly co-occur with PTSD, such as anxiety, depression, and poor sleep quality. However, no studies have examined the effects of high intensity resistance training on PTSD symptoms. **Purpose:** This study sought to examine the effects of a 3-week high intensity resistance training program on the PTSD hyperarousal and avoidance symptom clusters, sleep quality, anxiety, and depression symptoms in anxious adults who screened positive for PTSD. Additionally, this study explored potential mechanisms of action (e.g., cognitive appraisal, perceived exertion, acute changes in affect, arousal, and distress) between exercise and PTSD. **Methods:** Thirty trait anxious individuals who screened positive for PTSD were randomly assigned to either a 3-week high intensity resistance training intervention, or a 3-week time-matched attention control group, while blocking for gender. Both groups were required to attend 3 on-site sessions per week, for 3 weeks (i.e., 9 total sessions). Each resistance training session consisted of a 5-minute warm-up, 20 minutes of high intensity resistance training, and a 5-minute cool-down. Each control session consisted of a brief 30-minute educational video on topics not relating to exercise or PTSD. Changes in PTSD symptoms, sleep quality, anxiety and depression were analyzed using repeated measures

ANOVA, and potential mechanisms of action were explored with a series of longitudinal mixed-effects regression models. **Results:** Participants were 73.3% female, with a mean age of 29.1 years (SD = 7.4), and 63.3% identified as a racial minority. Groups did not significantly differ at baseline. There was a Time*Group interaction for hyperarousal symptoms (F = 4.7, p = .04, η^2 .18), demonstrating a significantly larger reduction in hyperarousal symptoms for the resistance training group (d = -1.84) relative to the control (d = -1.13). The Time*Group interaction for avoidance symptoms was not significant (F = 1.7, p = .20, η^2 = .08); however, the effect size of resistance training was larger (d = -2.71) than the control (d = -1.16). There was a significant Time*Group interaction for sleep quality (F = 4.7, p = .04, η^2 = .19), demonstrating greater improvements in global sleep quality for resistance training (d = -1.06) relative to the control (d = -.15). However, there was no significant effect of Time on PTSD-related sleep disturbances (F = 3.0, p = .1, η^2 = .13) nor was there a significant Time*Group interaction (F = .09, p = .80, η^2 < .01). Similarly, Time*Group interactions for anxiety (F = 3.5, p = .08, η^2 = .14) and depressive symptoms (F = 2.7, p = .12, η^2 = .11) were not significant. However, resistance training had a large effect on anxiety (d = -.81), and small effect on depression symptoms (d = -.41). Regarding the potential mechanisms of action, changes in cognitive appraisal significantly predicted changes in PTSD symptoms during the resistance training intervention (b = 7.1, SE = 2.9, p = .02). Similarly, changes in perceived exertion during exercise was a significant predictor of PTSD symptoms over the 3-week intervention period (b = -3.1, SE = 1.2, p = .01). However, changes in affect, arousal, and distress did not significantly predict changes in PTSD (p's >.05). **Conclusion:** This is the first randomized attention-controlled trial testing the effects of high intensity resistance training on PTSD symptoms. The overall results support the hypothesis that resistance training can beneficially affect PTSD symptoms and its commonly co-occurring conditions, such as poor sleep quality. Future adequately powered studies are warranted.

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DEDICATION

To my brothers and sisters of the armed forces, your courage and sacrifices are an ever-present reminder of why we must continue to drive forward in our fight against PTSD. No man or woman left behind! Infantry leads the way! Follow me!

To Lindsay, thank you for the many years of love and patience. You truly have inspired me to reach beyond what I thought possible.

CHAPTER I – INTRODUCTION

Overview

This dissertation is organized into three primary chapters. Following this overview, Chapter I reviews the observational and experimental research to date, and describes the theoretical rational used to guide the studies described in Chapters II and III. Chapter II discusses the pilot study that tested the feasibility and acceptability of a brief resistance training (i.e., weight lifting) intervention in individuals who screened positive for posttraumatic stress disorder (PTSD) using a randomized controlled design. The data collected from the pilot study provided valuable estimates of the effects of resistance training on PTSD symptoms and important correlates of PTSD, such as anxiety symptoms and sleep quality. Chapter III is the dissertation study, which sought to replicate the findings from the pilot study while making several methodological improvements.

Additionally, supporting materials are included in the Appendices following Chapter III. These materials include a published systematic review of exercise and PTSD (Whitworth & Ciccolo, 2016) (see Appendix A), and published observational studies that were used in the development of the dissertation study (Whitworth, Craft, Dunsiger, & Ciccolo, 2017; Whitworth, SantaBarbara, et al., 2017) (see Appendices B and C). Finally, the Teachers College, Columbia University Institutional Review Board approved study materials can be found in Appendix D.

Observational Research on PTSD and Exercise

To date, most of the research on PTSD and exercise has been observational in design, with few experimental trials. The results from the observational studies generally show that exercise participation is inversely associated with both a PTSD diagnosis (Chwastiak, Rosenheck, & Kazis, 2011) and PTSD symptoms (LeardMann, Kelton, Smith, Littman, & Boyko, 2011; Whitworth, Craft, et al., 2017; Whitworth, SantaBarbara, et al., 2017). Research has also linked PTSD and physical inactivity to poor sleep quality (Talbot, Neylan, Metzler, & Cohen,

2014) and chronic pain (Bourn, Sexton, Porter, & Rauch, 2016), and alcohol use (Medina et al., 2011).

Despite these encouraging findings, the research has several notable limitations. For instance, most studies used a cross-sectional design. Currently, there are only three published longitudinal studies that have measured both PTSD and exercise at multiple time points. The first demonstrated that trauma exposure and the emergence of PTSD symptoms predicted increases in physical inactivity over time (Winning et al., 2017). Another study showed that regular high intensity exercise longitudinally predicted better sleep quality and lower PTSD symptoms (Whitworth, Craft, et al., 2017). While the third study found that exercise participation had significant beneficial effects on sleep quality, but not PTSD symptoms (Bosch, Weaver, Neylan, Herbst, & McCaslin, 2017). The contrasting results of these studies highlight the need for further longitudinal examinations of these relationships.

Another important limitation of the observational research is the consistent use of single-item, self-report measures of exercise frequency. Other components of exercise dose, such as intensity, or volume, are rarely measured (Whitworth & Ciccolo, 2016). Importantly, in the few studies to have assessed exercise intensity, the strongest observed associations between exercise and PTSD have been for high intensity exercise (Harte, Vujanovic, & Potter, 2013; LeardMann et al., 2011; Whitworth, Craft, et al., 2017; Whitworth, SantaBarbara, et al., 2017). Another notable gap in the literature is that most of the observational work has primarily focused on the relationship between physical inactivity and a PTSD diagnosis (e.g., exploring physical inactivity as a risk factor for PTSD or as a possible consequence of PTSD), rather than examining the relationship between exercise and specific PTSD symptoms. This approach overlooks the potential benefits exercise may have on PTSD symptoms or related conditions.

Finally, many of the existing studies have relied heavily on samples of convenience and primarily focused on individuals connected to healthcare. This is an important limitation, as many individuals who have or screen positive for PTSD are not enrolled in care or choose not to

seek help (Elbogen et al., 2013). Furthermore, the relationship between exercise, and PTSD among those with other mental health conditions is not clear, as many studies have excluded individuals with a co-occurring mental illness. This has severely limited the generalizability of these studies, given the high prevalence of co-occurring mental illness in this population (Ginzburg, Ein-Dor, & Solomon, 2010).

As a whole, these studies suggest that there is a link between exercise, and PTSD. However, the numerous methodological limitations prevent a clear understanding of the nature of this relationship. Most prominently, the current body of observational research largely consists of cross-sectional designs, has biased samples, and does not adequately describe the relationship between exercise, PTSD, and its symptoms. As such, there is clear need and rationale to move forward with further investigations of the relationships between exercise and PTSD.

Experimental Research on PTSD and Exercise

In addition to the limitations present in the observational research, the field also suffers from a lack of experimental studies examining the relationship between PTSD and exercise. To date, there are few controlled trials, and most have been conducted in the past three years (Crombie, Brellenthin, Hillard, & Koltyn, 2018; Goldstein et al., 2018; Hall et al., 2016; Powers et al., 2015; Rosenbaum, Sherrington, & Tiedemann, 2015). The first published randomized controlled trial was conducted by Powers et al. (2015), and had participants complete 12 weeks of either cognitive behavioral therapy, or combined aerobic exercise and cognitive behavioral therapy. Both groups met once per week (i.e., 12 total sessions). For the exercise condition, each session consisted of 30 minutes of moderate intensity treadmill running followed immediately by a psychotherapy session. The combined aerobic exercise and cognitive behavioral therapy group had larger beneficial effects on PTSD symptoms than the cognitive behavioral therapy only group (i.e., Cohen's *d*'s = 2.65 and 1.08 respectively). However, while

this study used a control condition, it was not an attention control. The control condition was cognitive behavioral therapy only, and no attempt was made to standardize the participation time between the intervention and control group, resulting in the intervention group receiving at least six hours (i.e., twelve 30-minute exercise sessions) more attention from the researchers than the control group. As such, the effect of attention may have confounded the results of this study. Additionally, the sample size was small (n = 9), and consisted of predominantly white, non-Hispanic women, further limiting the generalizability of the results.

In the second published randomized controlled trial examining the effects of exercise on PTSD symptoms (Rosenbaum et al., 2015), 81 patients from a residential PTSD treatment facility were randomly assigned to usual care, or usual care plus exercise. The exercise intervention consisted of moderate intensity walking and resistance exercises with resistance tubing. There were up to three exercise sessions per week (i.e., one supervised and two unsupervised). Results showed significantly greater improvements in PTSD symptoms for the combined usual care plus exercise group, which is consistent with Powers et al. (2015). However, this study also suffers from several notable limitations. Similar to Powers et al. (2015), this study did not use an attention control, and it is unclear if the duration of the supervised exercise sessions were standardized in the exercise group. Another limitation is the usual care component. Participants received psychotherapy, medications, or a combination of both as part of their treatment. However, the treatment techniques were not consistent across all participants. This threatens the internal validity of this study because there are well known differences in the effect sizes of different evidence based treatments (Watts et al., 2013). Finally, this study had low participant adherence. The mean attendance of the supervised exercise sessions was only 58%, and nearly 30% of those randomized dropped out. Additionally, no data from the unsupervised exercise sessions were presented. Given the low or missing attendance data, the specific dose of exercise cannot be determined. In sum, the

numerous limitations in this study not only suggest caution when interpreting the results, but also make replication of the study difficult.

In another much larger experimental study Hall et al. (Hall et al., 2016) examined the effects of physical activity counseling on 302 older veterans (i.e., ages ≥60) with and without PTSD. Participants were randomly assigned to either six weeks of physical activity counseling or usual care. The physical activity counseling consisted of a single in person counseling session and three bi-weekly counseling sessions held over the phone. The results demonstrated that the physical activity counseling group had significantly larger increases in physical activity, improved 6-minute walk test scores, and improvements in health-related quality of life at the 12-month follow-up relative to the usual care condition. Additionally, subsequent analyses found no differences in any of the outcome variables when comparing individuals with and without PTSD, suggesting that individuals with PTSD responded similarly to the intervention as those without PTSD. This is an important finding because prior research has consistently linked PTSD to physical inactivity (Chwastiak et al., 2011; Winning et al., 2017), and further supports the potential value of physical activity interventions in this population.

In a more recent study, Goldstein et al. (2018) tested the effects of a group exercise program on PTSD symptoms. Participants (n = 47), were randomly assigned to a 12-week exercise intervention or a waitlist control. The exercise condition consisted of three, one-hour group exercise sessions per week for 12 weeks. Within each session participants engaged in a variety of activities including, aerobic exercise, resistance training with bands, yoga, and mindfulness meditation. The results showed that the exercise condition produced significantly larger improvements in PTSD symptoms relative to the control. Specifically, these improvements were attributed to changes in the hyperarousal symptom cluster. However, like the previously discussed studies testing exercise interventions, this study made no effort to account for attention or the social aspects of the intervention. Given the intervention was group exercise, this is a notable limitation of this study. A further confounding factor in this study is the

use of yoga, and meditation as part of the intervention. Both practices have been shown to have beneficial effects of PTSD symptoms (Gallegos, Crean, Pigeon, & Heffner, 2017). As such, determining the unique effects of exercise on PTSD from this study are impossible.

In a final example of the recent experimental research, Crombie et al. (2018) tested the effects of a single bout of moderate intensity aerobic exercise in individuals with and without PTSD (*n* = 24). The exercise session consisted of a 10-minute warm-up, 30 minutes of treadmill walking or running at 70-75% of the participant's estimated maximum heart rate, followed by a 5-minute cool-down. Both groups reported significant improvements in state affect, anxiety, increased arousal, and decreased fatigue, tension, confusion and pain. Additionally, the PTSD group reported significantly larger changes in affect, anxiety, fatigue, tension, and confusion from pre to post exercise. Taken as a whole, the findings of this study have some important implications. For instance, the acute beneficial psychological effects of exercise demonstrated in this study provide preliminary evidence that exercise may be an effective coping strategy for individuals with PTSD. These findings may also help to explain some of the chronic benefits of exercise described in the longitudinal experimental studies of exercise and PTSD. However, it is important to note the duration of these effects was not assessed. As such, it is not possible to tell how long lasting these effects are.

Despite the recent attention by researchers and overall positive findings reported in the presently available experimental research, the limitations of this work prevent a clear understanding how exercise affects PTSD. Future research will need to make use of more rigorous designs by controlling for attention, standardizing experimental and control conditions, and examining the specific components of exercise dose, such as mode of exercise or intensity.

Theoretical Rationale

To advance the field of PTSD and exercise research, we sought to address the limitations of the research discussed above by conducting a theoretically guided randomized

controlled trial testing the effects of high intensity resistance exercise on PTSD. The rationale for proceeding in this direction was based on three key factors.

First, few studies have described why excise may have unique benefits for PTSD beyond the known benefits of exercise on related conditions such as depression (Ekkekakis, 2015) and anxiety (Stubbs et al., 2017). As such, theoretically guided studies are needed. To fill this gap, we looked to the current evidence-based treatments for PTSD when designing this trial. Specifically, the current gold standard treatment for PTSD is prolonged exposure (PE) therapy (Rauch, Eftekhari, & Ruzek, 2012). PE is a form of trauma focused cognitive behavioral therapy that centers on overcoming the symptoms of PTSD by repeatedly facing triggering memories and situations that are pathologically avoided. Over time and repeated exposures, patients are able to process that the triggers are safe, facilitating fear extinction and enabling recovery (Foa, Hembree, & Rothbaum, 2007).

Similarly, the Cross-Stressor Adaptation Hypothesis posits that repeated exposures to a specific stressor that is of sufficient intensity and/or duration can facilitate adaptations in the stress response system that ultimately lead to a reduction in the stress response to other stressors (Sothmann et al., 1996). For example, repeated bouts of exercise may lead to the habituation to the feelings of the stress response (e.g., increased heart rate and breathlessness). Once habituation occurs, a reduction in the response to other stressors (e.g., PTSD symptom triggering stimuli) is possible. In sum, exercise can be viewed as a potential exposure intervention, targeting specifically the interoceptive cues elicited from the stress of exercise.

Importantly, application of this model requires the exercise to be sufficiently intense to facilitate adaptation. As such, the second factor is exercise intensity, specifically, high intensity exercise. Our prior observational research has demonstrated that high intensity exercise is longitudinally associated with the avoidance and hyperarousal symptom clusters of PTSD (Whitworth, Craft, et al., 2017). Specifically, these associations were such that those who

reported regular high intensity exercise also reported significantly less severe avoidance and hyperarousal symptoms when compared to those who were physically inactive. Importantly, moderate and light intensity were not associated with any of the PTSD symptom clusters, which is similar to the findings of other research that only found significant correlations between high intensity exercise and PTSD symptoms (Harte et al., 2013). Thus, there is a considerable amount of evidence from both our own and other research suggesting that exercise intensity plays a role in the relationship between PTSD and exercise.

The third factor is the mode of exercise. The available research examining the effects of exercise on PTSD is almost exclusively limited to aerobic exercise (Diaz & Motta, 2008; Fetzner & Asmundson, 2014; Manger & Motta, 2005; Newman & Motta, 2007). To our knowledge, only two studies have included resistance training in the exercise intervention (Goldstein et al., 2018; Rosenbaum et al., 2015). However, in these studies, resistance training was combined with aerobic exercise, leaving the standalone effects of resistance training on PTSD symptoms unexplored. Resistance training is well known to have its own independent and beneficial effects on physical and mental health (Ciccolo, Carr, Krupel, & Longval, 2010) and should therefore be tested. To address this gap, we designed this study to assess the feasibility and to test the effects of high intensity resistance training on PTSD symptoms.

CHAPTER II – PILOT STUDY

Research Questions

Research Question 1: What is the effect of a 3-week high intensity resistance training intervention on PTSD symptoms when compared to a 3-week time-matched attention control?

Hypothesis 1a: Total PTSD symptoms will decrease significantly more from baseline to follow-up for the resistance training group compared to the control.

Hypothesis 1b: Individual PTSD symptoms (i.e., re-experiencing, avoidance behaviors, mood, and hyperarousal) will decrease significantly more from baseline to follow-up for the resistance training group compared to the control

Research Question 2: What is the effect of a 3-week high intensity resistance training intervention on PTSD co-occurring conditions (i.e., anxiety, depressive symptoms, sleep quality, and physical pain) when compared to a 3-week time-matched attention control?

Hypothesis 2: Co-occurring anxiety, depressive symptoms, sleep quality, and physical pain will improve significantly more from baseline to follow-up for the resistance training group compared to the control.

Methods

Procedures

Participants were recruited from the local community using Craigslist, flyers, and advertisements in a local newspaper. Interested individuals were instructed to call an independent line to be screened for initial eligibility over the phone. Individuals initially eligible were invited to Teachers College for an in-person eligibility screening. Consenting participants completed baseline assessments over the course of a two-week run-in period. Participants were then randomly assigned to either the resistance training or time matched attention control group using a blocked design to ensure equal numbers of men and women in each group. Follow-up assessments were conducted in the week after the intervention. Participants completing the

study received $150 in compensation (i.e., $55 to compensate for 10 round trips, using public transportation, and $95 in cash incentives). The study was approved by the Teachers College Institutional Review Board. All data were collected between January 2016 and December 2016.

Participants

Participants were urban dwelling men and women, aged 18+, who reported having experienced at least one traumatic event, and scored above the cutoff score on the Posttraumatic Diagnostic Scale (see description in the measures section) (Foa et al., 2015). Exclusion criteria included medical contraindications to high intensity exercise or resistance training (e.g., musculoskeletal disorders, heart, lung, or metabolic disorders), currently in or seeking mental health treatment for PTSD, and currently engaging in >60 minutes of weekly leisure exercise or any resistance training.

Measures

Demographics and Health History

Demographic data collected included age, gender, race/ethnicity, height and weight, education, and income. Additionally, a health history interview was conducted to screen for any contraindications to exercise, and to determine if participants were seeking/currently engaged in treatment for PTSD.

Trauma History and PTSD Symptoms

PTSD screening and symptoms were assessed with the Posttraumatic Diagnostic Scale for DSM-5 (PDS5). The PDS5 is a four-part self-report PTSD screening scale (Foa et al., 2015). Section 1 is a trauma inventory, where individuals indicate what traumatic event(s) they have experienced (e.g., military combat, sexual assault, or child abuse). Section 2 consists of 20, 5-point items that assess the frequency and severity of PTSD symptoms in the past month. The

items are ranked from “Not at all” to “6 or more times a week/severe”, and represent each of the updated PTSD symptom clusters in the DSM-5 (i.e., re-experiencing, avoidance behaviors, negative changes in mood and cognitions, and hyperarousal symptoms) (American Psychiatric Association., 2013). Section 3 assesses how much distress and inference to activities of daily living the symptoms from section two cause individuals, while section four determines when the symptoms started and how long they have persisted.

For scoring, section two is summed for a total PTSD symptom severity score. Additionally, severity scores representing the each of the individual symptom clusters can be calculated. Valid total scores range from 0-80, with higher scores indicating worse PTSD symptoms. The PDS5 has excellent internal consistency ($\alpha = .95$) and test-retest reliability ($r = .90$) and is strongly correlated with the PCL ($r = .90$). Additionally, receiver operating characteristic analyses has identified a total score of ≥28 as the optimal cut off for a positive screening for PTSD (Foa et al., 2015).

Trait Anxiety

Trait anxiety was assessed using the State-Trait Anxiety Inventory (STAI)-Y2 form (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). The STAI-Y2 form is a 20-item sub scale representing trait anxiety. Each item has 4-points, ranking from “Almost never” to “Almost always”. Valid scores range from 20-80, with higher scores indicated greater levels of trait anxiety. The STAI has been shown to be a reliable and valid measure of both trait and state anxiety (Spielberger et al., 1983). Additionally, a score of ≥45 has been recommended as a cut off for a positive screening for a possible anxiety disorder (Bunevicius et al., 2013).

Depressive Symptoms

Depressive symptoms were assessed using the Center for the Epidemiological Studies of Depression Short Form (CESD) (Radloff, 1977). The CESD is a 10-item self-report scale that

assesses the frequency of depressive symptoms in the past week. Each of the 4-point items is ranked from “Rarely or none of the time (<1 day)” to “Most or all of the time (5-7 days)”. Items are summed to represent a total depressive symptom severity score. Valid scores range from 0-30, with higher scores representing greater levels of depression severity. The CESD has been found to be a valid and reliable depression assessment in the general population (Radloff, 1977) and in psychiatric populations (Bjorgvinsson, Kertz, Bigda-Peyton, McCoy, & Aderka, 2013), and a score of ≥10 can be used for a positive screening for depression (Andresen, Malmgren, Carter, & Patrick, 1994).

Sleep Quality

Global sleep quality for the past month was assessed with the full Pittsburgh Sleep Quality Index (PSQI). The PSQI is a self-report 19-item scale that assess seven components of sleep, including sleep quality, latency, duration, efficiency, disturbances, use of sleep medications, and daytime dysfunction (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989). Scores range from 0 to 21. Higher total scores indicate worse global sleep quality and a cut-point of >5 indicates poor global sleep quality (sensitivity 89.6% and specificity 86.5%). The PSQI has good internal consistency (α = .83) is a valid assessment of global sleep quality (Buysse et al., 1989).

Physical Pain

Overall physical pain in the past month was assessed using the 2-item self-report Bodily Pain sub-scale of the Short Form Health Survey (Ware & Sherbourne, 1992). In this scale, the first item corresponds with pain intensity, consisting of 6-points ranking from “none” to “very severe”. The second item represents the amount pain has interfered with work or activities of daily living, and it has a 5-point ranking from “not at all” to “extremely”. Total scores range from 0 to 100 with lower scores representing more bodily pain. The Pain sub-scale of the Short Form

Health Survey is a simple, valid, and reliable measure of overall physical pain in the past month (Hawker, Mian, Kendzerska, & French, 2011).

Alcohol Use

The 10-item interview version of the Alcohol Use Disorder Identification Test (AUDIT) was used to assess hazardous alcohol use (i.e., frequency and quantity of alcohol consumption), alcohol dependence, and harmful alcohol use (e.g., blackout, alcohol-related injuries, and guilt after drinking). For scoring, the 10-items are summed, with valid scores ranging from 0-40, and higher scores indicating a greater risk for alcohol dependence. Scores of ≥20 represent the cut point for "Zone IV" risk level and should be referred to a health provider for further evaluation for an alcohol use disorder. The reliability and validity of the AUDIT are well established (Spence, McGannon, & Poon, 2005).

Perceived Exertion

The Category Ratio Perceived Exertion Scale (Noble, Borg, Jacobs, Ceci, & Kaiser, 1983) was used to assess the participants' rating of perceived exertion (RPE) during each resistance training session. The Category Ratio Perceived Exertion Scale consists of a single item where participants were asked to rate how hard the exercise session was. The item is ranked from 0 through 10, with 0 representing "Rest" and 10 being "Maximal" effort. Prior research has shown scores >6 are consistent with high intensity for resistance training (Day, McGuigan, Brice, & Foster, 2004; Sweet, Foster, McGuigan, & Brice, 2004).

Muscular Strength Assessment

Muscular strength was tested following the guidelines established by the National Strength and Conditioning Association for determining a multiple repetition maximum (RM) (Haff, Triplett, & National Strength & Conditioning Association (U.S.), 2015). Specifically, using a

multiple RM approach in lieu of the traditional 1-RM is recommended when working with inexperienced individuals. Additionally, 1-RM testing is contraindicated for single joint exercises, such as biceps curls (Haff et al., 2015). An 8-RM was specifically selected for this study because it is equivalent to 80% of an individual's 1-RM, which is considered consistent with high intensity (Garber et al., 2011).

Muscular strength was assessed for squats, bench press, lat pull-down, overhead press, and biceps curls. Prior to testing, participants warmed up on a stationary bicycle for 3-5 minutes, followed by progressively heavier warm-up sets for each exercise. During testing, if a successful 8-RM attempt was made, then the load was increased by 5% to 10% for upper body exercises (i.e., bench press, lateral pull-down, overhead press, and biceps curls), and 10% to 20% for the lower body (i.e., squats). Participants rested for 2-4 minutes between each set and exercise and were given three attempts at reaching their 8-RM. Importantly, muscular strength was assessed twice during baseline; once in the first week, and again in the second week of baseline assessments. This was done to ensure the results of the strength testing were accurate.

Intervention Protocols

Resistance Training

The resistance training intervention consisted of three, 30-minute sessions per week for three weeks (i.e., nine total sessions). Each 30-minute session included a 5-minute warm up on a stationary bicycle, five resistance training exercises (i.e., squats, bench press, lat pull-down, overhead press, and biceps curls) done over the course of 20 minutes, and a 5-minute cool down on a stationary bicycle. For each of the exercises, the load was equal to the greatest 8-RM achieved during the initial baseline assessments. To ensure that the exercise intensity was high, participants were instructed to perform each exercise to muscular failure for each set (Arent, Landers, Matt, & Etnier, 2005). Two to three sets were performed for each exercise.

Additionally, participants rested for 60 to 90 seconds between sets and exercises. For safety, all training sessions were one on one, supervised by a certified personal trainer, and participant heart rate was monitored throughout each session. Additionally, training sessions were only conducted on nonconsecutive days (e.g., Monday, Wednesday, and Friday). This was done ensure proper recovery from each session.

Attention Control

In each of the nine, 30-minute sessions, participants learned about and discussed different educational topics (e.g., nutrition, anatomy and physiology, the universe) through educational videos and discussions. These topics carefully avoided any discussion of exercise, trauma, and PTSD. To be consistent with the experiences of the intervention group, sessions were one on one, and participants were also required to wear a heart rate monitor during their sessions. Additionally, appointments were only scheduled on nonconsecutive days (e.g., Monday, Wednesday, and Friday).

Statistical Analysis

Data were analyzed using two-way repeated measures analysis of variance (ANOVA). Specifically, the within-subjects factor “time” consisted of two levels (i.e., baseline and follow-up testing). Similarly, the between-subjects factor “group”, also consisted of two levels (i.e., resistance training and control). Primary (i.e., PTSD symptoms) and secondary (PTSD co-occurring conditions) outcomes were used as dependent variables. Statistical significance was set *a priori* at $p < .05$.

Results

A total of 211 individuals were screened by phone. Of these, 22 were fully eligible and randomized into the study. Figure 1 details the participant flow through the study from initial

screening to analysis. The mean age of the randomized sample was 33.0 years (SD = 13.3), with 81.8% women, and 77.3% identifying as a racial minority. Additionally, the average total PDS5 score at baseline was 41.0 (SD = 9.5), and scores for the re-experiencing, avoidance behaviors, mood and cognitions, and hyperarousal symptom clusters were: 9.7 (SD = 3.7), 5.2 (SD = 2.0), 14.8 (SD = 4.6), and 11.3 (SD = 5.4) respectively. Participants also reported an average of 3.9 (SD = 1.8) traumatic events. The most commonly reported traumas were child abuse (i.e., 59.1%) and serious accidents, such as a car accident (i.e., 54.5%). There were no significant between group differences for any variable at baseline. Baseline descriptive characteristics of the sample divided by group can be seen in Table 1, and a summary of the participants' trauma history are in Table 2.

The average number of the nine study sessions attended for the resistance training group was 8.4 (SD = 2.1), and 8.3 (SD = 2.1) for the control group. This equates to a 93.3% and 92.2% session attendance rate for the resistance training and control groups respectively. Importantly, the average number of sessions attended was not significantly different between groups, ensuring similar dose and comparability between groups. Additionally, the average session RPE for the resistance training group was 6.6 (SD = 1.2), which is consistent with what prior research has determined to be high intensity (Day et al., 2004; Sweet et al., 2004).

