

Treatment of Posttraumatic Stress Disorder Alleviates Tinnitus-related Distress Among Veterans: a Pilot Study

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Abstract

Background: Military service personnel are at increased risk for developing tinnitus due to heightened exposure to acoustic trauma. The auditory disorder is a leading service-connected disability among veterans and is highly comorbidly diagnosed with posttraumatic stress disorder (PTSD). The biopsychosocial model illustrates that chronic health conditions are exacerbated or maintained by psychiatric distress. Therefore, alleviation of such psychiatric distress can have beneficial impacts on health conditions, such as tinnitus. The aim of this study was to determine whether individuals with both disorders who receive evidence-based therapy for PTSD, will experience decreases in both PTSD and tinnitus-related distress.

Methods: Veterans with comorbid bothersome tinnitus and PTSD received Cognitive Processing Therapy (CPT) and were assessed for PTSD, tinnitus-related distress, and depression at baseline and one month post-treatment follow-up.

Results: At post-treatment follow-up, participants demonstrated significant decreases in PTSD symptoms compared to their baseline scores. Participants also demonstrated decreased tinnitus-related distress and depression, with high effect sizes.

Discussion: This pilot study demonstrated the benefit of addressing psychiatric distress, such as PTSD, to simultaneously target bothersome tinnitus. Although not statistically significant due to the small sample size, large effect sizes indicate that tinnitus-related distress decreased as a function of receiving evidence-based therapy for PTSD. Future clinical trials should increase sample sizes and compare effects to control conditions.

Trial Registration

ClinicalTrials.gov. NCT03702166. Registered October 10, 2018,
[https://clinicaltrials.gov/ct2/show/NCT03702166?](https://clinicaltrials.gov/ct2/show/NCT03702166?cond=tinnitus&cntry=US&state=US%3ATX&city=San+Antonio&draw=1&rank=1)
[cond=tinnitus&cntry=US&state=US%3ATX&city=San+Antonio&draw=1&rank=1](https://clinicaltrials.gov/ct2/show/NCT03702166?cond=tinnitus&cntry=US&state=US%3ATX&city=San+Antonio&draw=1&rank=1)

Background

Posttraumatic stress disorder (PTSD) is characterized as a psychological reaction to actual or threatened death, serious injury, or sexual violence [1]. Over 90% of service members and veterans deployed post-9/11 have been exposed to at least one type of traumatic event during their deployments [2] and up to 32% of military service members and veterans have been diagnosed with PTSD [3, 4]. Comorbid health conditions, such as headaches, traumatic brain injury (TBI), and depression have been shown to worsen overall PTSD symptom presentation [5]. Another common co-occurring disorder with PTSD is tinnitus, but it is unknown how it affects PTSD symptom presentation.

Tinnitus is defined as a phantom auditory perception, in one or both ears, without an objective noise source [6]. Types of tinnitus percept include ringing, buzzing, or a rushing sound; the intensity frequency and duration of these percepts vary among individuals [7]. Tinnitus-related distress includes the cognitive, emotional, and behavioral symptomatic sequelae related to the experience of chronic tinnitus. The symptom clusters of tinnitus-related distress are heterogeneous and affects cognitive and emotional well-being [8, 9] and can include symptoms of anxiety and depression [10].

Military personnel have a much higher risk of developing tinnitus due to significant exposure to acoustic trauma through proximity to military aircraft [11], weapon use [12], and combat-related hazards such as car bombs, improvised explosive devices (IEDs), incoming mortar attacks, and rocket-propelled grenades [13]. Exposure to acoustic trauma increases the likelihood of developing tinnitus before, during, and after deployment [14]. Although the defining symptoms of tinnitus (an illusory auditory percept) and PTSD (a trauma disorder) are distinct, their prevalence rates indicate a possible connection between the two disorders.

