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TREATING PRIMARY INSOMNIA: A COMPARATIVE STUDY OF SELF-HELP METHODS AND PROGRESSIVE MUSCLE RELAXATION

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Abstract
Insomnia is one of the most prevalent psychological disorders worldwide. Some of the deficiencies of the current treatments of insomnia are: side effects in the case of sleeping pills and high costs in the case of psychotherapeutic treatment. Some suggest that self-help treatments could be a viable alternative, with certain advantages such as low cost, and wide accessibility to a large number of people. In our study we used a modified Latin square experimental design for single subject research to verify the effect of multi-component treatment efficiency in primary insomnia. Another goal of our study was to compare the effects of the three treatment techniques (progressive muscle relaxation, sleep hygiene, binaural beats) included in the multi-component intervention package. Our results reflect the efficiency of the multi-component treatment. Significant differences were found only between muscle relaxation and binaural beat. Based on effects size measures we can say that muscle relaxation and sleep hygiene have a very similar effect. The effect of binaural beat treatment is lower than that of the other two types of intervention.

***Keywords**:* insomnia, single subject experiment, progressive muscular relaxation, sleep hygiene, binaural beats

Insomnia is a disorder characterized by the qualitative reduction of the sleep duration and efficacy (Morin, Hauri, Espie, Spielman, Buysse, & Bootzin, 1999; Pallesen, 2003). Out of all psychological disorders, insomnia displays some of the highest prevalence rates, epidemiological data reporting frequencies as high as 22% (Stinson et al., 2006) and even 33% (Harvey, 2001). Insomnia causes severe distress, social, interpersonal and professional dysfunction (Harvey, 2002). It

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affects well-being and the quality of life (Espie, 1991) and is often associated with affective disorders, such as irritability and dysphoria (Morin, 2003). The impredictibility and incontrolability of the sleeping pattern can lead to feelings of helplessness and to the onset of depressive and anxiety disorders (Morin, 2003; Neckelmann, 2007). Longitudinal studies conducted by Ford & Kamerow (1989) showed that persistent untreated insomnia can be a risk factor in the development of the major depressive disorder.

The global expenses for the treatment of insomnia and its consequences rise to several billion dollars. For example, in the United States, the cost of insomnia treatments in 2004 rose to over 2.1 billion dollars, and it is estimated to reach 3.2 billion dollars in 2009 (Gershell, 2006). A cost harder to quantify is due to the decrease of daytime performance of people affected by insomnia, due to the reduction of the cognitive and motor performances (Mendelson, Garnett, Gillin & Weingartner, 1984), as well as to the high rates of work absence (Johnson & Spinveber, 1983).

Theoretical models in the literature generally attribute insomnia to certain activating factors that interfere with the sleeping pattern. These factors can be organized along two dimensions: a. physiological, emotional and cognitive activation; b. the general level of activation of the person and the person's tendency to respond with activation to aversive life events. These models only consider certain factors in isolation, such as psychological, emotional and cognitive hyperactivity, level of arousal, excitability and habituation to stimuli, and the role of the activating events.

According to the integrative model of insomnia recently proposed by Lundh and Broman (2000), an essential component in the development and maintenance of insomnia is the physiological and cognitive arousal before sleep. The physiological processes of sleep interference are those that influence a person's sleeping pattern, independently of the way the person interprets the sleeping pattern and of daytime events (traumatic or stressful events, emotional conflicts, depression, worries). Psychological insomnia processes influence the way the person interprets sleep fluctuations, difficulties and daytime events (personal standards, beliefs and attitudes). The validity of the model was checked by a series of studies that investigated: the relationship between rumination, mood and sleep quality (Thomsen, 2003), the efficacy of meta-cognitive observations during insomnia (Lundh, 2002), the impact of acceptance and mindfulness therapies in the treatment of insomnia (Lundh, 2005).

