

# The effects of music relaxation and muscle relaxation techniques on sleep quality and emotional measures among individuals with posttraumatic stress disorder

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## Abstract

Posttraumatic stress disorder (PTSD), an anxiety disorder with lifetime prevalence of 7.8%, is characterized by symptoms that develop following exposure to traumatic life events and that cause an immediate experience of intense fear, helplessness or horror. PTSD is marked by recurrent nightmares typified by the recall of intrusive experiences and by extended disturbance throughout sleep. Individuals with PTSD respond poorly to drug treatments for insomnia. The disadvantages of drug treatment for insomnia underline the importance of non-pharmacological alternatives. Thus, the present study had three aims: first, to compare the efficiency of two relaxation techniques (muscular relaxation and progressive music relaxation) in alleviating insomnia among individuals with PTSD using both objective and subjective measures of sleep quality; second, to examine whether these two techniques have different effects on psychological indicators of PTSD, such as depression and anxiety; and finally, to examine how initial PTSD symptom severity and baseline emotional measures are related to the efficiency of these two relaxation methods. Thirteen PTSD patients with no other major psychiatric or neurological disorders participated in the study. The study comprised one seven-day running-in, no-treatment period, followed by two seven-day experimental periods. The treatments constituted either music relaxation or muscle relaxation techniques at desired bedtime. These treatments were randomly assigned. During each of these three experimental periods, subjects' sleep was continuously monitored with a wrist actigraph (Ambulatory Monitoring, Inc.), and subjects were asked to fill out several questionnaires concerned with a wide spectrum of issues,

such as sleep, depression, and anxiety. Analyses revealed a significant increase in objective and subjective sleep efficiency and a significant reduction in depression level following music relaxation. Moreover, following music relaxation, a highly significant negative correlation was found between improvement in objective sleep efficiency and reduction in depression scale. The study's findings provide evidence that music relaxation at bedtime can be used as treatment for insomnia among individuals with PTSD.

## Introduction

Posttraumatic stress disorder (PTSD), an anxiety disorder with lifetime prevalence of 7.8%,<sup>1,2</sup> is characterized by symptoms that develop following exposure to traumatic life events and that cause an immediate experience of intense fear helplessness or horror. These symptoms are manifested by three cardinal symptom domains: intrusions (*e.g.*, reliving the event), hyper-arousal (*e.g.*, difficulty in concentrating) and avoidance (*e.g.*, avoiding reminders of the event). A diagnosis of PTSD requires symptom duration of at least one month with significant function impairment in an important area of life, such as family and work.<sup>2</sup>

The *Diagnostic and Statistical Manual of Mental Disorders - Fourth Edition* criteria for PTSD include two aspects of sleep disorders: recurrent nightmares typified by recall of intrusive experiences and extended disturbance throughout sleep resulting from the elevated stimulation/awareness that characterizes this disorder.<sup>2</sup> Various studies that have explored the strength of the correlation between PTSD and sleep disorders have shown a correlation with nightmares and with insomnia and sleep duration.<sup>3-6</sup> An additional series of articles supports the specific connection between recurrent nightmares and PTSD.<sup>7-9</sup> All suggest that recurrent nightmares are the primary sleep disorder resulting from exposure to traumatic stress, particularly in combat, and that frequency of occurrence is closely tied to the extent of the trauma. Another study notes that the likelihood for sleep disorder increases among stress victims suffering from Cluster A personality disorder,<sup>10</sup> while other studies show that sleep disorder is not connected to prior psychotic disorders or to stressful life events in the past.<sup>11,12</sup>

Insomnia, including that secondary to PTSD, entails significant personal suffering and cost, both direct and indirect. Insomnia has been found to correlate with depression as well as with other psychological ailments, notably decreased attention, impaired memory,<sup>13,14</sup> increased likelihood of vehicular acci-

