Music improves sleep quality in older adults

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Submitted for publication 7 December 2003
Accepted for publication 12 March 2004

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LAI H.-L. & GOOD M. (2005) *Journal of Advanced Nursing* **49**(3), 234–244

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Aim. The aim of this paper is to report an investigation of the effects of soft music on sleep quality in older community-dwelling men and women in Taiwan.

Background. Sleep is a complex rhythmic state that may be affected by the ageing process. Few studies have focused on the effects of music, a non-pharmacological method of improving the quality of sleep in older adults.

Method. A randomized controlled trial was used with a two-group repeated measures design.

Sixty people aged 60–83 years with difficulty in sleeping were recruited through community leaders and screened using the Pittsburgh Sleep Quality Index (PSQI) and Epworth Sleepiness Scale. Those reporting depression, cognitive impairment, medical or environmental problems that might interfere with sleep; and those who used sleeping medications, meditation, or caffeine at bedtime were excluded. Participants listened to their choice among six 45-minute sedative music tapes at bedtime for 3 weeks. There were five types of Western and one of Chinese music. Sleep quality was measured with the PSQI before the study and at three weekly post-tests. Groups were comparable on demographic variables, anxiety, depressive symptoms, physical activity, bedtime routine, herbal tea use, napping, pain, and pretest overall sleep quality.

Results. Music resulted in significantly better sleep quality in the experimental group, as well as significantly better components of sleep quality: better perceived sleep quality, longer sleep duration, greater sleep efficiency, shorter sleep latency, less sleep disturbance and less daytime dysfunction ($P = 0{\cdot}04$–$0{\cdot}001$). Sleep improved weekly, indicating a cumulative dose effect.

Conclusion. The findings provide evidence for the use of soothing music as an empirically-based intervention for sleep in older people.

Keywords: music, sleep quality, community-residing elders, nursing

Background

Sleep, a vital ingredient in life, is an active and complex rhythmic state that may be affected by the aging process. Surveys have estimated that more than 50% of community-living people age 65 or older experience sleep disturbances (Bliwise *et al.* 1992, Foley *et al.* 1995). These changes in sleep patterns are reflected in the common sleep-related complaints of older adults, such as taking longer to fall asleep, awakening more often, and being sleepy in the daytime. Sleep disorders can result in tiredness, fatigue, depression, greater anxiety, irritability, pain sensitivity, muscle tremors, immunosuppression, and lack of daytime alertness (Pandi-Perumal *et al.* 2002). Although there is much research about

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sleep, few studies have focused on the effects of music in improving sleep quality, particularly in older adults.

One method to improve sleep is to take medication. Hypnotics are taken regularly by 15–19% of older adults (Clapin-French 1986, Morgan *et al.* 1988, Englert & Linden 1998), but can cause daytime residual effects, tolerance, dependence, altered sleep stages and rebound insomnia (Morin & Kwentus 1988, Gillin & Byerley 1990). Their safety and efficacy for sleep problems in older people has not been established (National Institute of Health 1991). Therefore, non-pharmacological methods that promote a mind–body interaction without side-effects should be tested to promote sleep in older people.

Only three investigators have studied the use of music to promote sleep. Each found that music had beneficial effects (Mornhinweg & Voignier 1995, Zimmerman *et al.* 1996, Levin 1998), but there were methodological problems of mixed age groups, small sample size, lack of randomization, unbalanced groups, and lack of rationale for the choice of music intervention. Further, none considered confounding factors of anxiety and depression, and none studied the effects of music on sleep in older people.

Based on a psychophysiological theory synthesized from the literature, sedative music induces relaxation and distraction responses (Good *et al.* 2001), which reduce activity in the neuroendocrine and sympathetic nervous systems, resulting in decreased anxiety, heart rate, respiratory rate, blood pressure (Standley 1986, Zimmerman *et al.* 1988, Good *et al.* 1999) and sleep (Johnson 1991). Music has been found to reduce circulating noradrenaline (Mockel *et al.* 1994, Gerra *et al.* 1998), which is associated with sleep onset (Irwin *et al.* 1999). Thus, a sedative music intervention was expected to improve sleep quality.