At present, the most frequently recommended treatment for occasional insomnias is medication, but not for chronic insomnia (Jacobs, 2004). This is due to the side-effects of medication and to the decrease in its efficacy after long periods of treatment. One of the effects of sleeping pills is the modification of sleep structure (Morin, 2003). Benzodiazepines improve sleep continuity and, at the same time, they increase the length of the first two stages of sleep, and decrease the length of the third and fourth stages (Morin, 2003). This sleeping pattern is also observed in the elderly and is perceived as superficial and non-resting (Morin, 2003). Frequently, high medication levels produces a toxic state associated with psycho-motor and cognitive delay (Grad, 1995; Roehrs, Merlotti, Zorick, & Roth, 1994). Side-effects are also noticed in the case of more recent drugs (Aragona, 2000), and, consequently, their use is not recommended for a period longer than four weeks (Holm & Goa, 2000).

Beginning with the 1980s, research on sleep disorders, insomnia in particular, was oriented towards the effectiveness of cognitive-behavioral interventions. Cognitive behavior therapy includes various combinations of cognitive and behavioral interventions. The cognitive component is aimed at changing the patients' beliefs and attitudes regarding insomnia. The behavioral component usually includes relaxation training (Morgenthaler et al., 2006). Relaxation training involves methods which focus on reducing physiological arousal (e.g., progressive muscle relaxation, autogenic training) or intrusive thoughts that occur around bedtime and that interfere with sleep (Lick & Heffler, 1977).

The superiority of cognitive-behavioral interventions as opposed to medication was proven in several studies (Morin & Schwartz, 1994). A recent study comparing cognitive-behavioral therapy with Zopiclone (Sivertsen, Omvik, Pallesen et al., 2006), highlights the superiority of the psychological interventions over medication. Thus, cognitive-behavioral therapy improved three of the four investigated parameters, while medication (i.e., Zopiclone) did not lead to significant changes compared to the placebo group.

Meta-analyses show that these interventions generally produce significant and long lasting sleep improvements in insomniacs (Morin, Culbert, & Schwartz, 1994; Murtagh & Greenwood, 1995). The Data confirm a significant modification in the following parameters: sleep latency, and time awake after sleep onset, as a consequence of this type of intervention.

In their review, Morgenthaler et al. (2006) summarize several studies that have shown the effectiveness of relaxation methods, even when not combined with cognitive interventions (Edinger et al., 2001; Lichstein et al., 2001; Means et al., 2000). These results are also confirmed by a study conducted by Lichstein & Johnson (1993) that reports a reduction in the dose of medication required by the relaxation group. Relaxation also proved efficient in improving the sleeping pattern usually found in the elderly (Riedel & Lichstein, 2001; Rybarczyk et al., 2002).

Validation studies of cognitive-behavioral interventions are scored with a high coefficient on the Sackett scale (Sackett, 1993), making this form of intervention the standard recommendation (Morgenthaler et al., 2006). But even though the psychological treatment is quite efficient, it is limited in terms of accessibility. Thus, surveys show that 85% of the individuals affected by insomnia remain untreated, due to the lack of information or due to financial reasons (Sivertsen, Omvik, Pallesen et al., 2006). In order to facilitate the access to these cognitive-behavioral programs, they are often offered on internet (Strom, Pettersson, & Andersson, 2004; Ritterband, 2008).

An alternative to psychotherapy is the self-help treatment, based on psychological techniques. This intervention method has the advantage of disseminating information about insomnia to a greater number of people, at a fairly low cost. Generally, these types of programs are a synthesis of cognitive-behavioral interventions and those aimed at life-style change (Oosterhuis, 1993; Morin, 1994; Harvey, 2000).

Studies investigating the impact of self-help insomnia treatments are quite scarce in the literature. These studies indicate that this kind of intervention is useful in the reduction of the sleep onset insomnia. Among the techniques used in these studies are: brochures or manuals and TV programs offering information about sleep physiology, sleep hygiene, relaxation and stimulus control (Alperson & Biglan, 1979; Morawetz, 1989; Morin, 1999, 2005; Riedel, Lichstein, & Dwyer, 1995).

A more recent meta-analysis of Smith et al. (2002) compared stimulus control interventions with medication. The effect size for subjective measures of sleep latencies, number of awakenings, wake time after sleep onset, total sleep time and sleep quality before and after treatment was medium to high. A meta-analysis on elderly individuals suffering from a sleep disorder confirmed the validity of the conclusions. Beyond the fact that the improvement of the sleeping pattern is clinically significant, it is also long lasting (Pallesen, Nordhus, & Kvale, 1998).