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dents, alcohol consumption, chronic fatigue,<sup>15,16</sup> and disruptions in work and in social function.<sup>13</sup> Additionally, physiological disorders are also correlated with insomnia, among them elevated body temperature and heart rate, electroencephalogram and cortisol levels in urine.<sup>13</sup> Insomnia tends to remain at chronic levels (defined as persisting for over three weeks), and when it dissipates, it often reappears later.<sup>16</sup> Insomnia has also been found related to decreased quality of life, even after controlling for comorbidity with other psychological disorders.<sup>13</sup> Consequently, insomnia presents significant personal and public challenges calling for further inquiry to improve identification and treatment of the condition, and the problem is only exacerbated by the relative lack of research in this area.<sup>13</sup> The existence of a connection between PTSD and insomnia is well understood based upon studies that have demonstrated insomnia's association with anxiety and depression. Nevertheless, there is still no consensus regarding the causal relationship among these disorders.<sup>13,17,18</sup> This topic is of critical importance since it suggests that identifying and treating the sleep disorder may lead to concomitant improvement in accompanying disorders. A meta-analysis comparing drug treatment in 9144 subjects with insomnia (123 articles) to cognitive behavioral therapy in 1324 subjects (331 articles) found both treatments

to be effective for subjective complaints and objective measures in short-term evaluation (a few weeks)<sup>16</sup>. Both resulted in decreases of 15-30 minutes in sleep latency and up to a one-third reduction in wake time when compared to baseline. This study and others as well indicate that pharmacological intervention is better suited to short-term treatment, while behavioral cognitive therapy provides superior long-term results.<sup>16,19,20</sup> Nevertheless, it should be mentioned that there have not been sufficient controlled experiments assessing long-term treatments over months or years.<sup>21-25</sup> Only a few studies have explored the long-term effectiveness of cognitive behavioral therapy. Studies of cognitive behavioral treatments over six months and three years have found these treatments effective.<sup>24,26-29</sup> Treatments integrating the two approaches have yet to be reported.

The most prominent shortcoming of drug treatment is its side effects. One of the most common treatments is with benzodiazepines, a heterogeneous class of anxiolytic drugs distinguished by their half-lives. At high doses, benzodiazepines result in across-the-board side effects, notably in memory problems, drowsiness, and increased likelihood of accidents.<sup>30</sup> Another accepted drug treatment is the use of imidazopyridines, whose effects have been found similar to those of short-acting benzodiazepines, but with lesser influence on sleep architecture, cognitive side effects, and withdrawal symptoms.<sup>31-33</sup> Anti-depressants, antihistamines, anti-psychotics and melatonin,<sup>34</sup> many of which also have been established to have serious side effects, particularly during prolonged use,<sup>35</sup> have been mentioned, but have only been the subject of a few controlled long-term studies. All drug treatments are relatively contraindicated in pregnancy, sleep apnea, liver or kidney dysfunction, prior history of substance abuse, or certain jobs requiring atypical shifts.

The disadvantages of drug treatment for insomnia underline the importance of non-pharmacological alternatives. Meta-analysis of the various drug-free treatments has shown that such treatments are more effective in measures such as sleep latency (decrease of 30 min *vs* 8 min for controls), quality of sleep, number of times person wakes during sleep, wakefulness minutes during sleep (decrease of 32 min *vs* 10 min for controls) and total sleep time (increase of 30 min *vs* 4 min for controls).<sup>34</sup> These treatments fall under the general title of behavioral cognitive therapy, which includes educational features such as sleep hygiene, stimulus control, limiting sleep time throughout the day, muscle relaxation exercises, biofeedback, paradoxical approach, guided imagination, hypnosis and self meditation. Cognitive behavioral therapy has been utilized for insomnia in various psychiatric

disorders, including depression, somatoform, bipolar disorder and schizophrenia,<sup>35,36</sup> and has been found effective for patients suffering from PTSD as well.<sup>37</sup> These treatments demonstrated marked improvements in measures of sleep quality and personal distress.<sup>37</sup> In contrast, individuals with PTSD respond poorly to drug treatments.<sup>37</sup> Taken together, these studies suggest the need to directly examine the role of different non-pharmacological interventions in treating insomnia among individuals with PTSD. In the present study, two relaxation techniques were compared. The two techniques chosen were music relaxation and progressive muscular relaxation. Although both techniques aim to calm and relax the individual, music relaxation allows the individual to concentrate on external or imagined situations, whereas muscular relaxation requires concentrating on the body and its physical tension and release.

