Investigation of the therapeutic effects of listening to music in reducing sleep problems and anxiety

Doctoral thesis

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I. BACKGROUND

Music therapy is an intervention used in several fields of medicine. Pharmacological treatment is very common in clinical sleep medicine; however, non-pharmacological treatments are also useful in curing sleeping problems. The most popular non-pharmacological treatments are cognitive behavioural therapy, sleep hygiene, sleep restriction, relaxation techniques, psychotherapy and music therapy.

Studies with self-reported measures of sleep

There are a number of studies focusing on the direct effects of music on sleep. All of the existing studies which assessed sleep quality by self-reported measures showed that music had a sleep-promoting effect. Zimmerman (1996) studied the effects of relaxing music on sleep and pain in 96 subjects who had undergone coronary artery bypass grafting. Two studies were conducted among children (Field, 1999; Tan, 2004). In the study conducted by Field (1999), the children in the experimental group listened to classical guitar music at naptime while in Tan's study (2004) music was played both at naptime and at bedtime. Three studies investigated the effects of music on sleep in older adults (Mornhinweg and Voignnier, 1995; Johnson, 2003; Lai and Good, 2004).

All of the studies using self-reported measures of sleep quality showed that music had a statistically significant sleep-promoting effect. However, these findings were not confirmed by studies using objective psychophysiological measurements.

Studies with polisomnography

Levin (1998) examined the therapeutical effects of "Brain Music" in 58 patients suffering from insomnia. "Brain Music" is basically the transformation of spontaneous bioelectrical activity of each person's EEG into music. Gitanjali (1998) examined a traditional Indian ragha that is similar to lullabies. Iwaki's study examined the effect of preferred familiar music on falling asleep. Lasic (2007) used quantitative EEG analysis to determine the effect of music on sleep. Results: Levin found a positive effect of „brain music" on insomnia symptoms in more than 80% of the patients. In Iwaki's study Stage 2 sleep latency was shorter in the music group. Neither Gitanjali (1998) nor Lasic (2007) found evidence for a positive effect of music on sleep. These objective measurements did not support the results of the studies using self-reported measures of sleep quality.

AIMS

The aims of this thesis were:

1. to confirm the positive effects of music on sleep quality that several of the aforementioned studies have shown.

2. to investigate the effect of the positive expectations of the participants regarding treatment.
3. to investigate and confirm the results of studies using self-reported measures of sleep using physiological measurements.

HYPOTHESIS

Three studies were carried out to support our aims. The first study was based on self- reporting of sleep by completion of the Hungarian version of Pittsburg Sleep Quality Index (PSQI). In the second study we compared the acute physiological and psychological effects of listening to slow classical music to those of listening to an audiobook. In the third study we measured the effects of listening to music on sleep quality by actigraphy. We hypothesised that listening to slow classical music would improve sleep quality as measured both subjectively with the PSQI and objectively during the psychophysiological measurements (HRV, actigraphy).

METHODS

Study 1: The therapeutic effect of listening to music on sleep problems

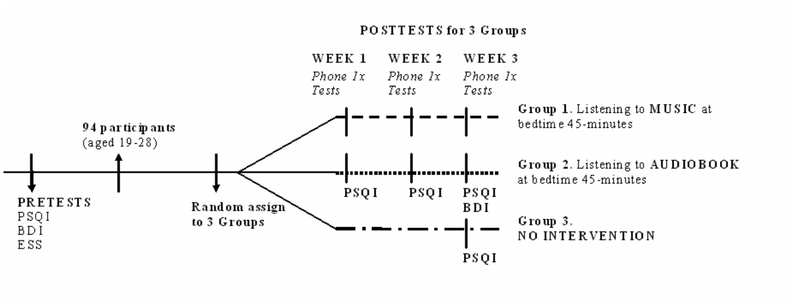
Participants

Ninety-four Hungarian university students with sleep complaints were recruited. Seventy-three were women and 21 were men (mean age=22.6 years, SD=2.83, range: 19-28) Randomized controlled trial was used with a three group repeated measures design. Study participants were randomized to one of the following 3 conditions:: listening to music (n=35), listening to audiobook (n=30) or no intervention (n=29).