In which the education for sleep hygiene is concerned, this strategy is often incorporated in the treatment of insomnia with the aim of preventing possible interference from poor sleep hygiene. Data show that, in the absence of some supplementary intervention methods, the education for the sleep hygiene has a reduced therapeutic value (Engle-Friedman, Bootzin, Hazlewood, & Tsao, 1992; Guilleminault, Clerk, Black, Labanowski, Pelayo, & Claman, 1995). This was also confirmed by a meta-analysis conducted by Straten & Cujpers (2009) who found a small to medium size effect for all sleep parameters.

Programs based on the use of binaural beats music are another type of self-help intervention. Binaural beats are auditory responses of the cerebral trunk that originate in the olivary nuclei of the cerebral trunk. They are the result of the interaction of two separate auditory impulses received from the two ears. The frequency of the tones must be below about 1,000 to 1,500 hertz for the beating to be heard. The difference between the two frequencies must be small (below about 30 Hz) for the effect to occur; otherwise, the two tones will be heard separately and no beat will be perceived (Oster, 1973). Normally, the frequency difference would offer information about the direction from which the sound comes, but in the moment of the head set hearing, the brain integrates information about the two signals, producing the sensation of the third sound, the binaural beat (Oster, 1973).

According to the model of the extended reticular ascendant activator system (Newman & Baars, 1993; Newman, 1997), binaural beats generate modifications in the cortical and subjective conscious experience EEG pattern, as the cortical-thalamic projections adapt the signals that came from the reticular formation (Atwater, 2001). This auditory sensation is directed towards the reticular formation (Swann et al., 1982) and, at the same time, to the cortex, where it can be objectively measured in frequency (Oster 1973, Smith, Marsh, & Brown 1975; Smith et al., 1978; Hink et al., 1980).

There are many neurophysiological studies which have documented the underlying mechanisms of the binaural beats (Newman, 1993, 1997; Oster, 1973; Smith, 1975, 1978). Despite this fact, the clinical utility of binaural beats is still a issue of controversy (Iuga & Bogdan, 2008). Binaural beats music has proved efficient in the management of certain psychological disorders such as alcoholism (Saxby & Peniston, 1995), neurological conditions (e.g., aphasia) (Barr, Mullin & Herbert, 1977), and preoperative anxiety (Padmanabhan, Hildreth, & Laws, 2005).

Concerning its effectiveness in primary insomnia, to our knowledge, there is only one published research paper. Thus, Levin (1998) records significant pre-post treatment differences as a consequence of using binaural beats for all the sleep quality parameters.

Taking into consideration the prevalence of this disorder in the case of adults (DSM-IV) and the fact that insomnia is not considered a serious enough factor to justify the call for psychological assistance (especially because of the stigma associated with these interventions; Stinson et al., 2006), the present study aims to validate the efficacy of two self-help programs (one based on sleep hygiene and one based on binaural beats), as compared to a behavioral technique whose efficacy has already been validated (i.e., progressive relaxation).

The study addressed the following questions: (1) Do patients undergoing a multi-component treatment improve compared to a baseline level? (2) Will there be any difference in terms of treatment effect between the three treatment approaches (sleep hygiene, binaural beats and progressive muscle relaxation)?

Methods

Participants

Participants were recruited from the records of a general practitioner's office and by advertisements posted on the psychology students' groups of the Department of Psychology at the Babes-Bolyai University in Cluj-Napoca. The selection was comprised of two consecutive phases. In the first phase the participants who presented evidence: a) of another sleep disorder, other than insomnia; b) that the sleep disorder was determined by physiological problems, which interfered with sleep; c) of frequent use of sleeping medication; d) of working on shifts, were excluded from the study.

In the second phase participants that remained in the study were evaluated for their match related to the inclusion criteria: a) aged between 18 and 60; b) sleep onset insomnia or sleep maintaining insomnia (sleep onset latency or time spent awake after sleep onset greater than 30 minutes per night for a minimum of 3 nights per week); c) insomnia lasting for at least 1 month; d) discontent regarding the effects of insomnia during the day (e.g., fatigue, mood disorders, functional impairments). These criteria are a combination of the diagnostic criteria described by The International Classification of Sleep Disorders (ICSD) (American Sleep Disorders Association, 1990) and by the Diagnostic and Statistical Manual of Mental Disorders (DSM IV) for primary insomnia.