Music relaxation has been found to influence mood, stimulate memories and accelerate associations, and has been used as treatment for quite some time in a variety of medical disciplines.<sup>13</sup> In recent years, music relaxation has become an increasingly viable tool for individuals with psychiatric disorders, cognitive disorders and neurological deficits resulting from brain trauma after vascular events, as well as for individuals with dementia or Parkinson's disease. In these cases, treatment is less point-specific and is used rather as a general mechanism for relieving stress, treating feelings of anxiety or depression, alleviating chronic pain or as part of a withdrawal program. For example, McCraty *et al.*<sup>38</sup> showed that among PTSD patients music relaxation significantly reduced anxiety, fatigue, and stress. Likewise, Blake and Bishop reported that among PTSD patients,<sup>39</sup> guided imagery and music (GIM) (*i.e.*, a type of music relaxation) has been effective in addressing PTSD symptoms of hyper-arousal, intrusion and constriction, as well as the core experiences of disempowerment and disconnection. These researchers contended that GIM allows access to subconscious feelings, images and memories and arouses empowerment and reconnection through self-understanding and cooperation with the therapist. In an updated study Carr *et al.*<sup>40</sup> showed that following music therapy PTSD patients experienced a significant reduction in the severity of their PTSD symptoms and a marginally significant reduction in depression compared with controls. The researchers also suggested that patients regarded music therapy as helpful and reported experiences that concur with current literature. Among non-clinical elderly individuals, music therapy has been shown to improve symptoms of depression and sleep disorder.<sup>41-44</sup> Recent studies have shown the positive effects of music therapy on sleep onset time,<sup>44,45</sup> and

all types of music with a fixed beat (even that of a metronome) have been shown to influence motor systems.<sup>13</sup> The positive effect of music relaxation has also been associated with improvements in immune system function.<sup>46,47</sup>

Progressive muscular relaxation (PMR) is a technique developed by Jacobson in 1934.<sup>48</sup> The technique is based on the notion that anxiety-provoking thoughts and events produce physiological tension. The technique involves progressively tensing and relaxing muscles in different parts of the body, leading to a reduction in physiological tension.<sup>49</sup> In 1973 Bernstein and Borkovec considered modifications to the technique to make it suitable to cognitive behavioral stress management.<sup>50</sup> Among these modifications are relaxation through recall, recall and counting, and counting. Empirical evidence indicates that PMR reduces tension headaches, anxiety levels and insomnia, and aids in treating cancer and in chronic pain management. Demiralp *et al.*<sup>51</sup> investigated the effect of PMR on secondary insomnia among patients diagnosed with different types of cancers. The patients were randomly assigned either to PMR intervention or to routine care. The findings showed that following PMR intervention, sleep latency was reduced from 124 to 29 min, while following routine care, sleep latency was only reduced from 116 to 104 min. Another controlled study among women with breast cancer undergoing chemotherapy investigated the effects of PMR compared to standard care on sleep quality and fatigue. The PMR group reported better sleep quality and less fatigue than the control group.<sup>51</sup> Zucker, Samuelson, Muench, Greenberg, and Gevirtz compared respiratory sinus arrhythmia (RSA) biofeedback to PMR as adjunctive interventions for 38 patients with PTSD symptoms in a residential treatment facility for substance use disorder.<sup>52</sup> Both groups were assessed for psychological measures (*e.g.* heart rate variability, depression) and PTSD symptoms (*e.g.* insomnia) at pre-intervention and four-week post-intervention. Results showed that PTSD and insomnia symptoms were significantly reduced among both groups, with a beneficial effect of RSA biofeedback. These results provide preliminary support for the efficacy of both treatments, RSA biofeedback and PMR, in improving the physiological and psychological health of individuals with PTSD.

The rationale of the current study is that PTSD is a serious and disabling mental disorder with a high illness burden. The sleep disturbances characterizing PTSD are quite profound and demonstrate a limited response rate to conventional pharmacological treatments, thus increasing the need to evaluate the efficacy of other therapeutic approaches. The two non-pharmacological therapies chosen in the current study - music relaxation and muscle

relaxation - were found to have positive effects on sleep disturbance and to be useful in stress symptom reduction.

The present study had three aims: first, to use objective and subjective measures of sleep quality to compare the efficiency of two relaxation techniques (muscular relaxation and progressive music relaxation) in alleviating insomnia among individuals with PTSD; second, to examine whether these two techniques have different effects on psychological indicators of PTSD, such as depression and anxiety; and finally, to examine how initial PTSD symptom severity and baseline emotional measures are related to the efficiency of these two relaxation methods.