Figure 1. Pilot Study Flow

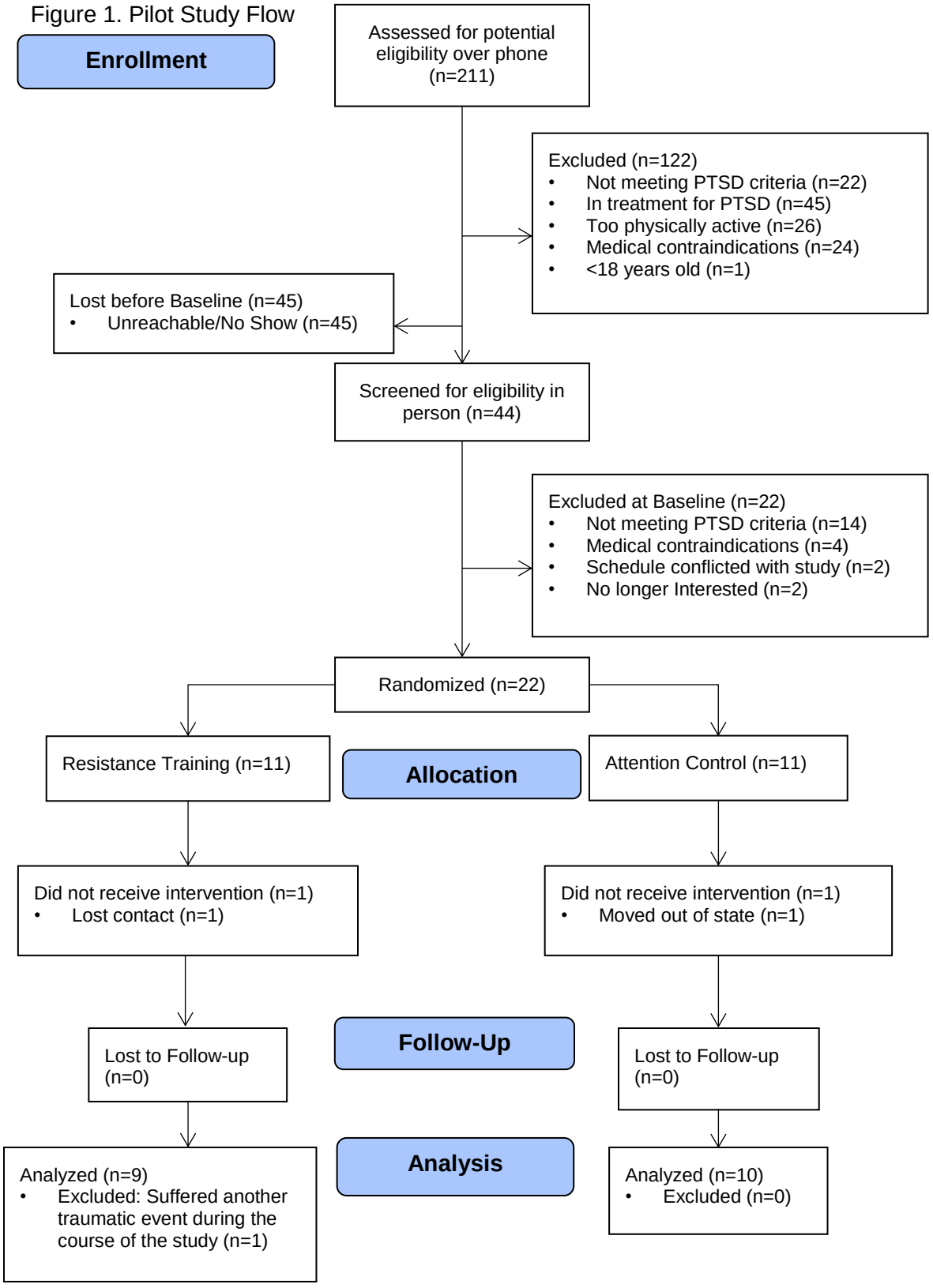


Table 1. Study II Sample characteristics (n=22)

	Intervention (n=11)	Control (n=11)
	Mean (standard deviation)	
Age	33.8 (11.1)	32.1 (15.6)
Body Mass Index	27.5 (11.4)	27.4 (4.6)
Muscular Strength, 8-RM		
Squats, lbs.	110.0 (45.6)	115.5 (58.0)
Bench press, lbs.	32.7 (40.5)	30.9 (30.2)
Lateral pull-down, lbs.	52.7 (19.5)	53.6 (22.4)
Overhead press, lbs.	35.0 (11.2)	31.8 (11.2)
Biceps curls, lbs.	33.2 (10.8)	31.4 (13.6)
	n (%)	
Gender (women)	9 (81.8%)	9 (81.8%)
Race		
White	3 (27.3%)	2 (18.2%)
Black or African American	4 (36.4%)	4 (36.4%)
Asian	2 (18.2%)	4 (36.4%)
Other	2 (18.2%)	1 (9.1%)
Education		
High school or less	2 (18.2%)	2 (18.2%)
Some college/vocational school	4 (36.4%)	1 (9.1%)
Completed college/vocational school	5 (45.4%)	8 (72.7%)
Employment status		
Employed at least part time	5 (45.4%)	6 (54.5%)
Unemployed	4 (36.4%)	2 (18.2%)
Other	2 (18.2%)	3 (27.3%)
Household Income		
≤$15,000	2 (18.2%)	3 (27.3%)
$15,001-$25,000	3 (27.3%)	0 (0.0%)
$25,001-$40,000	1 (9.1%)	0 (0.0%)
$40,001-$60,000	2 (18.2%)	1 (9.1%)
>$60,001	0 (0.0%)	2 (18.2%)
Do not know	3 (27.3%)	4 (36.4%)

RM=Repetition Maximum; lbs.=pounds

Table 2. Trauma Exposure History (n=22)

Trauma type	n (%)
Serious, life threatening illness	6 (27.3%)
Physical assault	10 (45.5%)
Sexual assault	11 (50.0%)
Military combat	1 (4.5%)
Child abuse	13 (59.1%)
Serious accident	12 (54.5%)
Natural disaster	4 (18.2%)
Other	6 (27.3%)

Resistance Training vs. Control for PTSD Symptoms

When comparing groups, there was a significant effect of Time (F = 15.3, p < .01, η^2 = .47) for total PTSD symptoms, such that the mean total score on the PDS5 significantly decreased from baseline to follow-up for both groups. However, there was no observed difference between groups (i.e., Time*Group: F <.01, p = .98, η^2 < .01). Additionally, there were significant effects of Time for re-experiencing (F = 11.8, p < .01, η^2 = .41), mood/cognitive (F = 10.6, p < .01, η^2 = .39), avoidance (F = 13.6, p < .01, η^2 = .45), and hyperarousal symptoms (F = 8.1, p = .01, η^2 = .32). However, similar to total PTSD symptoms, there were no significant Time*Group interactions for re-experiencing (F = .09, p = .77, η^2 < .01), mood/cognitive (F = .04, p = .85, η^2 < .01), avoidance (F = .09, p = .77, η^2 < .01), or hyperarousal symptoms (F = .10 p = .76, η^2 < .01). See Table 3 for specific a comparison of PTSD symptom scores by group.

Table 3. Comparison of PTSD Symptoms Between Resistance Training and Control

	Resistance Training, Mean (SD)		Control, Mean (SD)	
	Baseline	Follow-up	Baseline	Follow-up
Total PDS5	37.8 (10.7)	25.6 (16.7)†	43.3 (8.8)	30.9 (15.0)†
Re-experiencing	9.1 (4.9)	6.0 (4.7)	10.0 (3.1)	6.3 (2.8)†
Avoidance	4.8 (2.3)	2.7 (2.1)†	5.5 (1.8)	3.7 (2.1)†
Mood/cognitive	13.6 (4.4)	9.6 (6.4)	15.0 (5.1)	10.5 (7.6)†
Hyperarousal	10.3 (6.8)	7.3 (7.2)	12.8 (3.0)	10.4 (4.9)

PDS5=Posttraumatic Diagnostic Scale; SD=standard deviation; †=p<.05 vs. Baseline

Resistance Training vs. Control for PTSD Co-occurring Conditions

Examination of PTSD co-occurring conditions revealed significant effects of Time for trait anxiety (F = 5.3, p = .03, η^2 = .24). Additionally, there was a significant Time*Group interaction (F = 6.8, p = .02, η^2 = .29), such that the resistance training group reported significantly less anxiety at follow-up than the control group. Similarly, there was significant main effect of Time for sleep quality (F = 8.8, p < .01, η^2 = .36), as well as a significantly Time*Group interaction (F = 20.8, p < .01, η^2 = .57). Specifically, the resistance training group reported significantly better sleep quality at follow-up, relative to the control group. There were no significant main effects or interactions for depressive symptoms, alcohol use, or pain (p's > .05). See Table 4 for comparisons of PTSD co-occurring conditions by group.

Table 4. Comparison of Co-occurring Conditions Between Resistance Training and Control

	Resistance Training, Mean (SD)		Control, Mean (SD)	
	Baseline	Follow-up	Baseline	Follow-up
STAI	54.7 (11.5)	46.2 (12.6)†‡	48.3 (11.8)	48.8 (13.8)
CESD	15.1 (6.8)	11.0 (7.0)	13.2 (3.9)	13.6 (8.0)
PSQI	11.3 (4.9)	7.1 (4.1)†‡	7.6 (2.2)	8.4 (2.9)
AUDIT	1.9 (2.3)	1.6 (1.3)	4.2 (5.5)	4.5 (6.8)
Pain	80.0 (15.5)	78.1 (17.5)	79.0 (18.8)	84.0 (16.9)

STAI=State-Trait Anxiety Inventory; CESD=Center for the Epidemiological Studies of Depression Short Form; PSQI=Pittsburgh Sleep Quality Index; AUDIT=Alcohol Use Disorder Identification Test; SD=standard deviation; †=p<.05 vs. Baseline; ‡=p<.05 vs. Control

Effects of Resistance Training in Participants with PTSD Co-occurring Conditions

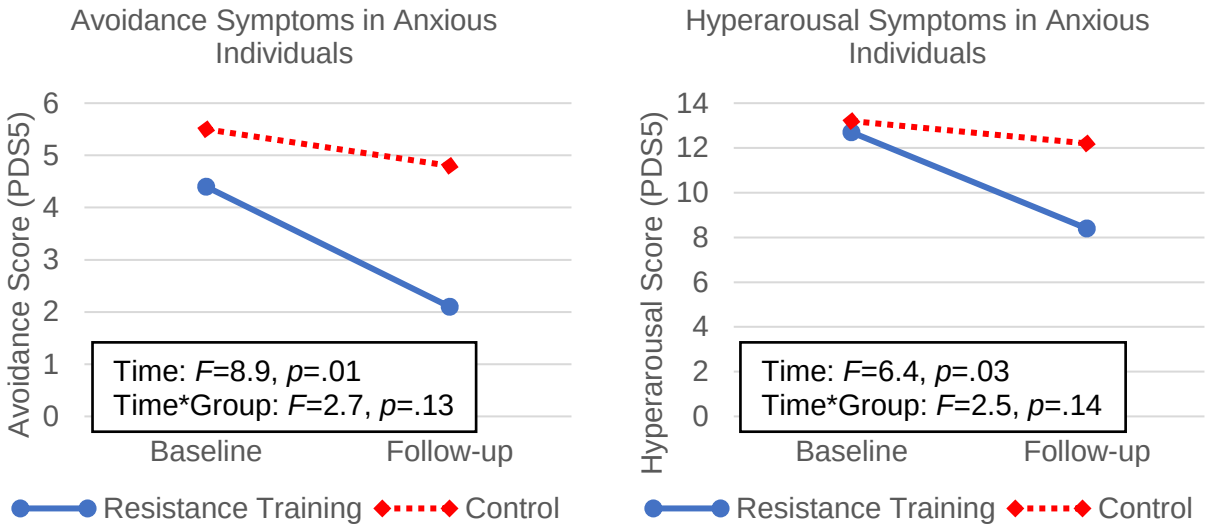
Given that the primary analysis demonstrated no significant between-group differences and similar effect size changes for PTSD symptoms, we further examined the individual responses of the participants to better understand the results. It appears there was a large amount of variability in how participants responded to the resistance training intervention, with a group potentially being classified as "responders". For example, some reported more than a 20-

point reduction in total PDS5 score from baseline to follow-up, while others reported little to no change. This suggests that some factor may be present in the “responder” group and had an influential role. As such, additional exploratory analyses were conducted on participants reporting co-occurring anxiety or depressive symptoms.

There were 13 participants (i.e., seven resistance training, and six control participants) who scored above the cut-off for a possible anxiety disorder (i.e., ≥45 on the STAI). Examining the intervention effects demonstrated a significant effect of Time for total PDS5 score (F = 10.1, p < .01, η^2 = .48), as well as the re-experiencing (F = 6.8, p = .03, η^2 = .38), mood/cognitive (F = 6.0, p = .03, η^2 = .35), avoidance (F = 8.9, p = .01, η^2 = .45), and hyperarousal (F = 6.4, p = .03, η^2 = .37) symptom clusters. Examination of potential Time*Group interactions, revealed no significant effects for total PDS5 score (F = 1.3, p = .28, η^2 = .11), re-experiencing (F = .11, p = .75, η^2 = .01), mood/cognitive (F = .51, p = .49, η^2 = .04), avoidance (F = 2.7, p = .13, η^2 = .20), and hyperarousal symptoms (F = 2.5, p = .14, η^2 = .18).

As significant differences between the groups would not be expected with such a small sample, it is notable that the effect size of the Time*Group interactions for the avoidance and hyperarousal symptoms were medium. Additionally, a visual inspection of mean avoidance and hyperarousal symptoms at baseline and follow-up for each group, suggest a potential Time*Group interaction (see Figure 2). Specifically, it appears that for avoidance and hyperarousal symptoms, trait anxious resistance training participants may have improved to a greater degree relative to the control group. As such, *post hoc* power analyses were conducted for the repeated measures within-between subjects interactions based on the 13 participants with trait anxiety and calculated effect sizes for avoidance and hyperarousal symptoms (using G*Power 3.1). The achieved power for these analyses was 32% and 30% for avoidance and hyperarousal symptoms respectively. Unsurprisingly, they were not adequately powered to detect a statistical difference.

Figure 2.



Regarding depressive symptoms, there were 17 participants (eight resistance training and nine control) who screened positive for depression (i.e., scoring ≥10 on the CESD). Examination of the treatment effects revealed similar results to the analysis of the full sample. Specifically, there was a significant effect of Time for total PDS5 score (F = 11.2, p < .01, η^2 = .43), re-experiencing (F = 8.1, p = .01, η^2 = .35), mood/cognitive (F = 8.3, p = .01, η^2 = .36), avoidance (F = 9.1, p < .01, η^2 = .38), and hyperarousal symptoms (F = 7.7, p = .01, η^2 = .34). Additionally, analysis of potential Time*Group interactions for total PDS5 score (F = .01, p = .94, η^2 < .01), re-experiencing (F = .32, p = .58, η^2 = .02), mood/cognitive (F = .02, p = .88, η^2 < .01), avoidance (F = .03, p = .86, η^2 < .01), and hyperarousal symptoms (F = .20, p = .66, η^2 = .01) were not significantly different. Furthermore, the effect sizes of these interactions were all small.

Discussion

This study aimed to assess the feasibility and test the effects of a 3-week high intensity resistance training intervention on PTSD symptoms using a randomized attention-controlled design. The results showed that both the resistance training and control group reported

significantly less total PTSD symptoms at follow-up. There were no group differences for total PTSD symptoms or any of the individual symptom clusters; however, the resistance training group did report significantly greater improvements in sleep quality and anxiety at follow-up, relative to the control group.

The null between group differences for PTSD symptoms was an unexpected finding. Prior research has shown exercise to be is inversely associated with PTSD symptoms (Chwastiak et al., 2011; LeardMann et al., 2011; Vujanovic, Farris, Harte, Smits, & Zvolensky, 2013); and multiple randomized controlled trials reported exercise to have a beneficial effect on PTSD symptoms (Powers et al., 2015; Rosenbaum et al., 2015). There are however, several possible explanations for the contrasting findings of the present study.

First, unlike prior research, this study used a time-matched attention control, and this resulted in a more rigorous test of the effects of exercise on PTSD symptoms. Thus, it may be that exercise provides a beneficial effect, but it is only equal to an attention control. In addition, it is also possible that, as hypothesized above, there is considerable variation in how individuals with PTSD respond to exercise, particularly those with other mental illness. This is supported by the findings of our exploratory analyses on those with high anxiety scores.

Second, while there were no significant differences between the groups for PTSD symptoms, the resistance training group reported significantly less anxiety, and better sleep quality than the control group at follow-up. Considering the findings discussed above, the beneficial effects of resistance training on anxiety and sleep quality are particularly important. Specifically, it is possible that the effects of resistance training on PTSD may occur indirectly by improving co-occurring conditions that are known to exacerbate PTSD, such as anxiety. Again, this is supported by our exploratory findings.

Finally, in contrast to previous research, this study recruited a community sample who screened positive for PTSD, rather than a clinical sample. In fact, none of the participants in this study were actively seeking or in treatment for PTSD. This is an important strength of this study

because it is well known that many individuals who have or screen positive for PTSD do not seek out traditional forms of treatment (Elbogen et al., 2013). Importantly, the excellent attendance of the resistance training group (i.e., 93% session attendance) suggests a willingness to engage in high intensity resistance training by this population as a potential treatment for PTSD.

Conclusion

In summary, the results of this study suggest that three weeks of high intensity resistance training is an acceptable and feasible intervention for individuals who screen positive for PTSD. Additionally, it appears that resistance training can help to improve anxiety symptoms and sleep quality in this population, and it may be particularly helpful for individuals with co-occurring anxiety symptoms. Thus, further investigating the effects of high intensity resistance training on anxious individuals with PTSD is an important next step for this research.

CHAPTER III – DISSERTATION STUDY

Research Questions

Primary Outcomes

Research Question 1: What is the effect of a 3-week high intensity resistance training intervention on the PTSD hyperarousal and avoidance symptom clusters in anxious adults who screen positive for PTSD when compared to a 3-week time-matched attention control?

Hypothesis 1a: Hyperarousal symptoms will decrease significantly more from baseline to follow-up for the resistance training group compared to the control.

Hypothesis 1b: Avoidance symptoms will decrease significantly more from baseline to follow-up for the resistance training group compared to the control.

Secondary Outcomes

Research Question 2: What is the effect of a 3-week high intensity resistance training intervention on anxiety symptoms in anxious adults who screen positive for PTSD when compared to a 3-week time-matched attention control?

Hypothesis 2: Anxiety symptoms will decrease significantly more from baseline to follow-up for the resistance training group compared to the control.

Research Question 3: What is the effect of a 3-week high intensity resistance training intervention on PTSD-related co-occurring conditions (e.g., sleep quality, depressive symptoms) in anxious adults who screen positive for PTSD when compared to a 3-week time-matched attention control?

Hypothesis 3: Co-occurring poor sleep quality and depressive symptoms will decrease significantly more from baseline to follow-up for the resistance training group compared to the control.

Exploratory Outcomes

Research Question 4: What is the relationship between potential mechanisms of action (e.g., cognitive appraisal, perceived exertion, acute changes in affect, arousal, and distress) and PTSD symptoms?

Hypothesis 4: Changes in posited mechanisms of action will significantly predict changes in PTSD symptoms during the 3-week resistance training intervention.

Methods

Procedures

Participants were recruited from the local community using online classified listings (e.g., Craigslist and Columbia RecruitMe), social media, flyers, word of mouth, and newspaper advertisements. Interested individuals were screened over the phone to determine initial eligibility. Potentially eligible individuals were invited to Teachers College for an in-person orientation to the study, and further screening. Eligible participants completed baseline assessments over the course of two weeks (details provided below). Participants were then randomly assigned to either the 3-week resistance training intervention or a time matched attention control. Follow-up assessments were conducted in the week after the intervention. The study was approved by the Teachers College Institutional Review Board (see Appendix D). All data were collected between July 2017 and April 2018.

Participants

To be eligible, participants had to be adults aged 18 to 45 years. All reported experiencing a recent traumatic event (i.e., within the past two years), and screened positive for PTSD, using the PSD5 (Foa et al., 2015). Additionally, all participants reported having persistent symptoms during the previous 90 days, as about 50% of the adult cases of PTSD resolve naturally within the first three months following the onset of symptoms (American Psychiatric

Association., 2013; Foa et al., 2007). Participants also scored ≥45 on the STAI-Y2 form to be considered trait anxious.

Participants were excluded from the study if they were in/or seeking treatment for PTSD or other mental health disorder, such as trauma-focused group or individual psychotherapies, or taking anti-anxiety medications (e.g., selective serotonin reuptake inhibitors; SSRIs). Additionally, anyone with current or a history of heart, lung, or metabolic diseases, or any other medical contraindications to high intensity exercise or resistance training (e.g., musculoskeletal disorders) were excluded. Finally, individuals who were physically active (i.e., ≥60 min/week or any resistance training) were excluded.

The age limit was restricted to 45 in this study as a safety precaution. Based on the newest guidelines, sedentary individuals older than 45 should not participate in high intensity exercise without the permission of a physician (Riebe et al., 2015).

Measures

Demographics and Health History

Demographic data such as age, gender, race/ethnicity, education, and income were collected through self-report. Additionally, a physical and mental health history interview (e.g., height, weight, resting blood pressure) was conducted to screen for any contraindications to exercise, and to determine if participants were seeking/currently engaged in treatment for a mental health disorder (e.g., PTSD).

Trauma History and PTSD Symptoms

PTSD screening and symptom assessment was assessed with the PDS5 (Foa et al., 2015). Specifically, experiencing ≥1 re-experiencing symptom, ≥1 avoidance symptom, ≥2 mood/cognitive symptoms, and ≥2 hyperarousal symptoms, and a total score of ≥28 was

required to screen positive for PTSD. For a detailed description of the PSD5 refer to the Chapter II.

Trait Anxiety and Depressive Symptoms

Trait anxiety was assessed using the STAI-Y2 form (Spielberger et al., 1983). A score of ≥45 was used as a cut off to be considered trait anxious (Bunevicius et al., 2013). Additionally, the CESD was used to assess co-occurring depressive symptoms (Radloff, 1977). For detailed descriptions of the STAI and CESD refer to the Chapter II.

Sleep Quality and PTSD Related Sleep Disturbances

Global sleep quality for the past month was assessed with the PSQI (Buysse et al., 1989). In addition, an addendum to the PSQI was used to specifically measure sleep disturbances caused specifically by PTSD (Germain, Hall, Krakow, Katherine Shear, & Buysse, 2005). The PSQI Addendum for PTSD (PSQI-A) consists of seven additional items that are ranked from 0 “Not in the past month” to 3 “Three or more times a week”. Each item represents a PTSD-related source of sleep disturbance (e.g., hot flashes, nervousness, trauma related nightmares, or physically acting out dreams). For scoring, the seven items are summed producing a score ranging from 0-21. The PSQI-A has good internal consistency ($\alpha = 0.85$), and a score of ≥4 is recommended as an indicator of PTSD (sensitivity 94% and specificity 82%) in women (Germain et al., 2005).

Cognitive Appraisal

A two-item, 7-point visual analog scale was used to assess the participants’ perception of the exercise task. Both items are ranked from 1 “Not at all” to 7 “Extremely”. The first item asked participants, “How stressful do you expect the upcoming task to be?” and the second “How able are you to cope with this task?”. For scoring, a ratio is calculated from dividing item-1

by item-2. Scores of <1 represent a perceived challenge, 1 being unsure, and scores >1 represent a perceived threat (Moore, Vine, Wilson, & Freeman, 2012).

Affect and Arousal

The Feeling Scale (FS) was used to assess acute changes in affective valance during exercise (Hardy & Rejeski, 1989). The FS is an 11-point, single-item scale with rankings ranging from -5 “Very Bad” to 0 “Neutral”, and through +5 “Very Good”. Acute changes in arousal (e.g., how “worked up” a person feels) were measured with the Felt Arousal Scale (FAS) (Svebak & Murgatroyd, 1985). The FAS is a 6-point, single-item scale. Rankings range from 1 “Low Arousal” to 6 “High Arousal”.

Distress

Acute changes in distress during study sessions were assessed with the Subjective Units of Distress Scale (SUDS) (Jaycox, Foa, & Morral, 1998). The SUDS is a single-item measure with rankings from 0 to 100. Zero represents “Totally Relaxed” and 100 is “Highest distress/fear/anxiety/discomfort that you have ever felt”, which is typically anchored with an individual’s traumatic event or a related experience. This measure was specifically selected to assess moment-to-moment distress because it is a clinical tool used to gauge a patient’s distress during PE therapy sessions (Foa et al., 2007).

Perceived Exertion

The 11-point, single item Category Ratio Perceived Exertion Scale (Noble et al., 1983) was used to assess the participants’ perceived exertion during each resistance training session, and to ensure the intensity of the training session was sufficiently intense. Scores >6 are consistent with high intensity for resistance training (Day et al., 2004; Sweet et al., 2004).

Muscular Strength Assessment

The National Strength and Conditioning Association's guidelines for determining multiple repetition maximum (RM) for muscular strength were followed (Haff et al., 2015). The exercises assessed were squats, bench press, lat pull-down, overhead press, and biceps curls. Prior to testing, participants warmed up on a stationary bicycle for 3-5 minutes, followed by progressively heavier warm-up sets for each exercise. During testing, if a successful RM attempt was made, the load was increased by 5% to 10% for upper body exercises (i.e., bench press, lat pull-down, overhead press, and biceps curls), and 10% to 20% for the lower body (i.e., squats). Participants rested for 2-4 minutes between each set and exercise.

Baseline Assessment Protocols and Randomization

Baseline session 1 included an orientation to the study protocols and was used to gain informed consent. Consenting individuals were then screened for full eligibility using 1) demographics and health history; 2) PDS5; and 3) STAI. If eligible, muscular strength was assessed and participants were scheduled for baseline session 2.

Baseline session 2 included assessments of secondary outcomes (i.e., PSQI, PSQI-A, and CESD), and a reassessment of muscular strength. Reassessing muscular strength was important to ensure accuracy of the muscular strength assessments because the maximum values were used as the load in the resistance training intervention. Furthermore, comparing the baseline muscular strength scores from the pilot study shows that the mean 8-RM significantly increased from baseline session 1 to 2 for all five exercises without further intervention (see Table 5 below). This is likely because the participants were inexperienced weight lifters and their proficiency with the exercises improved from baseline session 1 to 2.

Table 5. Comparison of Muscular Strength at Baseline Session 1 and 2 (n=22)

	Baseline session 1	Baseline session 2	P-value
	Mean (standard deviation)		
Muscular Strength, 8-RM			
Squats, lbs.	96.7 (53.2)	114.3 (51.6)	$p < 0.001$
Bench press, lbs.	24.0 (30.7)	31.7 (35.7)	$p < 0.001$
Lat pull-down, lbs.	49.8 (18.9)	52.9 (21.4)	$p = 0.039$
Overhead press, lbs.	29.3 (10.5)	33.6 (11.3)	$p < 0.001$
Biceps curls, lbs.	29.0 (10.2)	32.1 (12.4)	$p = 0.002$

RM=Repetition Maximum; lbs.=pounds

At the completion of baseline session 2, participants were randomized into either the resistance training group or the attention control group. Randomization was blocked on gender using a computerized random number generator (Sealed Envelope Ltd. 2016). Two sets of sequentially numbered opaque envelopes (i.e., one for each block) were filled with index cards containing the allocated condition. Preparation of allocation materials were completed by an individual not directly participating in the data collection for this study. Blocking on gender was done to ensure that gender was balanced between groups, as there are well known differences in the prevalence of PTSD between men and women (Sareen, 2014), and emerging evidence suggests that men and women may respond differently to the current treatments for PTSD (Voelkel, Pukay-Martin, Walter, & Chard, 2015).

Intervention Protocols

Resistance Training

Participants randomized into the resistance training intervention were required to attend three, 30-minute sessions per week for three weeks (i.e., nine total sessions). Each 30-minute session consisted of a 5-minute warm up on a stationary bicycle, five resistance training exercises (i.e., squats, bench press, lat pull-down, overhead press, and biceps curls) done over the course of 20 minutes, finishing with a 5-minute cool down on a stationary bicycle. Potential mechanisms of action (i.e., cognitive appraisal, acute changes to affect, arousal, and distress)

were assessed prior to the warm up, 15 minutes into the session (i.e., at the mid-point of the exercise bout), and again at the 30-minute mark, following the cool-down. Heart rate was monitored throughout the session, and the participant's RPE was assessed at the 15 and 30-minute mark.

The load of each exercise was equal to the 8-RM achieved during the initial baseline assessments. Participants were instructed to perform each set of each exercise to momentary failure, performing two to three sets for each exercise. Participants rested for 60 to 90 seconds between sets and exercises. This protocol was expected to produce RPE scores consistent with high intensity exercise.

All training sessions were individual, conducted on-site, and led by a certified personal trainer. Interpersonal interaction was limited and focused on guiding the participant through the protocol. To ensure sufficient recovery, sessions were conducted on nonconsecutive days (e.g., Monday/Wednesday/Friday).

Control Protocols and Description of Content

Participants randomized into the attention control group attended nine, 30-minute sessions over the course of three weeks. Each session consisted of videos on various educational topics (excluding exercise and mental health). Example topics included basic nutrition, the universe, and time perception. The purpose of these sessions was to ensure that participants in the control group had the same amount of exposure to the research staff as the resistance training group. Therefore, to be consistent with the experiences of the intervention group, individual sessions were conducted on-site, on nonconsecutive days, and participants were required to wear a heart rate monitor during each session.

Follow-up Assessment

In the week following the intervention, participants completed a follow-up assessment where all of the baseline measures were repeated. See Table 6 below for a summary of the assessments across the study.

Table 6. Study Assessments by Time Point

	Screen	Baseline	Intervention	Follow-up
Participant Characteristics				
Medical History	X	X		X
Demographics	X	X		
Height and Weight		X		X
Primary Outcome				
PTSD Symptoms	X	X	X	X
Secondary Outcomes				
Trait Anxiety	X	X		X
Depressive Symptoms		X		X
Sleep Quality		X	X	X
Exploratory Outcomes				
Cognitive Appraisal			X	
Affect & Arousal		X	X	X
Distress		X	X	X
Fitness Outcomes/Manipulation Checks				
Muscular Strength		X		X
Heart Rate		X	X	X
Perceived Exertion During Exercise			X	
Resting Blood Pressure		X		X

Participant Compensation Strategy

Cash incentives were provided to participants to compensate them for their time and expenses incurred traveling to and from the research site. Specifically, participants received $5.50 (i.e., roundtrip cost of New York City public transportation) for each session attended, starting at the first study session after randomization. With the travel fare reimbursed for a total of 9 sessions the cost per participant was $49.50.

Additionally, to compensate participants for their time, each received a $10 Target gift card in session 3 of the intervention/control, $15 gift card in session 6, $25 gift card in session 9,

and $50 gift card at the follow-up assessment session. In total, participants received $149.50 in compensation if they attended all study sessions.

Sample Size Calculation and Statistical Analysis

A power analysis was conducted using the data collected from the pilot study to estimate the number of participants required to achieve 80% power with an alpha level of 5%, using G*Power 3.1. Based on the exploratory analyses of the 13 participants who scored ≥45 on the STAI in the pilot study, the repeated measures, within-between subjects interactions for avoidance and hyperarousal symptoms produced effect sizes of f = 0.494 (η^2 = .196) and f = 0.473 (η^2 = .183) respectively. With a 2 (Group) X 2 (Time) factorial ANOVA design and using the more conservative effect size (i.e., f = 0.473) the following parameters were computed: 1) Noncentrality parameter λ = 8.51; 2) Critical F value = 4.10; 3) Numerator df = 1.0; 4) Denominator df = 38.0; 5) Actual power = 0.81; and 6) Total sample size = 40. As such, a total of 20 participants per group (n = 40) was the target recruitment goal to adequately compare the effects of resistance training to an attention control condition for the PTSD avoidance and hyperarousal symptom clusters.