After applying the exclusion criteria, three women, aged 22 (Participant 1), 24 (Participant 2) and 30 (Participant 3) were included in the study.

Experimental design

A modified latin square experimental design for single subject research was used. As it can be seen Table 1, the design involves a baseline recording stage (S1), 3 intervention stages (S2, S3 and S4) and a final stage of recording the persistence of the effect over time. (S5). The three participants were randomly assigned to each treatment sequence (see Table 1).

Tabel 1. Study Design

Participant/Stage	Baseline	Intervention			Follow-up
	S1	S2	S3	S4	S5
Participant 1	B	HS	MR	BB	PI
Participant 2	B	BB	HS	MR	PI
Participant 3	B	MR	BB	HS	PI

S1-S5 – experimental stages, B – baseline, SH – sleep hygiene, MR – muscle relaxation, BB- binaural beats, and PI – post intervention evaluation.

The design contains one random effect variable (Participant) and two fixed effect variables (Stage and Treatment). The carryover effect was not taken into account because the design is not a replicated Latin square. This effect will be estimated indirectly from the Stage x Treatment interaction. The dependent variable of the study was sleep onset time.

Procedure

The data collection procedure run over a period of 50 days, divided into five 10-day stages. In the first 10 days of the experiment (baseline stage) and the last 10 days (follow-up) each participant monitored their sleep pattern, recording the relevant parameters in the sleep. In stages 2-4 (treatment phases) each subject received the treatment procedure corresponding to that stage (see Table 1), and recorded their sleep pattern in the sleep diary. In each phase, the therapeutic intervention was supervised by a certified psychological counselor.

In the sleep hygiene condition subjects were instructed, during a one hour session, how to apply, on a day-to-day basis, the principles of stimulus control, fostering a healthy lifestyle, favorable to satisfactory sleep, as well as how to use sleep restriction. At the end of the session they were given the sleep hygiene brochure as a reminder for all the principles discussed.

In the progressive muscle relaxation condition, subjects were listening to an audio tape containing a relaxation session. The length of a relaxation session was based on the standards of an abbreviated progressive muscle relaxation session (30 minutes) (Bernstein, 2007). Before the intervention stage there was a learning session in which the participants learned how to apply the relaxation technique, supervised by the same psychological counselor.

In the binaural beats condition the subjects were listening to an audio tape containing binaural beat music. The length of the binaural beats music was matched to the length of the muscle relaxation session. Subjects were instructed to listen the tapes each day while lying in bed before sleep. Before the intervention stage there was an informative session regarding the underlying mechanism of binaural beats and the proper methodology of using the tape.

In order to get an accurate idea of how the intervention was going, subjects were interviewed regarding their difficulties with the treatment procedure of the corresponding stage every three days. The minor difficulties that appeared during the implementation of the treatment were solved by short correction periods, which did not exceed the standard limits of the interventions.

Measures and materials

The Sleep Diary used in this study is an adapted version of Morin (2003). It is a practical and economical instrument, frequently used in the sleep research (Lacks & Morin, 1992; Lichenstein & Riedel, 1994). The sleep diary included information regarding: bedtime, wake time, sleep onset, the number of awakenings during the night, time spent awake during the night, time spent asleep during the day. Because the main sleep problem of each participant was sleep onset insomnia we focused our attention on a single item of the sleep diary, namely sleep onset. Many studies have shown that subjective estimation on the sleep onset item gives a reliable and valid index of insomnia, even though it does not reflect the absolute values obtained by polysomnography (Coates et al., 1982).

The *sleep hygiene brochure* adapted after Morin (2003) contained: a short introduction regarding the neurological mechanisms of sleep and healthy lifestyle factors that facilitate a good night sleep; myths about sleep; rules for a good night sleep; healthy sleep related lifestyle and the proper environment for sleep.

