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Acupuncture for Treatment of Insomnia in Patients With Traumatic Brain Injury: A Pilot Intervention Study

Felise S. Zollman, MD; Eric B. Larson, PhD; Laura K. Wasek-Throm, MPH; Cherina M. Cyborski, MD; Rita K. Bode, PhD

Objectives: To assess the efficacy of acupuncture in treating insomnia in traumatic brain injury (TBI) survivors as compared to medication, to determine whether acupuncture has fewer cognitive and affective adverse effects than does medication. **Participants:** Twenty-four adult TBI survivors, randomized to acupuncture or control arms. **Setting:** Outpatient rehabilitation clinic. **Measures:** Insomnia Severity Index (degree of insomnia); actigraphy (sleep time); Hamilton Depression Rating Scale (depression); Repeatable Battery for the Assessment of Neuropsychological Status and Paced Auditory Serial Addition Test (cognitive function) administered at baseline and postintervention. **Results:** Sleep time did not differ between the treatment and control groups after intervention, whereas cognition improved in the former but not the latter. **Conclusion:** Acupuncture has a beneficial effect on perception of sleep or sleep quality and on cognition in our small sample of patients with TBI. Further studies of this treatment modality are warranted to validate these findings and to explore factors that contribute to treatment efficacy.
Keywords: *actigraphy*, *acupuncture*, *insomnia*, *sleep*, *TBI*, *traumatic brain injury*

INSOMNIA is a frequent problem in the traumatic brain injury (TBI) population. Sleep disturbances can appear as soon as 24 hours following injury and can continue for several years.[1] Several studies of individuals with TBI in both inpatient and outpatient settings suggest that 30% to 81% of survivors experience sleep difficulties.[1–5] In the outpatient population occurrence rates for sleep disturbances following recent TBI range from 36% to 73%.[6,7]

Insomnia can be clinically defined as the occurrence of trouble sleeping characterized by (*a*) difficulty falling asleep (ie, requiring more than 30 minutes to get to sleep) and/or difficulty maintaining sleep (ie, more than 30 minutes of nocturnal awakening), which (*b*) occurs at least 3 nights per week, and (*c*) results in impairment in daytime functioning.[8,9] It is likely that the mechanisms and/or factors involved in the development of insomnia are different in the TBI population than in non–brain-injured individuals. More specifically, according to Thaxton: "During the acute stage, dysregulation of sleep seems to be a function of the diffuse disruption of cerebral functioning in the wake of both direct physical damage to the brain and secondary neuropathological events."[6] As the brain undergoes repair and recovery, including reorganization via mechanisms such as adaptive plasticity, the neuroanatomical mechanisms underlying insomnia in the early postacute stage probably become less significant; behavioral and affective factors are likely to become more prevalent.

There is clearly a need to address sleep disturbance, given its potentially significant impact on the course of recovery from TBI. In particular, fatigue, mood disturbance, and cognitive deficits (speed of processing, attention, concentration, learning, memory, and executive functions), all impairments typically seen in patients with TBI, are also recognized consequences of insomnia.[2,9,10]

Current treatment for insomnia consists primarily of behavioral modification (eg, turning off lights and TVs at night, minimizing caffeine and alcohol intake) and pharmacotherapy. The classes of pharmacotherapeutic agents typically used include sedative-hypnotics and antidepressants with anticholinergic properties. Unfortunately, these agents are associated with undesirable

Author Affiliations: *Departments of Physical Medicine and Rehabilitation & Neurology, Northwestern University Feinberg School of Medicine (Dr Zollman), Department of Physical Medicine and Rehabilitation, Northwestern University Feinberg School of Medicine (Dr Larson), Department of Physical Medicine and Rehabilitation, The Rehabilitation Institute of Chicago (Ms Wasek), Department of Physical Medicine and Rehabilitation, Northwestern University Feinberg School of Medicine (Dr Cyborski), Northwestern University, Northwestern University Feinberg School of Medicine, Chicago, Illinois (Dr Bode).*

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Corresponding author: *Felise S. Zollman, MD, Departments of Physical Medicine and Rehabilitation & Neurology, Northwestern University Feinberg School of Medicine, Chicago, IL 60611 (f-zollman@northwestern.edu).*

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adverse effects, which are likely to be particularly onerous in the TBI population: daytime somnolence, impairment in memory, psychomotor impairment, rebound insomnia, and lowering of the seizure threshold (the latter is associated with use of agents with serotonergic properties).[11,12] Furthermore, in addition to the short-term consequences these adverse effects may have in impairing a patient's ability to optimally participate in a rehabilitation program, the central nervous system depressant effects of these medications may have long-term deleterious consequences for neural plasticity, and therefore on the ultimate degree of recovery post-TBI.