Procedure

At the beginning of the study the authors collected baseline data on the Pittsburg Sleep Quality Index (PSQI), the Beck Depression Inventory (BDI) and the Epworth Sleepiness Scale (ESS) and then randomly assigned participants to one of the three groups. The members of the music group were given a CD containing classical music (Most Relaxing Classical, edited by Virgin,1999). They were asked to listen to music for 45 minutes every night at bedtime during 3 consecutive weeks. The members of the audiobook group were given a CD containing 11 hours of short stories by Hungarian writers such as Frigyes Karinthy, Gyula Krúdy, Géza Gárdonyi, Zsigmond Móricz and Mihály Babits. Similarly to the subjects in the music group, the participants were asked to listen to the audiobook at bedtime for 45 minutes each night for 3 consecutive weeks. There was no intervention in the third (control) group.

Figure 1. Study design



Measurments

The Pittsburgh Sleep Quality Index (Buysee, 1989) is a commonly used questionnaire that measures self-reported sleep habits. The questionnaire can be filled in in a short time. Researchers receive information about the participant’s perceived sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance as well as about the use of sleep medication, and daytime functioning. These seven components form a global score that ranges between 0 and 21; the score of each component ranges from 0 to 3. A score of 5 (indicating poor sleep) yielded a diagnostic sensitivity of 89.6% and a specificity of 86.5%. A global PSQI score > 5 is indicative of severe sleep difficulties in at least two areas. The internal consistency of the Hungarian version is α = 0·79. We validated the Hungarian version of the questionnaire using data of 148 persons. .

We used a shortened version of BDI, a modified version of the original shortened BDI (Beck, 1972). The shortened version of BDI consists of 9 items and has an internal consistency of α = 0.85 in a nation-wide representative Hungarian sample (Rózsa 2003). The Epworth Sleepiness Scale (ESS) was used as a filter to assess depression and daytime somnolence.

Statistical analysis

We used **parametric tests** i.e. paired samples t-tests, t-tests for independent samples and ANOVA with three groups.

Study 2: The effects of listening to music on anxiety investigated with psychophysiological measurements

Participants

Twenty-one young healthy participants (mean age=32.3 years, SD=3.80, range=27-39) including 11 women and 10 men were recruited in the study by means of advertisements. Professional musicians were not accepted to participate in the study. Subjects had to be drug-free and non-smokers as well.

Procedure

Three classical pieces were chosen as slow and comforting musical stimuli: J.S. Bach: Air (On the G String), Grieg: Morning from the Peer Gynt suite and Pachabel: Canon. The musical pieces were performed by the orchestra St. Martin Academic of the Fields (Most Relaxing Classical Edited by Virgin 1999). The audiobook stimulation consisted of listening to a short novel in Hungarian (*The muteness of the gents)* from the Hungarian writer Frigyes Karinthy. Study participants were informed that a classical music and an audiobook session each lasting for 10 minutes would be played. Before and after each session participants reported their perceived anxiety with the Spielberger's State Anxiety scale.

Measurments

The participants' perception of anxiety was assessed with the Spielberger State-Trait Anxiety Inventory (STAI) (Spielberger 1972). The instrument consists of two scales which measure the distinct concepts of state (STAI-S) and trait anxiety (STAI-T). During the auditory stimulation we recorded physiological parameters using an electrocardiogram (ECG) and a frontal electromyogram (EMG), as well as chest and abdominal respiratory movements.

Statistical analysis

We used parametric tests, i.e. paired samples t-tests and repeated measures analysis of variance (ANOVA) with two groups. The assumption of the normal distribution of variables was checked. Paired samples t-tests were used to compare the music and the audiobook sessions on EMG data and on ECG parameters such as HR, the power spectral frequency bands in LF and HF (bpm) and the LH/HF ratio. A repeated measures ANOVA with the main factors CONDITION (2 levels) and TIME (2 levels, before and after) was conducted to analyse perceived anxiety within and between the two conditions before and after the stimulations

Study 3: Therapeutic effect of music on sleep quality measured by actigraphy

Participants

Seventeen healthy Hungarian subjects with sleep complaints were recruited. Eleven were women and 6 were men (mean age=27.87 years, SD=5.66, range: 21-38) Randomized controlled trial was used with a two group repeated measures design. The first group listened to music (n=8), the second one listened to audiobook (n=9).