In view of the above findings, we hypothesize that, if provided with muscular or music relaxation, individuals with PTSD will display improved sleep quality. Furthermore, we posit that muscular and music relaxation will have positive effects on psychological indicators of PTSD such as depression and anxiety and that emotional measures and the initial severity of PTSD symptoms will explain variance in individual reactions to the two chosen techniques.

## Materials and Methods

### Participants

The study began after being approved by the Helsinki Committee and after participants gave their informed consent. Thirteen individuals with PTSD that developed in the wake of combat experiences or terror attacks participated in the study: 8 males and 5 females, mean age 45.7 years,  $SD=11.4$ . All participants were outpatients at the psychiatric clinic of Haemek Medical Center, Afula, Israel, who met DSM-IV criteria,<sup>2</sup> according to the Mississippi Scale for Civilian PTSD (CMS) (mean score 146.54,  $SD=21.32$ ) and the Clinician Administered PTSD Scale (CAPS) (mean score 96.69,  $SD=15.06$ ).<sup>53</sup> Based upon their medical history and upon examination, all participants were found to be in good general health and free of restless leg syndrome, narcolepsy, and alcohol or other substance abuse for at least three months. All lived independently in the community and used sleep medication regularly before and during the study.

Likewise, all participants met the criteria for chronic insomnia outlined in the DSM-IV.<sup>2</sup> That is, all participants had subjective complaints of unsatisfactory sleep (*i.e.*, difficulty in initiating or maintaining sleep) for at least three nights a week for more than six months, and all had subjective complaints about one or more of the following symptoms: fatigue, deterioration in functioning, and mood disturbance. In addition to subjective complaints, all

participants exhibited objective difficulty in falling asleep or maintaining sleep, with sleep latency greater than 31 min or nocturnal waking for periods over 31 min.

## Measurements

### Sleep parameters

#### *Objective measures of sleep*

A miniature actigraph worn on the wrist (Mini Motionlogger, Ambulatory Monitoring, Inc. Ardsley, NY) was used to evaluate sleep quality objectively, making it possible to monitor sleep under natural circumstances with minimal distortions. The actigraph measures wrist activity using a piezoelectric element and translates wrist movements into an electrical signal that is digitized and memorized. Actigraphy has been well validated against polysomnography in trials among individuals with and without sleep disorders.<sup>54</sup> The actigraph collected data in one-minute epochs (activity level was sampled at ten-second intervals and summed across one-minute intervals) and stored the data at amplifier setting 18 (*i.e.*, manufacturer's technical code for frequency band pass 2 to 3 Hz, high gain and high threshold). This working mode is the standard mode for sleep-wake scoring.<sup>55,56</sup> Actigraphic raw data were translated to sleep measures using the Actigraphic Scoring Analysis program for an IBM-compatible personal computer (W2 scoring algorithm) provided by the manufacturer (Ambulatory Monitoring, Inc.). These sleep measures have been validated against polysomnography, with agreement rates for minute-by-minute sleep-wake identification of over 90%.<sup>57,58</sup>

Actigraphic sleep measures included time in bed (total number of minutes from bedtime to wake time), total sleep time (total number of minutes defined as sleep), sleep latency (time to fall asleep from bedtime), and sleep efficiency index (percentage of total sleep time out of total time in bed).

#### *Subjective measures of sleep*

In addition, for the purpose of evaluating sleep quality, all participants completed two questionnaires that subjectively evaluated their sleep patterns: 1) The Mini Sleep Questionnaire (MSQ)<sup>59,60</sup> (a quantitative questionnaire): this questionnaire includes ten questions on which participants are asked to rate, on scales ranging from 1 (never) to 7 (always), the frequency with which they experience symptoms related to sleep problems, such as trouble falling asleep, fatigue during the day, waking up in the middle of the night,

and so forth.<sup>59,60</sup> 2) The Technion Sleep Questionnaire (a qualitative questionnaire):<sup>61,62</sup> this questionnaire includes questions regarding trouble falling asleep, such frequency of arousals during the night, with participants rating the frequency of the trouble on various Likert-type scales. The following four questions serve as an indication of sleep quality: Question 3: How many times a week do you experience trouble falling asleep? Question 4: How many times a night do you typically wake up? Question 8: How many times a week do you wake up during the night? and Question 11: How many hours a night do you sleep?