The progressive muscle relaxation audio tape was based on a protocol that contained suggestions regarding the sequential relaxation/tension of thirteen muscle groups, while being aware of the differences between the two states (Bernstein, 2007). There is extensive empirical evidence that a similar relaxation protocol was used with success in the treatment of various psychological disorders (Sherman, 1979; Cheung et. al., 2002).

The binaural beats audio tape used is a product of Brainsync, by Kelly Howell, and it is called Sound Sleep. The basic principle on which binaural beats audio tapes are based is a progressive process that begins with a frequency difference, between the two sounds arriving at the two ears, which correspond to the brainwaves that characterize the actual state of consciousness (awake). From this point onward, the frequency difference is reduced progressively until it reaches the values of the brainwaves typical to deep sleep state (theta / delta waves) (Thaut, 2003). Binaural beats music has been previously used in the management of some psychological disorders, such as alcoholism (Saxby & Peniston, 1995), neurological conditions (e.g., aphasia) (Barr, Mullin, & Herbert, 1977), and preoperative anxiety (Padmanabhan, Hildreth, & Laws, 2005). To our knowledge, this is the first study attempting to validate its efficacy in sleep disorders.

Results

Data processing involved three phases. In the first phase we checked the resemblance of our data with the assumptions that would allow us to perform linear statistical models (Morley & Adams, 1989). In the second phase we verified if the therapeutic intervention as a whole had an effect, by statistically comparing the baseline, treatment and follow-up phase. Finally, in the third phase we used a GLM model for a latin square design to estimate the relative efficiency of each treatment procedure (Kutner, Nachtscheim, Neter, & Li, 2005).

Following Morley and Adams (1989) we applied to each baseline data set: the Turning Point Test (Bradley, 1968) to evaluate if the baseline data only reflect random fluctuations of performance, with no regularity or specific tendency; and the Record Test (Foster & Stewart, 1954), which verifies if there is a tendency or a change in baseline variance. Results are shown in Table 2.

Tabel 2. The results of the Turning Point Test and the Record Test for each participant's baseline scores

	Turning Points Test		**Record test**			
	T	*p*	d	*z*	s	*p*
Participant 1	5	0.54	2	1.01	4	0.70
Participant 2	5	0.54	0	0.00	4	0.70
Participant 3	5	0.54	0	0.00	2	0.14

All the cumulative distributions of the statistics presented in Table 2 followed the normal distribution, and as such, their values and cumulative probabilities could be interpreted as any other z test. The turning points test column indicates that neither of the computed p value drops below the critical value p=.05, meaning that baselines data reflect random fluctuations only (Kratochwill & Levin, 1992). This conclusion is confirmed by the other statistics in the table: the z value calculated for each d test and the probability associated with each s tests. All values are statistically insignificant, meaning that there are no signs of tendency or variance fluctuations in the baseline.

To confirm these patterns we computed an autocorrelation coefficient using tag-1 in order to detect the presence of a tendency in the data (Franklin, Allison, & Gorman (1997). Correlation values range between 0.01 – 0.21, all of them being statistically insignificant. These results re-confirm that baseline data were not affected by any source of systematic variation.

Consequently, we proceeded to the next phase concerning the effect of treatment phase (2-4) as a whole. In order to get an answer to the first question of the study, regarding the effects of the multi-component treatment, we used a 3x3 ANOVA, with two independent variables – the Subject variable, with three levels (participant 1, participant 2, participant 3) and the Treatment variable, with three levels (baseline, treatment and follow-up). Results are shown Table 3.

Table 3. Mean sleep onset (in minutes) in baseline and follow-up phase

	Participant	Mean	Std. Deviation
Baseline	1	33.89	9.61
	2	31.50	14.34
	3	35.30	17.87
Treatment	1	17.96	3.51
	2	19.33	8.39
	3	29.00	9.88
Follow-up	1	12.78	4.41
	2	15.00	4.08
	3	18.50	7.09

The calculated value of the Mauchly test for the within subject variable (Treatment) was W = 0.85; the approximated value is χ^2=4.76 (df=2, p=0.13), satisfying the assumption of sphericity. The statistical analysis indicates an effect of the treatment, F(2,52) = 27.09 (p=0.001, η^2 = 0.51), and its magnitude reflects a high effect size (Cohen, 1982). No significant effect of the subject variable was observed, F<1, meaning that all subjects improved their sleep onset time in the same amount. This conclusion is also confirmed by the insignificant value of the interaction between treatment x subject, F(2,52) = 0.73 (p = 0.57, η^2 = 0.05).