Procedure

At the beginning of the study the authors collected data on the Pittsburg Sleep Quality Index (PSQI), the Beck Depression Inventory (BDI) and the Epworth Sleepiness Scale (ESS) and randomly assigned participants to one of the three groups: music, audiobook and control group. The members of the music group were given a CD containing classical music (Most Relaxing Classical, edited by Virgin,1999). They were asked to listen to music for 45 minutes every night at bedtime during 3 consecutive weeks. The members of the audiobook group were given a CD containing 11 hours of short stories by Hungarian writers.

Measurment: actigraphy

We measured the activity on the wrist of the non-dominant hand using an instrument named Actiwatch (Model AW2, Cambridge Neurotechnology Ltd.). We analysed the following parameters: time in bed, assumed sleep, actual sleep time, actual wake time, sleep efficiency, sleep latency, minutes of immobile phase, minutes of moving phase. For each of these parameters we calculated an average score for seven days.

Statistical analysis

We used nonparametric tests to analyse the results from actigraph. Mann-Whitney U tests were used for between-groups comparisons (music and audiobook) and Wilcoxon-test were for within group comparisons.

RESULTS

Study 1: The therapeutic effect of listening to music on sleep problems

PSQI and BDI in the post-tests

A repeated measures ANOVA with GROUP (3 levels) and TIME (2 levels) as main factors was used to analyse sleep quality within and between groups before and after the study. We did not find a significant GROUP main effect. There was a significant main effect of TIME ($F=87.157$; $P<0.0001$) and a significant interaction between TIME and GROUPS ($F=14.748$; $P<0.0001$). Post-hoc comparison (Bonferroni correction) of pre-test scores with the three-weeks' post-test scores showed that music significantly improved sleep quality ($P<0.0001$). We did not find any improvement in the sleep quality in the audio group or in the control group (Fig. 2).

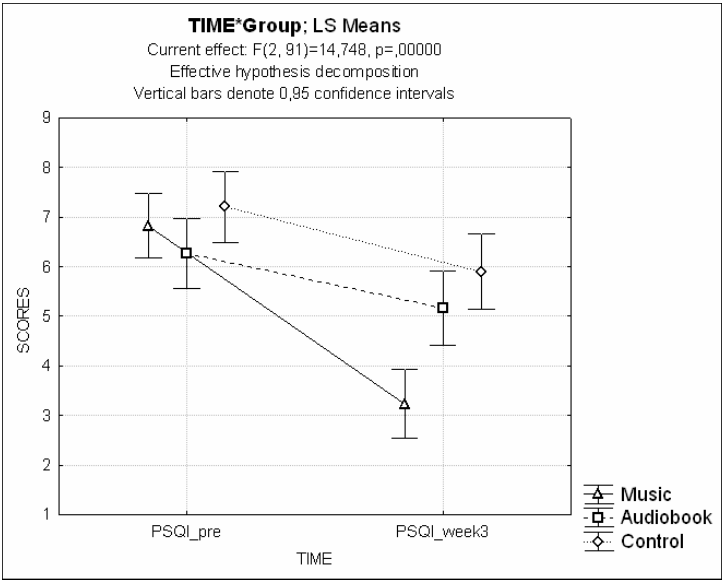


Figure 2. Pre-test and post-test global PSQI scores in the three groups: music, audiobook and control. Repeated Measures ANOVA with GROUP (3 levels) and TIME (2 levels) main factors revealed a significant main effect of TIME and a significant interaction between GROUP and TIME.

We used t-tests for independent samples to compare weekly changes in global PSQI scores in the two intervention groups, i.e. music (Group 1) and audiobook (Group 2). We could not include in these analyses the control group (Group 3) as we had data on only two TIME points for this group. The magnitude of the difference between groups (music vs. audio book) was significant after the second week (Week 2, P=0.0002; Week 3, P=0.0004). Improvement continued during the following week of the study (Table 2). Thus, listening to music has a cumulative effect on sleep quality (Figure 3).