Given the limitations associated with current treatment options for management of insomnia, investigation of additional treatment modalities is warranted. Acupuncture holds appeal because of its established efficacy in treating insomnia in other populations, its relative accessibility, and its favorable adverse-effect profile.[13,14]

Acupuncture refers to the technique of penetrating the skin with thin, solid, metallic needles that are manipulated by the hands or by electrical stimulation.[15] In the Chinese medicine paradigm, the human body is viewed as a microcosmic reflection of the universe. Health and illness are consequences of the state of balance or imbalance of smoothly flowing vital energy of the body known as "Qi" (pronounced "chee").[16] From a western medical perspective, needling acupuncture points stimulates the neurohumeral system to release hormones and neuropeptides in the muscles, spinal cord, and brain. These chemical mediators either change the experience of pain, or they trigger the release of other chemicals and hormones, which influence the body's internal regulating system.

The use of acupuncture for the treatment of insomnia is well-characterized in the medical literature,[13,17,18] and specific points known to influence insomnia are established in both the Chinese and western medical literature.[16,19] A recent meta-analysis of the English-language literature addressing the use of acupuncture for management of insomnia found that, despite the lack of randomized clinical trials in this realm, "Acupuncture using auricular meridian points is equivalent to the use of tranquilizers and sedation." Further, "there are no associated adverse effects, drug dependence, or habit formation." Of the 8 studies included in this meta-analysis, which specifically addressed outcomes, there was an aggregate greater than 80% efficacy. Ten of the eleven studies included in the review used a self-report instrument as the sole tool to assess efficacy; the eleventh study employed a wrist actigraph.[13]

Another recent study demonstrated that 5 weeks of acupuncture treatment, provided twice weekly resulted in a statistically significant increase in nocturnal endogenous melatonin secretion and improved sleep onset latency, arousal index, total sleep time, and sleep efficiency. Anxiety and depression were also significantly reduced, as measured by the Trait Anxiety scale and the Center for Epidemiologic Studies Depression Scale.[14] Of note, a recent study addressing melatonin levels in the TBI population found that levels were reduced in TBI patients treated in the intensive care unit.[20] Utilization of a modality that may have a potentiating effect on melatonin levels, therefore, may be particularly relevant for the TBI population.

Although acupuncture has been shown to be beneficial in treating insomnia, this modality has been minimally studied in adults with acquired brain injury. Acupuncture has been found to be effective in the treatment of insomnia poststroke[19] and has been utilized in the TBI population for treatment of various sequelae of TBI (eg, aphasia, pain, facial palsy, postconcussive syndrome). Most publications on this subject are case series found in the Chinese medical literature.[21–23] There are, however, no randomized controlled trials addressing the role of acupuncture in treating TBI or its sequelae.

The present study proposed to address the following hypotheses: (1) acupuncture will be as effective as medication in treating insomnia in the outpatient TBI population, and (2) cognitive and affective outcomes will improve to a greater degree in those treated with acupuncture than in those treated via current conventional means.

METHODS

Participants

Participants were recruited for this study via 2 mechanisms: (1) An IRB-approved review of the Rehabilitation Institute of Chicago medical records to identify (based on *ICD-9* code) those patients who had a diagnosis of TBI within the preceding 5 years, and (2) self-referral in response to an advertisement posted either on public transportation or at the Rehabilitation Institute of Chicago.

The enrolled participants included 24 people with TBI within 5 years of study entry and complaints of insomnia (based on a score of 15 or greater on the Insomnia Severity Index [ISI]). Other inclusionary criteria consisted of Rancho Cognitive Scale level V or above, capability of the participant or family member to give consent, and age 18 years or greater at the time of study entry. Patients were excluded if they had been diagnosed with an underlying respiratory or neurological condition known to be associated with sleep disorders (eg, sleep apnea). Pregnant patients were also excluded.

