

Music improves sleep quality in students

László Harmat, Johanna Takács & Róbert Bódizs

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Correspondence to L. Harmat:
e-mail: laszloharmat@yahoo.com

László Harmat MSc
Postgraduate Student
Semmelweis University, Institute of
Behavioural Sciences, Budapest, Hungary

Johanna Takács MSc
Postgraduate Student
Semmelweis University, Institute of
Behavioural Sciences, Budapest, Hungary

Róbert Bódizs PhD
Senior Research Fellow
Semmelweis University, Institute of
Behavioural Sciences, Budapest, Hungary

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Abstract

Title. Music improves sleep quality in students.

Aim. This paper is a report of a study to investigate the effects of music on sleep quality in young participants with poor sleep.

Background. Sleep disorders may result in fatigue, tiredness, depression and problems in daytime functioning. Music can reduce sympathetic nervous system activity, decrease anxiety, blood pressure, heart and respiratory rate and may have positive effects on sleep via muscle relaxation and distraction from thoughts. Control groups have not been used in most previous studies.

Methods. We used a three-group repeated measures design. Ninety-four students (aged between 19 and 28 years) with sleep complaints were studied in 2006. Participants listened for 45 minutes either to relaxing classical music (Group 1) or an audiobook (Group 2) at bedtime for 3 weeks. The control group (Group 3) received no intervention. Sleep quality was measured using the Pittsburg Sleep Quality Index before the study and weekly during the intervention. Depressive symptoms in experimental group participants were measured using the Beck Depression Inventory.

Results. Repeated measures ANOVA revealed a main effect of TIME ($P < 0.0001$) and an interaction between TIME and GROUPS ($P < 0.0001$). *Post hoc* tests with Bonferroni correction showed that music statistically significantly improved sleep quality ($P < 0.0001$). Sleep quality did not improve statistically significantly in the audiobook and the control group. Depressive symptoms decreased statistically significantly in the music group ($P < 0.0001$), but not in the group listening to audiobooks.

Conclusion. Relaxing classical music is an effective intervention in reducing sleeping problems. Nurses could use this safe, cheap and easy to learn method to treat insomnia.

Keywords: alternative therapy, depression, insomnia, psychology, sleep, stress

Introduction

Sleep quality is a very important factor in quality of life. Sleep disorders may result in fatigue, tiredness, depression and problems in daytime functioning. Several studies have focused on the effects of music on sleep quality, and

researchers have found, in a variety of study settings and populations, that music positively affects sleep.

The purpose of this research was to confirm the positive effects of music on sleep quality that the earlier studies have shown and investigate the specific effects of music on sleep quality by controlling for the confounding effect of relaxation

and positive expectations. Most earlier researchers did not take into consideration these factors that may influence participants' sleep quality and there remains the question whether music *per se* influences sleep or whether sleep quality is also affected by participants' expectations of the treatment.

Background

A number of studies conducted in clinical settings have suggested that sedative music may have positive effects on sleep via muscle relaxation and distraction from thoughts (Mornhigweg & Voigner 1995, Zimmermann *et al.* 1996, Johnson 2003, Lai & Good 2004). Music can reduce sympathetic nervous system activity, decrease anxiety, blood pressure and heart and respiratory rates (Standley 1986, Good *et al.* 1999, Salamon *et al.* 2003).

Eight studies have had a direct focus on the effects of music on sleep. Zimmermann *et al.* (1996) studied the effects of relaxing music on sleep and pain in 96 patients who had undergone coronary artery bypass graft surgery. Levin (1998) examined the effects of 'Brain Music' in the treatment of 58 patients suffering from insomnia. 'Brain Music' is basically the transformation of spontaneous bioelectrical activity into music. Gitangali (1998) examined a traditional Indian ragha, which is similar to lullabies. Two studies have been conducted with children (Field 1999, Tan 2004). In Field's study, children in the experimental group listened to music at naptime, while in Tan's study they also did so at bedtime. Three researchers have investigated the effects of music on sleep in older adults (Mornhigweg & Voigner 1995, Johnson 2003, Lai & Good 2004). All studies showed that music had a statistically significant sleep-promoting effect, except for that by Gitangali (1998) in which no evidence was found for the positive effect of music on sleep.