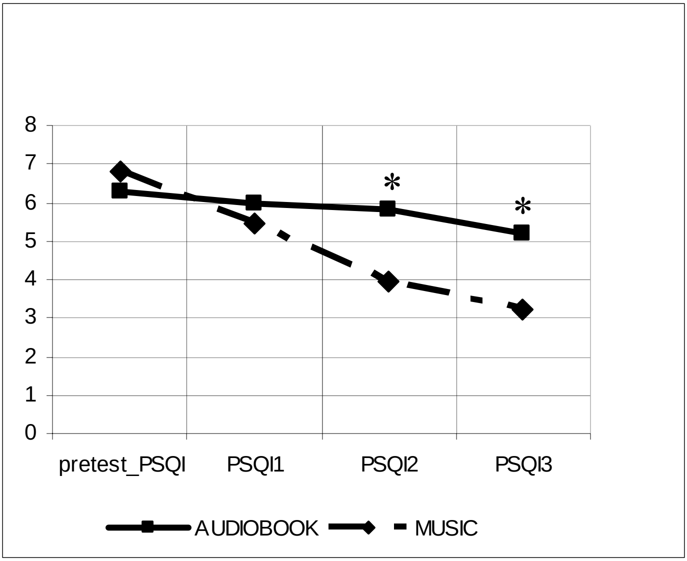


Figure 3. Weekly global PSQI scores in the music and audiobook groups* significant differences between groups (P<0·05)

According to our results, music altered mood (Fig. 4). Depressive symptomatology decreased in the music group (t= 6.124; P<0.0001). BDI scores did not change significantly after listening to audiobooks. The music group had significantly better scores on the six PSQI components during the 3 weeks. Paired samples t-test was used to compare pre-test scores and week 1, week 2, week 3 scores within the music group. Listening to music resulted in improved subjective sleep quality, shorter sleep latency, longer sleep duration, better sleep efficiency, reduced sleep disturbances and less daytime dysfunction week by week; however sleep duration showed a delayed effect since a significantly longer sleep duration occurred during the second (t=4·098; P<0·0001) and third weeks (t=4·828; P< 0·0001) in the PSQI tests (Fig. 5).

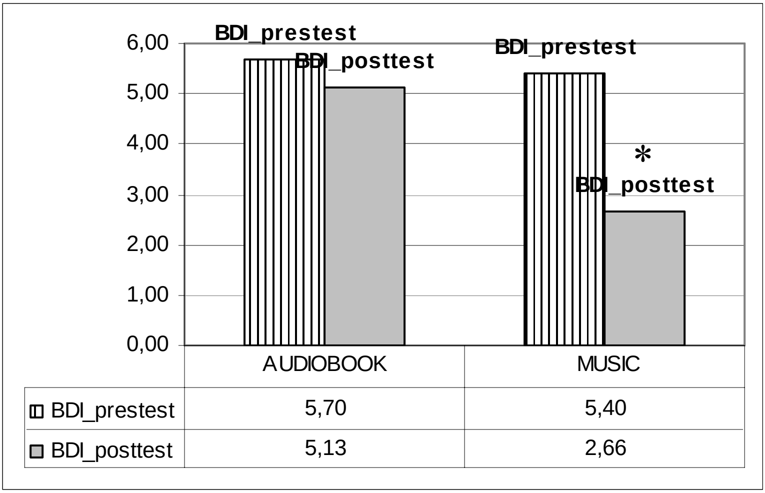


Figure 4. BDI scores in pre- and post-tests* significant differences between BDI pre-test and post-test within groups, (P<0·05)