Of the 31 individuals who volunteered for the study, 7 were excluded: 1 did not show evidence of insomnia on the ISI, 4 could not provide medical records to substantiate brain injury, 1 had a nontraumatic

TABLE 1 *Demographics*

Variable	Categories	Treatment, N (%)	Control, N (%)	Test statistic
Sex	Male	7 (58%)	2 (25%)	$\chi^2 = 2.16$; $P = .14$
	Female	5 (42%)	6 (75%)	
Race	White	5 (42%)	4 (50%)	$\chi^2 = 1.48$; $P = .69$
	Black or African American	5 (42%)	4 (50%)	
	Other	1 (9%)	0 (0%)	
Marital status	Never married	2 (29%)	2 (67%)	$\chi^2 = 2.08$; $P = .56$
	Married	4 (57%)	1 (33%)	
	Other	1 (14%)	0 (0%)	
Rancho Los Amigos Cognitive Scale Score	Level VII	0 (0%)	1 (13%)	
	VIII	12 (100%)	7 (88%)	
		Mean (SD)	Mean (SD)	
Education	Number of years	15.00 (2.26)	14.38 (2.93)	$t = 0.54$; $P = .60$
Age	Years	44.50 (15.15)	43.50 (16.10)	$t = 0.14$; $P = .89$
Time post-TBI	Years	2.17 (1.27)	3.00 (1.85)	$t = -1.2$; $P = .25$

injury, and 1 had comorbid sleep apnea. Four participants (2 in each group) dropped out (1 because of travel time, 1 left the city, and 2 completed a portion of the intervention period but were lost to follow-up). An intention to treat analysis including these 4 dropouts revealed no differences in significance or lack thereof for any of the data reported herein. Of the 20 individuals who did complete the study, 12 had been randomized to the treatment group and 8 to the control group. Analyses revealed that groups did not differ in sex ($\chi^2 = 2.16$; $P = .14$), race ($\chi^2 = 1.48$; $P = .69$), marital status ($\chi^2 = 2.08$; $P = .56$), age ($t = .14$; $P = .89$), education ($t = .54$; $P = .60$) or time since TBI ($t = -1.20$; $P = .25$) (see Table 1).

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Instruments

Degree of insomnia was rated by each participant utilizing the ISI.[24] The measure assesses symptoms of insomnia as well as distress caused by those difficulties. It has been shown to have adequate reliability and to be a valid and sensitive measure to detect improvement in sleep with treatment.[25] It has been used in previous studies with patients with TBI.[1]

Sleep was measured objectively via the use of actigraphy. An actigraph is a small portable device that can be attached to the wearer's arm, leg, or waist to monitor activity or movement by miniaturized acceleration sensors, which translate physical motion into a numeric representation. This representation is sampled every 10th of a second and aggregated at a constant interval referred to as an epoch. These epoch-by-epoch samples are stored in the internal memory of the device until the information is downloaded to a computer.[26] The use of actigraphy in the TBI population has also been described, and guidelines for its use proposed.[27]

Depression was monitored with the Hamilton Depression Rating Scale (HDRS),[28] a 21-item scale that evaluates depressed mood and related symptoms including sleep disturbance. Each item is rated on either a 5-point (0–4) or a 3-point (0–2) scale; higher scores reflect greater degrees of depression. The HDRS is frequently used to assess depression in patients with TBI[29,30] and has also been previously used in research on sleep disturbance in other populations.[31]

Cognitive impairment was evaluated with the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS)[32] and the Paced Auditory Serial Addition Test (PASAT).[33] The RBANS is a brief, portable instrument for detecting and characterizing abnormal cognitive decline. It requires about 20 to 30 minutes for administration and can be administered at bedside. The RBANS yields a total score as well as indices for 5 cognitive domains (immediate memory, visuospatial/constructional ability, language, attention, and delayed recall). The PASAT is a measure of divided attention that involves addition of a series of numbers that are presented at increasing rates of speed. Participants are instructed not to keep a running total but rather to add each number to the number immediately preceding it. There are 4 trials of 50 items each that can be summed to yield a single total score. The PASAT has been shown to be a useful measure of cognitive recovery in clinical trials of patients with TBI.[34]

Study design

After determining eligibility and obtaining consent, participants were given an Actigraph and instructed to wear it continually for 72 hours. They were also given a Medication Log and instructed in how to maintain it for the duration of the study period. They then underwent neuropsychological testing composed of the HDRS, RBANS, and PASAT. When testing was complete, they were randomized to either the treatment ($N = 14$) or control ($N = 10$) group.