These results indicated that music is a potential non-pharmacological intervention for the treatment of sleep disturbances such as insomnia. However, they were based on self-report measures and have further limitations. For example, in most studies a control group was not used, whilst in theirs (Fried 1990a,b, Lai & Good 2004) music was combined with relaxation therapy or some other intervention, making it difficult to draw conclusions about the effects of music *per se*.

The study

Aim

The aim of the study was to investigate the effects of music on sleep quality in young participants with poor sleep.

Design

A randomized controlled trial was used with a three group, repeated measures design was carried out in 2006.

Participants

Ninety-four students, 73 women and 21 men (mean age = 22.6 years, SD = 2.83, range: 19–28), with sleep complaints were recruited at a university in Hungary. Participants were randomized using a computerized randomization table and variable block randomization. Each block was randomly assigned to the groups and the three groups in each block received only one 'treatment': listening to music (Group 1; $n = 35$), listening to an audiobook (Group 2; $n = 30$) or no intervention (Group 3; $n = 29$).

The inclusion criteria were:

- age above 19 years,
- able to understand the Hungarian language,
- poor sleep: Pittsburg Sleep Quality Index (PSQI) global score > 5 (Buysee *et al.* 1989),
- no daytime somnolence: Epworth Sleepiness Scale (ESS) < 16 (Johns 1991) and
- no severe depressive symptoms: Beck Depression Inventory (BDI) score < 19 (Eaves & Rush 1984).

The exclusion criteria were:

- current use of hypnotics, sedatives or antidepressants; and
- medical diagnosis for primary sleep disorder.

Experimental interventions

Members of the music group were given a CD containing classical music and were asked to accept or refuse the music collection. No participant refused it. The music was a collection of relaxing classical music including some popular pieces from Baroque to Romantic (The Most Relaxing Classical, 2 CD, Edited by Virgin 1999). We did not offer a choice of the type of music to be listened to, but all the participants confirmed that they liked classical music. The music was the same for all participants. The music collection was introduced to the participants by the investigators before the study and they were to listen to it for 45 minutes every night at bedtime for 3 consecutive weeks. All participants in the music group listened to 3-minute excerpts.

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 those in the music group, they were asked to listen to the audiobook at bedtime for 45 minutes each night for 3 consecutive

weeks. They had the option to listen to new stories each night but could also listen repeatedly to the stories they preferred. All these participants listened to the same audiobook collection.

The music and audiobook participants were asked to listen to their CD before going to bed and to avoid physical activities during and after the music or audiobook session. They had no previous training in any relaxation technique.

Members of the control group did not receive any intervention, but participated in the pre- and postintervention assessment and were encouraged not to use music or an audiobook at bedtime.

Measures

The PSQI (Buysee *et al.* 1989) is a commonly used questionnaire that measures self-reported sleep habits and can be completed in a short time. It gives information about the participant's perceived sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, daytime dysfunctions and use of sleep medication. These seven components form a global score that ranges between 0 and 21; the score for each component ranges from 0 to 3. Buysee *et al.* (1989) reported that score of 5 (indicating poor sleep) yielded a diagnostic sensitivity of 89.6% and a specificity of 86.5% and that the scale had good internal consistency, with $\alpha = 0.83$. A global PSQI score >5 is indicative of severe sleep difficulties in at least two areas...

In order to develop the PSQI-H, the original PSQI was translated from English into Hungarian and then back-translated into English by an independent translator. We compared the original and the backtranslated PSQI versions and created a preliminary Hungarian version. The Cronbach α coefficient in our study was $\alpha = 0.79$, indicating good internal consistency. Validation of the Hungarian version of the questionnaire is in process. In the present study, both the global PSQI and the component subscale scores were analysed so that the effects of music on individual elements of sleep could be determined. In the intervention groups, the PSQI was administered four times: once before the intervention and subsequently at the end of each week during the study period. In the control group, the PSQI was used only twice, before and after the study, to minimize interference with usual practice and to avoid introducing any positive or negative expectations about sleep in this group.