First, a chart review of veterans treated over a four-year period indicated that 34% of veterans with tinnitus also carried a PTSD diagnosis [15]. Upon closer examination, tinnitus-related distress and PTSD may reflect common sources and/or symptoms. The same psychologically traumatic event could contribute to both PTSD and tinnitus (e.g., IEDs, car bomb). Tinnitus can be conceptualized as a conditioned stimulus, reminding the individual of the traumatic event (Criterion B of PTSD) [1]. In a study of Cambodian refugees with PTSD symptoms, an overwhelming 92% of that cohort reported that flashbacks were accompanied by tinnitus [16], suggesting the relationship between tinnitus and re-experiencing symptoms of PTSD. The same study demonstrated that tinnitus-associated negative mood and cognitive symptoms also predicted PTSD severity. Other studies have reported heightened symptoms of avoidance [15], hypervigilance, and hyperarousal [17] among tinnitus patients, representing Criterion C and E of PTSD, respectively.

There is strong evidence to support involvement of a shared neurobiological mechanism between tinnitus and PTSD. The auditory vigilance network (A1/VAN) is highly implicated among PTSD patients [18]. In fact, the auditory network contains the most regions that differentiate veterans with PTSD versus combat-exposed veterans and civilians without PTSD [19]. The A1/VAN is also the most frequently implicated network in patients with tinnitus [20–22]. Another study found dysregulated connectivity within the A1/VAN, and higher connectivity between the A1/VAN and the visual cortex among PTSD patients [18]. These findings suggest that the genesis and maintenance of tinnitus and PTSD may involve similar neurobiological substrates and/or processes.

Other studies point to exacerbation of tinnitus-related distress as a function of psychiatric distress. Between 32% and 45% of individuals with tinnitus also suffer from anxiety disorders [23], indicating a potentially strong psychiatric component of tinnitus-related distress, either as a premorbid factor or with tinnitus onset. The same study showed that 40% of individuals with tinnitus also reported a family history of psychiatric disorders. Functional outcomes for individuals with both tinnitus and PTSD are also

significantly worse than for those with tinnitus only, or tinnitus and any other psychological disorder [17]. This finding suggests especially deleterious outcomes when tinnitus co-occurs with PTSD. Investigation of innovative approaches to the simultaneous management of both conditions is warranted.

Current models borrowed from the chronic pain literature suggest that functional outcomes can be improved when psychological factors are targeted. The biopsychosocial model [24, 25] incorporates biomedical factors, behaviors, emotions, cognitions, cultural values, social support, and socioeconomic status as factors to more fully understand the origins of pain. Framed within the biopsychosocial model, the fear-avoidance model describes a cycle initiated by pain, followed by a constellation of cognitive, emotional, and behavioral responses that may reinforce pain and disability [26, 27]. A key component of the fear-avoidance model is its identification and restructuring of maladaptive cognitions related to the pain or to the implications of painful sensations. Catastrophic cognition, for example, can lead to a cascade of consequences, including overestimation of future pain, avoidance of activities, and physical deconditioning, resulting in reduced levels of function [28]. The fear-avoidance model emphasizes the connection between psychiatric distress and chronic pain, which is further supported by neurobiological [29] and psychological studies [30–32] studies. It is likely that PTSD, tinnitus, and chronic pain all manifest central nervous system changes that persist long after original external or peripheral trauma. It is reasonable to consider that evidence-based therapies for one of these conditions (e.g., PTSD) may also serve to reduce distress associated with another (e.g., tinnitus).

Cognitive processing therapy [33] is one such evidence-based psychotherapy for PTSD. Studies have demonstrated that CPT is efficacious among childhood sexual and physical abuse survivors [34, 35], female sexual assault survivors [36] and military service personnel and veterans [37–41]. Meta-analyses have also shown that CPT has the largest mean effect size compared to any other treatment for PTSD [42–44]. CPT usually consists of 12 sessions, each lasting 50–60 minutes. Patients learn how to recognize dysfunctional thoughts (“stuck points”) that are related to the traumatic experience and larger themes of safety, trust, power and control, esteem, and intimacy. Moving forward in therapy, patients challenge these stuck points and learn how to develop more realistic thoughts, acceptance of the traumatic event, and experiencing natural emotions associated with the trauma.