The study

Aim

The aim of the study was to test the hypotheses that, while controlling for identified covariates, Taiwanese older adults who used music as therapy at bedtime each night for 3 weeks would have (1) better global sleep quality and (2) better components of sleep quality over time than those who did not use music.

Design

A randomized controlled trial design was used. Permuted block randomization, with sealed envelopes stratified on gender, was used to assign participants to either the treatment or control group ($n = 30$). The envelopes were prepared by a different person so that the investigator (first author) was blind to block size and order of assignment.

Because sleep onset has been found to take about 13–35 minutes in adults (Hayter 1983, Gislason *et al.* 1993), we decided to use 45 minutes of music as therapy every night at bedtime to guard against music ending earlier than sleep onset. In addition, eight factors were identified in the literature as influencing sleep, and these were controlled in the research design. These were gender, caffeine consumption, meditation, disease, medication, cognitive status, sleep apnoea, and sleep environment (Addison *et al.* 1986, Rediehs *et al.* 1990, Ancoli-Israel *et al.* 1991, Gislason *et al.* 1993, Kelly *et al.* 1997, Neubauer 1999). Eight other factors found in the literature were considered as possible covariates: age (Bliwise 1993), anxiety (Morgan *et al.* 1989), depressive symptoms (Knowles & MacLean 1990), physical activity (Stevenson & Topp 1990), bedtime routine (Johnson 1986), herbal tea consumption, after-lunch napping (Floyd 1999) and reported pain (McCall 1995).

Participants were visited at home by the investigator at the start of the study to screen for eligibility, collect baseline data, allocate them to the study groups, and teach the experimental group to use the music intervention at bedtime each night. Thereafter, weekly visits for 3 weeks were made to measure sleep quality, collect completed sleep logs, and distribute new ones. Participants were also telephoned twice weekly during the study period to reinforce adherence to the protocol (Figure 1).

Participants

Convenience sampling was used to identify 10 local areas (called 'Li' in Taiwan) in a city with nearly one million people in central Taiwan in 2000. Community leaders in the local areas were contacted to spread information about the study to residents and to recruit a total of 60 volunteers who had difficulty sleeping.

To achieve a power of 0·8 at alpha = 0·05, one-tailed, with a medium effect size, a medium correlation ($r = 0{\cdot}50$) among four repeated measures, and using repeated measures analysis of covariance on Pittsburgh Sleep Quality Index (PSQI) scores, the size of each group was computed to be 27 (Stevens 1996). Measures were obtained once a week for 4 weeks; and so 10% was added for attrition. As a result, 30 participants were recruited for each group in 1999.

Over a 4-month period, a total of 93 older people with sleeping problems were contacted, and 10 decided not to participate after receiving more information about the study. Of the 83 who were willing to participate, 23 were