Mood and depression scores were measured by means of the BDI (Beck *et al.* 1961). We used a shortened version that is a modified version of the original shortened BDI (Beck & Beck 1972). The shortened version of BDI consists of 9 items

and has been shown to have an internal consistency of $\alpha = 0.85$ in a nationwide representative Hungarian sample (Rózsa *et al.* 2003). On the basis of comparison of BDI and the shortened version, a reliable transformation of the scores of the shortened questionnaire into the original score is possible. (Kopp 1985, Kopp & Skrabski 1990). The items of the shortened questionnaire assess the existence and intensity of the following depressive symptoms: social withdrawal, inability to make decisions, sleep problems, fatigue, exaggerated anxiety over somatic complaints, inability to work, pessimism, lack of satisfaction, difficulties with feeling pleasure and self-blame (Kopp *et al.* 1995). The BDI and its shortened version are reliable methods to measure the severity of depression. They correlate strongly with other estimates of depressive symptoms by psychiatrists. According to Eaves and Rush (1984), the severity of depression can be evaluated as follows:

0–9 points	Normal
10–18 points	Mild depressive symptoms
19–25 points	Moderately severe depressive symptoms
26 points or higher	Severe depressive symptoms

The ESS was used to assess depression and daytime somnolence. ESS is a simple, self-administrated questionnaire that measures general level of daytime sleepiness. Based on their recent way of life, participants rated on a scale from 0 to 3 the likelihood of dozing off or falling asleep in eight different situations commonly encountered in daily life. ESS values above 16 points are indicative of a high level of daytime sleepiness (Johns 1991). We used the ESS as a filter to exclude other sleep disturbances, such as obstructive sleep apnoea, periodic limb movement disorder, narcolepsy or idiopathic hypersomnia, which are associated with excessive daytime sleepiness.

Data collection

The study protocol is shown in Figure 1. At the beginning of the study baseline data were collected using the PSQI, BDI and ESS and participants were randomly assigned to one of the three groups. During the following 3 weeks, the PSQI was completed weekly by participants in the music and audiobook groups. In the control group, we administered PSQI only on the third week. Participants in the music and audiobook groups also completed the BDI at the end of the intervention; in addition, we contacted the participants by telephone weekly during the study period to assess compliance with the protocol and all said that they complied.

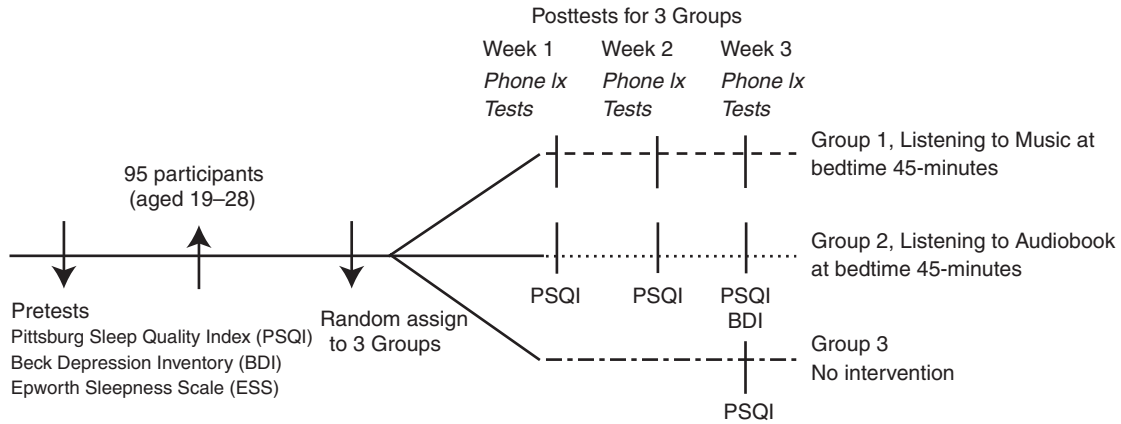


Figure 1 Study design.

Ethical considerations

The study was approved by the human research ethics committee of the study university. Participants received both oral and written information about the study signed an informed consent form.

Data analysis

We used parametric tests, i.e. paired samples *t*-tests, *t*-tests for independent samples and ANOVA with three groups. Independent sample *t*-tests were used to compare the PSQI and BDI scores of the two experimental groups at pretest and at weeks 1, 2 and 3. The Normality assumption was checked. A repeated measures ANOVA with main factors of GROUP (3 levels) and TIME (2 levels: pre and post) was used to analyse sleep quality between and within the three groups before and after the study. The assumptions of the parametric ANOVA model were also checked. Paired sample *t*-tests were used for within-group comparisons and Pearson’s correlation was used to assess any linear relationship between PSQI and BDI scores in the experimental groups. The Bonferroni correction was used to control for Type I error with multiple testing, and the more conservative statistical significance threshold of 0.001 was set. Statistical analyses were performed using SPSS 12 and STATISTICA 7.0.