The alleviation of PTSD may serve to decrease tinnitus-related distress in two ways. First, since tinnitus-related distress and PTSD share common symptoms [15–17], reduction of avoidance, improved emotional and cognitive flexibility, and reduced reactivity may extend to reduce tinnitus-related dysfunction. Additionally, according to the biopsychosocial and fear-avoidance models, PTSD patients who change their dysfunctional beliefs and learn to experience more positive emotions through evidence-based psychotherapy may also benefit by reduced tinnitus-related distress.

The current study investigated the relationship between PTSD-related psychiatric distress and tinnitus-related distress. Based on the reasoning of the biopsychosocial and fear-avoidance models, we expected that negative emotional, cognitive, and behavioral states associated with PTSD serve to exacerbate tinnitus-related distress. Therefore, it was hypothesized that from baseline to one month post-treatment

follow-up, individuals with PTSD and bothersome tinnitus who received CPT would experience decreased PTSD symptoms as well as decreased tinnitus-related distress.

Methods

Participants

Informed consent was obtained from all individual participants included in the study. Participants were U.S. veterans, 18 years of age or older who sought treatment for PTSD. Inclusion criteria required the experience of a Criterion A trauma defined by the DSM-5 [1], a diagnosis of PTSD from an independent evaluator using the Clinician-Administered PTSD Scale for DSM-5 (CAPS-5) [45], and self-reported bothersome tinnitus, operationalized as a score of 34 or higher on the Tinnitus Functional Index (TFI) [46]. English literacy and stability on psychotropic medications was also required. Exclusion criteria included suicide or homicide risk warranting immediate intervention, significant alcohol and/or substance abuse that would prevent participants from attending therapy or completing practice assignments, active psychosis, and/or severe traumatic brain injury (TBI).

This study was reviewed by the University of Texas Health Science Center at San Antonio Institutional Review Board (Protocol #HSC20180524H). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institution and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For each session and evaluation, adverse events were monitored using an AE-monitoring form used in previous studies [47].

Measures

Clinician-Administered PTSD Scale for DSM-5 (CAPS-5) [45]. The CAPS-5 is a semi-structured interview that measures the DSM-5 [1] symptoms of PTSD; to reach diagnostic threshold, this scale requires the presence of at least one intrusion symptom, one avoidance symptom, two cognition or mood symptoms, and two arousal symptoms for a period of one month or more. There are 20 symptom items and responses that are rated on a 5-point scale ranging from 0 (absent) to 4 (extreme/incapacitating); a total PTSD symptom severity score ranges from 0–80 as the sum of the 20 symptom items.

Patient Health Questionnaire-9 (PHQ-9) [48]. The PHQ-9 is a 9-item self-report measure that measures the severity of affective and somatic symptoms related to depression and depressive disorders. Respondents rate the frequency with which they have been bothered by depressive symptoms within the past two weeks on a scale from 0 (“not at all”) to 3 (“nearly every day”). The PHQ-9 has high internal consistency and correlates strongly with other measures of depression.

Tinnitus Functional Index (TFI) [49]. The TFI is used specifically for clinical trials in which tinnitus-associated symptom severity may change over time. The TFI is comprised of 25 questions forming 8 subscales. Subscales include intrusiveness of tinnitus, sense of control, cognitive interference, sleep

disturbance, auditory issues, relaxation issues, quality of life, and emotional distress. Individuals with TFI scores of below 25 are classified as “mild tinnitus,” while scores between 25 and 50 are considered “significant problems,” and scores above 50 indicate severe tinnitus that warrants more intensive therapeutic approaches. Additionally, reductions of approximately 14 points on the TFI represent clinically meaningful change [49]. The TFI was used in this study as a screener to ensure that enrolled participants had bothersome tinnitus, defined as a score of 34 or higher.