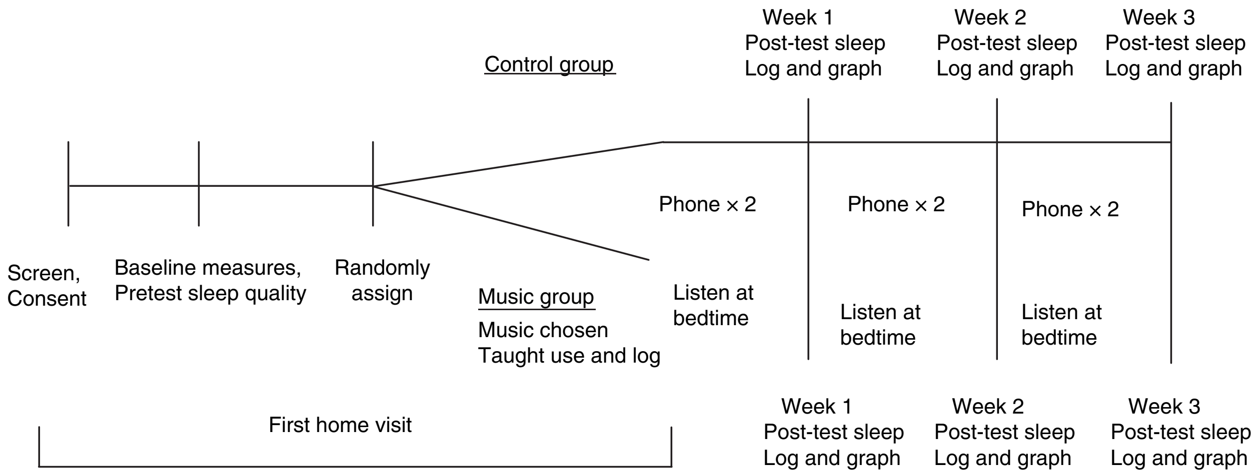

Figure 1 Study design.

disqualified after the screening interview according to the exclusion criteria. The most common reasons for elimination were taking sleep medicine ($n = 15$), followed by sleep apnoea scores >16 on the Epworth Sleepiness Scale (ESS, $n = 2$), meditating at bedtime ($n = 3$), and caffeine consumption ($n = 3$). One man was withdrawn because he was hospitalized.

Experimental intervention

The music intervention consisted of a choice of one of six types of audiotaped sedative music played for 45 minutes at bedtime. Introduction of the music to participants was accompanied by brief instructions in its correct use. The choices included five types of Western music, and one of Chinese music for those who preferred this. The tempo of the sedative music was 60–80 beats/minute without accented beats, percussive characteristics, or syncopation (Gaston 1951, 1968). The Western music had been tested by Good in postoperative pain studies and the types were: synthesizer (new age), harp (eclectic), piano (popular oldies), orchestra (classical) and slow jazz (Good 1995, Good & Chin 1998, Good *et al.* 1999, 2001), and the Chinese orchestra tape was of folk music (Tidewater Records Co. 1992). Because Taiwan is an Americanized country and most music played on radio or television is of Western origin, the music was expected to be familiar to the Taiwanese older people. Examples of the music selections are listed in Table 3; the complete list can be found in Good (1992) and the development methods in Good *et al.* (2000). The length of each tape of Western music was originally 30 minutes per side, but a recording company extended each to 45 minutes by adding a repeat of the first 15 minutes at the end.

At the first home visit, participants in the music group were asked to select one of six types of music from an introductory tape containing 30-second excerpts of each type. The investigator asked participants to sit back, unfold their legs, not to think about anything, let their lips go soft and, as they listened, to let the music relax their body from head to toe. They were asked to select the type that was most preferable and relaxing to them. The investigator replayed the selected music for 2 minutes at a comfortable volume, observed the participant's response, and gave them feedback and positive reinforcement. If participants appeared tense, the investigator reminded them to relax and sit quietly while listening.

To verify mastery of the use of music, the investigator rated participants on four criteria: (a) relaxed face, (b) no tension around the mouth, (c) slow, even respirations and (d) no tension when the investigator raised an arm. It was assumed that if participants could effectively relax for the 2-minute period of music, they might also relax to the music at bedtime. Criteria were rated using 'No' = 1 and 'Yes' = 2. Scores of <7 out of 8 points were considered to be an inadequate degree of relaxation, and participants were re-taught and observed again until they mastered the technique.

Before the introductory music was played, participants in the music group were asked about their music preference. The majority of these Taiwanese elders reported that when they listened to music for relaxation they usually listened to Western music ($n = 19$, 63%), while a quarter ($n = 8$, 27%) listened only to Chinese music, and three (10%) listened to both Western and Chinese music. Harp, piano and Chinese orchestra music were most frequently chosen ($n = 7$, 23% each), while 5 (17%) chose orchestra and a few chose synthesizer or slow jazz ($n = 2$, 7% each).