Primary outcomes (i.e., hypotheses 1a, and 1b), and secondary outcomes (i.e., hypotheses 2, and 3) were analyzed using 2 x 2 factorial ANOVA. Specifically, the between-subjects factor “Group” had two levels (i.e., Intervention and Control), and the within-subjects factor “Time” also consisted of two levels (i.e., Baseline and Follow-up). Estimates of effect size were calculated with Cohen’s d.

Exploratory outcomes (i.e., hypothesis 4) were analyzed using longitudinal mixed-effects regression models, assessing the effects of potential mechanisms of action on PTSD symptoms in the resistance training group. Specifically, the weekly measurement of the mechanism (e.g., cognitive appraisals, RPE, and acute changes in affect, arousal, and distress) were regressed on PTSD symptoms, while controlling for baseline values of the mechanism. Potential

confounders (e.g., age and gender) were also examined, and model selection was based on the evaluation of Akaike information criterion. Random intercepts were used to model an individual starting point for PTSD symptoms. Statistical significance was set *a priori* at $p < .05$.

Results

For details on the study flow and CONSORT table, see Figure 3. In summary, 217 individuals were screened for eligibility over the phone, resulting in 56 in-person screenings and 30 randomized participants. The sample was 73.3% female, with a mean age of 29.1 years (SD = 7.4), and 63.3% identified as a non-white racial group. The average PDS5 score for the total sample was 41.1 (SD = 10.6), and the mean scores for the re-experiencing, avoidance, mood and cognitive, and hyperarousal symptom clusters were 9.0 (SD = 3.2), 6.0 (SD = 1.6), 13.8 (SD = 5.8), and 12.4 (SD = 3.5), respectively. Additionally, participants reported an average of 2.5 (SD = 1.5) traumatic experiences. The most commonly reported traumatic event was sexual assault (36.7%), followed by other traumas (e.g., the sudden/unexpected loss of a child or spouse; 30.0%), and physical assault (23.3%). A summary of baseline descriptive characteristics divided by group can be seen in Table 7. Importantly, there were no significant baseline differences for any demographic or outcome variables.

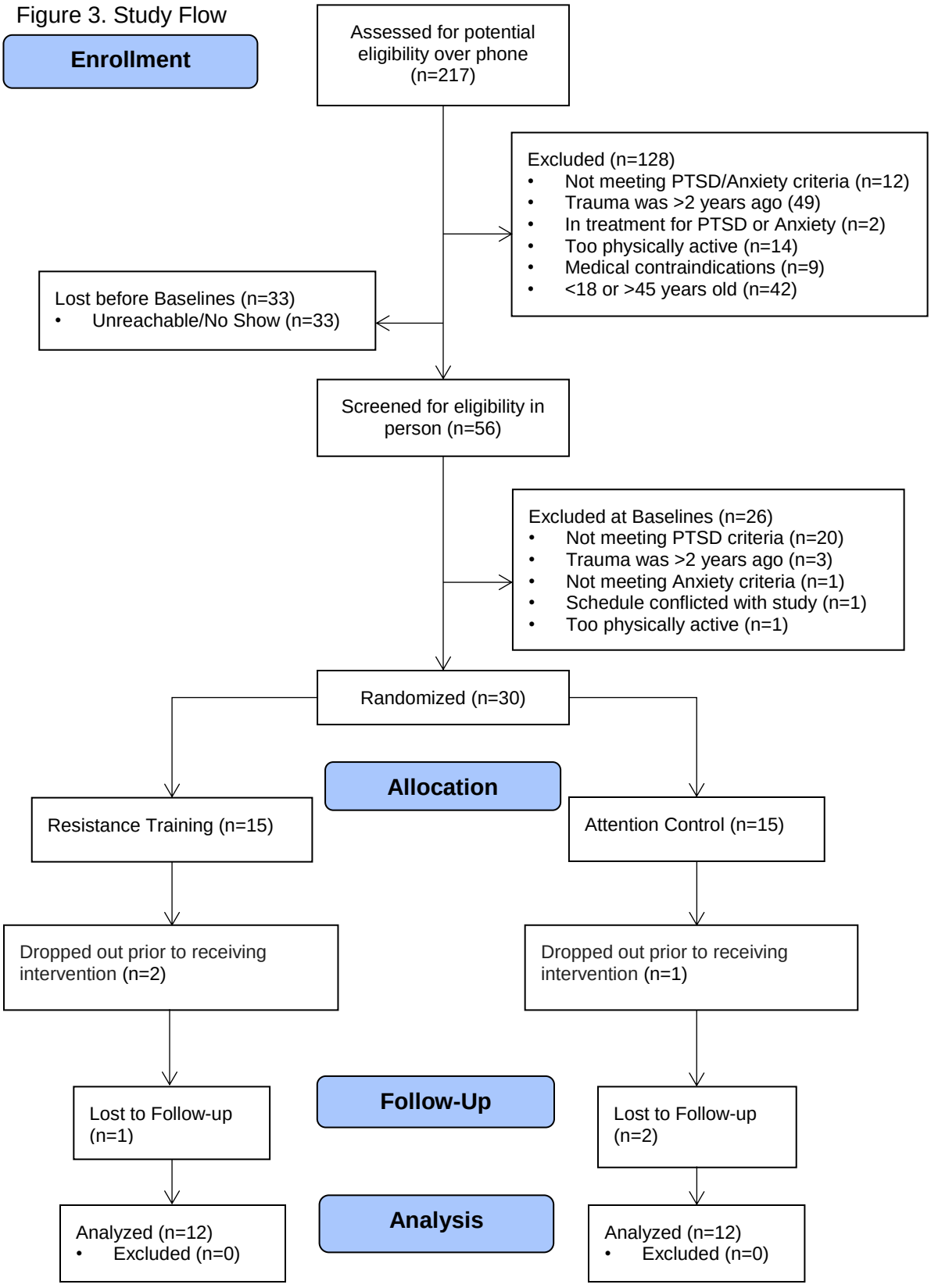
Participants attended a mean of 7.2 (SD = 2.3) and 6.6 (SD = 2.4) sessions for the resistance training and control groups respectively. The number of sessions attended was not significantly different between groups ($p = 0.50$). Specific to the resistance training group, the mean session RPE score was 8.2 (SD = 1.2), indicating the exercise intensity of the sessions was high (Day et al., 2004; Sweet et al., 2004). As a final manipulation check for the intervention, the resistance training group significantly improved on all measures of muscular strength (i.e., squats, bench press, lat pull-down, overhead press, and curls) from baseline to follow-up and relative to the control (all p's < 0.05, see Appendix E for specific values).

Table 7. Sample characteristics (n=30)

	Intervention (n=15)	Control (n=15)
	Mean (standard deviation)	
Age	27.7 (5.9)	30.5 (8.6)
Height, inches	64.8 (5.7)	65.7 (3.7)
Weight, lbs.	158.9 (44.3)	153.4 (40.6)
Muscular Strength, 8-RM		
Squats, lbs.	92.0 (69.9)	74.3 (36.6)
Bench press, lbs.	31.3 (34.1)	29.0 (34.0)
Lateral pull-down, lbs.	45.3 (32.4)	49.0 (27.0)
Overhead press, lbs.	33.0 (13.5)	33.3 (12.6)
Biceps curls, lbs.	36.3 (14.6)	34.0 (12.3)
	n (%)	
Women	11 (73.3%)	11 (73.3%)
Race		
White	4 (26.7%)	7 (46.7%)
Black or African American	6 (40.0%)	3 (20.0%)
Asian	4 (26.7%)	4 (36.7%)
Other	1 (6.7%)	1 (6.7%)
Education		
High school or less	0 (0.0%)	2 (13.3%)
Some college/vocational school	5 (33.3%)	0 (0.0%)
Completed college/vocational school	6 (40.0%)	10 (66.7%)
Completed graduate school	4 (26.7%)	3 (20.0%)
Employment status		
Employed at least part time	5 (33.3%)	7 (46.7%)
Student	7 (46.7%)	5 (33.3%)
Unemployed	2 (13.3%	3 (20.0%)
Other	1 (6.7%)	0 (0.0%)
Household Income		
≤$25,000	4 (26.7%)	4 (26.7%)
$25,001-$40,000	3 (20.0%)	1 (6.7%)
$40,001-$60,000	0 (0.0%)	3 (20.0%)
>$60,001	5 (33.3%)	3 (20.0%)
Do not know	3 (20.0%)	4 (26.7%)

RM=Repetition Maximum; lbs.=pounds

Figure 3. Study Flow



Research Question 1 – Resistance Training vs. Control for PTSD Symptoms

Results show a significant effect of Time (F = 40.7, p < .01, η^2 = .66) for hyperarousal symptoms, such that the mean hyperarousal score significantly decreased from baseline to follow-up for the total sample. There was also as significant Time*Group interaction (F = 4.7, p = .04, η^2 .18), demonstrating a significantly larger reduction in hyperarousal symptoms for the resistance training group (d = -1.84) relative to the control (d = -1.13).

Similarly, there was a significant effect of Time (F = 34.0, p < .01, η^2 = .62) for avoidance symptoms, such that the mean avoidance score significantly decreased from baseline to follow-up. The Time*Group interaction was not significant (F = 1.7, p = .20, η^2 = .08); however, the effect size was larger for resistance training (d = -2.71) than the control group (d = -1.16). A graphic representation of these findings can be seen in Figure 4, and a summary of the mean changes and effect sizes for all of the PTSD symptoms measured by the PDS5 can be referenced in Table 8.

Figure 4.

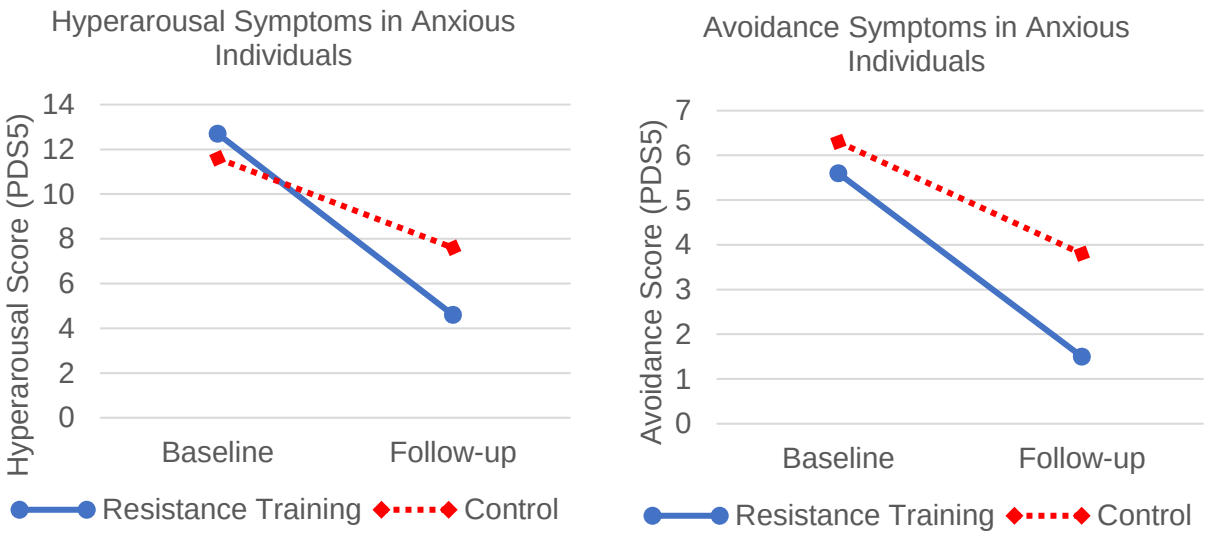


Table 8. Group Comparison of PTSD Symptoms

	Resistance Training, Mean (SD)			Control, Mean (SD)		
	Baseline	Follow-up	*d*	Baseline	Follow-up	*d*
Total PDS5	40.3 (11.7)	16.3 (11.3) †	-2.09	40.9 (8.7)	25.5 (14.7) †	-1.28
Intrusion	9.1 (3.0)	3.9 (1.2) †	-2.28	8.9 (2.5)	5.6 (3.9) †	-1.01
Avoidance	5.6 (1.7)	1.5 (1.3) †	-2.71	6.3 (1.6)	3.8 (2.6) †	-1.16
Mood/cognitive	12.8 (7.1)	6.2 (6.1) †	-1.00	14.1 (5.0)	8.6 (6.3) †	-0.97
Hyperarousal	12.7 (4.1)	4.6 (4.7) †‡	-1.84	11.6 (3.0)	7.6 (4.0) †	-1.13

PDS5=Posttraumatic Diagnostic Scale; SD=standard deviation; *d*=Cohen's *d*; †=p<.05 vs. Baseline; ‡=p<.05 vs. Control

Research Questions 2 and 3 – Resistance Training vs. Control for PTSD Co-occurring Conditions

There was a significant effect of Time for trait anxiety ($F = 9.8$, $p < .01$, $\eta^2 = .32$), such that the mean STAI score significantly decreased from baseline to follow-up. There was no Time*Group interaction ($F = 3.5$, $p = .08$, $\eta^2 = .14$). Of note, the effect size change in anxiety from baseline to follow-up for the intervention group was large (i.e., $d = -.81$), while it was small (i.e., $d = -.19$) for the control.

There was a significant effect of Time ($F = 13.0$, $p < .01$, $\eta^2 = .34$) on the PSQI, and a significant Time*Group interaction ($F = 4.7$, $p = .04$, $\eta^2 = .19$), demonstrating greater improvements in global sleep quality for the resistance training group ($d = -1.06$) when compared to the control ($d = -.15$). In contrast, there were no Time ($F = 3.0$, $p = .1$, $\eta^2 = .13$) or Time*Group ($F = .09$, $p = .8$, $\eta^2 < .01$) differences for the PTSD related sleep disturbances (i.e., the PSQI-A). The effect sizes for both the resistance training (i.e., $d = -.36$) and the control group (i.e., $d = -.32$) were small.

Depression symptoms (i.e., CESD) did not change significantly by Time ($F = 1.5$, $p = .24$, $\eta^2 = .07$) nor was there a significant Time*Group interaction ($F = 2.7$, $p = .12$, $\eta^2 = .11$). The effect size of resistance training on depression symptoms was small (i.e., $d = -.41$), while there

was no apparent effect of the control on depression symptoms (i.e., *d* = .07). See Table 9 for a detailed breakdown of the mean changes from baseline to follow-up by group for all of the secondary outcomes.

Table 9. Group Comparison of Co-occurring Conditions

	Resistance Training, Mean (SD)			Control, Mean (SD)		
	Baseline	Follow-up	*d*	Baseline	Follow-up	*d*
STAI	57.3 (10.7)	48.7 (10.6)†	-.81	53.8 (9.7)	51.7 (12.6)	-.19
PSQI	10.5 (3.4)	7.0 (3.2)†‡	-1.06	10.8 (5.1)	10.0 (5.3)	-.15
PSQI-A	7.5 (2.9)	6.3 (3.7)	-.36	8.8 (5.8)	7.1 (4.9)	-.32
CESD	14.5 (7.2)	11.6 (7.1)	-.47	13.4 (6.1)	13.8 (5.7)	.07

STAI=State-Trait Anxiety Inventory; PSQI=Pittsburgh Sleep Quality Index; PSQI-A=Pittsburgh Sleep Quality Index Addendum for PTSD; CESD=Center for the Epidemiological Studies of Depression Short Form; SD=standard deviation; *d*=Cohen's *d*; †=p<.05 vs. Baseline; ‡=p<.05 vs. Control

Research Question 4 – Potential Mechanisms of Action

Cognitive Appraisal

Changes in the perception of the resistance training sessions over the course of the 3-week intervention (i.e., changes from week 1 to 2, and week 2 to 3) significantly predicted changes in total PTSD symptoms (*b* = 7.1, SE = 2.9, *p* = .02). For example, a one unit decrease in cognitive appraisal score (e.g., perceiving exercise challenge from being uncertain) predicted a 7.1 point decrease in total PTSD symptoms. Age and gender were not significant covariates and including them in the model only reduced the model fit. As such, the model without age and gender was selected. The intraclass correlation coefficient (ICC) for the final model was 0.62, indicating moderate reliability (Koo & Li, 2016).

An examination of the specific symptom clusters revealed similar significant results for intrusion symptoms (*b* = 2.6, SE = .8, *p* < .01), and mood and cognitive symptoms (*b* = 2.5, SE = 1.1, *p* = .03), such that a change in the cognitive appraisal of exercise was positively associated with a change in these symptom clusters. The model ICC's = .71, and .68 for intrusion, and mood and cognitive symptoms respectively, again indicating moderate reliability.

The models for the avoidance and hyperarousal symptom clusters were not significant (*p*'s > .05).

Perceived Exertion During Exercise

Changes in session RPE was a significant longitudinal predictor of total PTSD symptoms over the 3-week intervention period (*b* = -3.1, SE = 1.2, *p* = .01). The relationship was such that a one unit increase in RPE score significantly predicted a 3.1 unit decrease in total PTSD symptoms. Similar to above, initial models included age and gender as potential confounders, but were non-significant and selecting a model without them did not change the results and increased the model fit. The ICC for the final model was .73, again suggesting moderate reliability of the model.

Regarding the individual symptom clusters, changes in session RPE significantly predicted changes in hyperarousal (*b* = -1.1, SE = .39, *p* < .01), avoidance (*b* = -.45, SE = .21, *p* = .04), and mood and cognitive symptoms (*b* = -1.1, SE = .43, *p* = .02), such that increases in RPE scores predicted reductions in these symptoms. However, session RPE was not a significant predictor of intrusion symptoms (*p* > .05). The model ICC's were .70 for hyperarousal symptoms, .47 avoidance symptoms, and .79 for the mood and cognitive symptom cluster, indicating moderate, poor, and good model reliability respectively.

Affect, Arousal, and Distress

Changes in affect (*b* = .82, SE = 1.7, *p* = .63), arousal (*b* = 2.4, SE = 1.5, *p* = .12), nor distress (*b* = .18, SE = .13, *p* = .17) significantly predict changes in total PTSD symptoms during the exercise sessions. Additionally, none of the models for the individual symptom clusters reached significance when examining changes in state affect, arousal, or distress as a predictor (*p*'s > .05). Adjusting for potential confounders did not change the results.

Discussion

This study sought to test the standalone effects of high intensity resistance training on PTSD symptoms in anxious adults who screened positive for PTSD. The findings show that three weeks of resistance training can produce significantly larger reductions in the PTSD hyperarousal symptom cluster when compared to a time-matched attention control. As hypothesized, resistance training also had significant beneficial effects on global sleep quality relative to the control. Additionally, changes in the perception of exercise (i.e., cognitive appraisal and perceived effort) over the course of the intervention had an impact on the results and may offer a potential explanation as to why high intensity exercise has a beneficial effect on PTSD symptoms.

To our knowledge, this is the first study to demonstrate an effect of resistance training on PTSD symptoms, specially hyperarousal symptoms. These results further support the link between exercise and PTSD, and help to move the field forward, as prior research examining this relationship has primarily been observational and cross-sectional (Harte et al., 2013; LeardMann et al., 2011; Whitworth, Craft, et al., 2017; Whitworth, SantaBarbara, et al., 2017). The findings of this study may also have clinical significance, as hyperarousal symptoms are associated with aggression, alcohol use (Taft et al., 2007), and are a large contributor to PTSD-related sleep problems (van Wyk, Thomas, Solms, & Lipinska, 2016).

This study also tested the effects of resistance training on the avoidance symptom cluster, as prior research has shown associations between high intensity exercise and avoidance symptoms (Whitworth, Craft, et al., 2017). The results showed a significant reduction in avoidance symptoms for the resistance training group from baseline to follow-up, but these effects were not significantly different than the control. Notably, the effect size was larger for the resistance training group (d = -2.71) vs. the control (d = -1.16) somewhat supporting our hypothesis.

Similar results were observed with the intrusion, and mood and cognitive symptom clusters. Specifically, resistance training produced large significant reductions in these symptoms; however, the effects did not differ significantly from the control group (see Table 8). Despite the lack of between-group differences for avoidance, intrusion, and mood and cognitive symptoms, the observed effects do represent clinically meaningful changes. For example, the mean total PDS5 score for the resistance training group decreased nearly 25 points from baseline to follow-up, while it was reduced by only 15 points in the control. In sum, these results provide supporting evidence of a beneficial relationship between exercise and PTSD.

Regarding the secondary outcomes, global sleep quality as measured by the PSQI significantly improved for the resistance training group from baseline to follow-up relative to the control. These results are consistent with the pilot study, and with our prior observational research. In contrast, there were no significant changes on the PSQI-A for either the resistance training or the control group. A potential explanation for this finding is that the PSQI-A quantifies disturbances directly relating to the trauma (e.g., nightmares), rather than quantifying changes in global sleep quality. Furthermore, the effects of resistance training on sleep appear to be specific to increases in sleep duration, improved sleep efficiency, and a lower usage of sleep medications (see Appendix F). Overall, the finding that sleep quality can be altered by resistance training is particularly important, as reduced sleep quality is one of the most common and persistent problems faced by those with PTSD (Pruiksma et al., 2016).

As for the intervention effects on trait anxiety and depression symptoms, resistance training appears to have a beneficial effect on both. Although the interaction terms were not significant, resistance training produced larger effects on trait anxiety and depression symptoms than the control. In fact, trait anxiety was significantly reduced from baseline to follow-up for the resistance training group but not for the control group. As such, it is possible the Time*Group interaction effects would reach significance with a larger sample. These findings are consistent with the majority of the research examining the effects of exercise on anxiety (Stubbs et al.,

2017) and depression (Ekkekakis, 2015). They are additionally relevant because these results add to a very small pool of studies that have examined the effects of exercise on PTSD co-occurring conditions, and they provide more evidence for the beneficial effects of resistance exercise on anxiety and/or depression.

In addition to replicating the findings of the pilot study, the present study sought to bring further innovation to the field by exploring several potential mechanisms of action that may help explain the relationship between exercise and PTSD. The selected potential mechanisms were chosen in order to explore the applicability of our guiding theory (i.e., the Cross-stressor Adaptation Hypothesis). Among the potential mechanisms explored, it seems that how a person's perception of exercise changes over time may be a factor in how their PTSD responds to the exercise. For instance, changes in the cognitive appraisal of exercise, such as reappraising exercise as a challenge from a threat over the course of the study significantly predicted reductions in PTSD symptoms (i.e., total symptoms, intrusion symptoms and avoidance symptoms). To our knowledge, this is the first study to show evidence supporting the beneficial effects of the habituation to the stress of exercise on PTSD symptoms and supports our use of the Cross-stressor Adaptation Hypothesis.

The results also showed that perception of effort during exercise significantly predicted reductions in PTSD symptoms (i.e., total symptoms, hyperarousal, avoidance, and mood and cognitive symptoms). In other words, the harder the participants worked, the more their PTSD symptoms tended to reduce over the course of the study. This finding is supported by prior observational research, suggesting the strongest relationships between PTSD symptoms and exercise are for high intensity exercise (Harte et al., 2013; Whitworth, Craft, et al., 2017). When considering this finding with the cognitive appraisal results, there is strong support for the Cross-stressor Adaptation Hypothesis, which states that in order for habituation to occur, the exercise must first be sufficiently intense (Sothmann et al., 1996).

Finally, we also explored acute changes in affect, arousal, and distress over the course of the intervention. Most of the participants (i.e., 78.6%) consistently reported positive changes in affect and decreases in distress from exercise; however, over one fifth of the participants (i.e., 21.4%) reported the exact opposite. There was even more diversity in the arousal scores, suggesting a large variability in how the participants felt in response to the resistance training sessions. Unfortunately, none of these potential mechanisms were associated with changes in PTSD symptoms. This can likely be attributed to a number of reasons. First, the changes in affect can be short-lived and the effects may not have carried over into an extended period of time after the exercise sessions. Second, reductions in distress are typically associated with changes in PTSD symptoms, however, research has shown that a change in moment-to-moment distress is not a requirement for reductions in PTSD symptoms (Bluett, Zoellner, & Feeny, 2014). Third, given that all participants were sedentary and new to exercise, it is possible that a nine-session, three-week intervention was too brief a period of time to comfortably adapt to the exercise and have an impact on PTSD symptoms via these mechanisms. Overall, these exploratory findings should be interpreted with caution.

Study Limitations

As with any study, this study has limitations. The most prominent is the lack of a blinding during the assessments. Specifically, the baseline and follow-up assessments were conducted by the same individual who administered the intervention. As such, it is possible the results are affected by unintentional bias and should be interpreted with caution. Additionally, the small sample size is another important limitation. The goal was to recruit at least 40 participants; however, this proved to be a formidable challenge and took much more time and consumed far more resources than expected. This directly resulted in several underpowered analyses based on the power estimates calculated from our pilot research. For example, post-hoc power

analyses for hyperarousal and avoidance symptoms showed an achieved power of 55.6% and 26.3%. As such, there is still a need for large adequately powered randomized controlled trials to fully examine the relationships between PTSD and exercise.

Another potential limitation of this study is the use of a self-report measure (i.e., the PDS5) to screen for, and assess, PTSD symptoms rather than a diagnostic interview. While the PDS5 is a validated measure of PTSD symptoms, its use prevents us from determining whether the participants met a clinical level of PTSD. Nonetheless, a strength of this study is that it specifically targeted community individuals who were not connected with care, and in many cases had no interest in seeking conventional forms of treatment (e.g., medication or therapy).

Finally, the brief intervention duration is another potential limitation of this study. Specifically, a longer intervention may have produced larger or even different results. However, the current intervention was intended to be brief and a minimal commitment because if shown to be effective, it could be easily replicated and put into practice. Even though the duration of the intervention was only three weeks, special attention was paid to the dose of typical course of therapy (e.g., 9-12 sessions for a standard course of Prolonged Exposure therapy) (Powers, Halpern, Ferenschak, Gillihan, & Foa, 2010), and the present intervention consisted of 9-sessions. Importantly, recent research has shown condensed therapy (i.e., multiple sessions per week for fewer weeks) produces similar reductions in PTSD symptoms when compared to traditional therapy (i.e., a single session over the course of many weeks) (Foa et al., 2018).

Conclusion

In sum, this is the first theoretically based randomized attention-controlled trial to test the effects of high intensity resistance training on PTSD symptoms and its co-occurring conditions. It fills an important gap in the research, as most studies to date have been observational or focused only on aerobic exercise interventions. The results suggest that 9, 30-minute sessions of high intensity resistance training over the course of three weeks can reduce hyperarousal

symptoms and improve global sleep quality in anxious adults who screened positive for PTSD. Additionally, changes in the perception of exercise, such as perceived effort and cognitive appraisal may help to explain some of the observed effects of resistance training on PTSD. This study also clearly demonstrated the importance of using an attention-control, as this group had significant changes in several of the measured PTSD symptoms. Overall, the results are encouraging and support a beneficial effect of exercise on PTSD. For the future, more randomized attention-controlled studies are needed to verify these results and to test other components of exercise, such duration or frequency. Additionally, further examination of potential mechanisms of action will be extremely valuable, as a better understanding of why exercise can reduce PTSD symptoms will directly inform the development of future evidence-based interventions.

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APPENDIX A

MILITARY MEDICINE, 181, 9:953, 2016

Exercise and Post-Traumatic Stress Disorder in Military Veterans: A Systematic Review

James W. Whitworth, MA; Joseph T. Ciccolo, PhD

ABSTRACT Post-traumatic stress disorder (PTSD) is a prominent mental health issue for many military veterans. Recent evidence from nonveteran populations with PTSD suggests that exercise may be a potential treatment option. As such, the purpose of this review was to (1) provide the rationale for the use of exercise in the treatment of veterans with PTSD and (2) systematically review studies examining the relationship between exercise and PTSD in military veterans. A search of electronic databases (PubMed, PsycINFO, and Web of Science) for relevant studies published in print or online from January 1980 to September 2015 produced 204 unique articles and 13 relevant studies (9 observational studies, 2 experimental, and 2 qualitative). Results of these initial studies are promising and suggest that regular exercise is inversely correlated with PTSD and its symptoms in military veterans. However, the longitudinal effect of exercise on PTSD in military veterans remains unclear because the current research lacks a common focus and suffers from several methodological limitations. Recommendations for the development of future trials are included.

INTRODUCTION

Post-traumatic stress disorder (PTSD) is defined by the *Diagnostic and Statistical Manual of Mental Disorders* (DSM) as an Axis I disorder characterized by re-experiencing distressing memories or images of a traumatic event, accompanied by prolonged negative changes in affective state or mood, markedly increased arousal, and avoidance behaviors.[1] The prevalence of PTSD varies greatly across the globe. Large differences are observed from country to country and may be due in part to cultural differences, varying levels of economic development, and the presence of war or political upheaval.[2]

In the United States, it is currently estimated that 6.8% of adults aged 18 or older have PTSD.[3] PTSD is highly comorbid with a number of medical conditions, such as chronic pain,[4] major depressive disorder,[5] and substance use disorder (SUD).[5] In fact, individuals with PTSD are about 80% more likely to meet diagnostic criteria for another mental disorder than nonpathological populations.[1] PTSD has also been shown to be associated with an increased risk of suicidal ideation,[6] neurocognitive impairment,[7] and poor adherence to health behaviors (e.g., exercise).[8]

A major subgroup of those with PTSD is military personnel and veterans. These individuals are well known to have significantly higher rates and are at a greater risk than the general population for developing PTSD. For instance, a recent meta-analysis of military personnel from the United States, Canada, and the United Kingdom found that 12.9% of Iraq veterans had PTSD.[9] Unfortunately, the rates of treatment for veterans are low.[10] Evidence-based therapies, such as psychotherapeutic interventions and pharmacotherapies, are more successful in nonveteran populations, as veterans tend to have a blunted response to these treatments.[11] Furthermore, the dynamics of military culture have presented several barriers to treatment (e.g., stigma) that often prevent veterans with PTSD from seeking help from mental health professionals.[10]

Importantly, research suggests that engagement in health behaviors such as regular exercise may be beneficial for individuals with PTSD.[12] Furthermore, recent observational studies of nonveterans have shown individuals with PTSD engage in less planned exercise than those without PTSD.[8] Thus, the purpose of this review is to (1) provide the rationale for the use of exercise in the treatment of veterans with PTSD and (2) systematically review studies examining the relationship between exercise and PTSD in military veterans. Recommendations on the directions that this research might take to maximize benefits are also included.