Individuals in the control arm had their first study visit with the physician acupuncturist and all subsequent study visits with the research nurse or research assistant. At the first visit, a medical history/medication use review was done, and participants were instructed to avoid caffeine and alcohol, and to limit environmental distractions when going to sleep (ie, provided with basic education about behavioral interventions for insomnia). Participants were asked to have any sleep-related medication prescribed only by a study physician during the course of the trial; however, those in the control arm were not required to change their medication usage and received no other intervention or procedure. Visits with the study staff were scheduled twice weekly for 5 weeks to parallel the clinic visits for the treatment group, and medication use, as documented in the Medication Log, was collected during each visit. Participants were allowed no more than one missed visit, which had to be made up.

Individuals in the treatment arm had all of their visits with the physician acupuncturist. At the first visit the same behavioral modification interventions were discussed, and a medical history/medication use review was undertaken. Treatment arm participants were asked to have any sleep-related medication prescribed only by a study physician during the course of the study and to safely taper off use of all sleeping medications under the direction of the physician acupuncturist. "Rescue" sleeping medication was available, if needed, throughout the study period; any use was documented in the Medication Log. Visits with the study staff were scheduled twice weekly for 5 weeks, and medication use was examined during each visit. Treatment arm participants were also allowed no more than one missed visit, which had to be made up.

Acupuncture needles used in this study are commercially available, single use, sterile, disposable needles, obtained from a US distributor (eg, Lhasa/OMS medical supply company, 230 Libbey Parkway Weymouth, Massachusetts, www.lhasaoms.com).

Acupuncture point selection was based on the classically described energetic qualities of given acupuncture points and further informed by review of recent Western medical literature describing a positive treatment effect with acupuncture for management of insomnia.[13,16–19] Acupuncture points included: Kidney 3, Heart 3, Bladder 60, Liver 3, Large intestine 4, Master of the Heart (also known as Pericardium) 7, Governor Vessel 20, and the ear points Tranquilizer and Shen Men. Needles were placed by the physician acupuncturist utilizing standard needle placement techniques. Body points were placed bilaterally; ear points were placed on only one ear or the other. This needle regimen was known as the "standard dose" formulation.

After placement of the needles, 4 Hertz electrical stimulation was applied to the kidney 3 (anode) and heart 3 (cathode) points, using a standard, commercially available, FDA-approved electroacupuncture device: the IC1107+ (manufactured by Ito Co, Ltd, Tokyo, Japan). The purpose of this device is to provide stimulation to selected points to potentiate the effect of the needles placed at these points. This is a standard clinical acupuncture intervention.

Each acupuncture treatment lasted approximately 20 minutes and utilized the earlier-described "standard dose" acupuncture protocol. If necessary, a "higher dose" protocol or a "lower dose" protocol was available, depending on the participant's response to the treatment. The "lower dose" protocol consisted of a subset of the "standard dose" protocol: kidney 3, heart 3, bladder 60, and governor vessel 20. The "higher dose" protocol, which was employed if participants reported no improvement in sleep after 4 to 5 treatments, consisted of the standard protocol plus 3 to 6 of the following points: Spleen 6, Stomach 43, Heart 7, Liver 2, Kidney 10, GB20, CV23, or the ear point sympathetic. The number (3, 4, 5, or 6) and location of points and how or whether to modify, which points are stimulated by electroacupuncture were determined by the principal investigator. The determination was made based on the individual's report of the nature of the persistent sleep disturbance and assessment of overall constitutional health. (This is analogous to titrating or altering medications in treating insomnia, and reflects a realistic acupuncture clinical approach to symptom management.)

At the conclusion of the study period, all participants were again given an Actigraph and instructed to wear it continually for 72 hours. They were again administered the ISI and underwent the same battery of neuropsychological tests. They continued keeping their Medication Log for another 4 weeks, at which point a research assistant phoned for a follow-up interview, inclusive of readministration of the ISI and reporting of medication use over the past month.