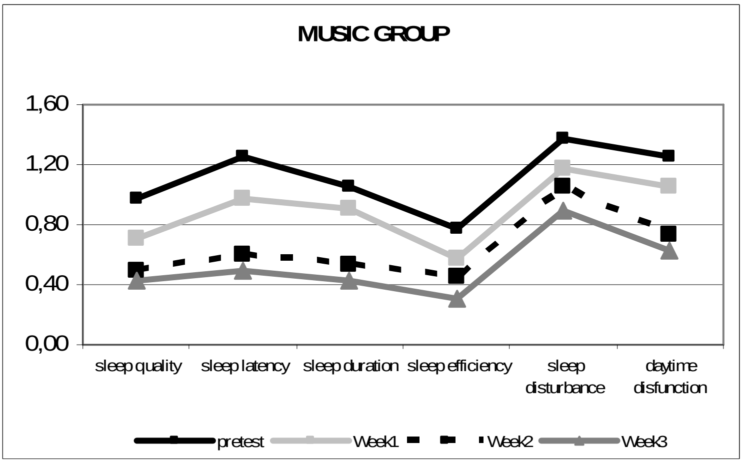


Figure 5. Weekly PSQI components outcomes in music group

None of the PSQI components improved significantly in the audiobook group during the first two weeks. On the third week we found significant changes in *subjective sleep quality* ($t=2.340$; $p= 0.026$), *sleep disturbances* ($t= 2.504$; $p= 0.018$), and *daytime dysfunction* ($t= 2.904$; $p= 0.007$).

Study 2: The effects of listening to music on anxiety investigated with psychophysiological measurements

We found a significant difference between the two conditions in muscle tension. The mean EMG activity was significantly higher during listening to music than during the audiobook condition ($t=2.210$; $P=0.039$ (Figure 6). We did not find significant changes in HR and between the LF and HF component of the HRV; however HF tended to be higher during listening to audiobook (455.67 ms^2) than during listening to music (428.33 ms^2) (Figure 7).

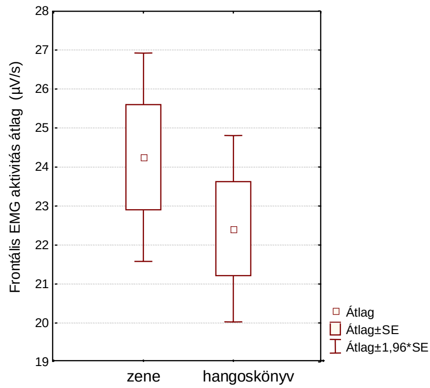


Figure 6. Means of frontal EMG (microvolt/sec) during listening to music and audiobook

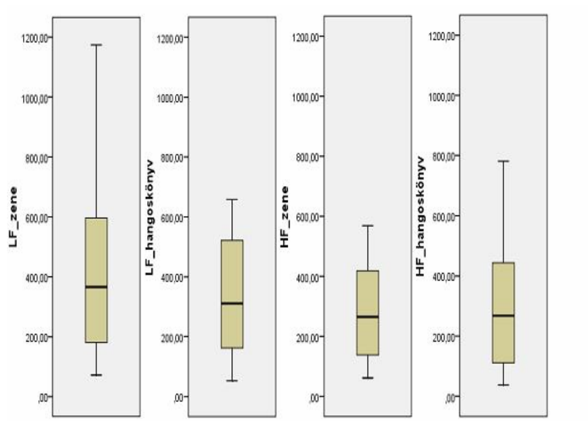


Figure 7. Results of heart rate variability (high and low frequency component)

Results of STAI-S

We found a statistically significant main effect for CONDITION (F=13.758, P=0.002) and for TIME (F=7.250; p=0.018) in the case of state anxiety. However, the interaction between TIME and CONDITION was not significant. The post-hoc Fisher-test indicated a significant increase in anxiety scores after the music intervention (p=0.035). Anxiety scores did not differ at the beginning of the conditions, but they differed at the end of the interventions (P=0.032). (Figure 8).

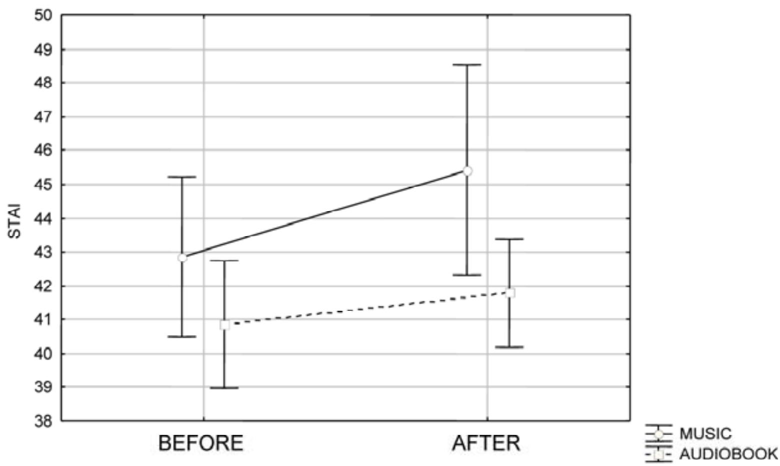


Figure 8. Results of Spielbereger Stait Anxiety Inventory (STAI-S) before and after the interventions.