RATIONALE FOR EXERCISE TRAINING

Exercise may be an ideal treatment or adjunct to treatment because it can positively affect many of the psychological and physiological symptoms and/or comorbid conditions specifically faced by military veterans with PTSD. The following sections discuss how exercise might be uniquely used to improve these conditions.

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Anxiety and Depression

Longitudinal research has shown that a majority (i.e., 74–80%) of military veterans with PTSD experience comorbid anxiety, depression, or both.[13] The effectiveness of exercise as a method to reduce each of these states is now well established. Specifically, a recent meta-analysis of randomized controlled trials revealed that exercise reliably produces a beneficial effect on state anxiety relative to control (Hedges' $g = 0.16$).[14] Similarly, exercise has been shown to have a beneficial effect on depression, as evidenced by a 2015 meta-analysis that found exercise to have a greater effect on depression than what is typically expected from antidepressants.[15] Finally, a recent review of exercise and stress suggests that regular exercise can reduce an individual's perception of stress, provide an effective coping mechanism, and improve overall mental health.[16]

Substance Use

The rates of substance use and SUD in military veterans with PTSD are extremely high.[5] Current evidence suggests that exercise may be an effective intervention for reducing substance use and treating SUD. The majority of work in this area has focused on cigarette smoking,[17] with more recent studies showing promise for other substances (e.g., alcohol, marijuana). It is theorized that exercise can help to reduce use or sustain abstinence via reductions in the most well-known predictors of use and relapse (e.g., negative affective states).[18] Other work has shown that exercise may reduce the likelihood of excessive use and the vulnerability to dependence.[19]

Pain

A great number of military veterans with PTSD also suffer from chronic pain.[4] Fortunately, exercise is known to have a hypoalgesic effect on pain. For example, a recent review of 83 randomized controlled trials found exercise therapy to be more effective than standard care at reducing pain, disability, and improving function for individuals with chronic low back pain.[20] Other research has long supported the use of exercise for acute pain, as reductions in pain perception, tenderness, and sensitivity have all been reported.[21]

Brain Structure and Function

Studies with military veterans have identified an association between PTSD and hypothalamic-pituitary-adrenal axis dysfunction,[22] reduced hippocampal volume,[23] and increased risk for neurocognitive decline.[7] Conversely, research has shown regular exercise to increase cognition,[24] improve attention and working memory,[25] and stimulate neurogenesis of the hippocampus.[26] Exercise has also been linked to elevations of brain-derived neurotrophic factor[27] and a reduction in the risk of premature neurocognitive decline.[25]

Barriers to Treatment

Despite the availability of effective treatments for PTSD, many military veterans report barriers to treatment, such as cost, access, and stigma.[28] As such, novel approaches to treatment that circumvent these barriers would be advantageous. Exercise may present a unique opportunity to reduce barriers to treatment because it can be done without the supervision of a mental health professional, and in many cases, requires minimal supervision or can be done at home. Moreover, exercise is something familiar to veterans given the physical fitness standards commonly found in military organizations. Exercise training also lends itself naturally to the logistic barriers, such as cost of treatment, scheduling, or transportation issues,[10,28] because it can be done at an individual's convenience, often at little or no cost.

RESEARCH ON EXERCISE AND MILITARY VETERANS WITH PTSD

A comprehensive search for articles published in print or online using electronic databases (PubMed, Web of Science, and PsycINFO) was conducted. The following search terms were used during the search: posttraumatic stress disorder, ptsd, post-traumatic stress disorder, exercise, exercise training, physical activity, physical inactivity, veterans, and military personnel. The search was limited to published studies conducted from January 1980 to September 2015. January 1980 was selected as the starting point because PTSD was first classified as a disorder in the DSM in 1980. The search

FIGURE 1. Flow diagram of search results.

TABLE I. Characteristics and Key Findings of Exercise and PTSD Studies in Military Veterans

Author, Year	Sample Size: Description	Mean Age (Years)	Study Design	PTSD Measure	Exercise Measure	Key Findings
Hamner and Hitri, 1992	18: 100.0% M, U.S. Veterans	23.9	Experimental	DSM-IIIR	None	During a maximal exercise test, veterans with PTSD produced significantly more beta-endorphins than those without PTSD
Buckley et al, 2004	826: 100.0% M, U.S. Veterans	51.7	Cross-Sectional	SCID-I, CAPS	Single-item measure	42.0% of the participants exercised 3 times a week for at least 20 minutes, although 26.0% exercised 1–2 days, and 33.0% reported no weekly exercise
Otter and Currie, 2004	14: 100.0% M, Australian Veterans	55.0	Qualitative	None	None	Participants reported reduced perceptions of stress and increase in activities of daily living, mental alertness, perceived health, social support, and motivation to be active
Arnson et al, 2007	55: 100.0% M, Israeli Veterans	49.7	Cross-Sectional	CAPS	Single-item measure	Physical functioning and bodily point tenderness were significantly better in regular exercisers than nonexercisers
Kozaric-Kovacic et al, 2009	478: 100.0% M, Croatian Veterans	PTSD 41.4; No PTSD 40.8	Cross-Sectional	ICD-10	Unspecified measure	Significantly more veterans without PTSD reported engaging in weekly exercise than those with PTSD (i.e., 48.8% vs. 27.9%)
Chwastiak et al, 2011	501,161: 95.9% M, U.S. Veterans	64.1	Cross-Sectional	ICD-9-CM	Single-item measure	6.2% of the sample had PTSD; PTSD was correlated with no weekly exercise, cigarette smoking, and obesity
LeardMann et al, 2011	38,883: 77.7% M, U.S. Veterans	Not Reported	Prospective	PCL-C	Modified 2001 NHIS	Vigorous exercise reduced the risk of developing new or having persistent symptoms
Davidson et al, 2013	346: 81.0% M, U.S. Veterans	45.5	Cross-Sectional	PCL-M	Single-item measure	PTSD symptoms were not correlated with exercise, but were with depression symptoms and sleep quality
Keller-Ross et al, 2014	39: 100.0% M, U.S. Veterans	33.0	Experimental	DSM-IV, PCL-C	PAQ	Veterans with PTSD fatigued faster and were more unstable during a handgrip task than those without PTSD
Talbot et al, 2014	736: 94.3% M, U.S. Veterans	PTSD 58.0; No PTSD 58.8	Prospective	CAPS	Single-item measure	Veterans with PTSD reported less exercise and worse sleep quality at baseline; baseline exercise and sleep quality were significant predictors of exercise at 1-year follow-up
Babson et al, 2015	217: 100.0% M, U.S. Veterans	52.2	Prospective	PCL-M	Total miles cycled	Exercise improved hyperarousal symptoms for veterans who had poor baseline sleep quality
Caddick et al, 2015	15: 100.0% M, British Veterans	Not Reported	Qualitative	None	None	Participants reported improved well-being, positive changes in affective state, and that recreational surfing served as a distraction from PTSD symptoms
Smith et al, 2015	735: 94.3% M, U.S. Veterans	58.5	Cross-Sectional	DSM-IV, CAPS	Single-item measure	Exercise was significantly associated with reduced odds of obesity in veterans with current and lifetime PTSD

DSM-IIIR, *Diagnostic and Statistical Manual of Mental Disorders, Third Edition, Revised*; ICD-9-CM, *International Classification of Diseases, 9th revision, Clinical Modification*; ICD-10, *International Classification of Diseases, 10th revision*; M, males; NHIS, National Health Interview Survey; PAQ, Physical Activity Questionnaire; SCID-I, Structured Clinical Interview for DSM-IV Axis I Disorders.

produced 204 unique articles, and 13 were identified as relevant on the basis of a review of the full text (Fig. 1). Studies were excluded if exercise (e.g., self-report or objectively measured) was not included as either an independent or dependent variable, the participants were not military veterans or did not have PTSD. The references of the identified articles were searched for any additional relevant articles. All of the studies were published in peer-reviewed journals. Characteristics of each study are highlighted in Table I.

Observational Research

Among the 13 relevant studies identified, 9 were observational. The focus within this group of studies varied, with the majority reporting on descriptives and correlates of PTSD and/or PTSD symptoms. In the sections below, studies are grouped by study design with a summary of each presented.

Cross-sectional Studies

In the first study to report on the relationship between PTSD and exercise, Buckley et al[29] examined high-risk (e.g., excessive alcohol consumption) and health (e.g., exercise) behaviors among a sample of treatment-seeking veterans. Data were collected from 826 cases during 1996–2002 from a Veteran Affairs (VA) PTSD clinic. PTSD was assessed using a Structured Clinical Interview for *DSM Fourth Edition* (DSM-IV) Axis I Disorders and the Clinician Administered PTSD Scale (CAPS). Exercise was measured using a single-item measure: "How often do you engage in physical activity which increases heart rate, causes you to breathe and/or sweat heavily, and is done for at least 20 minutes duration?" From this sample, 83.7% (691 cases) were found to have a primary diagnosis of PTSD. Descriptive analyses of the entire sample revealed that 42.0% exercised 3 times per week for a minimum of 20 minutes, although 26.0% exercised 1–2 days per week, and 33.0% did no exercise. A total of 45.0% of the sample were cigarette smokers and 36.5% had hazardous alcohol use. Unfortunately, the study did not report the differences in these variables among those with and without a PTSD diagnosis; however, it did provide an initial insight into the behaviors of this population.

A smaller study[30] uniquely investigated the relationship among PTSD, exercise, health-related quality of life, and fibromyalgia. Participants were 55 male Israeli veterans diagnosed with PTSD using DSM-IV criteria. Exercise was assessed with a single-item measure. A Hebrew version of the Short-Form Health Survey was used for health-related quality of life, and fibromyalgia was measured clinically using an 18-tenderpoint assessment. Participants were divided into three groups on the basis of the amount of exercise completed: regularly, infrequently, or none. The severity of PTSD was not significantly different among any of these groups. There were significant differences in the total Short-Form Health Survey score, as well as several of the subscales (e.g., physical function), with those who reported regular exercise scoring more favorably on the scale. Body-point tenderness was also significantly different among the three groups, with those reporting no exercise having the highest scores.

In another descriptive study, Kozaric-Kovacic et al[31] examined the relationship between body mass index (BMI) and lifestyle behaviors of male Croatian military veterans with and without PTSD. Data were collected on 478 participants (269 with PTSD and 209 without) during 2005 through 2008. Diagnostic criteria for PTSD were developed on the basis of *International Classification of Diseases, 10th revision*. Exercise was measured with an unspecified questionnaire, which dichotomized participants into those who reported any weekly exercise and those who reported none. Results showed that 27.9% of veterans with PTSD reported any exercise compared to 48.8% of veterans without PTSD. There were no observed group differences in BMI.

Chwastiak et al[32] examined the relationship among mental illness, exercise, cigarette smoking, and BMI using data collected from 501,161 respondents in the 1999 Large Health Survey of Veteran Enrollees. PTSD was defined as having had a primary or secondary PTSD diagnosis using the *ICD, 9th revision, Clinical Modification*. Exercise was measured using the following question: "How often do you engage in regular activities (e.g., brisk walking, jogging, bicycling) long enough to work up a sweat?" Responses ranged from never to 5 times per week, and these were dichotomized into regular exercise or none for the analysis. A total of 31,072 (6.2%) cases were identified as having PTSD. PTSD was found to be significantly and independently correlated with no weekly exercise, cigarette smoking, and obesity (i.e., BMI > 30 kg/m^2). PTSD was also associated with these three variables when all were simultaneously endorsed.

Davidson et al[33] tested the relationship among PTSD symptoms, exercise, depressive symptoms, sleep quality, and suicidality in 346 U.S. military veterans admitted to a VA 90-day residential rehabilitation program for PTSD. Data were collected via questionnaires and interview during treatment intake. PTSD symptoms were measured using the PTSD Checklist-Military Version (PCL-M) and exercise was assessed using the same single-item measure used by Chwastiak et al.[32] PTSD symptoms were not found to be correlated with exercise, but were with depression symptoms and sleep quality.

More recently, Smith et al[34] examined risk factors of obesity (e.g., sedentary lifestyle) in 735 U.S. military veterans with and without PTSD using the baseline data from the Mind Your Heart Study, a large cohort of U.S. military veteran outpatients. PTSD was assessed using the CAPS with DSM-IV criteria, and exercise was measured using a single-item scale that asked participants to rate how often in the past month they had spent 15–20 minutes being active. After

controlling for sex, ethnicity, antipsychotic medications, and depression, exercise was shown to reduce the risk of obesity in veterans with current and lifetime PTSD.

Longitudinal Studies

There were three prospective observational studies identified. In the first of these studies, LeardMann et al[35] examined the association between exercise and PTSD in a sample of 38,883 U.S. service members. Data from the Millennium Cohort Study, an ongoing study evaluating changes in health and behavior that may be related to military service, were used for this analysis. PTSD and its symptoms were assessed at two time points: baseline in 2001 and follow-up during 2004–2006. Both the DSM-IV criteria and the PTSD Checklist-Civilian Version (PCL-C) were used to assess PTSD. Exercise was not assessed at baseline, but was at the follow-up time point, using questions modified from the 2001 National Health Interview Survey. For the analysis, participants were dichotomously divided by whether or not they had PTSD symptoms at baseline, and then again subdivided on the basis of whether or not they had symptoms at follow-up. Exercise was categorized into aerobic exercise and strength training, and aerobic exercise was further divided into intensity (light/moderate or vigorous). Findings suggest that vigorously active participants with baseline symptoms were less likely to have persistent symptoms at follow-up. In addition, participants who reported no baseline PTSD symptoms who were vigorously active were also less likely of developing new symptoms.

In another study, Talbot et al[36] examined the relationship between PTSD, sleep quality, and exercise data from 736 U.S. military veterans enrolled in the Mind Your Heart Study, the same study as Smith et al.[34] PTSD, sleep quality, and exercise were assessed in person at baseline during the years 2008–2010, and exercise was reassessed at a 1-year follow-up by telephone. PTSD was measured using the CAPS, sleep quality was assessed using a single question taken from the Pittsburgh Sleep Quality Index, and exercise was measured using a single-item scale. Results showed that veterans with PTSD reported significantly less exercise and worse sleep quality at baseline. A regression analysis controlling for age and sex showed that baseline exercise and sleep quality were significant predictors of exercise at follow-up; however, baseline PTSD status was not.

Finally, Babson et al[37] examined the relationship between PTSD symptoms, sleep quality, and exercise in 217 male U.S. military veterans. Participants were patients of a VA residential PTSD treatment program, and all had the chance to participate in organized bicycling outings. PTSD symptoms were measured at intake and discharge using the PCL-M. Sleep quality was assessed only at intake using the full Pittsburgh Sleep Quality Index. Exercise completed was quantified as total miles cycled during the course of the participant's stay. Results showed that total miles cycled were not correlated with any PTSD symptom or sleep quality. However, further analysis showed that individuals who reported poor sleep quality at baseline and exercised during their stay had lower hyperarousal symptoms at post-treatment than those who did not report exercise.

Experimental Research

There were two experimental studies identified by the search. In the first, the effects of a single bout of aerobic exercise (i.e., maximal exercise test) on plasma beta-endorphin levels in veterans with and without PTSD were tested.[38] It was hypothesized that veterans with PTSD would have an elevated beta-endorphin response given previous research linking mental stress with increased endogenous opioids in those with PTSD. A total of 10 male Vietnam War veterans meeting the *DSM Third Edition, Revised* criteria for PTSD were compared with 8 age-matched apparently healthy veterans. There were no baseline differences in age or plasma beta-endorphin levels, nor were there differences in the heart rate, blood pressure, or exercise intensity achieved during the test. Posttest results showed that the participants with PTSD had a significantly larger increase in plasma beta-endorphin concentration from baseline to posttest when compared to the controls.

A more recent study by Keller-Ross et al[39] examined the effects of an acute cognitive stressor (i.e., a mental math test) on muscle fatigue and handgrip steadiness in males with PTSD. It was hypothesized that those with PTSD would fatigue more rapidly and would be less steady after the acute bout of stress. Participants were 18 veterans with PTSD (confirmed using DSM-IV criteria) and 21 controls (2 veterans) without PTSD. Results showed that individuals with PTSD did significantly worse on a handgrip task when compared to the controls (i.e., fatigued faster and were more unstable), but this outcome was not affected by the acute cognitive stressor.

Qualitative Research

Two qualitative studies were identified by the search. The first was conducted by Otter and Currie,[40] which evaluated the experiences of a group of 14 Australian Vietnam War veterans during and after their participation in a 40-week supervised aerobic exercise program. The program required participants to attend two 1-hour, low-to-moderate intensity sessions per week. Focus groups were used to collect data, with sessions conducted at weeks 10 and 25, and at the end of the intervention. Of the 14 participants, 5 self-reported being diagnosed with PTSD. Findings indicate that participants attributed a number of beneficial changes to participating in the program, including increase in activities of daily living (e.g., frequency, duration), mental alertness, perceived health, social support, and motivation to be active. Participants also reported reduced stress.

In the second qualitative study, Caddick et al[41] examined the effects of recreational surfing on PTSD in 15 British

combat veterans and 1 nonveteran. Participants engaged in a 3-week surfing camp, where they surfed and did yoga, meditation, and coastal walks. Data were collected from 2012 to 2013 in the form of interviews and direct participant observation. No formal diagnosis or assessment of PTSD was required for enrollment in this study; however, 10 of the participants reported being previously diagnosed with PTSD, and all of the participants self-identified as having PTSD. During follow-up interviews, the participants stated that surfing served as a meaningful distraction from the symptoms of PTSD. Additionally, they reported that participating in the surf camp improved their overall well-being and affective state.

DISCUSSION

To our knowledge, this is the first systematic review that describes the research on exercise and military veterans with PTSD. On the basis of the observational studies, it is likely that exercise is inversely correlated with PTSD and its symptoms, which is consistent with other observational research in nonveterans.[8] The longitudinal effect of exercise on veterans with PTSD is currently unclear, however, as each of the prospective studies identified suffers from at least one major methodological limitation. The experimental research conducted to date indicates that exercise might have unique effects in veterans with PTSD, which could be directly related to the physiological changes that typically occur with the disorder. Finally, the 2 qualitative studies suggest that veterans perceive sport and exercise to be helpful for coping with the symptoms of PTSD. Overall, the current research in military veterans is sparse, and it has considerable room for growth.

As this field continues to develop, it is important to build upon the strengths of the current research. For example, a significant strength among the identified studies is the assessment and identification of PTSD. All but two studies[40,41] assessed PTSD with either a validated instrument or clinical interview criteria. Unfortunately, such methodological rigor is often not present in other aspects of the research (e.g., the measurement of exercise). Another important strength in the current research is significant number of studies focusing on non-U.S. military veterans, specifically 4 of the 13 identified articles studied veterans with PTSD from outside the United States.[30,31,40,41] Such studies are essential for establishing the cross-culture generalizability, considering that the bulk of research on PTSD is conducted with U.S. military veteran samples.

In addition to building upon the strengths of the identified studies, future research must take caution to avoid the methodological pitfalls common in these preliminary studies. For instance, the most significant limitation of the research conducted to date is the reliance on medical chart data. This has produced a large body of observational work that is biased by samples of convenience. For example, seven of the nine observational studies collected their data from the medical charts of veterans at a VA hospital, and two of these used data that were or are being collected for a larger, longitudinal, government-sponsored trial. Although it is clear that VA hospitals are an ideal place to find veteran participants, there is a bias with respect to the data being derived from treatment-seeking veterans. Given the numerous personal and institutional barriers veterans face seeking out or receiving treatment,[10,28] it is unclear if the trends found in the current research represent the larger population of veterans with PTSD or a subsample of those engaged in care.

The current research is also hampered by the large number of cross-sectional studies. Of the nine observational studies, six were cross-sectional, preventing a clear understanding of the direction of the relationships found. For example, the reported inverse correlation between PTSD and exercise participation may be the result of veterans with PTSD choosing not to participate in exercise, or it could be that those who regularly exercise do not develop PTSD or experience PTSD symptoms. Of the three prospective studies identified, only Babson et al[37] assessed PTSD symptoms and exercise at more than one time point, and no relationship was found. As such, the longitudinal relationship between PTSD symptoms and exercise in veterans remains unclear.

Another major limitation of the current research is the lack of objective exercise measurement, and the common use of a single-item, self-report questionnaire that has not been validated. Only one of the studies identified by the search used an objective measure to assess exercise and only one used a validated self-report measure. Relying on unvalidated, single-item measures is clearly problematic, particularly when there are known weaknesses even when using validated measures.[42]

Finally, the primary outcomes of the research conducted to date have been diverse. Of the 13 studies identified, the purpose of three of them was to examine PTSD and several different behaviors (e.g., alcohol consumption), rather than specifically targeting PTSD and exercise. This is in addition to three of the studies that did target exercise and PTSD or PTSD symptoms, but only in relation to other variables, such as fibromyalgia[30] and suicidal tendencies.[33] The two experimental studies examined exercise as an independent variable, but these were separated by 22 years and focused on widely different outcomes.

Recommendations for Future Research

Although the research examining the role of exercise in this area is currently equivocal, there is a sufficient amount of evidence to suggest that a beneficial relationship between exercise and PTSD exists. Overall, there is a clear rationale to examine exercise as a tool for PTSD symptom management (e.g., depression, anxiety), especially given that exercise has recently been shown to reduce PTSD symptom severity in nonveteran adults with PTSD.[43] Moreover, other studies of disabled veterans have shown recreational

physical activity to be beneficial for overall well-being,[44] suggesting that similar effects could also occur in military veterans with PTSD.

In addition, there are numerous other opportunities for research relating to exercise and PTSD in military veterans. For example, given the high rates of comorbid SUD in this population, this type of work should also be extended to examine the effects of exercise on substance use in military veterans with PTSD. The therapeutic effect of exercise on chronic pain and pain management also needs to be investigated, as military veterans with PTSD often report chronic pain.[4] The changes in cognition, hypothalamic-pituitary-adrenal axis function, and hippocampal volume shown to occur in military veterans with PTSD may also be affected by exercise and should therefore be examined. In addition, two of the reviewed studies found that exercise participation was associated with a reduced risk of having PTSD.[31,32] These findings support a role for exercise in the prevention of PTSD; however, both studies were cross-sectional in design, preventing such a determination. As such, additional studies exploring the longitudinal effects of exercise on trauma-exposed veterans with subclinical post-traumatic stress symptoms would be particularly meaningful. Finally, exercise may be uniquely suited for reducing barriers to treatment (e.g., stigma) in military veterans with PTSD, as many do not seek mental health treatment because of a fear of social consequences.[10,28] Exercise is a familiar and valued behavior among military veterans[45]; thus, this is an important new area to investigate.

In conclusion, the results of the first studies to investigate the relationship between exercise and PTSD in military veterans are promising. However, it is critical to conduct more high-quality observational and intervention research to move the field forward. Specifically, researchers should consider the following when designing future studies: (1) the current body of research has relied heavily on convenience sampling. Efforts to recruit veterans not currently seeking treatment within the VA system are critical to ensure results are generalizable. (2) Longitudinal observational studies that measure both PTSD and exercise at multiple time points are needed to determine the directionality of the inverse association reported by the current research. (3) To improve reliability and validity, future work should ensure that exercise is measured objectively or by a validated questionnaire. (4) Randomized controlled trials are needed to establish the effect of key components of exercise (i.e., frequency, intensity, and mode) on PTSD and its symptoms before strong and generalizable recommendations for an exercise prescription can be made.

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APPENDIX B

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Exercise behavior and gender-related differences in posttraumatic stress disorder symptoms

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ABSTRACT

Objectives: Exercise has been proposed as a potential treatment for posttraumatic stress disorder (PTSD). However, the relationship between exercise, gender, and PTSD symptoms is unknown.
Design: This study examined the cross-sectional relationship among these variables in a national sample of 165 men and women who screened positive for PTSD.
Method: Participants completed an online survey consisting of the Godin Leisure-Time Exercise Questionnaire and the PTSD Checklist-Civilian.
Results: Active participants had significantly lower PTSD symptoms than insufficiently active participants. Significant interactions between gender and exercise for PTSD symptoms were found, such that active men had significantly lower PTSD symptoms than active women, and insufficiently active men and women. Additionally, strenuously active men reported significantly lower hyperarousal symptoms than strenuously active women, and insufficiently active men and women.
Conclusion: Findings suggest that the relationship between PTSD and exercise may differ for specific subpopulations of individuals with PTSD, such as men and women.

1. Introduction

Posttraumatic stress disorder (PTSD) is a mental disorder that affects about 5% of men and 10% women in the United States (Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995). Its disabling symptoms include re-experiencing (e.g., flashbacks), avoidance behaviors, hyperarousal, and mood symptoms, such as negative affect (American Psychiatric Association, 2013). There are several effective treatments for PTSD, including psychotherapy and medication (Watts et al., 2013), however, the rates of use are low. For example, only about a third of individuals with PTSD seek treatment from a healthcare professional (Kessler et al., 2005; Madsen, Andersen, & Karstoft, 2016), often because of barriers to treatment such as stigma, the fear of negative social consequences, cost, and/or access to care (Kantor, Knefel, & Lueger-Schuster, 2017).

In addition, although PTSD has been shown to contribute to physical inactivity (Winning et al., 2017), exercise has recently been proposed as a possible treatment or treatment adjunct for PTSD (Whitworth & Ciccolo, 2016) given its well-known beneficial effects on negative mental health states (Ekkekakis, 2015; Herring, O'Connor, & Dishman, 2010). This is supported by several large cross-sectional studies that have repeatedly shown exercise to be inversely correlated to PTSD and its co-occurring conditions. More specifically, exercise has consistently been found to be inversely correlated with a PTSD diagnosis (Chwastiak, Rosenheck, & Kazis, 2011) and its symptoms, such as poor sleep quality (Talbot, Neylan, Metzler, & Cohen, 2014) and co-occurring depressive symptoms (Rutter, Weatherill, Krill, Orazem, & Taft, 2013). There is also emerging evidence supporting an inverse relationship between exercise participation and the severity of PTSD symptoms. For instance, regular participation in strenuous intensity exercise has been shown to be longitudinally associated with reductions in PTSD severity over time (Whitworth, Craft, Dunsiger, & Ciccolo, 2017). Additionally, exercise participation has been shown to be inversely associated with hyperarousal and avoidance symptoms in individuals who have experienced a traumatic event (Harte, Vujanovic, & Potter, 2013; Vujanovic, Farris, Harte, Smits, & Zvolensky, 2013).

The proposed beneficial relationship between exercise participation and PTSD symptoms is also theoretically supported by the

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Cross-Stressor Adaptation Hypothesis (Sothmann et al., 1996). Specifically, repeated exposure to a stressor, such as exercise for a sufficient intensity and duration can lead to adaptations in the stress response system. Further, these adaptations may lead a reduction in negative cognitive appraisals in response to a stressor (e.g., a reduction in PTSD symptoms).

Despite the growing amount of observational research in the field of PTSD and exercise, several important areas need further research. For instance, given the increased risk of PTSD for military personnel (American Psychiatric Association, 2013), a majority of the current studies have specifically targeted treatment seeking veterans, and by proxy, men (Chwastiak et al., 2011; LeardMann, Kelton, Smith, Littman, & Boyko, 2011). Additionally, other studies have purposefully excluded individuals with a current or past diagnosis of axis-1 psychological disorders in order to better understand the relationship between exercise and PTSD. However, these studies lack generalizability to other at-risk populations, such as women, non-treatment seeking individuals, or those who have a history of mental illness. This is an important shortcoming of the current research because it is not likely to be representative of the typical adult with PTSD, who is most likely to be female with co-occurring conditions (e.g., depression) (Sareen, 2014), and is less likely to engage in treatment (Kantor et al., 2017).

The above issues are further compounded by a lack of scientific rigor applied to the measurement of exercise. For instance, most studies have not used a validated measure of exercise. In fact, the most common practice has been to use an unvalidated single-item questionnaire that only assesses exercise frequency (Whitworth & Ciccolo, 2016), leaving out other important components of exercise dose, such as intensity and total exercise volume. Importantly, the intensity of exercise is known to have a meaningful psychological impact (e.g., changes to affective valence) even after a single session of exercise (Ekkekakis, Parfitt, & Petruzzello, 2011). As such, the lack of studies measuring exercise dose variables beyond frequency has therefore created a major gap in the current literature.

Overall, more work is needed in this area, as the limitations of the current research reduce the generalizability of the reported findings and prevent a rigorous examination of the relationship between PTSD symptom severity and exercise participation. This is particularly problematic for determining any relationship that might exist or differ among certain sub-populations, such as men and women or those with a history of psychiatric illness. Therefore, the purpose of this study was to overcome limitations of previous research on exercise and PTSD by examining the relationship between PTSD symptoms (i.e., re-experiencing, avoidance/numbing, and hyperarousal), gender, and exercise dose (i.e., frequency, intensity, and total volume) in a national sample of adults who screened positive for PTSD.

2. Methods

2.1. Procedures

This study used a cross-sectional design. Potentially interested individuals were recruited through online-classified listings (e.g., Craigslist) and social media, such as Facebook and Twitter from each of the major US regions (i.e., Northeast, South, West, and Midwest). The listings sought to recruit individuals who were currently bothered by a previous traumatic life event. However, PTSD or other psychological disorders were not specifically mentioned in the recruitment materials in order to encourage those without a formal diagnosis to participate. Each listing provided a link to the study's informed consent, where the consenting participants were redirected to an online survey. All participants completing the survey were entered into a raffle to win a $50 gift card. The odds of winning were 1 in 25. The study was approved by the University's Institutional Review Board. All data were collected between May and August 2015.

2.2. Participants

To be eligible, participants needed to be living in the United States with access to the Internet. All had to be at least 18 years old, read English, report experiencing a traumatic life event (e.g., sexual assault, violent crime, natural disaster, military combat), and screen positive for PTSD (see PTSD screening and symptoms below for details).

2.3. Measures

Demographic questionnaire. This questionnaire assessed participant age, gender, race/ethnicity, education, income, military veteran status, physical disability status, and history of psychiatric illness.