### Emotional factors

Depression level was assessed through the Beck depression inventory (BDI).<sup>63</sup> The BDI is a 21-item self-report questionnaire. The 21 items correspond to symptoms such as mood, pessimism, and suicidal ideas. Participants rate each item on a four-point Likert scale ranging from 0 (absent) to 3 (severe). The recommended cutoff of 17 is used to define depression; higher scores indicate greater depression. The BDI is an internally consistent and valid measurement.<sup>64</sup>

Anxiety level was assessed by the State-Trait Anxiety Inventory (STAI).<sup>65</sup> The STAI is a 40-item self-report measure consisting of two 20-item scales. The first scale measures state anxiety, defined as a transitory emotional state or condition, and the second measures trait or characterological anxiety. The STAI has demonstrated high internal consistency and high test-retest reliability.<sup>65-67</sup>

In addition, anxiety level was assessed by the Hamilton Anxiety Scale (HAMA). The HAMA is a 14-item scale used to measure the severity of anxiety symptoms. This instrument provides measures of overall anxiety, psychic anxiety (mental agitation and psychological distress), and somatic anxiety (physical complaints related to anxiety).<sup>68,69</sup>

### Relaxation CDs

1. *Muscle relaxation disc*: a CD or cassette containing audio instructions recorded in a male voice for muscle relaxation according to Jacobson's method.<sup>70</sup> Each relaxation session is 40 minutes in duration.
2. *Music relaxation disc*: a CD or cassette containing music composed for the study. The music consists of a slow melody accompanied by minor harmony played on a piano with background violins and bells that develops slowly over ten minutes. The melody repeats itself four times. The relaxation begins with a recorded male voice asking participants to relax and imagine themselves in a calm place. The male voice is the same as on the muscle relaxation CD or cassette.



## Study design

A mixed design with two variables was used. The intra-subject independent variable was type of relaxation and included three levels (no relaxation, muscle relaxation and music relaxation). The inter-subject independent variable was order of relaxations. The dependent variable was efficiency of relaxation methods, measured using objective measures, *i.e.* actigraph recording, and subjective measures, *i.e.* sleep questionnaires, anxiety questionnaires, and depression questionnaire.

## Study procedure

The study comprised one seven-day running-in period, followed by two seven-day experimental periods. The treatments were either music relaxation or muscle relaxation therapy at desired bedtime. These treatments were randomly assigned. During each of these three experimental periods, participants' sleep was continuously monitored with a wrist actigraph (Ambulatory Monitoring, Inc.), and participants were asked to fill out several questionnaires concerned with a wide spectrum of issues, among them subjective sleep, depression, and anxiety.

**Base level:** In the first phase, participants received actigraphs and were instructed on how to use them. Each participant's sleep was continuously monitored by a miniature actigraph. After each night, participants filled out a sleep log, in which they noted whether or not there had been any exceptional occurrences during the previous night, such as illness or alcohol consumption or any other incidents that might influence actigraph data. They also were administered the depression questionnaire, the anxiety questionnaires, and the sleep questionnaires. At the end of a week of baseline measurements, the questionnaires

were collected. In the *second phase*, which also lasted a week, seven participants received the CD or cassette with the muscle relaxation method, and six participants received the music relaxation CD or cassette. Participants' sleep was continuously monitored by a miniature actigraph. Participants also filled in the sleep log, the depression and anxiety questionnaires and the sleep questionnaires. At the end of the week questionnaires were collected.

The *third phase* was identical to the second phase, but the group that had received the muscle relaxation technique in the previous week now received the music relaxation CD or cassette, and the group that had begun with the music relaxation technique received the muscle relaxation cassette or CD. Participants' sleep was continuously monitored during this week by a miniature actigraph. Questionnaires completed in the previous phase were distributed again. At the end of the week, the questionnaires were collected.

During the entire experimental period, participants received a telephone call every day inquiring about their adherence to the relaxation instructions. As a result of the daily phone calls to the participants, there was no difference in adherence between the two techniques during the entire experimental period.