PTSD Checklist for DSM-5 (PCL-5) [50]. The PCL-5 has excellent psychometric characteristics for screening and as a secondary indicator of PTSD symptom severity [51]. The PCL-5 is a 20-item self-report measure, selected for its dimensional sensitivity; higher scores reflect greater PTSD severity.

Procedures

Participants were recruited from advertisements on social media and by direct referrals from Department of Veterans Affairs (VA) providers. All participants met criteria for PTSD and tinnitus during baseline assessment conducted by an independent evaluator who was blinded from the treatment condition and assessment timepoint. Baseline measures of PTSD (CAPS-5), depression (PHQ-9), and tinnitus-related distress (TFI) were gathered.

If participants were found eligible and provided consent, they met with the study therapist (JCM) prior to beginning CPT. This initial session focused on gathering psychosocial information, a review of the participant’s index traumatic event, discussion of treatment goals and expectations of therapy, and creation of a therapy schedule. Throughout CPT, participants completed the PCL-5 (even numbered sessions) and the PHQ-9 and TFI (odd numbered sessions). Upon completion of CPT, participants were scheduled for a one-month follow-up to assess for PTSD, depression, and tinnitus-related distress.

Data Analytic Strategy

Primary variables of interest to this study included change scores of the CAPS-5, PHQ-9, and TFI, from baseline to post-treatment. Multiple t-tests were conducted with Bonferroni correction for multiple comparisons. Alpha level for significance, with three tests, was set at $\alpha = .017$.

Results

Participants were 10 veterans diagnosed with PTSD and bothersome tinnitus. Table 1 shows participants’ demographic information. The mean age of participants was 45.3 years, with an average of 15.74 years of service in the military. One participant (10%) dropped out of the study after session 4 of CPT, and 1 participant did not complete post-treatment assessments.

Multiple t-tests, with Bonferroni corrections for multiple comparisons, showed significant decreased symptoms of PTSD as measured by the CAPS-5 from pre-treatment ($M = 33.13$, $SD = 8.08$) to post-

treatment ($M = 16.13$, $SD = 14.45$), $t(1, 7) = 3.42$, $p = .01$, $d = 1.29$. Decreases in depression from pre-treatment ($M = 14.10$, $SD = 6.59$) to post-treatment ($M = 7.38$, $SD = 4.98$), $t(1, 7) = 2.68$, $p = .031$, and tinnitus-related distress from pre-treatment ($M = 65.16$, $SD = 15.97$) to post-treatment ($M = 41.95$, $SD = 24.42$), $t(1, 7) = 2.56$, $p = .038$, approached significance. Cohen's d effect sizes for depression and tinnitus-related distress were 1.01 and .97, respectively. Figure 1 shows pre- and post-treatment scores. Figure 2 shows session-by-session mean PCL-5, PHQ-9, and TFI scores. The mean change on the TFI was $M = 22.34$ ($SD = 24.71$), and half ($N = 4$) of the participants experienced a clinically meaningful change on the TFI, with reductions greater than 14 points [49].

Discussion

Tinnitus and PTSD are the first and third most common service-connected disabilities, respectively, in U.S. military veterans. The development and prevalence of these conditions will likely increase over time among veterans who served post-9/11 deployments to Iraqi, Afghanistan, and surrounding locations. During deployment, service members are at higher risk of experiencing acoustic trauma [14] and psychological trauma [52]. There is a continuing need for evidence-based PTSD and tinnitus treatments that can improve veterans' level of functioning and quality of life.

Based on prior research and existing models of pain and psychiatric distress, it was hypothesized that treatment for PTSD symptoms would also reduce tinnitus-related distress. Research on the prevalence, functional outcomes, and neurobiological basis of these conditions indicate a possible connection. Shared symptoms include flashbacks when tinnitus reminds individuals of their psychological trauma [16], avoidance and aversions to loud signals [15], exaggerated and erroneous beliefs [16], and hyperarousal [17]. Biopsychosocial and fear-avoidance models account for the role of cognitions and emotion in disability status among chronic pain patients. More specifically, Marshall et al. [53] showed that the relationship between pain and disability was significantly mediated by fear, catastrophic thinking, and depression for individuals who were active on a weekly basis. Emotional and psychiatric distress appears to have a negative impact on pain and on functional outcomes related to pain. Therefore, we hypothesized that alleviation of PTSD-related psychiatric distress, through CPT, would also help to alleviate depression-, and tinnitus-related distress.