The results of the Sidak post-hoc are presented in Table 4. All statistical comparisons were significant. This means that the mean sleep onset time progressively decreases from m=33.55 (sd=14.06) at Baseline, to m=22.04 (sd=9.09) during Treatment and to m=15.52 (sd=5.72) at Follow-up.

Table 4. Sidak post-hoc pair wise comparison for the main stages of the study

Stage	Treatment	Mean Difference	Sig.
Baseline	Treatment	11.46	.001
	Follow-up	18.13	.001
Treatment	Baseline	-11.46	.001
	Follow-up	6.67	.006
Follow-up	Baseline	-18.13	.001
	Treatment	-6.67	.006

We have shown that the treatment phase as a whole has a significant effect, but we were also interested to analyze the independent effect of each treatment type compared to baseline. Thus, we compared each treatment type in stage 2 (first treatment intervention) with the baseline, using a repeated measure t test. Results are: $t = 10.26$ (df=9, $p=0.001$) for sleep hygiene, $t = 6.28$ (df=9, $p=0.001$) for binaural beats and $t = 5.89$ (df=9, $p=0.001$) for muscle relaxation.

In the last phase of data analysis we transformed the design into a simple Latin square using a dependent variable obtained by computing the differences between baseline score and each intervention stage score (see Table 5). Data were analyzed using a GLM for Latin square, with one random factor (Participant) and two fixed effect factors (Stage and Treatment type).

Table 5. Baseline - Stage mean differences for each treatment type

Participant/Stage	S2	S3	S4
Participant 1	8.5	16.5	20
	SH	MR	BB
Participant 2	3	16.5	17
	BB	SH	MR
Participant 3	13.3	-9.7	15.3
	MR	BB	SH

S2-S4 – intervention stages, SH – sleep hygiene, MR – muscle relaxation and BB - binaural beats

The most important finding is that no significant Stage x Treatment interaction effect was observed, $F(2,81)=2.18$ ($p=0.065$), meaning that the effect of treatment type is not influenced by the stage in which it was introduced. Since each stage involved a different treatment type for each subject, we can assume that the effect of the stage is not influenced by the treatment type variable. There is a significant main effect of Treatment, $F(2,81)=3.24$ ($p=0.04$) which means that there is a difference in the effectiveness of different treatment interventions. To find out which one is the most efficient, we conducted a Sidak pot-hoc pair wise comparison (see Table 6).

Table 6. Sidak post-hoc pair wise comparison for the treatment types

Treatment	Treatment	Mean Difference	Sig.
Sleep Hygiene	Muscular Relaxation	-2.16	.95
	Binaural Beats	9.00	.15
Muscular Relaxation	Sleep Hygiene	2.16	.95
	Binaural Beats	11.16	**.04**
Binaural Beats	Sleep Hygiene	-9.00	.15
	Muscular Relaxation	-11.16	.04

Data in Table 6 indicate that the only significant difference is between Muscular relaxation and Binaural beats, while all other comparisons are insignificant. The effect of Sleep Hygiene could not be differentiated from that of Binaural Beats and relaxation.

Discussion

The main objective of this study was twofold: to compare the effect of two types of self-help treatment (i.e., sleep hygiene, binaural beats) with the effect of progressive muscle relaxation in the treatment of primary insomnia; we were also interested in the relative efficacy of two self-help methods (i.e., sleep hygiene, binaural beats).

The research design was a modified latin square experimental design for single subject research. This design allows valid inferences regarding treatment, and has a high practical value in clinical research (Kutner, Nachtsheim, Neter, & Li, 2005).

The significant main effect of treatment and the significant differences between baseline, treatment phase and follow-up indicate that treatment improves sleep onset time for all the participants. These results support the already-proven effect of multi-component interventions in primary insomnia (Morgenthaler et al., 2006). The post-hoc differences between follow-up and treatment phase indicate that, during the intervention, all subjects gained some abilities that improved their sleep onset time over the treatment phase. This feature is common to all therapeutic interventions and, moreover, it is a desirable outcome (Beck, 1995).