STATISTICAL ANALYSIS

Actigraphic data was considered valid for use in analysis if the nighttime reading (designated for the purpose of this study as the 12 hour period from 8 pm to 8 am) sleep

TABLE 2 *Sleep time (in minutes per night)*

	Acupuncture	Control	Wilcoxon *W*
Baseline sleep time	Mdn = 384 ($n = 11$)	Mdn = 452 ($n = 7$)	$Z = -1.13$ $P = .29$
Posttreatment sleep time	Mdn = 379 ($n = 11$)	Mdn = 398 ($n = 7$)	$Z = -0.68$ $P = .54$

Abbreviation: Mdn, Median.

recording contained no more than 2 consecutive hours of zero activity. Absence of activity detection by actigraphy for an extended period was presumed to equate with failure to wear the device, yielding a falsely high assessment of actual sleep time.[35] Validity was examined on a per day basis.

Demographic characteristics were examined using univariate statistics and were compared for equivalency between groups using χ^2 statistics (for categorical data) and independent sample t tests (for continuous data) with a significance level of 0.05. Because of sample size limitations, nonparametric statistics were used for bivariate comparisons. Pretreatment/posttreatment/follow-up comparisons were done using Wilcoxon Signed Ranks tests, and treatment/control group comparisons were done using Wilcoxon-Mann-Whitney tests.

RESULTS

Sleep time

Valid actigraphic data was not available for 1 treatment group participant at baseline and 1 control at posttreatment evaluation; data for these individuals was excluded. The analysis showed that treatment and control groups did not differ in baseline ($Z = -1.13$; $P = .29$) or posttreatment sleep time ($Z = -0.68$; $P = .54$) (see Table 2).

Subjective report of insomnia

Insomnia Sleep Index scores did not significantly differ between the treatment and control groups at baseline ($Z = -0.78$; $P = .47$), at posttreatment ($Z = -1.51$, $P = .14$), or at 1-month follow-up ($Z = -1.78$; $P = .08$) (see Table 3). Within group comparison, however, showed that, in the treatment group, ISI scores decreased from baseline to posttreatment ($Z = -3.07$; $P < .01$) and from baseline to 1-month follow-up ($Z = -3.07$; $P < .01$) (see Figure 1 and Table 4). In the control group, there was no significant difference in the perception of insomnia severity from baseline to posttreatment ($Z = -1.75$ $P = .08$) and from baseline to 1-month follow-up ($Z = -1.41$; $P = .16$) (see Figure 1 and Table 4).

Medication use

Overall, medication use was scant in both study arms at study entry, limiting statistical comparison of this parameter. By intervention week 1, the treatment arm participants had discontinued use of medication entirely, and this persisted throughout the study period; the control arm participants continued to utilize medication to a minimal degree, which was not significantly different from baseline.

Cognitive functioning

Because of reduced motor control, 2 participants were unable to complete the entire neuropsychology battery at baseline and one could not do so at posttreatment. For the 7 participants in the control group who completed the entire battery, overall cognitive functioning as measured by the RBANS Total Scale did not improve over the course of the study ($Z = -0.52$; $P = .60$). However, for the 11 participants in the treatment group who completed the entire battery, RBANS Total Scale did improve ($Z = -2.81$, $P < .01$) (see Figure 2). Similarly, divided attention as measured by the PASAT improved for the treatment group ($Z = -2.50$; $P = .01$) but not in the control group ($Z = -1.47$; $P = .14$) (see Figure 3).

TABLE 3 *Insomnia severity index (between groups)*

	Acupuncture ($n = 12$)	Control ($n = 8$)	Wilcoxon W
Baseline ISI	Mdn = 20	Mdn = 18.5	$Z = -0.78$; $P = .47$
Posttreatment ISI	Mdn = 9.5	Mdn = 13.5	$Z = -1.51$; $P = .14$
1 month follow-up	Mdn = 11	Mdn = 15.5	$Z = -1.78$; $P = .08$

Abbreviation: Mdn, Median.

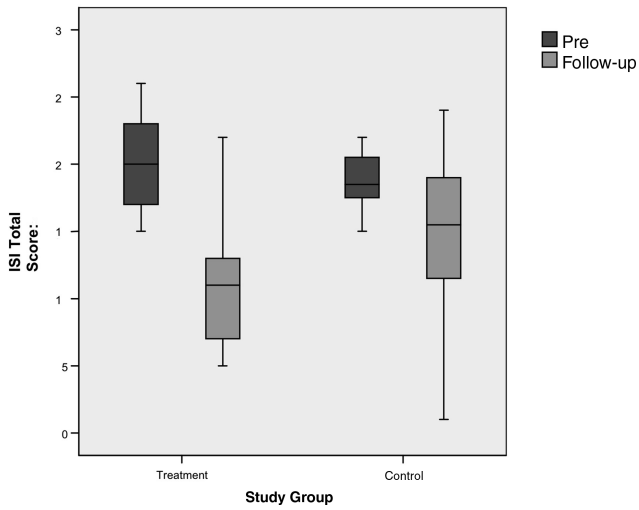

Figure 1. Preintervention versus one-month follow-up ISI comparison (treatment group $P = 0.01$, control $P = 0.16$).