Results of this study partially supported its hypothesis. A total of 10 participants with comorbid bothersome tinnitus and PTSD completed CPT [33]. At a one-month post-treatment follow-up, participants showed a significant reduction in their PTSD symptoms, with a large effect size. Though not statistically significant, participants also experienced decreases in symptoms of depression and tinnitus-related distress, with large effect sizes. This study demonstrated promising results for the possible alleviation of tinnitus through evidence-based psychotherapy for PTSD.

Limitations of this study include its small sample size, which reduced its statistical power and limited the significance of pre- to post-treatment changes in depression and tinnitus-related distress. The Cohen's d effect sizes of all analyses were large, indicating that these changes likely would have reached

significance in a larger cohort. Other limitations of the study include the lack of audiometric evaluation to characterize participants' auditory function more fully as it relates to tinnitus. Future studies should include larger participant sets and more detailed evaluation of tinnitus and hearing status; a randomized clinical trial to include and compare other treatments would be informative.

Conclusions

In summary, the hypotheses for the current study were partially supported. Through CPT, participants learned how to recognize and challenge maladaptive thoughts related to trauma and present-day difficulties, and to generate more balanced thoughts to reduce their PTSD symptom. Attenuation of their tinnitus-related distress was also observed, though this change did not reach statistical significance. Future, larger studies should examine the neurobiological relationship between tinnitus and PTSD, and consider approaches to more specifically tailor psychotherapy, compare alternative treatment strategies, or develop innovative neuro-modulatory therapies.

Abbreviations

A1/VAN

Auditory Vigilance Attention Network; CAPS-5: Clinician-Administered PTSD Scale for DSM-5; CPT: Cognitive Processing Therapy; DSM-5: Diagnostic and Statistical Manual of Mental Disorders, 5th Edition; IED: Improvised Explosive Device; PCL-5: PTSD Checklist for DSM-5; PHQ-9: Patient Health Questionnaire-9; PTSD: Posttraumatic Stress Disorder; TFI: Tinnitus Functional Index

Declarations

Ethics approval and consent to participate

All study procedures were approved and monitored by the Institutional Review Board at the University of Texas Health Science Center at San Antonio. The study was conducted in accordance with the Declaration of Helsinki. All study participants provided written informed consent prior to any study procedure.

Consent for publication

Not applicable.

Availability of supporting data

Final data sets from this pilot study will be shared in accordance with a Data Use Agreement that prohibits the recipient from identifying or re-identifying any individual whose data are included in the dataset. We will make sufficient data and descriptors available to confirm conclusions in the publication, run duplicate statistical analyses, and perform additional analyses.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

JCM, PAR, ALP, FTM, CE, and PF assisted with the design, writing, and interpretation of results. SY-M assisted with writing and regulatory aspects of the study. EG assisted with participant recruitment and study design.

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Tables

Table 1. *Demographic Characteristics*

Characteristic	Total Sample (<i>N</i> = 10)
Age	45.3 (SD, 9.75)
Male	9 (90%)
Married	7 (70%)
Ethnicity	
Hispanic	4 (40%)
Caucasian/Non-Hispanic	4 (40%)
African American	2 (20%)
Education	
Associates degree	2 (20%)
College/Graduate degree	8 (80%)
Branch	
Army	8 (80%)
Airforce	1 (10%)
Marines	1 (10%)
Enlisted Rank	9 (90%)
Months in Military	188.9 (SD, 105.75)
Typical Duty	
Combat Arms	5 (50%)
Combat Support	2 (20%)
Combat Service Support	3 (30%)