Self-reported exercise. The Godin Leisure-Time Exercise Questionnaire (GLTEQ; Godin & Shephard, 1985) was used to measure the amount of self-reported leisure-time exercise done in a typical week. Respondents were asked to indicate how many times in a typical week they participated in 15 min or more of minimal effort (e.g., easy walking), moderate (e.g., resistance training), and strenuous (e.g., vigorous running or cycling) exercise. For scoring, the frequency of minimal effort, moderate, and strenuous exercise was multiplied by 3, 5, and 9 metabolic equivalents, respectively. After scoring the individual intensities, moderate and strenuous intensity exercise were also summed to represent total leisure-time exercise (Godin, 2011). Higher scores on the GLTEQ represent greater exercise participation, and for interpretation, a cut-off score of 24 was used to determine if an individual was likely to be meeting the national physical activity guidelines of $\geq$150 min of moderate-to-vigorous weekly physical activity (Amireault & Godin, 2015; Garber et al., 2011). Specifically, participants scoring a 24 or more on moderate or strenuous intensity exercise independently, or through a combination of moderate and strenuous intensity exercise (i.e., total leisure-time exercise) were likely to be meeting the guidelines and considered to be "active". Thus, those scoring less than a 24 were not likely to be meeting the recommendations and considered "insufficiently active". The GLTEQ has been shown to be a reliable and valid measure of total leisure-time exercise, and exercise done at strenuous, moderate, and minimal intensities (Amireault & Godin, 2015; Godin & Shephard, 1985).

PTSD screening and symptoms. The PTSD Checklist-Civilian corresponding to the DSM-IV (PCL-C) was used to screen for PTSD, and to measure the severity of PTSD symptoms in the past month (Weathers, Litz, Herman, Huska, & Keane, 1993). The PCL-C is a 17-item, 5-point self-report scale that asks individuals to rate their PTSD symptoms from "Not at all" to "Extremely". Total scores range from 17 to 85, with higher scores indicating worse PTSD symptoms. Additionally, each of the items on the PCL-C corresponds with specific PTSD symptoms (i.e., re-experiencing, avoidance/numbing, and hyperarousal). Specific scores for the re-experiencing, avoidance/numbing, and hyperarousal symptom clusters range from 5 to 25, 7 to 35, and 5 to 25 respectively. The PCL-C is a reliable and valid measure of PTSD and strongly correlates with the gold standard measure of PTSD (i.e., Clinician Administered PTSD Scale; Blanchard, Jones-Alexander, Buckley, & Forneris, 1996). Importantly, the PCL-C has been shown to be reliable when administered via computer (Campbell et al., 1999). Given that participants were recruited from the general population, a recommended cut-point total score of 30 was used to indicate a positive screening for PTSD (Walker, Newman, Dobie, Ciechanowski, & Katon, 2002).

3. Data analysis

Descriptive statistics are presented as mean ± standard deviation for continuous variables, and percentages for categorical variables. Potential differences in PTSD symptoms were examined by gender and activity status using two-way analysis of covariance. PTSD symptoms were defined as the dependent variable, while gender and activity status were defined as independent variables. Exercise engagement was examined as a bivariate variable (i.e., active or insufficiently active) for total leisure-time exercise, strenuous, moderate, and minimal intensity exercise. In all analyses, age, race/ethnicity, income, education, physical disability status, and history of psychiatric illness were controlled for as potential confounds. All analyses were conducted using IBM SPSS 21, and statistical significance was set *a priori* at $p < 0.05$.

4. Results

A total of 234 individuals expressed interest in the study. Of these, 39 declined to participate, and an additional 30 participants screened negative for PTSD, leaving a final sample of 165. These 165 participants consisted of 44 men and 121 women ages 19–59. Additionally, a majority of the participants reported living in the Northeast (66.1%) or the South (21.1%), with fewer participants from the West (8.5%), and Midwest (4.2%). Demographic data for the entire sample is reported in Table 1. The mean total leisure-time exercise score for the aggregate sample was 23.0 ± 25.8. The scores for strenuous, moderate, and minimal intensity exercise were 13.4 ± 19.6, 9.6 ± 11.6, and 9.4 ± 9.0 respectively. Additionally, 42.5% of women were classified as being active according to their total leisure-time exercise score (i.e., ≥24 on the GLTEQ), while 25.0%, 15.8%, and 5.8% were classified as being active from strenuous, moderate, and minimal intensity exercise scores respectively. For men, 45.2% were classified as active from their total leisure-time exercise score, 38.1% from strenuous intensity, and 11.9% and 9.3% were considered active from their moderate and minimal intensity exercise scores respectively. The mean total PTSD symptom score was 57.5 ± 14.5. Mean scores for individual symptoms were 16.8 ± 5.0 for re-experiencing, 23.5 ± 6.6 for avoidance/numbing, and 17.2 ± 5.0 for hyperarousal.

Table 1
Demographic characteristics of men and women screening positive for PTSD (n = 165).

Characteristic	
Age (stdev)	33.7 (11.3)
Body Mass Index (stdev)	26.2 (6.3)
	n (%)
Gender	
Men	44 (26.7)
Women	121 (73.3)
Race	
American Indian/Alaskan Native	7 (4.2)
Asian	12 (7.3)
Black/African American	14 (8.5)
White	118 (71.5)
Other	14 (8.5)
Ethnicity	
Hispanic	17 (10.3)
Non-Hispanic	148 (89.7)
Education	
High school or less	18 (10.9)
Vocational school or some college	57 (34.5)
College graduate	90 (54.5)
Annual household income	
<$15,000	47 (28.5)
$15,001-$40,000	41 (24.8)
$41,001-$80,000	39 (23.6)
>$80,001	26 (15.8)
Unsure	12 (7.3)
Military Veteran	25 (15.2)
Active Military/Law Enforcement	13 (7.9)
Other first responder/Fire/EMT	4 (2.4)
Physical Disability	26 (15.8)
History of psychiatric disorder	
PTSD	93 (56.4)
Depression	98 (59.4)
Anxiety	88 (53.3)
Alcohol use disorder	15 (9.1)
Substance use disorder	8 (4.8)
Bipolar Disorder	21 (12.7)
Schizophrenia	8 (4.8)
Other	14 (8.4)

4.1. Total leisure-time exercise by PTSD symptoms

When comparing total PTSD symptoms of the sample by total leisure-time exercise and gender, active men and women had significantly lower mean total PTSD symptoms relative to insufficiently active men and women (55.0 ± 14.4 vs. 60.4 ± 14.1; $F = 5.77$, $p = 0.018$, $\eta^2 = 0.04$). In addition, there was a significant interaction between gender and total leisure-time exercise for total PTSD symptoms ($F = 5.01$, $p = 0.027$, $\eta^2 = 0.04$; see Fig. 1), such that active men had significantly lower total PTSD symptoms than insufficiently active men (49.0 ± 13.3 vs. 65.2 ± 12.5; $F = 7.12$, $p = 0.009$, $\eta^2 = 0.05$) and active women (49.0 ± 13.3 vs. 57.4 ± 14.3; $F = 4.73$, $p = 0.031$, $\eta^2 = 0.03$). Insufficiently active men and women did not significantly differ ($F = 0.95$, $p = 0.332$). The model $R^2 = 0.275$, with covariates contributing to about 23% of the variance.

Additionally, active men and women had significantly less avoidance/numbing (22.6 ± 6.5 vs. 24.9 ± 6.3; $F = 4.84$, $p = 0.029$, $\eta^2 = 0.03$) and hyperarousal (16.3 ± 4.7 vs. 18.1 ± 4.9; $F = 5.77$, $p = 0.018$, $\eta^2 = 0.04$) symptoms than insufficiently active men and women. Importantly, there were no gender differences in avoidance/numbing ($F = 0.11$, $p = 0.743$) and hyperarousal symptoms

Fig. 1. Differences between men and women by activity status using total leisure-time exercise for PTSD symptoms. PTSD scores are reported as adjusted means with error bars representing standard error. Active men reported significantly lower total PTSD symptoms than active women, and insufficiently active men and women. $n = 165$, $^*p < 0.05$.

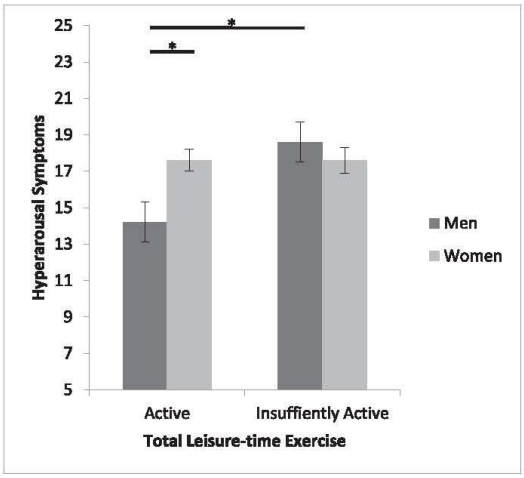

Fig. 2. Differences between men and women by activity status using total leisure-time exercise for hyperarousal symptoms. PTSD scores are reported as adjusted means with error bars representing standard error. Active men reported significantly less hyperarousal symptoms than active women, and insufficiently active men and women. $n = 165$, $^{*}p < 0.05$.

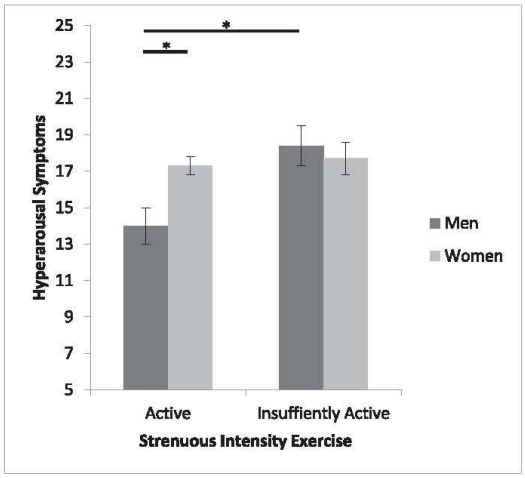

Fig. 3. Differences between men and women by activity status using strenuous intensity exercise for PTSD hyperarousal symptoms. PTSD scores are reported as adjusted means with error bars representing standard error. Active men reported significantly lower hyperarousal symptoms than active women, and insufficiently active men and women. $n = 165$, $^{*}p < 0.05$.

($F = 1.74$, $p = 0.190$). However, there was a significant interaction between gender and total leisure-time exercise for hyperarousal symptoms ($F = 6.37$, $p = 0.013$, $\eta^2 = 0.04$; see Fig. 2). Pairwise comparisons revealed that insufficiently active men and women did not differ significantly for hyperarousal symptoms ($F = 0.753$, $p = 0.387$), but active men had significantly lower hyperarousal symptoms than both insufficiently active men (13.7 ± 4.3 vs. 19.6 ± 4.0; $F = 8.00$, $p = 0.005$, $\eta^2 = 0.06$) and active women (13.7 ± 4.3 vs. 17.3 ± 4.5; $F = 7.15$, $p = 0.008$, $\eta^2 = 0.05$). The avoidance/numbing model $R^2 = 0.256$, with 23% of the shared variance accounted for by the covariates. Additionally, the hyperarousal model $R^2 = 0.207$, with covariates accounting for 15% of the variance. There were no significant differences in re-experiencing symptoms ($F = 2.36$, $p = 0.127$) or interactions between gender and total leisure-time exercise ($F = 2.58$, $p = 0.110$).

4.2. Strenuous intensity exercise by PTSD symptoms

When comparing total PTSD symptoms of the sample by total strenuous intensity and gender, there were significant differences in total PTSD symptoms and hyperarousal symptoms. Specifically, strenuously active men and women had significantly less total PTSD symptoms (53.6 ± 14.5 vs. 59.9 ± 14.1; $F = 4.61$, $p = 0.034$, $\eta^2 = 0.03$) and hyperarousal symptoms (15.6 ± 4.8 vs. 18.0 ± 4.8; $F = 6.22$, $p = 0.014$, $\eta^2 = 0.04$) than insufficiently active men and women. Also, there was a significant interaction between gender and strenuous exercise for hyperarousal symptoms ($F = 4.65$, $p = 0.033$, $\eta^2 = 0.03$; see Fig. 3). Similar to the above, insufficiently active men and women did not differ significantly by hyperarousal symptoms ($F = 0.35$, $p = 0.553$), but active men had significantly lower hyperarousal symptoms than both insufficiently active men (13.9 ± 4.5 vs. 18.9 ± 4.5; $F = 7.82$, $p = 0.006$, $\eta^2 = 0.05$) and active women (13.9 ± 4.5 vs. 16.6 ± 4.7; $F = 5.20$, $p = 0.024$, $\eta^2 = 0.04$). The model $R^2 = 0.207$ with 15% of the variance explained by covariates. There were no significant differences in re-experiencing symptoms ($F = 2.36$, $p = 0.127$) or interactions between gender and strenuous intensity exercise ($F = 0.11$, $p = 0.743$). Similarly, there were no significant differences in avoidance/numbing symptoms ($F = 2.50$, $p = 0.116$) or interactions ($F = 2.74$, $p = 0.100$).

4.3. Moderate intensity exercise by PTSD symptoms

No significant differences were found in total PTSD symptoms for moderate intensity exercise ($F = 0.10$, $p = 0.757$), nor were there any significant interactions between moderate intensity exercise and gender for total PTSD symptoms ($F = 0.06$, $p = 0.801$).

4.4. Minimal intensity exercise by PTSD symptoms

There were no significant differences found in total PTSD symptoms for minimal intensity exercise ($F = 0.02$, $p = 0.882$). Additionally, there was no significant interaction between gender and minimal intensity exercise for total PTSD symptoms ($F = 0.10$, $p = 0.755$).

5. Discussion

This is the first study to examine the relationships between gender, PTSD symptoms, and components of exercise dose (i.e., frequency, intensity, total volume) in a national sample of men and women who screened positive for PTSD. As expected, active individuals reported significantly less PTSD symptoms than insufficiently active individuals. However, the key findings of this study suggest several gender-related differences in PTSD symptoms based on exercise participation. Specifically, there was a significant interaction between gender and total leisure-time exercise (i.e., the summation of strenuous and moderate exercise) demonstrating that active men had significantly lower total PTSD symptoms than active women, and insufficiently active men and women. Importantly, this interaction only remained significant for hyperarousal symptoms when total PTSD symptoms were subdivided into the individual symptom clusters.

Additionally, when exercise was examined by intensity, there was a significant interaction between gender and strenuous intensity exercise for hyperarousal symptoms, such that active men had significantly lower symptoms than active women, and insufficiently active men and women. Importantly, there were no additional significant differences or interactions found for moderate or minimal intensity exercise. As such, these data suggest that the relationship between specific PTSD symptoms (i.e., hyperarousal symptoms), and exercise intensity differs among subpopulations, such as men and women.

These results were initially unexpected. However, gender differences in the prevalence (Pietrzak, Goldstein, Southwick, & Grant, 2011) and severity of PTSD (Hourani, Williams, Bray, & Kandel, 2015) have been reported. Research has also shown that there may be meaningful differences between men and women for treatment responses and recovery (Voelkel, Pukay-Martin, Walter, & Chard, 2015). To our knowledge, this is the first study to provide evidence supporting gender differences in the relationship between PTSD and exercise. One possible explanation for these differences is exercise preferences. Specifically, recent investigations of exercise interest and preferences of individuals with depression (Busch et al., 2015) and substance use disorders (Abrantes et al., 2011) have shown that more men prefer strenuous intensity exercise than women. Moreover, a large cohort study of military veterans and personnel (i.e., 78% male) reported a significant inverse correlation between regular strenuous intensity exercise and PTSD symptoms (LeardMann et al., 2011).

In addition to the novel findings reported above, this study moves the field forward in two meaningful ways. First, this study sought to increase external validity by avoiding convenience samples commonly used in prior observational studies (e.g., treatment-seeking veterans). Instead, these data represent nationally recruited men and women who screened positive for PTSD. Recruitment was accomplished outside of the hospital setting, allowing both treatment and non-treatment seeking individuals to participate. This is critical given that the underuse of mental health services is a well-known issue in the treatment of PTSD (Kantor et al., 2017). As such, the results of this study are more generalizable than much of the prior observational work in this field. Second, exercise was measured using the GLTEQ, a reliable and validated self-report instrument of total exercise volume, and exercise intensity (Godin & Shephard, 1985). The use of validated measures of exercise is necessary for reliably establishing the relationship between PTSD symptoms and components of exercise dose, as well as allowing for more meaningful between study comparisons.

Despite these strengths, this study is not without its limitations. For instance, all data were collected online by self-report. This limits the assessment of PTSD status to a positive/negative screening vs. a clinical interview to determine an actual diagnosis. However, the screening tool used in this study (i.e., the PCL-C) has strong psychometric properties and can be reliably administered electronically (Blanchard et al., 1996; Campbell et al., 1999). Regarding exercise, there are known limitations when measuring exercise by self-report (Sallis & Saelens, 2000); however, given that participants were recruited nationally, objective measurement of exercise behaviors was not feasible for this study. Additionally, online data collection limited participation to individuals who had access to the internet, and increased the chances of duplicate responses from a single participant. To minimize duplicate responses, we blocked multiple responses from the same IP address and required participants to provide a valid email address.

Finally, this study used a cross-sectional design, which prevents any directional interpretations of these results. Thus, it is possible that individuals with worse PTSD symptoms are more likely to avoid participating in exercise than those with less severe symptoms. Specifically, the overlap between the physical sensations of strenuous exercise and hyperarousal symptoms (e.g., increased breathing, heart rate, sweating) may cause individuals with higher hyperarousal symptoms to avoid strenuous exercise. Alternatively, it is also possible that regular strenuous intensity exercise may have a therapeutic effect on PTSD. For instance, as posited by the Cross-Stressor Adaptation Hypothesis, regular exposure to the physical stressors of exercise, may lead to adaptations in the stress response system, allowing for an improved response to other non-exercise stressors, such as PTSD symptom triggering stimuli (Sothmann et al., 1996).

Importantly, recent longitudinal studies of PTSD symptoms and exercise behavior have found evidence supporting both directions. For example, a study by Winning et al. (2017) found that worsening PTSD symptoms longitudinally predicted decreases in physical activity. In contrast, Whitworth et al. (2017) found that individuals who regularly engaged in exercise experienced less PTSD symptoms over time. As such, it is important to consider the possibility of a bidirectional relationship between PTSD and exercise. One where exercise engagement may both beneficially affect PTSD symptoms, and be inhibited by the disabling effects of the disorder. Further examination of the mechanisms of these relationships is clearly needed.

6. Conclusion

The results of this study suggest that the relationship between PTSD symptoms and exercise is more complex than previously reported. Specifically, this study demonstrates that the relationship between exercise and PTSD symptoms may be different for men and women. As such, it is recommended that future observational research continue to explore potential differences in the relationship between exercise dose and PTSD symptoms by gender and in specific sub-populations (e.g., military veterans/non-veterans, and treatment seeking/non-treatment seeking individuals). This research will be essential in the development of targeted exercise interventions for future experimental trials.

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APPENDIX C

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Research paper

Direct and indirect effects of exercise on posttraumatic stress disorder symptoms: A longitudinal study

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ABSTRACT

Objective: Emerging evidence suggests that exercise may have beneficial effects on posttraumatic stress disorder (PTSD), and that this relationship may be indirectly affected by sleep, pain, and alcohol/substance use. The present study examined the longitudinal direct and indirect effects of exercise on PTSD symptoms.
Method: A national sample of 182 individuals, screening positive for PTSD, completed online assessments of PTSD symptoms, exercise behavior, psychological distress, sleep quality, and alcohol/substance use at baseline and three-month follow-up.
Results: There were direct effects of strenuous intensity exercise on avoidance/numbing ($b = -2.18$, $SE = 1.12$, $p = 0.05$) and hyperarousal symptoms ($b = -1.87$, $SE = 0.82$, $p = 0.03$); and direct effects of total exercise on avoidance/numbing symptoms ($b = -1.76$, $SE = 0.94$, $p = 0.05$). Strenuous intensity exercise was indirectly associated with total PTSD symptoms (ab = −2.53, 95% CI: −5.72 to −0.38), avoidance/numbing (ab = −0.99, 95% CI: −2.43 to −0.05), and hyperarousal symptoms (ab = −0.78, 95% CI: −1.88 to −0.07) through sleep, while total exercise was indirectly associated with total PTSD symptoms through alcohol use (ab = 0.32, 95% CI: 0.18–1.42).
Conclusion: Findings suggest that exercise has a complex, longitudinal, and beneficial association with PTSD symptoms. Future studies should continue to examine this relationship and any direct and indirect effects exercise may have on PTSD and its related conditions.

1. Introduction

The beneficial effects of exercise on many psychological disorders are well established. For instance, a recent meta-analysis demonstrated that exercise has a large effect (i.e., standardized mean difference = −0.90) on depression [12]; larger in fact, than what is typically expected from pharmaceutical interventions [14]. Similarly, exercise has been shown to have a beneficial effect on anxiety (i.e., standardized mean difference = −0.58) [33], and research even supports exercise participation as an effective coping strategy for stress [34]. Despite the recent advances in this area, the effects of exercise on less prevalent mental health disorders are largely unknown.

Posttraumatic stress disorder (PTSD) is one such disorder. Defined by the Diagnostic and Statistical Manual of Mental Disorders (DSM) as a trauma and stressor-related disorder [2], PTSD is estimated to affect between 6% and 9% of adults in Canada and the US [31]. While the field of PTSD and exercise is still developing, there is strong theoretical support for a beneficial relationship between PTSD and exercise. For example, the Cross-stressor Adaptation Hypothesis posits that participation in regular exercise of sufficient intensity and duration will lead to habituation to the stressors of exercise, such as rapid breathing, increased heart rate, and arousal. This in turn can cause adaptations in the stress response system, and potentially improved responses to non-exercise related stressors (e.g., trauma-related stimuli) [32].

Further support for a beneficial relationship between exercise engagement and PTSD can be found in the exercise research on conditions that commonly co-occur with PTSD. For example, exercise has been shown to reduce bodily pain [36], improve sleep quality [1], and alter substance use patterns [39]. Additionally, exercise can be done at little or no cost, when it is convenient for the individual, and in various environments (e.g., at home, in public spaces). This is particularly helpful, as there are several well-known barriers that prevent individuals with PTSD from seeking treatment, such as stigma, cost, and access to care [27].

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Currently, there are a growing number of studies seeking to explore the relationship between exercise and PTSD. The majority of the research in this area has been observational in design, with only two randomized controlled trials conducted to date [28,30]. The two controlled trials suggest that exercise, when paired with psychotherapy, produces greater reductions in PTSD symptoms than psychotherapy alone. The results from the observational studies have shown that exercise participation is inversely associated with both a PTSD diagnosis [11] and PTSD symptoms [24]. For example, in a recent longitudinal study, Winning et al. [43] showed that the onset of PTSD symptoms after experiencing a trauma longitudinally predicted decreases in physical activity, suggesting that PTSD may be a risk factor for physical inactivity. Other research among those with PTSD indicates that physical inactivity is associated with poor sleep quality [35] and chronic pain [6]; and a prior study reported that physically active trauma-exposed individuals with possible PTSD were less likely to use alcohol-based coping strategies than those who were less active [26].

Despite these promising findings, the research to date has several important limitations that have informed the design of the present study. For instance, most studies have been cross-sectional, and, there have been few longitudinal observational studies to date. Additionally, a recent review of PTSD and exercise research found that few studies have evaluated exercise behavior with a validated instrument. In fact, the components of exercise dose beyond frequency (e.g., intensity, volume) have rarely been measured [42]. This review also highlighted the fact that many studies have relied heavily on samples of individuals connected to healthcare, such as using the medical record data of military veterans. This is particularly problematic because a significant proportion of individuals who have or screen positive for PTSD are not enrolled in care or do not seek out help [13]. Additionally, the relationship between exercise and PTSD among those with other mental health conditions is not clear. In an effort to better describe exercise and PTSD symptoms, studies have purposely excluded individuals with a history of mental illness. This has severely limited the generalizability of results, given the high prevalence of co-occurring mental illness in this population [17].

Given the above, the present study aimed to examine the longitudinal relationship between exercise participation (i.e., frequency, intensity, and volume), and PTSD symptoms (i.e., re-experiencing, avoidance/numbing, and hyperarousal), while also examining the indirect effects of potential intervening variables (i.e., poor sleep quality, bodily pain, alcohol and substance use). This study also aimed to move the field forward by making additional methodological improvements, such as using a validated measure of exercise, as well as recruiting a national non-clinical sample of men and women who screen positive for PTSD. Using this approach, we hypothesized that: 1) exercise participation would longitudinally predict changes in PTSD symptoms, such that more active individuals would report less PTSD symptoms; and 2) exercise participation would have significant indirect effects on PTSD symptoms through sleep quality, chronic pain, and alcohol and substance use.

2. Methods

2.1. Procedures

Potential participants were recruited from major metropolitan areas across all four US regions (i.e., Northeast, South, Midwest, and West). Recruitment was accomplished through online-classifieds, such as Craigslist. The classified listings provided a brief description of the study and a link to the study's informed consent. Consenting individuals were then directed to an Internet platform and asked to complete the baseline questions of the study. Participants completing the baseline assessment were emailed a link to complete the follow-up questions three months after the completion of baseline. Additionally, all participants received a reminder one month prior to their follow-up date. Participants completing both waves of the study were entered into a raffle to win a $50 gift card. The odds of winning were 1 in 25. The study was approved by the Teachers College, Columbia University Institutional Review Board. All data were collected between October 2015 and December 2016.

2.2. Participants

To be eligible for the study, participants had to be living within the continental US, and have access to the Internet. All had to be at least 18 years in age, have the ability to read English, report experiencing a traumatic event, and screen positive for PTSD at baseline, according to the PTSD Checklist-Civilian (see measures section for PTSD screening criteria) [41].

2.3. Measures

2.3.1. Demographics questionnaire

Demographic data collected included age, gender, race/ethnicity, height and weight, education, income, physical disability status, and history of psychiatric illness.

2.3.2. PTSD Checklist-Civilian (PCL-C)

PTSD screening and symptoms were assessed with the PTSD Checklist-Civilian (PCL-C). The PCL-C is a 17-item, 5-point self-report scale used to assess PTSD symptom severity over the past month [41]. Items are ranked from "Not at all" to "Extremely" and correspond with the individual symptoms clusters of PTSD: re-experiencing, avoidance/numbing, and hyperarousal. Items are summed to represent a total PTSD symptom severity score. Valid total scores range from 17 to 85, with higher scores representing greater symptom severity. Valid scores for the re-experiencing, avoidance/numbing, and hyperarousal symptom clusters range from 5 to 25, 7 to 35, and 5 to 25 respectively. The PCL-C has been shown to be a valid measure of PTSD symptoms. It is strongly correlated with the Clinician Administered PTSD Scale (C-APS; $r = 0.93$) [5], and is reliable when administered electronically [9]. Additionally, a cut-off total score of ≥ 30 was used at study entry as a positive screening of PTSD [38].

2.3.3. Godin-Shephard Leisure-Time Exercise Questionnaire (GLTEQ)

Self-reported exercise behaviors were measured using the Godin-Shephard Leisure-Time Exercise Questionnaire (GLTEQ) [19]. The GLTEQ asks individuals to report, "During a typical 7-Day period (a week), how many times on average do you do the following kinds of exercise for more than 15 minutes during your free time." This was asked for strenuous (e.g., vigorous running or cycling), moderate (e.g., non-exhaustive sports, jogging, or weight training), and minimal intensity exercise (e.g., yoga, or easy walking). The GLTEQ is scored by multiplying the frequency of strenuous, moderate, and minimal intensity exercise by corresponding metabolic equivalent values 9, 5, and 3 respectively. Additionally, strenuous and moderate intensity exercise scores are summed to represent total-leisure time exercise, with higher scores representing greater levels of exercise participation. Importantly, minimal intensity exercise is no longer used in the calculation of total-leisure time exercise [18]. For interpretation, individuals who achieved a score of ≥ 24 from either moderate, or strenuous intensity exercise, or a combination of both (i.e., total leisure-time exercise) were classified as "active", and were likely to have met the national weekly physical activity recommendations set forth by the Centers for Disease Control and American College of Sports Medicine [3,15]. In contrast, individuals who scored < 24 were considered "insufficiently active", as such, were not likely to have met the recommendations. The GLTEQ is a reliable and valid measure of total leisure-time exercise, as well as strenuous, moderate, and minimal intensity exercise [3,19].

2.3.4. Kessler Psychological Distress Scale (K10)

The Kessler Psychological Distress Scale (K10) is a self-report scale which assess overall psychological distress over the past four weeks [22]. Each of the 10-items contains five points ranging from "Never" to "All of the time". Valid scores range from 10 to 50, with higher scores representing greater levels of psychological distress. The K10 has been shown to be a valid and reliable measure of psychological distress [22].

2.3.5. Pittsburgh Sleep Quality Index (PSQI)

Global sleep quality for the past month was assessed with the full Pittsburgh Sleep Quality Index (PSQI). The PSQI is a self-report 19-item scale that assesses seven components of sleep, including sleep quality, latency, duration, efficiency, disturbances, use of sleep medications, and daytime dysfunction [8]. Scores range from 0 to 21. Higher scores represent worse global sleep quality and a cut-point of > 5 indicates poor global sleep quality. The PSQI is a reliable and valid assessment of global sleep quality [8].

2.3.6. Short Form Health Survey, Bodily Pain Sub-scale

Overall physical pain in the past month was assessed using the 2-item self-report Bodily Pain sub-scale of the Short Form Health Survey [40]. In this scale, the first item corresponds with pain intensity, consisting of 6-points ranking from "none" to "very severe". The second item represents the amount pain has interfered with work or activities of daily living, and it has a 5-point ranking from "not at all" to "extremely". Total scores range from 0 to 100 with lower scores representing more bodily pain. The Pain sub-scale of the Short Form Health Survey is a simple, valid, and reliable measure of overall physical pain in the past month [21].

2.3.7. Alcohol Use Disorder Identification Test (AUDIT-C)

The 3-item alcohol consumption version of the Alcohol Use Disorder Identification Test (AUDIT-C) was used to assess alcohol use [7]. Each of the 3-items relates to the frequency of alcohol consumption. Specifically, items ask how often one consumes alcohol (i.e., never, less than monthly, monthly, weekly, or daily), how many alcoholic drinks when drinking, and the frequency of binge drinking (i.e., six or more alcoholic drinks on one occasion). For scoring, responses of the three questions are summed, with valid scores ranging from 0 to 12. Higher scores on the AUDIT-C indicate increased hazardous/heavy drinking behaviors, with scores of 4 or more in men, and 3 or more in women, are considered a positive screening for hazardous/heavy drinking or a possible alcohol use disorder. The variable was treated as a continuous measure in the final analysis. The AUDIT-C has been shown to perform similarly to the full 10-item AUDIT scale for identifying heavy drinking and/or alcohol use or dependence [7].