Depression

In depression, as in cognitive functioning, improvement over the course of the study was not observed in the 8 controls ($Z = -0.86$, $P = .39$), but improvement was seen in the 12 participants in the treatment group ($Z = -2.68$, $P < .01$).

Subjective report of insomnia and depression

In the 18 participants who completed the entire protocol, baseline depression was positively associated with subjective report of insomnia (ISI) at baseline ($r_{ranks} = 0.67$, $P < .01$). However, this association disappeared at the time of posttest ($r_{ranks} = 0.19$, $P = .45$).

Subjective report of insomnia and cognitive functioning

At baseline, divided attention as measured by the PASAT was positively associated with perception of insomnia ($r_{ranks} = 0.55$, $P = .02$) as measured by the ISI. Similarly, divided attention measured at posttest was associated with perception of insomnia measured at follow-up ($r_{ranks} = 0.52$, $P = .03$). Repeatable Battery for the Assessment of Neuropsychological Status Total Scale was not associated with any sleep variable at any of the time points assessed.

DISCUSSION

The purpose of the present study was to (*a*) determine whether acupuncture was as effective as medication in treating insomnia in outpatients with TBI, and (*b*) determine whether the acupuncture treatment group, in part due to reduced use of medication, would have better cognitive and affective outcomes posttreatment than would the control group. Although our subject enrollment was sufficient only to perform nonparametric statistics for bivariate comparisons, our results do support our hypotheses.

Those in the treatment arm tapered entirely off medication during the first week of the intervention period; total sleep time was equivalent to that seen in the control arm. Notably, medication use was scant in both study arms at study entry despite that fact that all participants met ISI criteria for insomnia, and the aggregate average sleep time at study enrollment was 6.5 hours over 3 nights. This unexpected finding may be due to the chronicity of symptomatology at study enrollment (time post-TBI = 2.17 ± 1.27 years for treatment and 3.00 ± 1.85 for controls), may reflect providers' intent to minimize use of central nervous system depressant medication in those with TBI, or may reflect underrecognition/underreporting of insomnia symptoms.

Despite the fact that total sleep time had not significantly changed from preintervention to post, perception of sleep (as measured via the ISI) improved in the treatment group versus the control group. This improvement in perception of sleep was sustained for at least 1 month after cessation of acupuncture. This suggests that, in addition to providing equal efficacy in sleep time achieved, acupuncture offers a sustained benefit in perception of sleep time/quality, a benefit not seen in those undergoing conventional treatment for insomnia. This is significant because others have proposed that distorted perception of sleep (ie, tendency to underestimate sleep

TABLE 4 *Insomnia severity index (within group comparison)*

	Acupuncture ($n = 12$)	Wilcoxon signed rank (baseline to posttreatment)	Wilcoxon signed rank (baseline to) 1 month follow-up)	Control ($n = 8$)	Wilcoxon signed rank (baseline to posttreatment)	Wilcoxon signed rank (baseline to 1 month follow-up)
Baseline	Mdn = 20	$Z = -3.07$ $P < .01$	$Z = -3.07$ $P < .01$	Mdn = 18.5	$Z = -1.75$ $P = .08$	$Z = -1.41$ $P = .16$
Posttreament	Mdn = 9.5			Mdn = 13.5		
1 month follow-up	Mdn = 11			Mdn = 15.5		

Abbreviation: Mdn, Median.