Figures

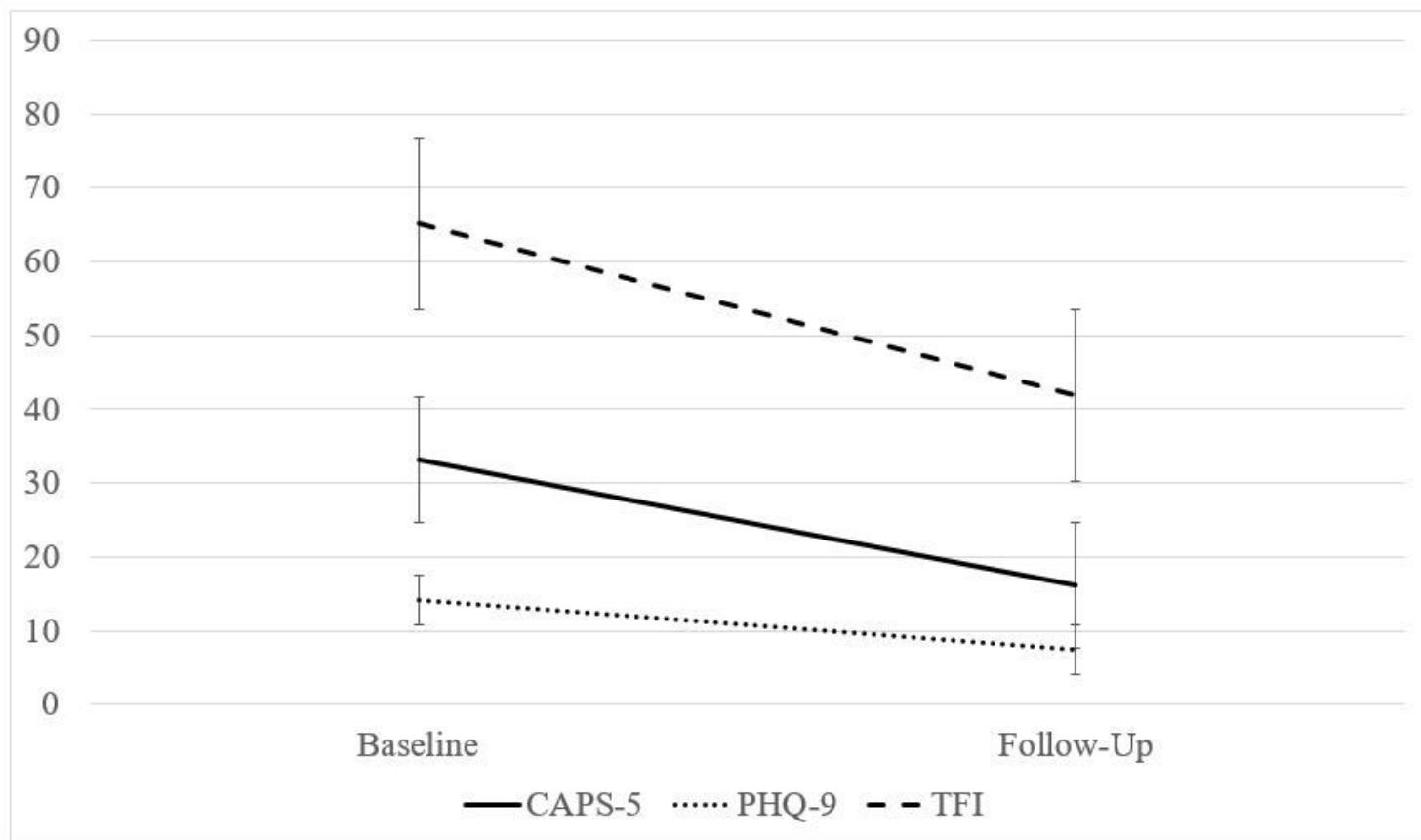


Figure 1

Pre-Post Treatment Scores of the CAPS-5, TFI, and PHQ-9