Results

Pretest scores

At pretest (first meeting) the global PSQI and BDI were completed by all participants. The global PSQI scores ranged from 6 to 13 in the music group and from 6 to 11 in the audiobook group (Table 1). These scores indicate some sleep difficulties. BDI scores ranged from 0 to 13 in the music group and from 0 to 14 in the audiobook group. The independent *t*-tests showed no statistically significant pretest differences between the two experimental groups in age, BDI and global PSQI scores ($P > 0.05$).

There were no statistically significant differences between the three groups in global PSQI scores.

PSQI and BDI outcomes in post-tests

Global sleep quality and BDI scores

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 statistically 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

	Music group (<i>n</i> = 35)		Audiobook group (<i>n</i> = 30)		<i>t</i>	95% CI
	Mean	SD	Mean	SD		
Pretest						
Pittsburg Sleep Quality Index	6.83	2.093	6.27	1.721	1.170	-0.398 to +1.522
Beck Depression Inventory	5.40	3.767	5.70	3.564	-0.328	-2.127 to +1.527

Table 1 Pittsburg Sleep Quality Index and Beck Depression Inventory mean scores by group

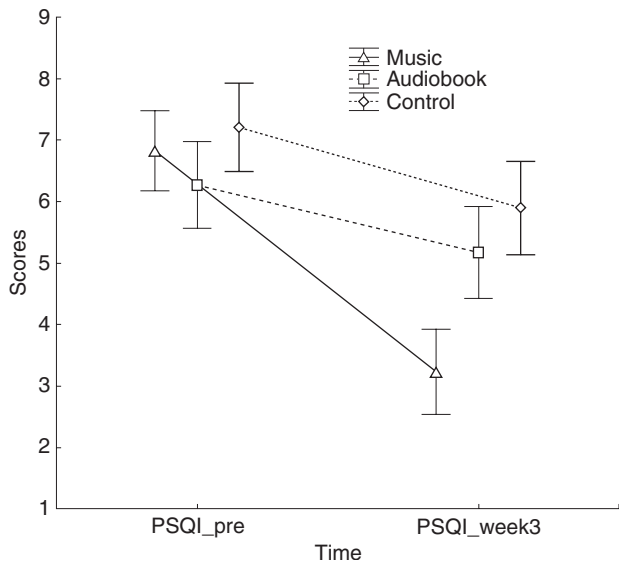


Figure 2 Pretest and post-test global Pittsburgh Sleep Quality Index (PSQI) scores in the three groups: music, audiobook and control. Vertical bars represent 95% confidence intervals.

(Bonferroni correction) of pretest 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 sleep quality in the audio or control groups (Figure 2).

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 the control group (Group 3) in these analyses as we had data on only two TIME points for this group. The magnitude of the difference between groups (music vs. audiobook) was statistically significant after the second week (week 2, $P = 0.0002$ and 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).

According to our results, music altered mood (Figure 4). Depressive symptoms decreased in the music group ($t = 6.124$; $P < 0.0001$) but did not change statistically significantly after listening to audiobooks.

The improvement of sleep quality (PSQI pretest minus PSQI3) correlated statistically significantly with decrease in depressive symptoms (BDI pretest minus BDI post-test) in the audiobook group ($r = 0.400$; $P = 0.029$), but this *P* value was not statistically significant when the Bonferroni correction factor was taken into account.

PSQI component scores

The music group had statistically significantly better scores on the six PSQI components during the 3 weeks. A paired samples *t*-test was used to compare pretest scores and weeks 1, 2 and 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 statistically 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 (Figure 5).

None of the PSQI components improved statistically significantly in the audiobook group. We measured PSQI components at the pretest and post-test assessment in the control group as well, but found no statistically significant changes in any of the component scores.