To prove that this global effect could not be explained by the high effect size of only one intervention (e.g., progressive muscle relaxation combined with insignificant effect of hygiene and binaural beats), we compared each treatment type with the baseline scores. Our results show statistically significant effects for each treatment type.

In which muscle relaxation and sleep hygiene are concerned, our results are in line with the conclusions of other empirical studies (Engle-Friedman, Bootzin, Hazlewood, & Tsao, 1992; Guilleminault, Clerk, Black, Labanowski, Pelayo, & Claman, 1995). The main component of these two techniques is based primarily on behavior modification. The target of progressive muscle relaxation is to reduce arousal before falling asleep, which is an important component of the integrative model of insomnia (Lundh & Broman, 1999).

The second procedure has a behavioural component which consists in stimulus control, sleep restriction and adopting a healthy lifestyle favourable to a good night sleep. Lifestyle change is focused on avoiding high arousal prior to sleep (e.g., limiting physical exercise after 6 P.M., limiting caffeine and alcohol intake in the afternoon, etc.). Based on stimulus control and sleep restriction, the individual can develop a healthy sleep-related cognitive schema. For example, through sleep restriction the patient will associate staying in bed only with sleep and not with other activities such as eating, watching TV, etc. (Bower, Black, & Turner, 1979; Miclea, 2003). The convergence of these two mechanism results in an improvement of sleep quality which was demonstrated in the present and in many other studies (Harvey, 2001; Stepanski, 2003).

The empirical data regarding the utility of binaural beats in treating primary insomnia in particular, and other types of disorders is nearly missing, notwithstanding the fact that the underling physiological mechanism of this phenomenon is relatively well-known (Newman, 1993, 1997; Oster, 1973; Smith, 1975, 1978). According to the theoretical model of the binaural beats (Lane, Kasian, Owens, & Marsh, 1998) the statistically significant difference between baseline and binaural beats condition could be explained by neural-level phenomena which take place in the presence of these particular beats (for a detail description see Newman, 1997).

Regarding the statistical significant effect of binaural beats, there is a possible confounded variable which might affect our conclusion. During the binaural treatment, each subject listened to an audio tape playing music and background binaural beats. It is possible that the significant reducing in sleep onset time is explained by the effect of the relaxation music itself, not by the presence of the binaural beats. This explanation would contradict the findings reported by Padmanabhan et al. (2005) in a study comparing the effect of binaural beats music, control, and placebo (i.e., same music without binaural beats) in treating of preoperative anxiety. They found significant differences between the experimental group and both control and placebo group.

Regarding the relative effect of the three treatment types, progressive muscle relaxation, sleep hygiene and binaural beats, our results indicate that there is a significant difference only between muscle relaxation and binaural beats. We did not find any significant differences between muscle relaxation and sleep hygiene, binaural beats and sleep hygiene. This lack of difference could be explained by the moderate effect size reported in most studies using progressive muscle relaxation and low to moderate effect size of self-help treatment. To verify this, we computed the effect size of our post hoc comparisons and found an effect size of $d=0.23$ for the difference between muscle relaxation and sleep hygiene and an effect size of d=0.96 between sleep hygiene and binaural beats. According to Cohen's norms, the first calculated effect size is low, and we can say that the effect of the two interventions is nearly similar.

In which the difference between hygiene and binaural beats is concerned, a beta type error is more probable. Probably this effect size would have been observed by an increase in statistical power (i.e., increasing the number of evaluations in each stage) or, by using a replicated Latin square design instead of simple one, which allows a more precise evaluation of the carryover effect (Kutner, Nachtsheim, Neter, & Li, 2005).

Summarizing our findings, we can say that the cognitive behavioral intervention and the self-help treatment have both proved to be efficient related to baseline. The effect of the cognitive behavioral intervention is very similar to the effect of hygiene and it is very probable that the effect of binaural beat is somewhat reduced compared to the other two. Based on the above mentioned empirical evidence, we believe that self-help treatment strategies could offer a viable alternative in the treatment of primary insomnia for individuals who do not have the possibility or chose not to enter cognitive behavioral treatment.

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