## Data analyses

A two-way mixed analysis of variance (ANOVA) was used, with types of relaxation as within-subjects factor and order of relaxation as between-subjects factor. The dependent variables were each of the measures taken. Moreover, Pearson's correlation was used to compare different measures. All tests were two tailed, and P-values less than 0.05 were considered significant. Data are presented as mean  $\pm$  standard deviation.

## Results

Comparisons between the three experimental conditions were conducted for each of the measures taken.

### Subjective measures: anxiety and depression

A two-way mixed ANOVA was used, with types of relaxation as within-subjects factor and order of relaxation as between-subjects factor. The dependent variables were the average scores on the depression questionnaire (*Beck Depression Inventory*) and on the anxiety questionnaires (*The State Anxiety Inventory* and *Hamilton Anxiety Scale*).

Analysis revealed a significant effect of the two relaxation conditions on depression [ $F(2,10)=26.46, P<0.001$ ] (Table 1), whereas both the order of relaxations [ $F(1,11) = 1.2, P>0.31$ ] and the interaction between the relaxation condition and its order of application [ $F(2,10) = 2.0, P>0.18$ ] were found to be not significant. Moreover, a significant reduction in depression level was found following music relaxation compared with baseline [ $F(1,11)=14.8, P<0.003$ ], and similarly following muscle relaxation compared with baseline [ $F(1,11)=11.2, P<0.007$ ].

No significant differences between relaxation techniques were found on the anxiety questionnaires scores ( $P>0.05$ ) (Table 1).

### Objective sleep measures as recorded by the actigraph

A two-way mixed ANOVA with repeated measures was conducted to compare objective measures of sleep under the three experimental conditions. The four dependent variables

**Table 1. Sleep measures and emotional measures (means and standard deviations) after each phase of the study and analysis of the comparisons between them.**

	Baseline mean ( $\pm$ SD)	Following music relaxation mean ( $\pm$ SD)	Following muscle relaxation mean ( $\pm$ SD)	F-value
<b>Objective sleep measures</b>				
Sleep efficiency	79.24 ( $\pm$ 11.8)	82.5 ( $\pm$ 12.2)	81.6 ( $\pm$ 11.4)	9.21**
Sleep latency	36.54 ( $\pm$ 27.6)	23.21 ( $\pm$ 18.9)	29.73 ( $\pm$ 25.8)	3.86
Mean wake episode	9.35 ( $\pm$ 5.9)	6.15 ( $\pm$ 3.0)	6.7 ( $\pm$ 3.3)	5.33*
Activity mean	23.34 ( $\pm$ 10.3)	19.97 ( $\pm$ 9.08)	20.75 ( $\pm$ 8.9)	10.75**
<b>Subjective sleep measures</b>				
MSQ	6.36 ( $\pm$ 0.6)	5.72 ( $\pm$ 1.2)	6.18 ( $\pm$ 0.9)	4.75*
TSQ	3.85 ( $\pm$ 0.46)	3.85 ( $\pm$ 0.55)	3.78 ( $\pm$ 0.55)	0.26
<b>Emotional measures</b>				
Depression (BACK)	52.38 ( $\pm$ 10.5)	47.46 ( $\pm$ 11.9)	47.2 ( $\pm$ 9.7)	26.46***
Anxiety (STAI)	69.7 ( $\pm$ 6.7)	65.7 ( $\pm$ 11.4)	67.4 ( $\pm$ 8.6)	1.28
Anxiety (HAS)	40.62 ( $\pm$ 9.2)	37.92 ( $\pm$ 10.4)	38.15 ( $\pm$ 10.3)	1.89

SD, standard deviation; MSQ, mini sleep questionnaire; TSQ, trauma screening questionnaire. \* $P<0.05$ , \*\* $P<0.01$ , \*\*\* $P<0.001$

recorded by the actigraph were sleep latency, mean wake episode, mean activity, and sleep efficiency.