Responders vs. non-responders

Similarly to Lai's study (Lai & Good 2004), we divided the participants into 'responders' and 'non-responders' after the intervention in the music and audiobook groups. Participants were considered responders if their total PSQI post-treatment scores dropped into the normal range (PSQI < 5). By the end of the study, 30 out of the 35 people (86%) in the music group responded to the intervention and became 'good sleepers', while five remained 'poor sleepers'. In the audiobook group there were nine 'responders' (30%), while 21 from this group (70%) remained in the 'poor sleepers' range at the end of the study.

There were differences in pretest scores between 'responders' and 'non-responders' from the music group. The pretest

Table 2 Weekly Pittsburgh Sleep Quality Index scores by groups

Time points	Music group (n = 35)		Audiobook group (n = 30)		t	95% CI
	Mean	SD	Mean	SD		
Pretest	6.83	2.093	6.27	1.721	1.170	-0.398 to +1.522
Week 1	5.43	2.417	5.97	2.059	-0.957	-1.166 to +0.585
Week 2	3.97	2.135	5.83	2.520	-3.325	-3.015 to -0.708
Week 3	3.27	1.800	5.17	2.214	-3.892	-2.933 to -0.943

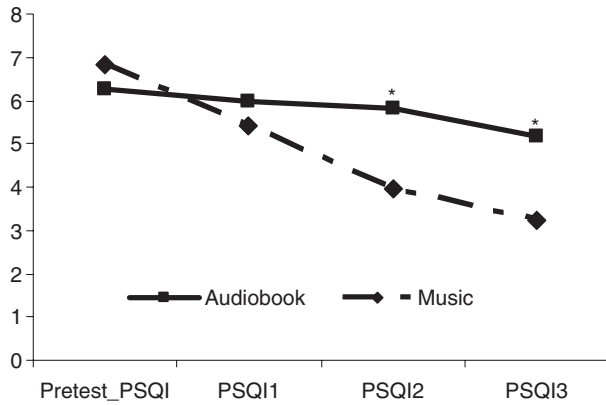


Figure 3 Weekly global Pittsburgh Sleep Quality Index (PSQI) scores for music and audiobook groups. *Statistically significant differences between groups ($P < 0.05$).

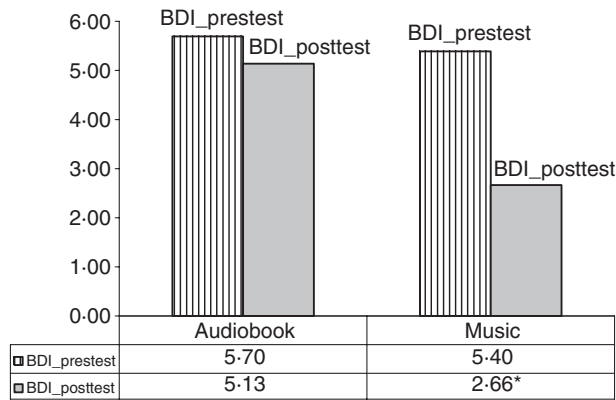


Figure 4 Beck Depression Inventory (BDI) scores in pretest and posttests. *Significant differences between BDI pretest and post-test within groups ($P < 0.05$).

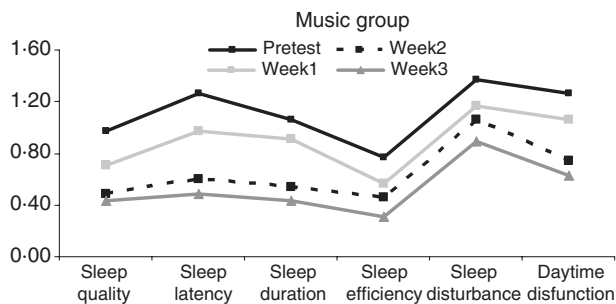


Figure 5 Weekly Pittsburgh Sleep Quality Index outcomes in the music group.

scores of the ‘responders’ were also statistically significantly lower on three of the six components of sleep quality: perceived sleep quality, sleep latency and sleep efficiency ($P < 0.05$). Lai and Good (2004) had the same results for

pretest scores between ‘responders’ and ‘non-responders’. In our study, there were nine ‘responders’ in the audiobook group at the end of the intervention, while 21 participants remained in the ‘poor sleepers’ range. Among ‘responders’, we did not find statistically significantly lower pretest scores for any components of sleep quality.