2.3.8. Self-Report Substance Use Questionnaire

Respondents self-reported the frequency of use (i.e., daily, weekly, monthly, less than monthly, or never) of cigarettes, cannabinoids, stimulants, inhalants, hallucinogens, opioids, and sedatives. Specific examples were provided for each category. The variable was treated as a continuous measure in the final analysis.

3. Data analysis

Descriptive statistics were used to describe the sample at study entry. As a preliminary step, correlations between potential confounders, (e.g., baseline demographics and medical history variables) and predictor (i.e., exercise) and outcome (i.e., PTSD symptoms) were considered. Any variable significantly correlated with both outcome and predictor were considered confounders and adjusted for in the subsequent analyses.

In order to estimate the longitudinal effects of exercise participation and exercise intensity on changes in PTSD symptoms a series of longitudinal mixed effects models were used, with a random intercept to adjust for repeated measures over time within individuals. Specifically, mean PTSD symptoms at baseline and follow-up were simultaneously regressed on the time-varying predictor (exercise participation measured at both baseline and follow-up), adjusting for confounders (e.g., age). Models were run separately using each of the activity participation and intensity variables as predictors: 1) activity based on total leisure-time exercise, 2) activity based on total amount of strenuous intensity exercise, and 3) activity based on total amount of moderate intensity exercise. Subsequently, a similar modelling approach was used to assess longitudinal effects of exercise participation (and intensity) on changes in each of the three PTSD symptom subscales (i.e., re-experiencing, avoidance/numbing, hyperarousal).

To explore potential intervening effects of PTSD-related conditions (psychological distress, sleep quality, physical pain, alcohol consumption, and substance use) on the associations between exercise participation and PTSD symptoms, we used a product of coefficients approach with bootstrapped standard errors. The effects of each potential intervening variable were examined separately from the others, while adjusting for baseline value of the outcome (PTSD total score/subscale score) and baseline exercise and confounders identified in the preliminary step (e.g., age) This model has the advantage of estimating both path coefficients (a path: effects of exercise participation on the intervening variable and b path: effects of the intervening variable on PTSD symptoms) and the indirect effects (ab path: effects of exercise on PTSD symptoms through the intervening variable). As with models for the direct effects of exercise, we considered both PTSD symptoms and the subscales as the outcomes and exercise as the time-varying binary indicator of activity level based on both overall activity and intensity-specific exercise.

4. Results

A total of 505 individuals responded to the advertisements, expressing potential interest in the study. Of these, 143 individuals declined to participate, 15 did not screen positive for PTSD during the baseline assessments, and an additional 165 participants were lost between baseline and follow-up (e.g., did not respond to the follow-up questionnaires). The participants completing the study (n = 182) were aged 18–69, and consisted of 38 men, 132 women, 7 transgender men, and 5 identified as other. Additionally, the sample was primarily non-military veterans (91.8%), and slightly less than half were considered physically active (47.8%) based on the GLTEQ at baseline. The average total PCL-C score was 58.4 (13.1), and average scores for total-leisure time exercise, minimal, moderate, and strenuous intensity exercise participation at baseline were 27.6 (27.2), 15.5 (14.8), 15.8 (15.1), and 11.5 (18.7) respectively. Further descriptive data for the sample are reported in Tables 1 and 2.

4.1. Direct effects of exercise on PTSD symptoms

4.1.1. Total leisure-time exercise and PTSD symptoms

There was a significant direct effect of total leisure-time exercise on the avoidance/numbing symptom subscale, suggesting that those who were active experienced less symptoms at follow-up than those who were insufficiently active ($b = -1.76$, $SE = 0.94$, $p = 0.05$). The direct effects of total leisure-time exercise on total PTSD symptoms, re-experiencing, and hyperarousal symptoms were not significant (p's > 0.05).

4.1.2. Strenuous intensity exercise and PTSD symptoms

Similar to total leisure-time exercise, there was a significant direct effect of strenuous intensity exercise on avoidance/numbing symptoms ($b = -2.18$, $SE = 1.12$, $p = 0.05$), suggesting that strenuously active individuals experienced lower avoidance/numbing symptoms at follow-up than those who were insufficiently active, after controlling for baseline exercise, avoidance/numbing symptoms, and age.

Table 1
Sample characteristics at study entry (n = 182).

	Mean (SD)
Age	34.60 (13.34)
Body mass index	27.53 (7.81)
	n (%)
Gender (female)	132 (72.5)
Race	
White	115 (63.2)
Black or African American	20 (11.0)
Asian	19 (10.4)
Other	28 (15.4)
Education	
High school or less	24 (13.2)
At least some college/vocational	121 (66.5)
At least some graduate school	37 (20.3)
Military veteran	15 (8.2)
History of mental illness	161 (88.5)
PTSD	126 (69.2)
Anxiety disorder	112 (61.5)
Depression	127 (69.8)
Other disorder	57 (31.3)

Table 2
Unadjusted outcome, predictor, and intervening variables over time.

Predictor	Min	Max	Mean (SD)
Total leisure-time exercise			
Baseline	0	125	27.7 (27.2)
Follow-up	0	185	27.5 (29.5)
Strenuous intensity exercise			
Baseline	0	108	11.5 (18.7)
Follow-up	0	135	11.3 (19.2)
Moderate intensity exercise			
Baseline	0	75	15.8 (15.1)
Follow-up	0	150	16.0 (17.7)
Outcome			
Total PTSD symptoms			
Baseline	30	85	58.4 (13.1)
Follow-up	17	82	50.8 (16.1)
Re-experiencing symptoms			
Baseline	7	25	16.9 (4.3)
Follow-up	5	25	14.7 (5.2)
Avoidance/numbing symptoms			
Baseline	11	35	24.0 (6.3)
Follow-up	7	35	21.2 (7.6)
Hyperarousal symptoms			
Baseline	5	25	17.5 (4.4)
Follow-up	5	25	15.0 (5.0)
Intervening variable			
Sleep quality			
Baseline	2	21	11.1 (4.3)
Follow-up	2	21	10.5 (4.6)
Psychological distress			
Baseline	10	50	32.0 (8.7)
Follow-up	10	48	28.6 (9.4)
Pain			
Baseline	0	100	57.5 (27.8)
Follow-up	0	100	61.2 (25.8)
Alcohol use			
Baseline	0	11	2.3 (2.4)
Follow-up	0	11	2.0 (2.2)
Substance use			
Baseline	1	5	2.9 (1.6)
Follow-up	1	5	3.1 (1.7)

Additionally, strenuous intensity exercise had a significant effect on hyperarousal symptoms (b = − 1.87, SE = 0.82, p = 0.03), suggesting that those who were strenuously active experienced less hyperarousal symptoms at follow-up after controlling for baseline exercise, hyperarousal symptoms, and age. Finally, there was no significant direct effect of strenuous exercise on total PTSD symptoms or re-experiencing symptoms (p's > 0.05).

4.1.3. Moderate intensity exercise and PTSD symptoms

There were no significant direct effects of moderate intensity exercise on total PTSD symptoms or any of the individual PTSD symptom clusters (p's > 0.05).

4.2. Indirect effects of exercise on PTSD symptoms

A complete description of path coefficients and indirect effects for each of the PTSD outcomes are presented in Fig. 1 for activity based on strenuous intensity exercise.

4.2.1. Exercise, PTSD, and psychological distress

There were no significant indirect effects of total leisure-time exercise, strenuous intensity, or moderate intensity exercise on total PTSD symptoms or any of the individual PTSD symptom clusters via psychological distress (p's > 0.05).

4.2.2. Exercise, PTSD, and global sleep quality

There was a significant indirect effect of strenuous intensity exercise on total PTSD symptoms through global sleep quality, such that strenuously active individuals reported lower PSQI scores and lower total PTSD symptoms at follow-up than those who were insufficiently active (ab = − 2.54, 95% CI: − 5.72 to − 0.38). These indirect effects remained significant when examining the avoidance/numbing (ab = − 0.99, 95% CI: − 2.43 to − 0.05) and hyperarousal symptoms (ab = − 0.78, 95% CI: − 1.88 to − 0.07), but not re-experiencing symptoms. There were no significant effects related to total leisure-time exercise or moderate intensity exercise (p's > 0.05).

4.2.3. Exercise, PTSD, and bodily pain

There were no significant indirect effects of total leisure-time exercise, strenuous intensity, or moderate intensity exercise on total PTSD symptoms or any of the individual PTSD symptom clusters via bodily pain (p's > 0.05).

4.2.4. Exercise, PTSD, and alcohol

Total leisure-time exercise had a significant indirect effect on total PTSD symptoms through alcohol consumption, such that active individuals reported higher AUDIT-C scores, and worse total PTSD symptoms at follow-up (ab = 0.32, 95% CI: 0.18–1.42). There were no significant effects related to strenuous or moderate intensity exercise (p's > 0.05).

4.2.5. Exercise, PTSD, and substance use

There were no significant indirect effects of total leisure-time exercise, strenuous intensity, or moderate intensity exercise on total PTSD symptoms or any of the individual PTSD symptom clusters via substance use (p's > 0.05).

5. Discussion

This is the first longitudinal observational study to examine the direct and indirect effects of exercise on PTSD symptoms in a national sample of individuals screening positive for PTSD. The key findings suggest that total leisure-time exercise and strenuous intensity exercise is longitudinally associated with PTSD symptoms, such that those who report being active (i.e., meeting the physical activity guidelines), as measured by the Godin Leisure-Time Questionnaire, experience less PTSD symptoms than those who report being insufficiently active. In addition, it appears that global sleep quality and alcohol use may play an indirect role in this relationship.

The strongest direct effects of exercise on PTSD symptoms were observed for strenuous intensity exercise. Specifically, individuals who reported strenuous intensity activity experienced significantly less avoidance/numbing, and hyperarousal symptoms. This is in contrast to those who reported both strenuous and moderate intensity (i.e., total

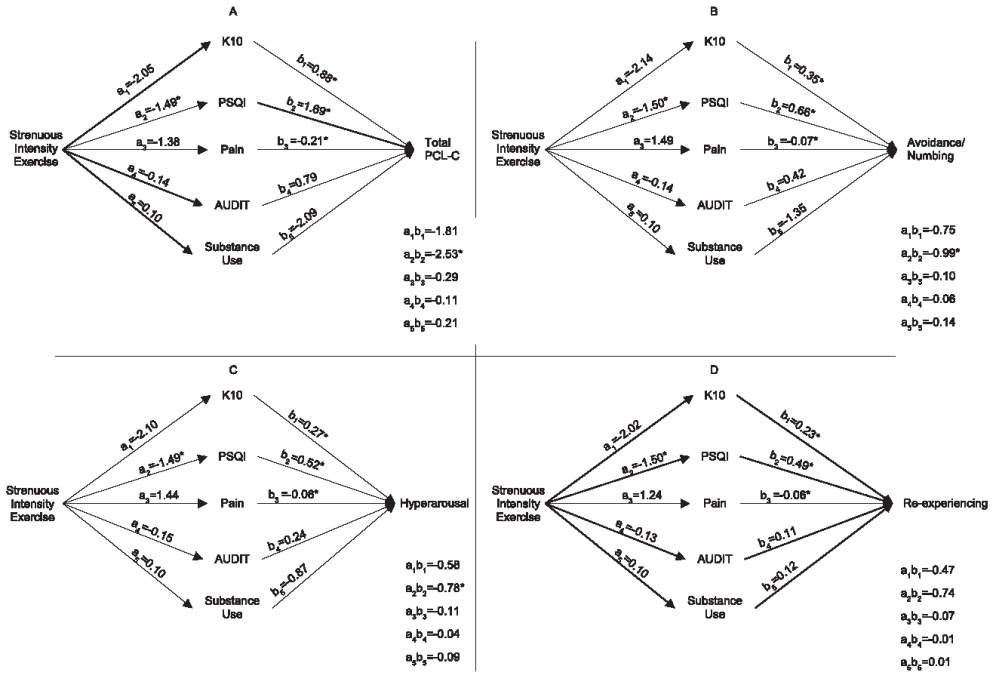

Fig. 1. Arrows represent the paths between strenuous intensity exercise and *A*. Total PTSD symptoms; *B*. Avoidance/numbing symptoms; *C*. Hyperarousal symptoms; or *D*. Re-experiencing symptoms. Asterisks (*) denotes significant effects, $p < 0.05$. ab paths denote indirect effects. PCL-C = PTSD Checklist-Civilian; PSQI = Pittsburgh Sleep Quality Index; AUDIT = Alcohol Use Disorder Identification Test.

leisure-time exercise), which was associated with less avoidance/numbing symptoms only. In addition, there was no significant relationship between PTSD symptoms and exercise for individuals reporting moderate intensity exercise only. These results agree with the findings of prior cross-sectional research that have shown inverse associations between exercise and avoidance/numbing, and exercise and hyperarousal symptoms [20,37].

When examining the relationship between strenuous intensity exercise and PTSD-related conditions, there was a significant beneficial effect on total PTSD symptoms, avoidance/numbing, and hyperarousal symptoms via improved global sleep quality. More specifically, strenuously active individuals reported significantly better sleep quality and less total PTSD symptoms than those who were insufficiently active. Importantly, these paths remained significant for the avoidance/numbing and hyperarousal symptom subscales. In contrast, no such indirect effects were observed for total leisure-time or moderate intensity exercise.

Taken together, it appears that strenuous intensity exercise can provide a substantial benefit for this population. The mechanisms responsible for the reduction in avoidance/numbing and hyperarousal symptoms could be attributed to the those outlined by the Cross-Stressor Adaptation Hypothesis [32], which posits that exercise of a sufficient intensity and duration can cause habituation to the physical stressors of exercise. This may ultimately lead to an adaptation in the stress response system, and reduction in negative cognitive appraisals in response to a stressor (i.e., a reduction in avoidance and hyperarousal symptoms). Such a change would support the current findings that strenuous intensity activity was associated with less avoidance/numbing and hyperarousal symptoms, while total leisure-time exercise (i.e., both strenuous and moderate intensity) was associated with less avoidance/numbing symptoms only.

With respect to sleep, previous research has shown that exercise has beneficial effects on sleep [23] and this was supported in the current findings. Additionally, preliminary research has demonstrated that poor sleep quality is associated with physical inactivity in those diagnosed with PTSD [35]. The current study extends this work by describing the longitudinal relationship between exercise and PTSD symptoms through sleep. The results of which confirm the findings of Babson et al. [4], suggesting that the effects of exercise on PTSD symptoms through sleep may be specific to certain symptom clusters. Importantly, however, the present study also demonstrates that exercise intensity is an important factor in this relationship, which was previously unexplored. These results could be particularly meaningful, given that individuals with PTSD commonly experience and struggle with disrupted and low quality sleep [16]. Moreover, research has shown that even after receiving psychological treatment for PTSD, many individuals continue to suffer from residual sleep issues [29].

The significant negative effect of total leisure-time exercise on total PTSD symptoms through alcohol consumption was unexpected, as prior research has shown that regular exercise participation is inversely associated with alcohol-related coping strategies in trauma exposed individuals [26]. However, the contrasting results may be due to the assessment of different constructs (e.g., alcohol use vs. alcohol-related coping strategies). Another possible explanation is that the present study likely represents a different population than that of Medina et al. [26], who excluded individuals with any prior diagnosis of a mental health disorder. Given that individuals with PTSD are at an increased risk for developing an alcohol use disorder [25], more research will be needed to better understand this dynamic relationship.

Another surprising finding of this study was the lack of significant indirect effects of exercise on PTSD symptoms through distress, pain, or substance use. Given the known relationship among exercise and these

variables, and the fact that individuals with PTSD commonly experience these conditions and have higher rates of substance use, it is unclear why significant results were only found with the similarly related factors of sleep and alcohol consumption.

This study is not without limitations. All of the data were self-report and collected anonymously using the Internet. This increased the risk of false responses, limited the sample to those who had access to the Internet, and increased the chances of multiple responses from a single individual. To combat these issues, the study required participants to provide a valid email address to participate, and blocked multiple responses from the same IP address. The benefit of this approach is that it allowed for a national distribution of the survey, and it increased the geographic diversity of the sample. In addition, while this study improved upon previous exercise studies with respect to using a validated self-report measure of exercise participation, it was not objectively verified. Future studies should incorporate an objective measure of exercise to help confirm self-report. Finally, the period of participation for this study was relatively brief (i.e., three months from baseline to follow-up), which may help explain the null findings for psychological distress and substance use. Future studies should consider using longer and multiple follow-up periods to further assess how exercise participation affects the course of PTSD.

In contrast with these limitations, this study has several notable strengths. First, this study used a longitudinal design, measuring PTSD symptoms, exercise, and the intervening variables at both time points. To our knowledge, only one other observational study has accomplished this [43]. An additional strength of this study is the sample. Specifically, the sample was predominantly non-military and consisted mostly of women. The prevalence of PTSD is known to be higher in women [2], and much of the prior PTSD research has focused on samples of military veterans, and by proxy has consisted largely of men [11,24]. As such, the results of this study may better generalize to women and non-military populations.

Finally, it is important to discuss the results of this study in context with the growing body of research describing PTSD as a predictor of physical inactivity. An excellent example of this research is the recent longitudinal study by Winning et al. [43], which demonstrated that trauma exposure followed by PTSD symptoms longitudinally predicted reductions in physical activity. In contrast, the findings of the present study suggest that exercise engagement predicts lower PTSD symptoms over time. Initially, the results of these studies appear to be contradictory. However, they are not mutually exclusive because it is possible that the mechanisms of these relationships are different. For instance, Winning et al. [43] posited that PTSD symptoms may interfere with an individual's motivation to participate in exercise, such as a concern of safety around strangers or in public places (e.g., gyms or parks). Whereas adaptations to the stress response or improvements in sleep quality may better explain the beneficial effects of exercise on PTSD symptoms shown in the current study. Importantly, these studies when considered together may provide preliminary evidence for a more complex reciprocal relationship between PTSD, its symptoms, and physical activity. Similar relationships have been proposed between exercise and stress [34], as well as exercise and sleep [10]. Thus, further research is clearly needed.

6. Conclusion

The purpose of this study was to address the limitations of previous research and examine the longitudinal relationship of exercise with PTSD symptoms, while also examining its related conditions. In sum, the findings suggest that exercise participation, particularly strenuous intensity exercise, is longitudinally associated with less PTSD symptoms among individuals screening positive for PTSD. Moreover, it seems that strenuous intensity exercise has the greatest potential to affect the symptoms of avoidance/numbing and hyperarousal, rather than re-experiencing. Additionally, these effects appear to be partially explained by improvements in sleep quality. This finding may have considerable clinical value, as insomnia commonly co-occurs with PTSD, and often persists even after successful treatment of PTSD symptoms. As such, it appears that exercise intensity and sleep quality should be carefully considered by researchers seeking to develop interventions for PTSD using exercise. Future studies will need to further investigate the initial findings of this study, and further explore the direct and indirect relationships surrounding exercise, PTSD, its symptoms, and related conditions.

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APPENDIX D

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INFORMED CONSENT

DESCRIPTION OF THE RESEARCH: You are invited to participate in this research study because you are an adult who has experienced a traumatic life event(s). The purpose of this study is to examine the physical and mental effects of exercise in adults who have experienced a traumatic life event(s). Participation in this study requires you to attend 12 sessions at Teachers College Columbia University, which will take place over the course of six weeks. Each session will last between 30 and 60 minutes. The total time for participating in the study is about 7.5 hours. Additionally, you must agree to abstain from doing any exercise outside of the study during your participation.

If you decide to take part in this study, you will provide written consent (by signing this form) to enroll. Immediately after that, the following will occur:

During your first session, you will answer several questionnaires about yourself and your lifestyle behaviors. After this is done, we will determine if you are eligible for this study based on the answers you provided for us on the questionnaires. If you are not eligible, we will provide you with a round trip metro card to compensate you for your travel. If you are eligible, we will then guide you through a series of physical assessments (e.g., height, weight, and blood pressure). Additionally, we will ask you to provide a saliva sample with the purpose of measuring an enzyme in your saliva. It will require you both to place a cotton roll under your tongue for 45-60 seconds, and to spit into a collection apparatus. Once these assessments have been completed, we will then measure your upper and lower body muscular strength.

Next, you will be asked to return approximately one week later during the same time of day as your first appointment. At this appointment, you will answer new questionnaires, provide another saliva sample, and repeat the upper and lower body muscular strength testing. At the end of this session, you will be randomized into one of two groups:

Group 1 – Exercise: You will exercise three times/week for three weeks. Each session will consist of a 5-minute warm-up, 20 minutes of vigorous intensity resistance training, and a 5-minute cool down. During the training sessions, you will wear a heart rate monitor for safety and to ensure the maintenance of proper exercise intensity. Additionally, blood pressure will be measured prior to and after exercise to ensure it is within a safe range for exercise. Questionnaires will be administered before, during, and after exercise, and you will provide a saliva sample at the beginning and end of one training session per week.

Group 2 – Health education: You will attend three sessions/week for three weeks. During each session, you will watch a 30-minute video on a health related topic. For comparison with the exercise group, you will complete the same questionnaires and physical assessments (e.g., heart rate, blood pressure, saliva).

After completion of the three-week intervention you will complete one follow-up appointment in which the baseline measures (e.g., muscular strength and mental health questionnaires) will be repeated.

The research study will be conducted by James Whitworth MA, under the supervision of Joseph Ciccolo, PhD and will take place at Teachers College, Columbia University.

RISKS AND BENEFITS: The following risks and possible benefits associated with this study include:

You may find the exercise component of this study to be difficult. You may feel out of breath or uncomfortable from having an elevated heart rate. To keep you safe, we will assess your blood pressure before and after exercise and your heart rate before, during, and after exercise. If we find that, either of these are too high and pose too great of a risk, we will reschedule your appointment or you will be excluded from the study. Lastly, the exercise could result in muscle soreness, or less likely, a muscle sprain. We have taken all precautions to help you to avoid any injuries.

Participation in this study is entirely voluntary. If you decide to participate now but change your mind later, there will be no penalties.

You may feel some emotional discomfort while answering sensitive questions. You may choose not to answer questions that make you uncomfortable; however, by doing so you may be excluded from the study. In the unlikely event that you experience a significant amount of distress after leaving one of your sessions with us, please call the free New York City Crisis Intervention hotline: 1-800-LIFE-NET (1-800-543-3638).

The benefits include: The resistance training group will participate in a 3-week exercise program. Regular exercise is well known to reduce the risk of numerous chronic diseases and death.

PAYMENTS: By enrolling and completing all aspects of the study (all 12 sessions), you will be compensated for your time with $149.50. This includes compensation for travel starting at your third session ($5.50 per session totaling $49.50). Additionally, you will receive $10 gift card at session 5, $15 gift card at session 8, $25 gift card at session 11, and $50 gift card at session 12. Please note: You must attend all 12 sessions to receive the full $149.50. Additionally, the operating hours for the study will be Monday-Friday 9am-5pm.

DATA STORAGE TO PROTECT CONFIDENTIALITY: Your privacy will be protected at all times. All of the data collected is considered confidential. Your name will not be on any of the questionnaires collected. We will also numerically code all of your data and disguise the identifying information by using a two-code system. Specifically, you will have a screening ID and a participant ID. The master list linking your name with the code numbers will be locked in an office and will only be accessible to our research staff.

TIME INVOLVEMENT: Your participation will take approximately 7.5 hours, which is broken down into two, one-hour baseline assessment sessions, nine 30-minute sessions, and one 60-minute follow-up over the course of six weeks.

HOW WILL RESULTS BE USED: The results of the study will be used to advance our understanding of how exercise affects the physical and mental health of individuals that have experienced a

traumatic life event(s). We will also use the data collected at the screening process even if you are deemed ineligible to help us understand the current physical and mental status of individuals that have experienced a traumatic life event(s). The results of this study may be used for scientific publication. Any publications (e.g., at conferences, in journal articles, etc.) that result from this study will only use de-identified data.

Teachers College, Columbia University
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New York NY 10027
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PARTICIPANT'S RIGHTS

Principal Investigator: James Whitworth

Research Title: Affective state and exercise duration in a trauma exposed sample

- I have read and discussed the Research Description with the researcher. I have had the opportunity to ask questions about the purposes and procedures regarding this study.
- My participation in research is voluntary. I may refuse to participate or withdraw from participation at any time without jeopardy to future medical care, employment, student status or other entitlements.
- The researcher may withdraw me from the research at his/her professional discretion.
- If, during the course of the study, significant new information that has been developed becomes available which may relate to my willingness to continue to participate, the investigator will provide this information to me.
- Any information derived from the research project that personally identifies me will not be voluntarily released or disclosed without my separate consent, except as specifically required by law.
- If at any time I have any questions regarding the research or my participation, I can contact the investigator, who will answer my questions. The investigator's phone number is (212) 641-0726.
- If at any time I have comments, or concerns regarding the conduct of the research or questions about my rights as a research subject, I should contact the Teachers College, Columbia University Institutional Review Board /IRB. The phone number for the IRB is (212) 678-4105. Or, I can write to the IRB at Teachers College, Columbia University, 525 W. 120th Street, New York, NY, 10027, Box 151.
- I should receive a copy of the Research Description and this Participant's Rights document.
- My signature means that I agree to participate in this study.

Participant's signature: _____ Date:____/____/____

Name: _____

Teachers College, Columbia University
Institutional Review Board
Protocol Number: 15-328
Consent Form Approved Until: 05/23/2018

Investigator's Verification of Explanation

I certify that I have carefully explained the purpose and nature of this research to _____ (participant's name) in age-appropriate language. He/She has had the opportunity to discuss it with me in detail. I have answered all his/her questions and he/she provided the affirmative agreement (i.e. assent) to participate in this research.

Investigator's Signature: _____

Date: _____

Teachers College, Columbia University
Institutional Review Board
Protocol Number: 15-328
Consent Form Approved Until: 05/23/2018

ID #_____

HIPAA RESEARCH AUTHORIZATION

Authorization for the Creation, Use, and Disclosure of Protected Health Information for Institutional Review Board Approved Research

Instructions: This authorization should be attached to each Informed Consent Form.
Investigators: Please complete information fields below and questions 2-8. Leave the name of research subject and signature areas blank.

Title of Study: Affective state and exercise duration in a trauma exposed sample
Name of Principal Investigator: James Whitworth (under the supervision of Dr. Joseph Ciccolo) _____
Phone Number: (212) 641-0726 Sponsor: _____
IRB Protocol Number: _____ Protocol Approval Date:

This form authorizes **Teachers College, Columbia University (TC)** to use and disclose certain protected health information about _____ that we will collect and create in this research study.

This authorization is voluntary, and you may refuse to sign this authorization. If you refuse to sign this authorization, your health care and relationship with your provider and with TC will not be affected; however, you will not be able to enter this research study.
Note: We will use this information for research purposes only. Any information we get from you or your health records will be identified by a number only, not by your name.

1. If you sign this form, you are agreeing that TC may use and disclose protected health information collected and created in this research study.
2. The specific health information and purpose of each use and disclosure are:

Health Information (Check as applicable)	**Purpose(s)** (Enter matching letter(s) from Purpose Categories)
__Medical records	_____
__X-ray/MRI/CT/Diagnostic Images	_____
__Photographs, videotapes, or digital or other images	_____
_X_Questionnaires, interview results, focus group survey, psychology survey, behavioral performance tests (e.g., memory & attention)	_____a, c, d, h, i_____
__ Other:	

Purpose Categories

a. To learn more about the condition/disease being studied
b. To learn more about the costs of treating the condition/disease being studied
c. To improve health care for persons with the condition/disease being studied
d. To analyze research results
e. To facilitate treatment, payment, and operations related to the study
f. To complete research obligations in this study
g. To comply with federal or other governmental agency regulations
h. To monitor for adverse events/side effects
i. To determine the safety and effectiveness of the treatment(s)
j. To perform quality assessments related to research at TC
k. To teach TC students
l. To place in a repository or "bank" for future research purposes
m.

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3. If the information to be used or disclosed contains any of the types of records or information listed below, additional laws relating to use and disclosures of the information may apply. You understand and agree that this information will be used and disclosed only if you place your initials in the applicable space next to the type of information. *(Investigators please type N/A in irrelevant fields).*
   - NA AIDS or HIV infection information
   - ___Drug/alcohol diagnosis, treatment, or referral information
   - ___Mental or behavioral health or psychiatric care
   - NA Genetic testing information
4. The persons who are authorized to use and disclose this information are:
   - ___All the investigators listed on page one of the Research Consent Form
   - ___Others at TC who are participating in the conduct of this research protocol:
   - ___The TC Institutional Review Board
5. The persons who are authorized to receive this information are:
   - ___The sponsor of this study:
   - NA Federal or other governmental agencies responsible for research oversight:
   - NA Others:
6. Protected health information that we collect from you in this study will be kept by us until:
   - NA The study is completed
   - ___ Indefinitely
   - NA Other:
7. You have the right to revoke this authorization and can withdraw your permission for us to use your information for this research by sending a written request to the Principal Investigator listed on page one of the research consent form. If you do send a letter to the Principal Investigator, the use and disclosure of your protected health information will stop as of the date he/she receives your request. However, the Principal Investigator is allowed to use information collected before the date of the letter or collected in good faith before your letter arrives. Revoking this authorization will not affect your health care or your relationship with TC.
8. If we have disclosed your protected health information outside of TC, to persons or agencies identified in item #5 above, it is possible that this information could be released again without your permission. TC tries to protect against this by being very careful in releasing your information. The ways in which we will limit the further release of your protected health information are:
   - NA Contractual agreements with those who may not receive the information
   - NA Not releasing your information in a way that could identify you
   - NA Other: We will use this information for research purposes only. Any information we get from you or your health records will be identified by a number only, not by your name.

You will receive a copy of this authorization form after you sign it.

_____
Printed name of research subject

_____ _____
Signature of subject Date

This HIPAA Research authorization form must be used exactly as it is presented here. Any alteration or editing of the form will render it unapproved for research use at TC. The use of an unapproved research consent /authorization form will require that any data collected from subjects who received such a form, must be excluded.

Teachers College, Columbia University
Institutional Review Board
Protocol Number: 15-328
Consent Form Approved Until: 06/24/2016

Section I: PROTOCOL DESCRIPTION (Please answer each question in the space below it)

1. Please describe the purpose of your research. Provide relevant background information and scientific justification for your study. You may provide citations as necessary.