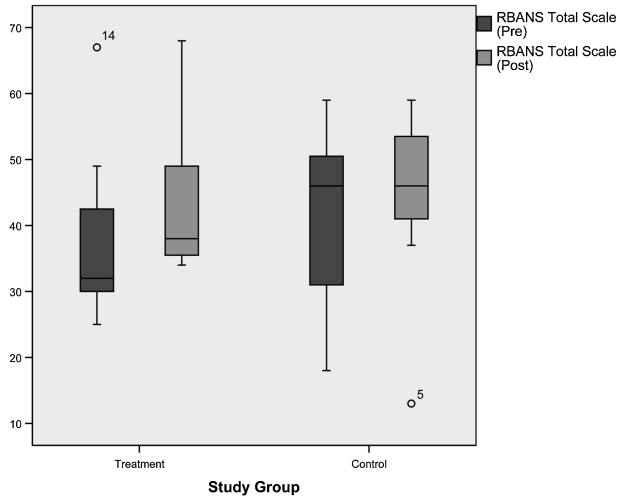

Figure 2. Pre/post RBANS T-scores by study group.

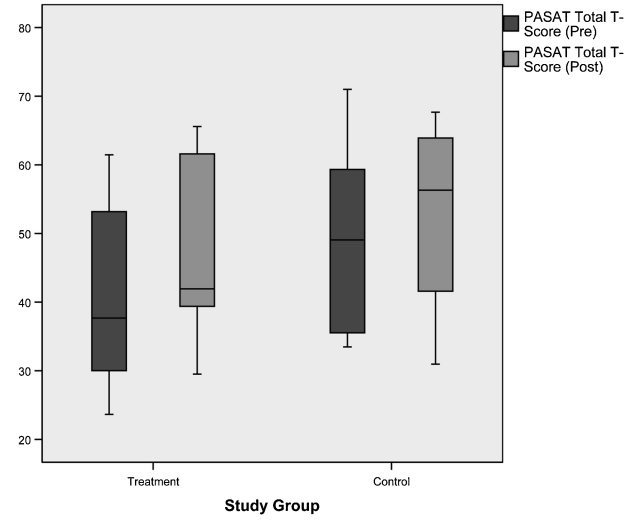

Figure 3. Pre/post PASAT T-scores by study group.

time or quality) plays a key role in maintaining insomnia, and that correcting that distortion can help resolve complaints of insomnia.[36]

Not surprisingly, regardless of study arm, a positive association was found between perception of insomnia (ISI) and depression (HDRS) at all 3 data points. This is consistent with prior reports by Ouellet et al[1] and Fichtenberg et al.[37] Since sleep disturbance is a symptom of depression, and because the HDRS includes items assessing insomnia, this association is expected.

Cognitive function, as measured via the PASAT and the RBANS, did not change for the control group over the course of the study. Cognitive function did, however, improve to a significant degree for the acupuncture treatment group, as measured by both of these instruments. This is an interesting finding. Total sleep time was not significantly different between the 2 groups, so this cognitive improvement does not appear to be a result of improved sleep. Further, while the acupuncture treatment group did use less medication than did the control group, medication use overall was not substantial in either group, and so the difference was not statistically significant.

The finding of postintervention improvement in cognition therefore raises the question of whether some other indirect effect of acupuncture treatment positively affected cognitive function. Others have shown that stimulation of acupuncture points results in modulation of the limbic-paralimbic-neocortical network and subcortical grey matter.[38,39] Although our study was not designed or intended to address this question, it is intriguing to consider the possibility that this effect may directly enhance cognition in TBI, independent of the primary intended focus of the treatment regimen (in this case, insomnia).

This pilot intervention study, although not conclusive, supports the contention that acupuncture has a beneficial effect on perception of sleep or sleep quality and on cognition in patients with TBI. The study is limited by the effect of small sample size on the power of our results. Further investigation is indicated to verify our findings, as well as to determine whether acupuncture is also beneficial in treating insomnia in other stages and degrees of TBI (ie, subacute stage of severe TBI).

The notion that acupuncture could replace central nervous system sedatives as a primary modality in treating insomnia in those with TBI is intriguing; this approach could not only provide symptomatic relief, but also reduce the risk of impeding neural plasticity,[38,39] particularly in the first several months postinjury, when insomnia is reported to occur at its greatest frequency and neural plasticity is felt to play its most prominent role in recovery. Another area for future exploration involves investigation of the neuropsychological (cognitive, affective, and behavioral) benefits of acupuncture independent of its effect on somatic symptomatology; this is of particular interest in light of recent fMRI studies, suggesting a broad effect (seen with stimulation of a variety of acupuncture points) on limbic, prefrontal and basal ganglia function.

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