Analysis revealed a marginal significant effect of the two relaxation conditions on sleep latency [ $F(2,10) = 3.86, P < 0.057$ ] (Table 1). A significant effect was found for the order of the applied relaxation conditions on sleep latency [ $F(1,11) = 5.81, P < 0.035$ ], showing lower sleep latency following muscle relaxation-music relaxation order than following music relaxation-muscle relaxation order. No significant interaction was found between the relaxation condition and its order of application [ $F(2,10) < 1$ ]. Moreover, test of within-subject contrasts revealed a significant decrease in sleep latency following music relaxation compared with baseline [ $F(1,11) = 7.82, P < 0.017$ ], while no significant decrease in sleep latency following muscle relaxation compared with baseline was found [ $F(1,11) < 1$ ]. Furthermore, the results indicate that following music relaxation and muscle relaxation, the participant's sleep latency did not meet the criteria for insomnia, *i.e.*, sleep latency shorter than 31 min.

Likewise, a significant effect of relaxation conditions on mean wake episode was found [ $F(2,10) = 5.33, P < 0.02$ ] (Table 1). A marginal significant effect was found for the order of the applied therapy conditions on mean wake episode [ $F(1,11) = 4.55, P < 0.056$ ]. No significant interaction was found between the relaxation condition and its order of application [ $F(2,10) = 2.32, P > 0.15$ ]. Moreover, a significant reduction in mean wake episode was found following music relaxation compared with baseline [ $F(1,11) = 11.31, P < 0.006$ ], while no significant reduction in mean wake episode was found following muscle relaxation compared with baseline [ $F(1,11) = 3.96, P > 0.072$ ].

Likewise a significant effect of relaxation conditions on mean sleep activity was found [ $F(2,10) = 10.75, P < 0.003$ ] (Table 1). However, no significant effect was found for the order of the applied relaxation conditions on mean sleep activity [ $F(1,11) = 2.2, P > 0.17$ ], nor for the interaction between the relaxation condition and its order of application [ $F(2,10) < 1$ ]. Moreover, a test of within-subject contrasts revealed a significant reduction in sleep activity following music relaxation compared with baseline [ $F(1,11) = 14.93, P < 0.003$ ], while no significant reduction in sleep activity following muscle relaxation compared with baseline was found [ $F(1,11) < 1$ ].

In examining sleep efficiency, a significant effect of relaxation conditions was found [ $F(2,10) = 9.21, P < 0.005$ ] (Table 1). No significant effect on sleep efficiency was found for the order of the applied relaxation conditions [ $F(1,11) < 1$ ], nor for the interaction between the relaxation condition and its order of application [ $F(2,10) = 2.55, P > 0.13$ ]. Moreover, test

of within-subject contrasts revealed a significant increase in sleep efficiency following music relaxation compared with baseline [ $F(1,11) = 9.95, P < 0.003$ ], while no significant increase in sleep efficiency was found following muscle relaxation compared with baseline [ $F(1,11) < 1$ ].

### Subjective sleep questionnaires

A two-way mixed ANOVA with repeated measures was used to compare subjective sleep measures in the three phases of the study, applied separately to the Mini Sleep Questionnaire and to the Technion Sleep Questionnaire.

Analysis revealed a significant effect of relaxation conditions on the subjective insomnia sub-scale (average of items 1, 2 and 7 in the MSQ) [ $F(2,10) = 4.75, P < 0.03$ ] (Table 1). No significant effect was found for the order of the applied relaxation conditions on subjective sleep efficiency [ $F(1,11) < 1$ ], nor for the interaction between the relaxation condition and its order of application [ $F(2,10) < 1$ ]. Moreover, a significant reduction was found in reported complaints of subjective insomnia following music relaxation compared with baseline [ $F(1,11) = 7.83, P < 0.017$ ], while no significant decrease in subjective sleep following muscle relaxation compared with baseline was found [ $F(1,11) < 1$ ]. No significant effects of relaxation conditions were found for the relevant questions on the Technion Sleep Questionnaire [ $F(2,10) < 1$ ].

### Relationships between emotional measures and treatment improvements on objective sleep measures

In order to examine whether the baseline emotional measures were associated with treatment improvements on objective sleep parameters, correlations were conducted between the baseline emotional measures [*i.e.*, the average scores on the anxiety questionnaires (*The State Anxiety Inventory* and *Hamilton Anxiety Scale*) and on the depression questionnaire (*Beck Depression Inventory*)] and the treatment improvements on objective sleep parameters (calculated as the difference between relaxation score and baseline for each treatment type).