Discussion

This is the first study to show that music *per se* improves sleep quality by controlling for the confounding effects of relaxation and positive expectations. Students who listened to sedative classical music for 45 minutes at bedtime for 3 weeks had better global sleep quality in the second and third week than those who did not. A possible explanation for the lack of a significant group main effect could be that the magnitude of difference between groups (music vs. audiobook) was statistically significant after the second week only. The improvement continued during the third week and more greater at the end of the study. The intervention was based on the effects of listening to music, but we do not yet have sufficient knowledge about the effects of music on sleep quality. Several studies conducted in clinical settings have suggested that sedative music may have positive effects on sleep via muscle relaxation and distraction from thoughts. Music can decrease sympathetic nervous system activity, as well as anxiety, heart rate, respiratory rate and blood pressure (Standley 1986, Good *et al.* 1999, Salamon *et al.* 2003).

Several factors may help to explain our findings. One group of explanatory factors is related to the psychophysiological effect of musical tempo and the type of music that participants prefer. Reinhardt (1999) investigated the influence of musical rhythm on the synchronisation and coordination of heart rate. Twenty-eight patients with chronic cancer pain in a stable phase of the disease underwent a 14-day relaxation training designed to improve the process of falling asleep. The therapy included 30-minute lullaby-like, rhythmically dominated music with gradually decreasing tempo. Reinhardt found that during the relaxation therapy trained patients showed increasing synchronisation and coordination of heart rate and musical beat. At a musical tempo between 48 and 42 beats/minute, a very stable 2:3 synchronisation was observed. Trained patients who reported the best relaxing and analgesic effects showed the highest degree of synchronisation. Bernardi *et al.* (2006) also confirmed that slow or meditative music can have a relaxing effect as well as an arousal effect, predominantly depending on the tempo. Sedative music with a slow tempo (42–65 beats/minute) induces relaxation and reduces activity in

What is already known about this topic

- Sleep disorders may result in fatigue, tiredness, depression and problems in daytime functioning.
- Music can reduce sympathetic nervous system activity, decrease anxiety, blood pressure, heart and respiratory rate and may have positive effects on sleep via muscle relaxation and distraction from thoughts.
- Control groups have not been used in previous research.

What this study adds

- Music had a positive effect on sleep quality and depressive symptoms, but listening to audiobook had no statistically significant effect on sleep quality and depressive symptoms.
- More research is needed to confirm the effectiveness of music on sleep quality in patients suffering from insomnia, and objective, physiological measures such as polysomnography should be used.
- Nurses could use this safe, cheap and easy to learn method to treat insomnia.

the neuroendocrine system, and slow music produces a lower heart rate and blood pressure (Standley 1986). Salamon *et al.* (2003) confirmed that preferred classical music statistically significantly decreases systolic and diastolic blood pressure as well as anxiety levels.

In addition, studies have also shown that relaxation may be induced with approximately 30 minutes of sedative music (Mockel *et al.* 1994). Based on knowledge from previous studies (Tan 2004, Lai & Good 2004), and to ensure that all participants had sufficient time to fall asleep, we decided to use a CD-recording approximately 45 minutes long. The selection of music type was based on previous studies with sedative music (Field 1999, Johnson 2003, Lai & Good 2004). According to Gaston (1951), the tempo should be somewhere around 60–80 beats/minute.

It is very important to differentiate between the efficacy of music in advancing sleep onset and its efficacy in improving sleep quality. In some studies (Fried 1990a,b, Lai & Good 2004) music was combined with relaxation therapy or with some other intervention, making it difficult to draw conclusions about the effects of music *per se*. In addition, a control group without any intervention has rarely been used, preventing investigation of the effects of the positive expectations of the experimental group. In contrast, we used a control group (no intervention) and an audiobook group to

compare non-intervention and the effect of another intervention (listening to audiobooks) to listening to music.

The auditory processes implied by listening to audiobooks are similar to those implied by listening to music. Elements of speech and musical sound can be characterized by the same parameters: pitch, duration, loudness, rhythmic metrical structure, contour, articulation and timbre. A large number of researchers have tried to reveal the similarities and differences between the two domains in the brain. A recent study has provided neurophysiological data to prove the similarity between listening to music and verbal material. In this research, Broca's area, known for its specialization to syntactical processing in language, was also activated by music perception (Koelsch *et al.* 2002). This suggests that the mechanisms underlying syntactical processing are shared between music and language (Patel 2003). In addition, there is a similar brain response between speech and music boundary processing, and Knösche also discovered EEG and EMG correlates for phrase boundaries in music. Neither music nor spoken language form uniform auditory streams; rather, they are structured into phrases (Knösche *et al.* 2005).