Posttraumatic stress disorder (PTSD) is a prevalent mental disorder that affects about 7% of adults in the United States (Kessler et al., 2005), with rates known to be higher in at-risk populations (i.e., military veterans, first responders) (Gates, Holowka, Vasterling, & Keane, 2012). The disabling effects of PTSD include symptoms of anxiety and depression, markedly increased physiological arousal, and sleep disturbances (American Psychiatric Association., 2013). Additionally, research consistently links PTSD to neuroendocrine and immune dysfunction, through observed abnormal levels of cortisol, tumor necrosis factor alpha (TNF-a), and interleukin 6 (IL-6) (Gill, Vythilingam, & Page, 2008). Moreover, individuals with PTSD often report increased risky behaviors (e.g., heavy drinking and substance use) (Dedert et al., 2009). As such, PTSD is a disabling condition that affects people both psychologically and physiologically.

Currently there is strong evidence to support the use of exercise as a method to reduce several well-known symptoms and side effects of PTSD. For instance, anxiety (Herring, O'Connor, & Dishman, 2010), depressive symptoms (Cooney et al., 2013), chronic pain (van Middelkoop et al., 2011) and poor sleep quality (Chennaoui, Arnal, Sauvet, & Leger, 2014). However, the direct relationship between PTSD and exercise is currently not well understood. Recent evidence suggests that exercise training can reduce PTSD severity in adults (Fetzner & Asmundson, 2014; Manger & Motta, 2005). Additionally, observational studies have linked vigorous, but not moderate or light intensity exercise to improvements in PTSD symptoms (Godfrey, Lindamer, Mostoufi, & Afari, 2013; Harte, Vujanovic, & Potter, 2013). While these results are promising, it is still too early to make concrete recommendations for an exercise prescription. The current research is sparse and has not systematically examined the key components of an exercise program (e.g., intensity, frequency or type). As such, determining an exercise prescription for maximizing the benefits of exercise for individuals with PTSD is not currently possible.

For this reason, we propose a pilot study designed to test the effect of vigorous intensity exercise on both affective state, and physiological markers of stress (e.g., salivary cortisol and heart rate) in a community sample of trauma exposed adults who have symptoms consistent with PTSD.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders : DSM-5* (5th ed.). Washington, D.C.: American Psychiatric Publishing.

Chennaoui, M., Arnal, P. J., Sauvet, F., & Leger, D. (2014). Sleep and exercise: A reciprocal issue? *Sleep Med Rev*. doi: 10.1016/j.smrv.2014.06.008

Cooney, G., Dwan, K., Greig, C., Lawlor, D., Rimer, J., Waugh, F., . . . Mead, G. (2013). Exercise for depression. *Cochrane Database Syst Rev, 9*, CD004366. doi: 10.1002/14651858.CD004366.pub6

Dedert, E., Green, K., Calhoun, P., Yoash-Gantz, R., Taber, K., Mumford, M., . . . Beckham, J. (2009). Association of trauma exposure with psychiatric morbidity in military veterans who have served since September 11, 2001. *J Psychiatr Res, 43*(9), 830-836. doi: 10.1016/j.jpsychires.2009.01.004

Fetzner, M., & Asmundson, G. (2014). Aerobic exercise reduces symptoms of posttraumatic stress disorder: a randomized controlled trial. *Cogn Behav Ther*, 1-13. doi: 10.1080/16506073.2014.916745

Gates, M., Holowka, D., Vasterling, J., & Keane, T. (2012). Posttraumatic stress disorder in veterans and military personnel: epidemiology, screening, and case recognition. *Psychological services, 9*(4), 361-382. doi: 10.1037/a0027649

Gill, J., Vythilingam, M., & Page, G. G. (2008). Low cortisol, high DHEA, and high levels of stimulated TNF-alpha, and IL-6 in women with PTSD. *J Trauma Stress, 21*(6), 530-539. doi: 10.1002/jts.20372

Godfrey, K., Lindamer, L., Mostoufi, S., & Afari, N. (2013). Posttraumatic stress disorder and health: a preliminary study of group differences in health and health behaviors. *Annals of General Psychiatry, 12*(1), 30.

Harte, C. B., Vujanovic, A. A., & Potter, C. M. (2013). Association Between Exercise and Posttraumatic Stress Symptoms Among Trauma-Exposed Adults. *Evaluation & the Health Professions*. doi: 10.1177/0163278713494774

Herring, M., O'Connor, P., & Dishman, R. (2010). The effect of exercise training on anxiety symptoms among patients: a systematic review. *Arch Intern Med, 170*(4), 321-331. doi: 10.1001/archinternmed.2009.530

Kessler, R., Berglund, P., Demler, O., Jin, R., Merikangas, K., & Walters, E. (2005). Lifetime prevalence and age-of-onset distributions of dsm-iv disorders in the national comorbidity survey replication. *Archives of General Psychiatry, 62*(6), 593-602. doi: 10.1001/archpsyc.62.6.593

Manger, T., & Motta, R. (2005). The impact of an exercise program on posttraumatic stress disorder, anxiety, and depression. *International Journal of Emergency Mental Health, 7*(1), 49-57.

van Middelkoop, M., Rubinstein, S., Kuijpers, T., Verhagen, A., Ostelo, R., Koes, B., & van Tulder, M. (2011). A systematic review on the effectiveness of physical and rehabilitation interventions for chronic non-specific low back pain. *Eur Spine J, 20*(1), 19-39. doi: 10.1007/s00586-010-1518-3

2. Federal guidelines state that research cannot exclude any classes of subjects without scientific justification. Will your study purposely exclude any classes of subjects (e.g. by gender, class, race or age)? If so, please justify.

Participants who do not speak English will be excluded because the study outcomes will be measured using questionnaires that have been validated only in English.

Participants under age of 18 will be excluded because these individuals would benefit more from a program that addresses their specific needs (e.g., school-based concerns, parental involvement).

Pregnant women will be excluded for safety.

3. Please state your research question (in one or two sentences, if possible).

What is the effect of vigorous intensity resistance training on affective state and physiological markers of stress in adults with symptoms consistent with clinical PTSD?

4. Please describe the *specific data* you plan to collect and explain how data and the subjects you choose will help to answer your research question/s.

1. Telephone Screener: to determine eligibility
2. Medical History: a medical history questionnaire will be used to determine eligibility and assess if there are any medical contraindications to exercise.
3. Demographics Questionnaire: will be used to collect information on age, sex, race, ethnicity, relationship status, socioeconomic status, occupation, income and education.
4. Physical Activity: physical activity done in the past 7 days will be measure by the Modifiable Activity Questionnaire (MAQ).
5. Alcohol Use Disorders Identification Test (AUDIT-C): will be used to assess problematic drinking

6. Alcohol Consumption: alcohol consumed in the past 7 days will be collected
7. Depression: The Center for Epidemiological Studies Short Depression Scale (CES-D 10) will be used to assess symptoms of depression for the last week.
8. Posttraumatic Stress Disorder (PTSD): Symptoms of PTSD will be evaluated with the PTSD Checklist-civilian version (PCL-C).
9. Anxiety: The State-Trait Anxiety Inventory will be used to determine state (form Y-1) and trait (form Y-2) anxiety.
10. Self-esteem: The Self Esteem Questionnaire (SEQ) will be used to assess participant's self-esteem.
11. Distress Tolerance: Ability to tolerate distress will be measured with the Distress Tolerance Scale.
12. Self-reported substance use: Participants will be asked to self-report any nonprescription substances used in the past 30 days. Additionally, the Drug Abuse Screening Tool (DAST-10) will be used to assess substance use in the past 12 months.
13. Affect: The Feelings Scale and Felt Arousal Scale will be used to determine the current mood state of the participant.
14. Perceived Exertion: The Borg Category-Ratio Scale will be used to assess how hard participants are working.
15. Height and Body Weight: Height will be measured without shoes using a stadiometer. Weight will be measured in light indoor clothing without shoes using a calibrated electronic scale.
16. Heart Rate/Blood Pressure: will be measured using standard techniques.
17. Breath Holding Challenge: Participants will be asked to hold their breath as long as possible. This is an objective indicator of distress tolerance.
18. Saliva sample: Will be collected to measure acute changes in salivary hormones (cortisol) and inflammatory markers (interleukin-6 (IL-6) and tumor necrosis factor alpha (TNF-alpha). For cortisol, this requires each participant to place a cotton roll under their tongue for 45-60 seconds, which will produce 0.5-1.0ml volume of saliva. For IL-6 and TNF-alpha participants will need to drool into a saliva collection aid attached to a tube with the goal of producing 0.5-1.0ml volume of saliva.
19. Muscular Upper and Lower Body Strength will be determined using a valid measure of upper and lower body strength. We will follow the American College of Sports Medicine's (ACSM) protocol for 1-RM testing which involves several steps. Participants will complete a light warm-up of 5-10 repetitions at 40-60% of perceived maximum. They will then take a short rest (<5 min) and perform light stretching followed by a trial of 3-5 reps of 60-80% perceived maximum. The maximum weight lifted will be recorded at the maximal upper and lower body strength.
20. Sleep: A self-report sleep questionnaire will be used to collect information on individual sleep habits, such as total hours slept, and time of awakening. Additionally, overall sleep quality will be assessed using the Pittsburgh Sleep Quality Index (PSQI).
21. BodyMedia FIT, an elastic band worn around the upper arm will be used to track caloric expenditure and step count during the exercise sessions.
22. Fagerstrom Test of Nicotine Dependence (FTND): will be used to assess level of nicotine dependence.
23. Trauma exposure: History of trauma exposure will be assessed using the Life Events Checklist (LEC)
24. Distress: State distress will be assessed used the Subjective Units of Distress Scale (SUDS)
25. Pain: Chronic pain over the past 4 weeks will be assessed with 2-items from the Short Form Health Survey (SF-36). Additionally, pain intensity and unpleasantness will be measured using the Gracely Box Scale.
26. Cognitive function: The Trail Making Test will be used to assess the participants' attention, mental flexibility, task switching, and psychomotor speed.
27. Self-Concept: The Physical Self Description Questionnaire will be used to assess the participants' physical self-concept.
28. Cognitive Appraisals will be assessed a brief 3-item measure in order to determine the participants' perceptions of the study sessions.

Section II: DESCRIPTION OF RECRUITMENT AND PROCEDURES

5. Please describe your recruitment methods. **How** and **where** will subjects be recruited (flyers, announcement/s, word-of-mouth, snowballing, etc.)? You will need to include your IRB Protocol number in all recruitment materials, including announcements, online and email text. Paper copies of submitted recruitment materials to be distributed will be stamped with your IRB Protocol number once your study has been approved.

Advertisements will be placed in local newspapers, online using Craigslist and Facebook, and flyers will be posted on local bulletin boards.

6. Are you recruiting subjects from institutions other than Teachers College? If so, documentation of permission or pending IRB approval from the institution/s is required with this submission.

No

7. How many subjects are you planning to recruit?

20

8. Please list what *activities* your subject will be engaging in (e.g. surveys, focus groups, interviews, diagnostic procedures, etc.). [**PLEASE NOTE**: If you are collecting any private medical information from your subjects, please see our website **www.tc.edu/irb** under Forms and Guidelines for the HIPAA consent document.]

Participants who are determined to be initially eligible on the phone will be free of medical contraindications to exercise (i.e., having no signs or symptoms of cardiovascular disease, or with no history of cardiovascular, pulmonary, or metabolic disease), not engaging in more than 60 minutes of structured exercise a week, and will have symptoms consistent with PTSD (i.e., endorsing at least one item on the Life Events Checklist (LEC) and scoring at least a 35 on the PTSD Checklist-Civilian; PCL-C). A cut off score of 35 on the PCL-C is the current recommendation for minimizing false positives in a community based sample ("Using the PTSD Checklist for DSM-IV (PCL)," 2014). Anyone actively in or seeking treatment for PTSD (e.g., psychotherapy) will be excluded.

If initially eligible, individuals will be invited to Teachers College for a single visit. This visit will first serve the purpose of confirmation of eligibility, orientation to the study and protocols, and obtaining informed consent. To be fully eligible for the study, individuals must be willing to abstain from participating in structured exercise outside of the study, and to commit to consistent appointment times during the course of the study. Specifically, the baseline appointments will be scheduled at the same time of day approximately one week apart, and at least one intervention session per week must be scheduled at the same time of day (plus or minus one hour of flex) as the baseline appointments. This step is critical to ensure the validity of the salivary cortisol samples, as cortisol is highly subject to a diurnal rhythm.

Eligible participants will answer a battery of questionnaires on physical and mental health history, demographics, and lifestyle. Following the questionnaires, a saliva sample, height, weight, resting heart rate, blood pressure, and muscular strength (see section I, question 4, item 19 for protocol) will be collected. At the end of this session, participants will be scheduled for their second baseline assessment session approximately one week later. At the second baseline visit, participants will answer questionnaires, provide another saliva sample, and repeat the physical assessments to ensure accuracy and safety. At the end of this session, participants will be randomized into one of the following conditions:

Group 1 – Exercise. Participants will exercise three times/week for three weeks, Each session will consist of a 5-minute warm-up, 20 minutes of vigorous intensity resistance training, and a 5-minute cool down. During the training sessions, participants will wear a heart rate monitor for safety. Additionally, blood pressure will be measured prior to and after exercise to ensure it is within a safe range for exercise. Questionnaires will be administered before, during, and after exercise, and participants will provide a saliva sample at the beginning and end of one training session per week.

Group 2 – Contact control. Participants will attend three sessions/week for three weeks. During each session participants will watch a 30-minute video on a health related topic. For comparison with the exercise group, participants will complete the same questionnaires and physical assessments (e.g., heart rate, blood pressure, saliva).

After completion of the three week intervention, all participants will complete one follow-up appointment in which the baseline measures (e.g., muscular strength and mental health questionnaires) will be repeated.

References

Using the PTSD Checklist for DSM-IV (PCL). (2014). from http://www.ptsd.va.gov/professional/pages/assessments/assessment-pdf/PCL-handout.pdf

Name of activity	# of times the activity occurs	Duration of activity per instance	Total time period of active participation per subject (days, weeks, etc.)	Describe the Data collected
Baseline testing (Groups 1 and 2)	2	60min	2 hours	Questionnaires (demographics, physical and mental health), saliva, exercise tests, resting heart rate and blood pressure
Resistance Training Session (Groups 1 only)	9	30min	4.5 hours	Heart rate, caloric expenditure, blood pressure, questionnaires, saliva samples
Contact Control Session (Group 2 only)	9	30min	4.5 hours	Heart rate, caloric expenditure, blood pressure, questionnaires, saliva samples
Follow-up testing (Groups 1 and 2)	1	60min	1 hour	Questionnaires (demographics, physical and mental health),

				saliva, exercise tests, resting heart rate and blood pressure

Total hours of participation: 7.5 hours **Duration of participation: 6 weeks**

9. Where will your data collection take place specifically (e.g., in classroom, outside of classroom, waiting room, office, other location)?

In the Biobehavioral Resistance Training Laboratory within the Department of Biobehavioral Sciences, 958 and 958B Thorndike Hall.

10. Will subjects be remunerated for their participation? If, so please describe. [**PLEASE NOTE**: If using a lottery system, please remember to state odds of winning in consent form. Also, if you will be offering course credit for study participation, you must discuss this here and include the alternative assignment for those who decline to participate in the study].

Participants will be paid $149.50 for completing all 12 sessions. Specifically, participants will receive: 1) $5.50 at each study session (9 sessions = 49.50) to cover the cost of travel; 2) an additional $10 gift card at the third study session, $15 gift card at the sixth study session, $25 gift card at the ninth study session, and a final $50 gift card after the follow-up session is completed (totaling $149.50). We will explicitly explain to all participants prior to consent that all sessions must be completed to receive the entire incentive. The schedule for the study will be Monday-Friday, 9:00 am-5:00 pm.

To compensate for travel, a round trip Metro Card will be given to those who are initially eligible during phone screening, but ineligible once rescreened in person.

11. Will deception be used? If so, please provide a rationale for its use. How will subjects be debriefed afterward? Submit debriefing script. Scripts should include a statement that gives your subjects the opportunity to withdraw their participation at that time. [**PLEASE NOTE**: studies involving deception are given **Full Board Review** unless the deception is minor and risks are minimal].

No

12. Will you have a control group? Please describe your procedures and explain the purpose of using a control group.

Yes, this is provided in question #8.

13. Will you be videotaping your subjects? If so, please describe in detail. [**PLEASE NOTE**: The IRB will only approve videotaping when there is adequate scientific and ethical justification].

No

Section III: CONFIDENTIALITY PROCEDURES

14. How will you ensure the subjects' confidentiality? Describe in detail your plans for ensuring confidentiality of data regarding subjects. [**PLEASE NOTE**: If you will be remunerating subjects after their participation, please make it clear if and how you will link their names/contact information confidentially to their compensation].

Verifying information (i.e. name, date of birth, phone number) will only be collected as part of the informed consent and contact information sheet that will include a separate I.D. number. From that point forward, their I.D. number will be the sole identifier of that data. All data will only be accessible to research staff. The master list linking names with coded numbers will be locked in Dr. Ciccolo's office. In addition, all investigators have undergone (and any new staff will undergo) human subjects' ethics training as required by Teachers College.

15. If you will be audio/videotaping, please state how you will ensure that subjects have consented to being recorded, **and** if some subjects do not consent to being recorded, explain how you will protect their confidentiality. (This must also be clearly stated in your consent form/s).

N/A

16. Will data be collected anonymously? Will you be able to link the data? If data will not be collected anonymously, how will subjects' identity/ information be protected? (e.g. codes, pseudonyms, masking of information, etc.)?

Yes. All data will be numerically coded and disguised using the I.D. number provided at the baseline assessment. The master list connecting names with code numbers will be locked in Dr. Ciccolo's office.

17. Where will coding and data materials be stored (e.g. 'in a locked file cabinet in the Principal Investigator's home or office')?

The master list linking names with code numbers will be locked in Dr. Ciccolo's office.

18. Will you need bilingual interpreters or interviewers, and if so, what will you do to ensure confidentiality of the subjects? What are your procedures for recruiting interpreters/interviewers? Indicate the name of the interpreter/interviewer and for whom he/she works. Submit copies of all questionnaires or interview questions for each subject population.

N/A

SECTION IV: DESCRIPTION OF RESEARCH RISKS & BENEFITS

19. What are the potential risks, if any, (physical, psychological, social, legal, or other) to your subjects? What is the likelihood of these risks occurring, and/or their seriousness? How will you work to minimize them? [**PLEASE NOTE**: The IRB regards no research involving human subjects as risk-free. You may describe minimal risks for your study (such as discomfort, boredom, fatigue, etc.), or state that the research will involve minimal risk, similar to an activity (named) like that which participants will perform as part of your study.]

The potential risks of this investigation are considered to be low. These include: (a) loss of confidentiality; (b) complications associated with resistance training; and (c) psychological distress. Each will be addressed in the following ways:

(a) See Section III, question 14 for information on protecting loss of confidentiality.

(b) In accordance with the recommendations of the American College of Sports Medicine for risks associated with exercise, all participants be screened for any symptoms of, or known cardiovascular, pulmonary or metabolic disease prior to participation (American College of Sports Medicine, 2014; Riebe et al., 2015). Moreover, participants will be screened for any orthopedic limitations that might make resistance training uncomfortable or unsafe. In addition, James Whitworth (doctoral student) will conduct all resistance training sessions. He has a master's degree in applied exercise physiology, is Advanced Cardiovascular Life Support (ACLS), CPR and Automated External Defibrillator (AED) certified, and is a current American College of Sports Medicine (ACSM) certified personal trainer. Participants will be given instructions on how to properly care for muscle soreness following the resistance training.

(c) The participants recruited in this study may have some psychological distress related to PTSD. We will only recruit individuals who are not currently seeking or undergoing treatment for any comorbid mental health issues associated with PTSD (please see telephone screener). The reason for this is that these individuals are in need of intervention and classified as an at-risk, high priority group. As such, we will take extra precautions monitoring participants throughout the duration of this study. Specifically, we will closely monitor all participants for any signs of acute or chronic severe psychological stress (e.g., verbal suicidal ideation). However, it is important to note, that there is no evidence indicating that strength training can worsen PTSD symptoms or cause suicidality. As a precaution responses to the mental health questionnaires will be scored and compared to high-risk cut-off points. If any participant is found to be at risk, they will be referred to a mental health service. In the event of acute psychological emergency (e.g., threats of self-harm) during a session James Whitworth (doctoral student PI) will call 911 and inform Dr. Ciccolo (Faculty advisor) of the emergency. Lastly, all participants will receive a reference list of local mental health services at the conclusion of the study (e.g., Dean Hope Center, Ryan Center Mental Health, Mount Sinai St. Luke's Mental Health).

References:
American College of Sports Medicine. (2014). ACSM's guidelines for exercise testing and prescription. Philadelphia, PA: Lippincott Williams & Wilkins.

Riebe, D., Franklin, B. A., Thompson, P. D., Garber, C. E., Whitfield, G. P., Magal, M., & Pescatello, L. S. (2015). Updating ACSM's Recommendations for Exercise Preparticipation Health Screening. Med Sci Sports Exerc, 47(11), 2473-2479. doi:10.1249/mss.0000000000000664

20. What are your plans for ensuring necessary intervention in the event of a distressed subject and/or your referral sources if there is a need for psychological and/or physical treatment/assistance?

Staff will alert Dr. Ciccolo who will determine what further action needs to be taken if needed (e.g., medical referral out of study). Dr. Ciccolo will be available in person or by cell phone during all study hours. When onsite, he will typically be in his office, one floor away from the study location. If not, he will be available by cell phone. In addition, Dr. Ciccolo or one of his doctoral students will be the personnel conducting the exercises. Each member of Dr. Ciccolo's lab is certified in CPR and Automated External Defibrillator (AED) use. All sessions will take place in Dr. Ciccolo's laboratory (958 Thorndike Hall), which is equipped with an AED and phone landline to call 911 if needed.

21. What are your qualifications/preparations that enable you to estimate and minimize risk to subjects?

James Whitworth has earned a master's degree in applied exercise physiology, and is currently a doctoral student in this program. He has been working with clinical populations in his graduate work for three years. He is additionally certified in ACLS, CPR and AED use, and is a current ACSM certified personal trainer.

Dr. Ciccolo has been conducting exercise research for the past 10 years, and he has been a principal investigator, co-investigator, or consultant on 17 NIH-funded clinical trials. The majority of these studies have recruited an at-risk population (i.e., individuals with a chronic illness, substance use disorder) providing Dr. Ciccolo with a wealth of experience to draw upon.

22. What are the potential benefits of this study to the subjects? Most research conducted at TC provides NO DIRECT BENEFIT to participants and must be STATED as such in the INFORMED CONSENT FORM. Occasionally, study design will include a diagnosis, evaluation, screening, counseling or training, etc., that have a concrete benefit to participants, independent of the nature or results of a research study that may be listed below. Benefits such as "an opportunity to reflect," "helping to advance knowledge," etc., ARE NOT BENEFITS and MUST NOT be included in this section.

Participants of the resistance training group will participate in a 3-week exercise program. Regular exercise is well known to reduce the risk of numerous chronic diseases and death.

Section V: INFORMED CONSENT PROCEDURES (Please use the templates on the website in preparing your consent form/s, and note that Informed consent is a process, not a form).

23. What are your procedures for obtaining subject's informed consent to participate in the research?

People interested in the study will have the study described in detail while being screened for initial eligibility over the phone. If an individual is initially eligible and interested, s/he will be scheduled for the first session. At the beginning of the first session, the details of the study will be explained again, and the participant will be rescreened for eligibility. Time will be given to the potential participant to ask questions and clarify any concerns. Once all questions have been answered, and the participant decides to participate, consent will be obtained.

24. How will you describe your research to potential subjects? [**Please note:** if working with a population under eight (8) years of age, a script is necessary.]

Participants will be told they have been asked to participate in this study because they are adults that have experienced a traumatic life event(s), and that the purpose of this research is to determine the physical and mental effects of exercise in that population.

25. What will you do to ensure subjects' understanding of the study and what it involves?

At the time of consent, participants will be given the chance to ask any questions and clarify any concerns. We will also directly ask participants if they have understood the procedures and whether or not they have any further concerns about the tests and sessions that will be ensued.

26. If you are recruiting students from a classroom during normal school hours, what will the **alternative** activities be for those who wish not to participate? (This should also appear in your consent form/s)

N/A

27. Use this section to provide a request for a full or partial waiver of informed consent, and justify this request. You may site criteria from the following link regarding Federal regulations and guidelines: http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.html#46.116

N/A

Note for Researchers: Submit all consent forms/scripts, using the templates provided on the website. **Drafts of consent forms will not be accepted**. Each consent form must be a separate document and titled for its respective subject population (e.g. teachers, parents, etc.). All consent documents must be in English, even though you may translate them. **All consent documents should be printed on Teachers College letterhead or include the name and address of the college, per the online Informed Consent and Participant's Rights templates.**

If your research project requires using documents that are translated into other languages, please submit both the translated English version AND the translated document with your application. You must sign and date the document. TC strongly urges investigators to use back translation (translation into the target language and back into English) as a method of ensuring the translation's accuracy. Revised consents will also need to be translated.

NOTE: If you are conducting any part of your research within NYC DEPARTMENT OF EDUCATION [DOE] Schools: It is required that you receive approval from TEACHERS COLLEGE prior to submitting to the NYC Board of Education's Division of Assessment and Accountability.

Telephone Screener

Screener ID: _____

Begin call:
Hello, this is _____. Do you have about 10 minutes to talk about the study? Just in case we get disconnected, can I have your name and phone number?

First I will read some information to you about the study, and if you are interested we can go forward to see if you are eligible.

This study is being conducted by researchers at Teachers College Columbia University, which is located at 120th St. between Amsterdam and Broadway. The purpose of the study is to examine the physical and mental effects of exercise duration in adults who have experienced a traumatic life event(s).

To test this, participants will be randomly assigned to one of two brief intervention groups. One of the groups will participate in three weeks of guided exercise and the other group will participate in a three weeks of health education. To be eligible for this study you must be willing to be in either of these groups.

Are you willing to accept the random assignment to one of these groups?
_____ YES _____ NO
If NO: Thank you for your interest.

The study also requires you to come to Teachers College for 12 sessions over the next six weeks, totaling about 7.5 hours. To compensate you for your time, we will pay you $150. Importantly, you will not be paid for partial participation, and must attend all 12 sessions to receive the $150.

Does this sound like a study that you would be interested to participate in?
_____ YES _____ NO
If NO: Thank you for your interest.

If YES: Now I need to read through a brief questionnaire with you to determine if you are initially eligible to participate. If it is determined that you are eligible, you will be invited to attend the first session of the study, where we will reassess your full eligibility. If you remain eligible at that time, you will continue with the study. If you are ineligible, we will provide you with a round trip metro card to compensate you for your travel to our site.

This questionnaire is completely confidential and anonymous, as your full name or any other identifying information cannot be connected to any of your answers. Also, you don't have to answer any question that you don't want to answer; however failing to do so may make you ineligible for the study. If you don't know an answer, please just let me know.

1) Do you identify as a:
   a. Male
   b. Female
   c. Transgender Male
   d. Transgender Female
   e. Other

2) Which of the following do you consider to be your racial group?
   a. American Indian/Alaskan Native
   b. Asian
   c. Native Hawaiian or Other Pacific Islander
   d. Black or African American
   e. White
   f. Other (describe):_____

3) Are you also Hispanic or Latino/Latina: Yes No

4) What is your age? _____ years of age *(if <18 ineligible)*

5) **IF FEMALE**: Are you pregnant?
   1. Yes
   2. No
   If yes, ineligible

6) How did you hear about this research study? (Select all that apply)
   a. Subway ads
   b. AM New York
   c. Craigslist
   d. Radio
   e. Internet
   f. Other _____

7) Have you ever experienced and traumatic life event? (if unsure give examples: experienced a natural disaster, physical assault, serious accident or injury, or military combat)
   1. YES
   2. NO *if no, ineligible*

8) Please indicate how much you have been bothered by the following problems in the last month. You can choose the answers: Not at all, A little bit, Moderately, Quite a bit, or Extremely

Repeated, disturbing memories, thoughts, or images of a stressful experience from the past?	Not at all (1)	A little bit (2)	Moderately (3)	Quite a bit (4)	Extremely (5)
Feeling very upset when something reminded you of a stressful experience from the past?	Not at all (1)	A little bit (2)	Moderately (3)	Quite a bit (4)	Extremely (5)
Avoid activities or situations because they remind you of a stressful experience from the past?	Not at all (1)	A little bit (2)	Moderately (3)	Quite a bit (4)	Extremely (5)
Feeling distant or cut off from other people?	Not at all (1)	A little bit (2)	Moderately (3)	Quite a bit (4)	Extremely (5)
Feeling irritable or having angry outbursts?	Not at all (1)	A little bit (2)	Moderately (3)	Quite a bit (4)	Extremely (5)
Having difficulty concentrating?	Not at all (1)	A little bit (2)	Moderately (3)	Quite a bit (4)	Extremely (5)

Sum Score_____. If sum score is <14, then ineligible

9) Are you currently in active treatment for a mental health disorder?
   1. YES *if yes, ineligible*
   2. NO

10) Are you currently seeking treatment for a mental health disorder?
   1. YES *if yes, ineligible*
   2. NO

11) Do you smoke cigarettes?
   1. YES
   2. NO

12) **IF YES,**
   How many per day?
   For how long have you smoked?

13) Have you ever been diagnosed with posttraumatic stress disorder (PTSD)?
1. YES
2. NO
An anxiety disorder?
1. YES
2. NO
Depression?
1. YES
2. NO
Bipolar disorder?
1. YES
2. NO
Or Schizophrenia?
1. YES
2. NO

14) Do you have a current or past illicit drug addiction?
1. Current
2. Past
3. No

15) Do you have a current or past alcohol addiction?
1. Current
2. Past
3. No

16) Do you currently exercise?
1. YES
2. NO ***(If no, skip to number 20)***

17) What type of exercise do you usually complete?
1. Aerobic activity (like walking, biking, swimming)
2. Strength training (this includes free weights, machines, rubber bands, or body weight exercises)
3. Both

18) How many days per week do you usually exercise? _____

19) How many minutes do you usually spend exercising each time you exercise?
1. 0-10 minutes
2. 11-20 minutes
3. 21-30 minutes
4. 31-40 minutes
5. 41-50 minutes
6. 51-60 minutes
7. 61 or more minutes

Ineligible if they do any resistance training or if they exercise >60 minutes per week

IF INELIGIBLE AT THIS POINT, STOP. GO TO END, READ INELIGIBLE TEXT

Now I have a series of questions about your physical and mental health.