No significant Pearson correlations were found between treatment improvements on objective sleep measures and baseline emotional measures.

In contrast, when the calculated variables following music relaxation were used, a highly significant negative correlation was found between improvement in objective sleep efficiency and reduction in depression scale ( $r = -0.83, P < 0.001$ ).

No significant correlations were found between the therapeutic effects of each relaxation technique and anxiety scores.

### Relationships between initial post-traumatic stress disorder symptom severity and treatment improvements on objective sleep measures

In order to examine whether the severity of initial PTSD symptoms was associated with treatment improvements on objective sleep parameters, correlations were conducted between initial PTSD symptom severity (as measured by CAPS and CMS) and the treatment improvements on objective sleep parameters (calculated as difference between relaxation score and baseline, for each treatment type). No significant Pearson correlations were found between initial PTSD symptom severity and treatment improvements on objective sleep parameters ( $P > 0.05$ ).

## Discussion and Conclusions

The first objective of this study was to offer a prospective analysis characterizing sleep disorders among participating individuals with PTSD based on DSM-IV criteria for insomnia, determined via a battery of subjective questionnaires and actigraph examination of sleep.<sup>2</sup> Additionally, we aimed to evaluate the influence of music relaxation and progressive muscle relaxation on various measures of sleep. Additional research objectives were to investigate how music and muscle relaxation techniques correlate with sleep quality and what impact they have on measures of depression and anxiety. Furthermore, we were interested in identifying predictive variables for successful therapy, for example initial PTSD symptom severity or emotional state (depressed or anxious) at the time of experiment participation.

We found that the severity of depression differed significantly during the three phases of the experiment: baseline, music relaxation and muscle relaxation. Depression values subsequent to music relaxation were found to differ meaningfully compared to baseline levels. Actigraph evaluations showed that music relaxation led to significant improvements in sleep latency, sleep activity, mean wake episode and sleep efficiency relative to baseline. The subjective sleep questionnaire also revealed a significant reduction in reported subjective complaints of insomnia following music relaxation compared with baseline. Likewise, following music relaxation, improvement in objective sleep efficiency was highly correlated to improvement in depressive symptoms according to BDI. Following muscle relaxation, the results indicate a reduction on depression score, though no significant differences in sleep parameters (objective and subjective sleep) were found. However, following

muscle relaxation sleep latency was reduced to levels below the minimal requirements to qualify for insomnia diagnosis. Nevertheless, the results indicate no significant differences in sleep parameters (objective and subjective sleep) or in emotional measures (depression and anxiety) between the two relaxation techniques. Music and muscle relaxation therapy belong to a larger group of non-medical therapies recommended as treatments for sleep disorders or nightmares and shown to be effective for different sleep measures and several emotional measures (*e.g.*, anxiety) among various populations, including individuals with PTSD.<sup>38-40,50-52,71</sup> Music and muscle relaxations were both administered in this study. Music relaxation in particular was found to be effective and led to significant improvements in sleep measures and significant reduction of depression score.

Additionally, we found that initial severity of PTSD symptoms or baseline levels of depression and anxiety are not accurate predictors of treatment success, although it should be mentioned that for music relaxation a correlation was found between levels of improvement on measures of depression and sleep efficiency. This raises a complicated question regarding the ultimate target of the two relaxations administered in this research. Is insomnia itself the primary target? Or is the impact on insomnia secondary to the impact on PTSD or depression? And if the second alternative is the case, what is the primary target: PTSD or depression?

Additional limitations of this research include its small sample size along with sleep measures that are not ascertainable due to the use of an actigraph. One of the reasons for using such a small sample was the decision to include individuals whose insomnia had been verified using both objective and subjective measures. Although the sample was small, participants were exceptionally cooperative and credible. No one dropped out during the study, and every participant who began the study was able to complete all three periods and provide all measures. It goes without saying that achieving such levels of response, persistence and cooperation requires massive investment on the part of the investigative team in encouraging, supporting and supervising participants almost daily. The intensive and sensitive supervision required for this study may have had placebo effects. Future studies should also aspire to gather data on structure of sleep, eye movements, body temperature and dream disorders, as well as to consider participants' preferences regarding treatment method, which has been shown to be an important factor in treatment success.<sup>72</sup>

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