Study 3: Therapeutic effect of music on sleep quality measured by actigraphy

We analysed the following parameters: time in bed, assumed sleep, actual sleep time, actual wake time, sleep efficiency, sleep latency, minutes of immobile phase, minutes of moving phase. For each of these parameters we calculated an average score for seven days. We used non-parametric tests to analyse the results from actigraph. Mann Whitney test were used between the groups (music and audiobook) and Wilcoxon-test were used whitin the groups. We did not found significant differences in the datas from the actigraph neither between the groups nor within the groups.

DISCUSSION

The results of the studies with physiological outcomes are not consistent with those of psychological outcomes (Harmat 2008). The results of the first study supported our hypothesis that listening to slow classical music at bedtime improves sleep quality.

We measured the acute physiological effects of listening to music which includes heart rate (HR) and heart rate variability (HRV), muscle tension (EMG), and respiratory rate. The results did not support our previous hypothesis that listening to music for ten minutes would decrease the physiological arousal. We did not find significant changes in any of the other physiological outcome. However these results did not support our previous hypothesis concerning the acute physiological effects of listening to sedative music. The study of Lai and Good and our first investigation focused on additive effects of listening to music on sleep quality. This effect developed during two or three weeks.

The third study was conducted according to a very similar procedure to the first one. There were differences only in the participating subjects and the time. This study did not support our previous findings. We did not find significant differences in the data from the actigraph neither between the groups nor within the groups. There was no therapeutic effect of listening to music and audiobooks. There were limitations in our studies. The sample was too small in the third study with actigraphy and actigraphy has some disadvantage compared to polisomnography.

In my opinion we need to investigate therapeutic effects of sleep quality by polisomnography but we have to measure macro- and microstructure of sleep as like as changes in cyclic alternating pattern (CAP).

Articles related to the dissertation:

1.Harmat L (2008): A zene terápiás hatásainak alkalmazása az alvászavarok kezelésében. *Lege Artis Medicinae*

2. Harmat L., Takács J., Bódizs R. (2008): Music improves sleep quality in students. *Journal of Advanced Nursing* 62 (3), 327-335.

3. Harmat L. (2007): Alvászavarok kezelés zenével. *Komplementer Medicina* 11. (1): 47-50.

Other articles:

4. Harmat L., Theorell T. (2010): Heart rate variability during singing and flute playing. Music and Medicine 2, 10-17.
5. Manzano O., Theorell T., Harmat L., Ullén F. (2009): The psychophysiology of the Flow during piano playing. Emotion. (Accepted 2009 10.01.)
6. Harmat L. (2004): Zene és lelki egészség) Embertárs (Lelkigondozói és Mentálhigiénés Folyóirat) 2.(1): 22-31. old.
7. Harmat L. (2003): Piacképes-e az ének-zene oktatás? Köznevelés 59. (40): 20-21.
8. Harmat L (2003): Kutatások a zenei nevelés hatásairól a gyermek személyiségfejlődésében. Tanító (Módszertani folyóirat)

Book chapter:

1. Harmat L. (2005):Nevel-növel a zene In: Balázsné Szűcs Judit (szerk)*Barangolás a zene világában*. OVIZUÁL Kreatív Műhely, Budapest, 2005: 91-103.

2.Ullén F, Manzano O, Theorell T, Harmat L. The physiology of effortless Attention: correlates of state flow and flow Pronenness. In: Brian J. Bruya (ed.) A New Perspective in the Cognitive Science of Attention and Action MIT Press Cambrigde 2010 (in press)

Posters related to the dissertation

1. Harmat L.,Takács J., Bódizs R. (2006): Music improves sleep quality in students" *Journal of Sleep Research* 15 (1): 133. .
2. L.,Takács J., Bódizs R. (2006): Music improves sleep quality in students. *International Journal of Behavioural Medicine* 13: 241.