20. Do you feel pain in your chest at rest? (if yes, describe)	No (0)	Yes (1)
21. Do you feel pain in your chest during your daily activities of living, or when you do physical activity? (if yes, describe)	No (0)	Yes (1)

22. Have you lost consciousness in the past month? (if yes, describe)	No (0)	Yes (1)
23. Do you lose your balance because of dizziness? (if yes, describe)	No (0)	Yes (1)
24. Has a doctor ever said you should only do medically supervised exercise? (if yes, describe)	No (0)	Yes (1)
25. Have you been hospitalized in the past 3 months? (if yes, describe)	No (0)	Yes (1)
26. Has a doctor ever said you have a heart condition? (if yes, describe)	No (0)	Yes (1)
27. Do you have high blood pressure? (if yes, are you taking medications)	No (0)	Yes (1)
28. Type 1 Diabetes or Type 2 Diabetes	Type 1 (1)	Type 2 (2)
29. Do you have a history of heart disease in your family? (if yes, describe)	No (0)	Yes (1)
30. Do you have Asthma? (If yes, is it made worse by exercise?)	No (0)	Yes (1)
31. Do you have any trouble breathing during or immediately after exercise, such as coughing, wheezing, or tightness in your chest?	No (0)	Yes (1)
32. Please tell me if you have had or been diagnosed with any of the following		
33. Heart attack	No (0)	Yes (1)
34. Coronary artery disease	No (0)	Yes (1)
35. Stroke	No (0)	Yes (1)
36. Blood clots	No (0)	Yes (1)
37. Aneurysm	No (0)	Yes (1)
38. Pulmonary diseases, such as COPD, Emphysema, or Chronic bronchitis	No (0)	Yes (1)
39. Have you broken any of your bones? (If yes, describe)	No (0)	Yes (1)
40. Do you have any problems with your:		
41. Neck	No (0)	Yes (1)
42. Shoulders	No (0)	Yes (1)
43. Elbows	No (0)	Yes (1)
44. Wrists	No (0)	Yes (1)
45. Hips	No (0)	Yes (1)
46. Lower back	No (0)	Yes (1)
47. Knees	No (0)	Yes (1)
48. Ankles	No (0)	Yes (1)
49. Do you have any other physical or mental health issue that we have not talked about? (if yes, describe)	No (0)	Yes (1)
50. Are you taking any prescription medication? (if yes, describe)	No (0)	Yes (1)
51. Are you currently enrolled in any other research study? (if yes, describe)	No (0)	Yes (1)

IF YES TO ANY HIGHLIGHTED MEDICAL HISTORY QUESTIONS, INELIGIBLE.
IF YES TO ANY TO ANY OTHER MEDICAL HISTORY QUESTIONS, CLARIFY WITH PI.

Determination: (circle one)

1. Clearly eligible
2. May be eligible (need to follow up with PI or Dr. Ciccolo)
3. Clearly not eligible

1. CLEARLY ELIGIBLE
Thank you for taking the time to answer our questions. You appear to be eligible for the study. First, I'll need to get some contact information from you and we need to set up a time for your first appointment.

Complete Contact Information Sheet and schedule an appointment time/date. Thank participant and tell him/her you will call back to remind them of their appointment on the day prior.

2. MAY BE ELIGIBLE – NEED TO CONSULT DR. CICCOLO/PI
Thank you for taking the time to answer our questions. You may be eligible for the study, but I need to check with principal investigator first.

Complete Contact Information Sheet and schedule a time to call individual back once eligibility status is confirmed.

CLEARLY NOT ELIGIBLE:

Thank you for taking the time to answer these questions. Because this is a research study, we need to ensure that our participants don't have any characteristics that might make participating difficult or dangerous, and that all participants are similar to one another with respect to certain characteristics. At this time, I'm sorry to tell you that you are not eligible for this study.

If you are interested in speaking to a mental health professional, please contact New York City Crisis Intervention hotline: 1-800-LIFE-NET (800-543-3638) or the Dean Hope Center for Educational and Psychological Services, which can be reached at (212-678-3262)

END

Demographics Questionnaire

1) What is your age in years _____

2) Do you identify as a:
   1 Male
   2 Female
   3 Transgender Male
   4 Transgender Female

3) Which of the following do you consider to be your racial group?
   1 American Indian/Alaskan Native
   2 Asian
   3 Native Hawaiian or Other Pacific Islander
   4 Black or African American
   5 White
   6 Other (describe):_____
   7 Do not know

3a) Are you:	Yes = 1	No = 0
Hispanic or Latino	☐	☐

4) Right now, you are:
   1 Living Alone
   2 Living with a Romantic Partner
   3 Living with Spouse (Legally Married)
   4 Living with Roommate(s)
     4a) How many roommates_____
   5 Other living condition
     5a) Please describe_____

5) Which best describes your formal education?
   1 Less than high school graduate
   2 High school graduate
   3 Some vocational school or college
   4 Completed vocational school
   5 Completed college
   6 Some graduate school
   7 Completed graduate school (masters degree)
   8 Completed graduate school (doctoral degree)

6) Which of the following best describes your employment status?
   1 Employed full time
   2 Employed part time
   3 Unemployed
   4 Retired
   5 Student
   6 Other:_____

7) Are you a first responder (EMT, Fire fighter, Police):
   1 Yes
   2 No
   IF YES: Are you (check all that apply):
   1 Military/Law Enforcement
   2 Fire department

3 EMT/Paramedic

2) Are you a Veteran of the United States Armed Forces?
   1 Yes
   2 No

3) What is your current **total household** income per year?
   1 Under $11,500
   2 Between $11,501 and $15,000
   3 Between $15,001 and $25,000
   4 Between $25,001 and $40,000
   5 Between $40,001 and $60,000
   6 Between $60,001 and $80,000
   7 Between $80,001 and $100,000
   8 $100,001 or more
   9 Do not know

4) Do you identify as a:
   1 Heterosexual
   2 Homosexual
   3 Bisexual
   4 Other

5) Have you ever been diagnosed with: (check all that apply)
   1 An anxiety disorder
   2 Depression
   3 Posttraumatic stress disorder (PTSD)
   4 Schizophrenia
   5 Bipolar disorder
   6 Substance use disorder (SUD)
   7 Alcohol use disorder (AUD)
   8 Other
   IF OTHER: Please describe: _____

6) Do you have any bone or joint problem that prevents you from participating in exercise?
   1 No
   2 Yes
   IF YES: Please describe: _____

Date:_____ ID:_____

Health History Questionnaire

1. Do you feel pain in your chest at rest? (if yes, describe)	No (0)	Yes (1)
2. Do you feel pain in your chest during your daily activities of living, or when you do physical activity? (if yes, describe)	No (0)	Yes (1)
3. Have you lost consciousness in the past month? (if yes, describe)	No (0)	Yes (1)
4. Do you lose your balance because of dizziness? (if yes, describe)	No (0)	Yes (1)
5. Has a doctor ever said you should only do medically supervised exercise? (if yes, describe)	No (0)	Yes (1)
6. Have you been hospitalized in the past 3 months? (if yes, describe)	No (0)	Yes (1)
7. Has a doctor ever said you have a heart condition? (if yes, describe)	No (0)	Yes (1)
8. Do you have high blood pressure? (if yes, are you taking medications)	No (0)	Yes (1)
9. Type 1 Diabetes or Type 2 Diabetes	Type 1 (1)	Type 2 (2)
10. Do you have a history of heart disease in your family? (if yes, describe)	No (0)	Yes (1)
11. Do you have Asthma? (If yes, is it made worse by exercise?)	No (0)	Yes (1)
12. Do you have any trouble breathing during or immediately after exercise, such as coughing, wheezing, or tightness in your chest?	No (0)	Yes (1)
13. Have you ever been diagnosed with posttraumatic stress disorder (PTSD)?	No (0)	Yes (1)
14. An anxiety disorder?	No (0)	Yes (1)
15. Depression	No (0)	Yes (1)
16. Bipolar disorder?	No (0)	Yes (1)
17. Or Schizophrenia	No (0)	Yes (1)
18. Please tell me if you have had or been diagnosed with any of the following		
19. Heart attack	No (0)	Yes (1)
20. Coronary artery disease	No (0)	Yes (1)
21. Stroke	No (0)	Yes (1)
22. Blood clots	No (0)	Yes (1)
23. Aneurysm	No (0)	Yes (1)
24. Pulmonary diseases, such as COPD, Emphysema, or Chronic bronchitis	No (0)	Yes (1)
25. Have you broken any of your bones? (If yes, describe)	No (0)	Yes (1)
26. Do you have any problems with your:		
27. Neck	No (0)	Yes (1)
28. Shoulders	No (0)	Yes (1)

Date:_____ ID:_____

29. Elbows	No (0)	Yes (1)
30. Wrists	No (0)	Yes (1)
31. Hips	No (0)	Yes (1)
32. Lower back	No (0)	Yes (1)
33. Knees	No (0)	Yes (1)
34. Ankles	No (0)	Yes (1)
35. Do you have any other physical or mental health issue that we have not talked about? (if yes, describe)	No (0)	Yes (1)
36. Are you taking any prescription medication? (if yes, describe)	No (0)	Yes (1)
37. Are you currently enrolled in any other research study? (if yes, describe)	No (0)	Yes (1)

Staff Notes:

PTSD Diagnostic Scale for DSM-5 (PDS-5)

Participant ID_____ **Date_____**

TRAUMA SCREEN

Have you ever experienced, witnessed, or been repeatedly confronted with any of the following:
(Check all that apply)

□ Serious, life threatening illness (heart attack, etc.)

□ Physical Assault (attacked with a weapon, severe injuries from a fight, held at gunpoint, etc.)

□ Sexual assault (rape, attempted rape, forced sexual act with a weapon, etc.)

□ Military combat or lived in a war zone

□ Child abuse (severe beatings, sexual acts with someone 5 years older than you, etc.)

□ Accident (serious injury or death from a car, at work, a house fire, etc.)

□ Natural disaster (severe hurricane, flood, earthquake, etc.)

□ Other trauma (Please describe briefly):

_____

_____

_____

□ None

*** If NONE, please STOP and return this questionnaire ***

If you marked any of the above items, which single traumatic experience is on your mind and currently bothers you the most:
(Check only one)

□ Serious, life threatening illness (heart attack, etc.)

□ Physical Assault (attacked with a weapon, severe injuries from a fight, held at gunpoint, etc.)

□ Sexual assault (rape, attempted rape, forced sexual act with a weapon, etc.)

□ Military combat or lived in a war zone

□ Child abuse (severe beatings, sexual acts with someone 5 years older than you, etc.)

□ Accident (serious injury or death from a car, at work, a house fire, etc.)

□ Natural disaster (severe hurricane, flood, earthquake, etc.)

□ Other trauma (Please describe briefly):

Instructions: Below is a list of problems that people sometimes have after experiencing a traumatic event. Write down the most distressing traumatic event that you checked on the last page:

Please read each statement carefully and circle the number that best describes how often that problem has been happening and how much it upset you over THE LAST MONTH. Rate each problem with respect to the traumatic event that you wrote above.

For example, if you've talked to a friend about the trauma one time in the past month, you would respond like this: (because one time in the past month is less than once a week)

Talking to other people about the trauma

0	(1)	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

1. **Unwanted upsetting memories about the trauma**

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

2. **Bad dreams or nightmares related to the trauma**

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

3. **Reliving the traumatic event or feeling as if it were actually happening again**

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

4. **Feeling very EMOTIONALLY upset when reminded of the trauma**

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

5. **Having PHYSICAL reactions when reminded of the trauma (for example, sweating, heart racing)**

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

6. **Trying to avoid thoughts or feelings related to the trauma**

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

7. **Trying to avoid activities, situations, or places that remind you of the trauma or that feel more dangerous since the trauma**

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

8. Not being able to remember important parts of the trauma

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

9. Seeing yourself, others, or the world in a more negative way (for example "I can't trust people," "I'm a weak person")

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

10. Blaming yourself or others (besides the person who hurt you) for what happened

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

11. Having intense negative feelings like fear, horror, anger, guilt or shame

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

12. Losing interest or not participating in activities you used to do

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

13. Feeling distant or cut off from others

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

14. Having difficulty experiencing positive feelings

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

15. Acting more irritable or aggressive with others

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

16. Taking more risks or doing things that might cause you or others harm (for example, driving recklessly, taking drugs, having unprotected sex)

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

17. Being overly alert or on-guard (for example, checking to see who is around you, being uncomfortable with your back to a door)

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

18. Being jumpy or more easily startled (for example when someone walks up behind you)

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

19. Having trouble concentrating

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

20. Having trouble falling or staying asleep

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

DISTRESS AND INTERFERENCE

21. How much have these difficulties been bothering you?

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

22. How much have these difficulties been interfering with your everyday life (for example relationships, work, or other important activities)?

0	1	2	3	4
Not at all	Once a week or less/a little	2 to 3 times a week/somewhat	4 to 5 times a week/very much	6 or more times a week/severe

SYMPTOM ONSET AND DURATION

23. How long after the trauma did these difficulties begin? [circle one]
    a. Less than 6 months
    b. More than 6 months

24. How long have you had these trauma-related difficulties? [circle one]
    a. Less than 1 month
    b. More than 1 month

SELF-EVALUATION QUESTIONNAIRE

STAI Form Y-2

Name_____ Date_____

DIRECTIONS

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you *generally* feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe how you generally feel.

	ALMOST NEVER	SOMETIMES	OFTEN	ALMOST ALWAYS
21. I feel pleasant	1	2	3	4
22. I feel nervous and restless	1	2	3	4
23. I feel satisfied with myself	1	2	3	4
24. I wish I could be as happy as others seem to be	1	2	3	4
25. I feel like a failure	1	2	3	4
26. I feel rested	1	2	3	4
27. I am "calm, cool, and collected"	1	2	3	4
28. I feel that difficulties are piling up so that I cannot overcome them	1	2	3	4
29. I worry too much over something that really doesn't matter	1	2	3	4
30. I am happy	1	2	3	4
31. I have disturbing thoughts	1	2	3	4
32. I lack self-confidence	1	2	3	4
33. I feel secure	1	2	3	4
34. I make decisions easily	1	2	3	4
35. I feel inadequate	1	2	3	4
36. I am content	1	2	3	4
37. Some unimportant thought runs through my mind and bothers me	1	2	3	4
38. I take disappointments so keenly that I can't put them out of my mind	1	2	3	4
39. I am a steady person	1	2	3	4
40. I get in a state of tension or turmoil as I think over my recent concerns and interests	1	2	3	4

STAIP-AD Test Form Y
www.mindgarden.com

Date:_____ ID:_____

(CES-D)

For the following 10 items, please select the choice that best describes how you have felt over the past week:

	Rarely or none of the time (<1 day)	Some or a little of the time (1-2 days)	Occasionally or a moderate amount of the time (3-4 days)	Most or all of the time (5-7 days)
1. I was bothered by things that don't usually bother me	0	1	2	3
2. I had trouble keeping my mind on what I was doing	0	1	2	3
3. I felt depressed	0	1	2	3
4. I felt that everything I did was an effort	0	1	2	3
5. I felt hopeful about the future	3	2	1	0
6. I felt fearful	0	1	2	3
7. My sleep was restless	0	1	2	3
8. I was happy	3	2	1	0
9. I felt lonely	0	1	2	3
10. I could not get "going"	0	1	2	3

Subject's Initials_____ID#_____Date_____Time_____AM PM

PITTSBURGH SLEEP QUALITY INDEX

INSTRUCTIONS:
The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, what time have you usually gone to bed at night?

   BED TIME _____

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

   NUMBER OF MINUTES _____

3. During the past month, what time have you usually gotten up in the morning?

   GETTING UP TIME _____

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

   HOURS OF SLEEP PER NIGHT _____

For each of the remaining questions, check the one best response. Please answer all questions.

5. During the past month, how often have you had trouble sleeping because you . . .

a) Cannot get to sleep within 30 minutes

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Wake up in the middle of the night or early morning

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Have to get up to use the bathroom

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

d) Cannot breathe comfortably

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

e) Cough or snore loudly

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

f) Feel too cold

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

g) Feel too hot

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

h) Had bad dreams

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

i) Have pain

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

j) Other reason(s), please describe_____

_____

How often during the past month have you had trouble sleeping because of this?

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

6. During the past month, how would you rate your sleep quality overall?

Very good _____

Fairly good _____

Fairly bad _____

Very bad _____

7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

No problem at all _____

Only a very slight problem _____

Somewhat of a problem _____

A very big problem _____

10. Do you have a bed partner or room mate?

No bed partner or room mate _____

Partner/room mate in other room _____

Partner in same room, but not same bed _____

Partner in same bed _____

If you have a room mate or bed partner, ask him/her how often in the past month you have had . . .

a) Loud snoring

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

b) Long pauses between breaths while asleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

c) Legs twitching or jerking while you sleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

d) Episodes of disorientation or confusion during sleep

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

e) Other restlessness while you sleep; please describe_____

_____

Not during the past month_____	Less than once a week_____	Once or twice a week_____	Three or more times a week_____

Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ: Psychiatry Research, 28:193-213, 1989.

recherche en santé du Québec, Canadian Institutes of Health Research. Special thanks to Jean Miewald and Barbara Kumer for logistical support.

Appendix A. PSQI Addendum for PTSD

INSTRUCTIONS:
Please answer the following additional questions regarding your sleep in the past month. Include any observations from your bedpartner/ roommate.

1. During the past month, how often have you had trouble sleeping because you...

a) Feel hot flashes:

Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week

b) Feel general nervousness:

Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____

c) Had memories or nightmares of a traumatic experience:

Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____

d) Had severe anxiety or panic, not related to traumatic memories:

Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____

e) Had bad dreams, not related to traumatic memories:

Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____

f) Had episodes of terror or screaming during sleep without fully awakening:

Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____

g) Had episodes of "acting out" your dreams, such as kicking, punching, running, or screaming:

Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____

2. If you had memories or nightmares of a traumatic experience during sleep (question 11-c above)....

a) How much anxiety did you feel during the memories/nightmares?

None_____ | Very little_____ | Moderate_____ | Severe_____

b) How much anger did you feel during the memories/nightmares?

None_____ | Very little_____ | Moderate_____ | Severe_____

c) What time of night did most memories/nightmares occur?

Early in the night_____ | Middle of the night_____ | Late night, near morning_____ | No particular time_____

Box 4

The Alcohol Use Disorders Identification Test: Interview Version

Read questions as written. Record answers carefully. Begin the AUDIT by saying "Now I am going to ask you some questions about your use of alcoholic beverages during this past year." Explain what is meant by "alcoholic beverages" by using local examples of beer, wine, vodka, etc. Code answers in terms of "standard drinks". Place the correct answer number in the box at the right.

1. How often do you have a drink containing alcohol?
   (0) Never [Skip to Qs 9-10]
   (1) Monthly or less
   (2) 2 to 4 times a month
   (3) 2 to 3 times a week
   (4) 4 or more times a week

2. How many drinks containing alcohol do you have on a typical day when you are drinking?
   (0) 1 or 2
   (1) 3 or 4
   (2) 5 or 6
   (3) 7, 8, or 9
   (4) 10 or more

3. How often do you have six or more drinks on one occasion?
   (0) Never
   (1) Less than monthly
   (2) Monthly
   (3) Weekly
   (4) Daily or almost daily

   Skip to Questions 9 and 10 if Total Score for Questions 2 and 3 = 0

4. How often during the last year have you found that you were not able to stop drinking once you had started?
   (0) Never
   (1) Less than monthly
   (2) Monthly
   (3) Weekly
   (4) Daily or almost daily

5. How often during the last year have you failed to do what was normally expected from you because of drinking?
   (0) Never
   (1) Less than monthly
   (2) Monthly
   (3) Weekly
   (4) Daily or almost daily

6. How often during the last year have you needed a first drink in the morning to get yourself going after a heavy drinking session?
   (0) Never
   (1) Less than monthly
   (2) Monthly
   (3) Weekly
   (4) Daily or almost daily

7. How often during the last year have you had a feeling of guilt or remorse after drinking?
   (0) Never
   (1) Less than monthly
   (2) Monthly
   (3) Weekly
   (4) Daily or almost daily

8. How often during the last year have you been unable to remember what happened the night before because you had been drinking?
   (0) Never
   (1) Less than monthly
   (2) Monthly
   (3) Weekly
   (4) Daily or almost daily

9. Have you or someone else been injured as a result of your drinking?
   (0) No
   (2) Yes, but not in the last year
   (4) Yes, during the last year

10. Has a relative or friend or a doctor or another health worker been concerned about your drinking or suggested you cut down?
    (0) No
    (2) Yes, but not in the last year
    (4) Yes, during the last year

Record total of specific items here

If total is greater than recommended cut-off, consult User's Manual.

How Hard Are You Working?

0 Nothing at all

0.5 Extremely weak (just noticeable)

1 Very weak

2 Weak (light)

3 Moderate

4 Somewhat strong

5 Strong (heavy)

6

7 Very strong

8

9

10 Extremely strong (almost max)

- **Maximal**

Feeling Scale

Circle how you feel right now, in this very moment:

+5 Very good

+4

+3 Good

+2

+1 Fairly good

0 Neutral

-1 Fairly bad

-2

-3 Bad

-4

-5 Very bad

Felt Arousal Scale

Estimate your level of arousal by circling the appropriate number. By “arousal” we mean how “worked-up”.

High arousal might feel like excitement or anxiety or anger.

Low arousal might be something like relaxed or bored or calm.

1 LOW AROUSAL

2

3

4

5

6 HIGH AROUSAL

Cognitive Appraisal

Primary Appraisal:
How stressful do you expect the upcoming task to be?
1 Not at all
2
3
4
5
6
7 Extremely

Secondary Appraisal:
How able are you to cope with this task?
1 Not at all
2
3
4
5
6
7 Extremely

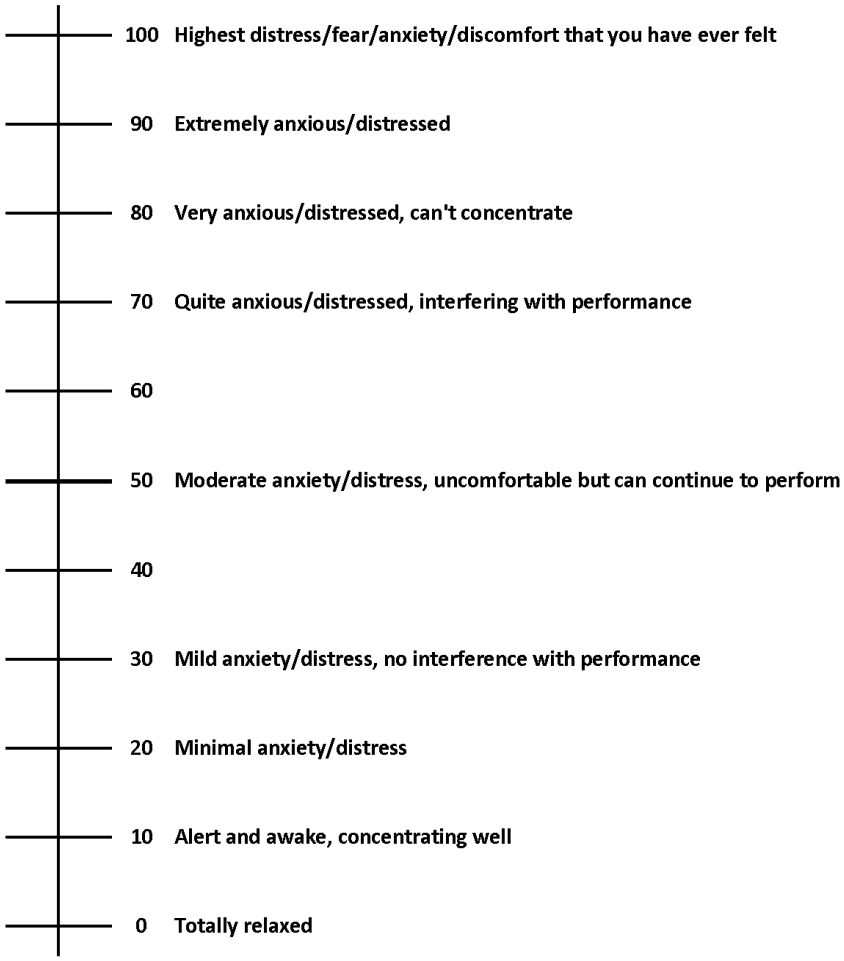
Post Session Assessment:
How stressful was the task you just completed?
1 Not at all
2
3
4
5
6
7 Extremely

Tomaka et al., (1993)

Please **circle the number** which is the **most correct** statement about you.

Statement	False True
01. I feel confident when doing coordinated movements.	1 2 3 4 5 6
02. I am a physically strong person.	1 2 3 4 5 6
03. I am quite good at bending, twisting and turning my body.	1 2 3 4 5 6
04. I can run a long way without stopping.	1 2 3 4 5 6
05. Overall, most things I do turn out well.	1 2 3 4 5 6
06. I usually catch whatever illness (flu, virus, cold etc) is going around.	1 2 3 4 5 6
07. Controlling movements of my body comes easily to me.	1 2 3 4 5 6
08. I often do exercise or activities that make me breathe hard.	1 2 3 4 5 6
09. My waist is too large.	1 2 3 4 5 6
10. I am good at most sports.	1 2 3 4 5 6
11. Physically, I am happy with myself.	1 2 3 4 5 6
12. I have a nice looking face.	1 2 3 4 5 6
13. I have a lot of power in my body.	1 2 3 4 5 6
14. My body is flexible.	1 2 3 4 5 6
15. I am sick so often that I cannot do all the things I want to do.	1 2 3 4 5 6
16. I am good at coordinated movements.	1 2 3 4 5 6
17. I have too much fat on my body.	1 2 3 4 5 6
18. I am better looking than most of my friends.	1 2 3 4 5 6
19. I can perform movements smoothly in most physical activities.	1 2 3 4 5 6
20. I do physically active things (e.g. jog, dance, bicycle, aerobics, gym, swim) at least three times a week.	1 2 3 4 5 6
21. I am overweight.	1 2 3 4 5 6
22. I have good sports skills.	1 2 3 4 5 6
23. Physically, I feel good about myself.	1 2 3 4 5 6
24. Overall, I am no good.	1 2 3 4 5 6
25. I get sick a lot.	1 2 3 4 5 6
26. I find my body handles coordinated movements with ease.	1 2 3 4 5 6
27. I do lots of sports, dance, gym, or other physical activities.	1 2 3 4 5 6
28. I am good looking.	1 2 3 4 5 6
29. I could do well in a test of strength.	1 2 3 4 5 6
30. I can be physically active for a long period of time without getting tired.	1 2 3 4 5 6
31. Most things I do, I do well.	1 2 3 4 5 6
32. When I get sick, it takes me a long time to get better	1 2 3 4 5 6
33. I do sports, exercise, dance or other physical activities almost every day.	1 2 3 4 5 6
34. I play sports well.	1 2 3 4 5 6
35. I feel good about who I am physically.	1 2 3 4 5 6
36. I think I would perform well on a test measuring flexibility.	1 2 3 4 5 6
37. I am good at endurance activities like distance running, aerobics, bicycling, swimming, or cross-country, skiing.	1 2 3 4 5 6
38. Overall, I have a lot to be proud of.	1 2 3 4 5 6
39. I have to go to the doctor because of illness more than most people my age.	1 2 3 4 5 6
40. Nothing I ever do seems to turn out right.	1 2 3 4 5 6

Thank you


100 Highest distress/fear/anxiety/discomfort that you have ever felt
90 Extremely anxious/distressed
80 Very anxious/distressed, can't concentrate
70 Quite anxious/distressed, interfering with performance
60
50 Moderate anxiety/distress, uncomfortable but can continue to perform
40
30 Mild anxiety/distress, no interference with performance
20 Minimal anxiety/distress
10 Alert and awake, concentrating well
0 Totally relaxed

Do you avoid thinking about a stressful experience?

Are you jumpy or easily startled?

Teachers College at Columbia University is conducting a 6-week study testing a program designed to examine your physical and mental health

127

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APPENDIX E

APPENDIX E. Group Comparison of Muscular Strength

	Resistance Training, Mean (SD)		Control, Mean (SD)	
	Baseline	Follow-up	Baseline	Follow-up
Squats	94.1 (77.6)	139.1 (78.0) †‡	72.5 (39.0)	69.2 (32.4)
Bench press	30.9 (40.2)	44.1 (44.0) †‡	26.7 (32.4)	21.7 (30.3)
Lat pull-down	49.5 (35.7)	64.1 (38.2) †‡	47.1 (27.4)	42.5 (25.0)
Overhead press	33.2 (15.7)	41.8 (17.5) †‡	31.7 (10.7)	28.8 (9.6)
Biceps curls	35.9 (16.9)	45.0 (22.0) †‡	32.9 (11.0)	31.7 (9.1)

SD=standard deviation; †=p<.05 vs. Baseline; ‡=p<.05 vs. Control

APPENDIX F

APPENDIX F. Group Comparison of the PSQI Subcomponents

	Resistance Training, Mean (SD)		Control, Mean (SD)	
	Baseline	Follow-up	Baseline	Follow-up
Sleep Duration	1.3 (0.9)	0.6 (0.7) †‡	1.2 (1.4)	1.5 (1.3)
Sleep Disturbances	1.5 (0.5)	1.4 (0.5)	1.5 (0.7)	1.7 (0.9)
Sleep Latency	2.2 (1.0)	1.7 (1.0)	2.0 (1.0)	1.8 (1.1)
Daytime Dysfunction	1.6 (1.1)	1.3 (0.9)	1.8 (1.0)	1.2 (0.7)
Sleep Quality	1.6 (0.8)	1.2 (0.9)	1.6 (0.9)	1.5 (0.7)
Sleep Medications	0.7 (0.9)	0.3 (0.9) †	1.1 (1.2)	0.8 (1.2)
Sleep Efficiency	1.5 (1.1)	0.5 (0.8) †‡	1.3 (1.2)	1.3 (1.3)

SD=standard deviation; PSQI=Pittsburgh Sleep Quality Index; †=p<.05 vs. Baseline; ‡=p<.05 vs. Control