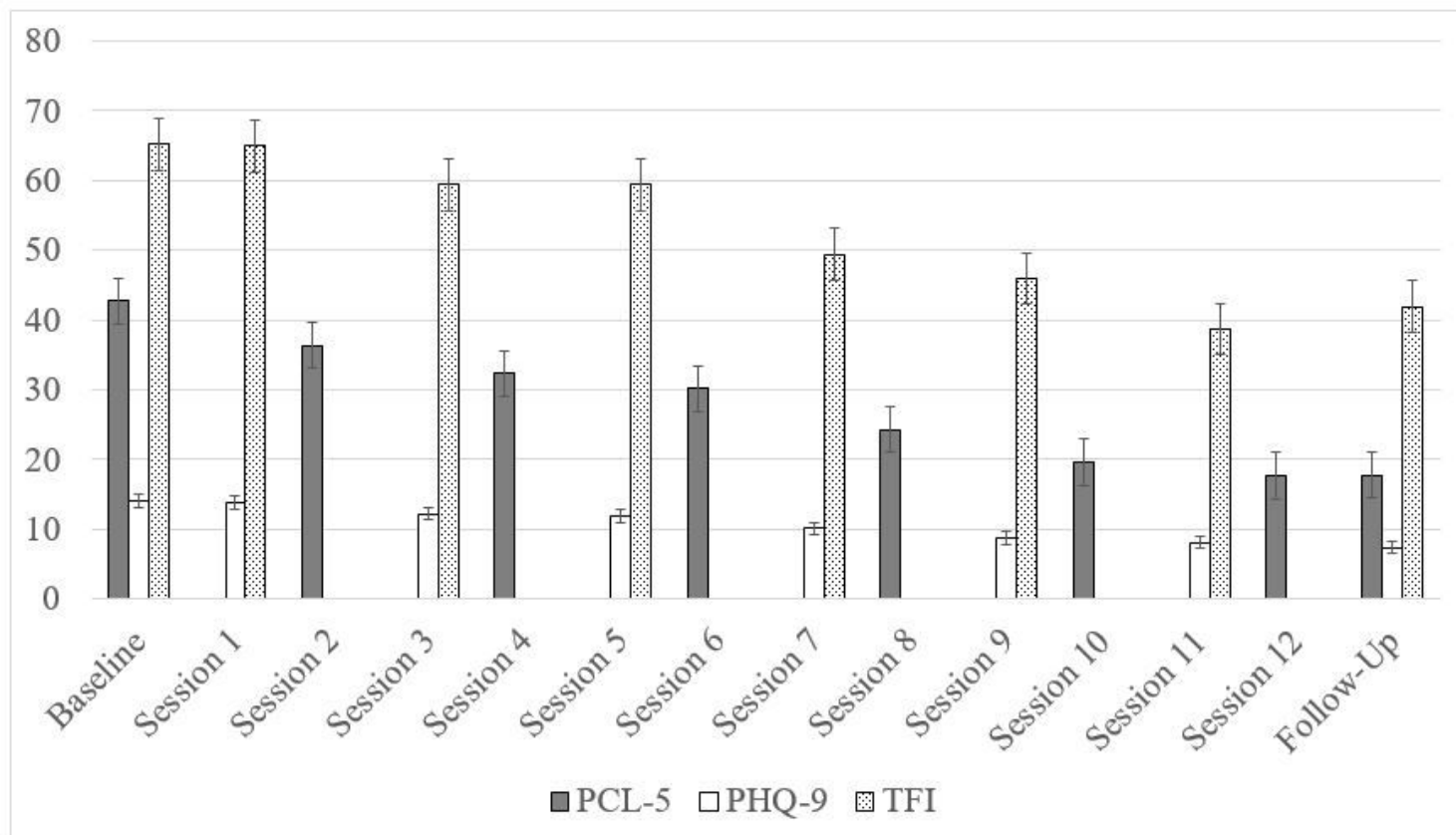


Figure 2

Session-by-Session Scores of the PCL-5, TFI, and PHQ-9