Despite the similar cognitive and neurobiological specificity of music and language, audiobooks had no effect on sleep quality in our study. The specificity of music may concern different processing components. Some processing components appear to be genuinely specialized for music (Peretz & Hyde 2003), while other components can be involved in the processing of both music and speech (Patel *et al.* 1998).

Audiobooks also had no statistically significant effect on depressive symptoms in our study, as measured by the BDI. However, music decreased depressive symptoms scores in the experimental group. Several researchers have examined the therapeutic effect of music on depression (Hanser & Thompson 1994, Lai 1999, Hsu & Lai 2004) and found that music had beneficial effects on depressive symptoms. Music has been found to increase circulating endorphin levels (Mockel *et al.* 1994), which are associated with positive moods (Gerra *et al.* 1998). By the end of our study, mood scores had improved in the music group; however, our results suggest that music-induced improvement in sleep quality is not due to the effect of music on depressive symptoms. Nevertheless, this might be true in the case of audiobooks.

The effect of music on sleep duration appeared later, since significantly longer sleep duration occurred in the second and third weeks in the PSQI tests. Sleep duration also showed a delayed improvement in a previous study (Lai & Good 2004). Listening to music in the present study resulted in reduction of global PSQI mean values to the normal range.

Following the 3-week intervention, 30 out of the 35 members of the music group became 'good sleepers', while

the global PSQI mean scores of the audiobook group remained in the 'poor sleepers' range.

Study limitations

The first limitation of our study is that participants were recruited as 'poor sleepers' (PSQI global score > 5). They were healthy people with some sleeping problems which can return into the normal range without any intervention. Secondly, we used self-report measures of sleep without verifying them objectively. Thirdly, a 3-week study period may not be sufficiently long to draw any conclusions about the sustainability of improved sleep on longer time periods. Fourthly, the stories to which participants in the audiobook group listened to may have induced different emotions, while the emotional effect of slow classical music was considerably more balanced. Fifthly, we contacted by telephone every participant once a week to assess their compliance with the protocol, but we have no further information about how frequently they listened to music or to the audiobook during the study period. Finally, a Hawthorne effect may have occurred in the study. The Hawthorne effect refers to a phenomenon which is thought to occur when people observed during a research study temporarily change their behaviour and performance.

Future research

We recommend that researchers investigate the effects of music and audiobooks on sleep quality for more than three weeks. Music has a cumulative effect of sleep quality and our findings suggest that all poor sleepers might become good sleepers with a longer music intervention. It is also necessary to investigate the effects of music using objective, physiological measures of sleep such as polysomnography. Findings from the study by Lasic and Ogilvie (2007), in which the effects of music on sleep quality were investigated using a polysomnographic and quantitative EEG analysis, are not in line with our results. However, his study was conducted over a four-night period and such a short time is probably not sufficient to observe a positive effect of music on sleep quality. More research is needed to confirm the effectiveness of music on sleep quality in clinical populations such as in patients suffering from insomnia. However, it is difficult to find and enrol in a study patients suffering from insomnia who are medication-free.

Conclusion

Our findings provide evidence for the usefulness of relaxing classical music as an intervention for sleeping problems in

young adults. In line with former studies, we confirmed that listening to relaxing classical music has a positive effect on sleep quality. Hospitalized patients often suffer from sleeping problems, such as insomnia, and listening to music is a simple intervention that may reduce these problems. Nurses should use music therapy in their practice because it is a safe and cheap method which may be used to treat insomnia in different populations. In addition, the intervention is quick and easy to learn.

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Author contributions

LH, JT and RB were responsible for the study conception and design. LH and JT performed the data collection. LH and JT performed the data analysis. LH was responsible drafting of the manuscript. RB made critical revisions to the paper for important intellectual content. JT provided statistical expertise. LH and JT obtained funding. RB provided administrative, technical or material support. RB supervised the study.

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