Measures

The PSQI (Buysse *et al.* 1989) is a questionnaire that measures self-reported sleep habits during the previous week. It is a global measure with seven components: perceived sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of sleep medication, and daytime dysfunction. The score for each component ranges from 0 to 3, and the sum is a global score that ranges from 0 to 21. As those who took sleep medication were excluded, only six components were used, with global scores from 0 to 18. Higher scores indicated poorer sleep quality. Both the global PSQI and the component subscale scores were analysed so that effects of music on individual elements of sleep could be determined. The PSQI was administered four times, with one pretest and three weekly post-tests.

A score of 5 (indicating poor sleep) yielded a diagnostic sensitivity of 89·6% and a specificity of 86·5%, with an internal consistency of $\alpha = 0{\cdot}83$, and test–retest reliability, $r = 0{\cdot}85$ (Buysse *et al.* 1989). The Chinese language PSQI had $\alpha = 0{\cdot}72$ and a split half reliability of 0·84 (Wang 1997). In this study, the 18-point Chinese version had a Cronbach's reliability coefficient of 0·74 overall and a split half reliability of 0·79 for the six component scores.

To improve accuracy of recall each week, participants were asked to record their sleep each morning in a sleep log consisting of information on bedtime, sleep onset latency, rising time, number of hours asleep, and presence of pain. At each subsequent home visit (Weeks 2 and 3), the investigator collected the logs in exchange for new ones. To improve compliance, each week the investigator made an individualized graph from the log and showed participants their daily sleep patterns.

Using instruments translated into Chinese, several variables were measured at the first home visit to determine whether they would confound the effects of music on sleep. Trait anxiety and recalled state anxiety before going to sleep the previous night were measured with the State-Trait Anxiety Inventory (STAI) (Spielberger 1983); the alpha coefficient was 0·90 in this study for both scales. Depressive symptoms over the past week were measured using the short form Geriatric Depression Scale (GDS) (Lee *et al.* 1993); $a = 0{\cdot}87$ with a split-half reliability coefficient of $r = 0{\cdot}83$. Physical activity during the past year was measured with the Physical Activity Questionnaire (PAQ) (Voorrips *et al.* 1991); $a = 0{\cdot}76$. Participants were asked whether or not they had a bedtime routine, napped after lunch, used herbal tea to sleep, or had pain that interfered with sleep. Heart rate (radial pulse) and observed respiratory rate were measured for 30 seconds by the investigator at the first home visit before and after listing to the introductory tape. These rates were used to determine whether relaxing to the music resulted in decreased autonomic reflexes.

Data collection

Screening for eligibility occurred at the first home visit and included testing for cognitive function (using the Short Portable Mental Status Questionnaire: Pfeiffer 1975); sleep quality (PSQI), sleep apnoea (ESS), and caffeine consumption (James & Crosbie 1987). The scores were immediately calculated, and participants were told whether or not they were eligible. They were then randomly assigned either to the treatment or control group, while controlling for gender. The investigator interviewed them to obtain demographic data and used questionnaires to measure physical activity (PAQ), bedtime routine, anxiety (STAI), and depressive symptoms (GDS).

Those in the music group were asked at the first home visit about their music preferences. They then selected their music and practised relaxing to it until they mastered the technique. The investigator measured heart and respiratory rates before and after listening and taught them about home use of the music at bedtime. Participants in the control group were not asked about music preferences, and their heart and respiratory rates were not measured. All participants were taught to use a daily sleep log.

The investigator gave participants in the treatment group standardized instructions for using music for sleep each night for three consecutive weeks: (1) lie in bed at the usual bed time with a comfortable room temperature, wearing comfortable nightclothes, and with lights out, and eyes closed; (2) play the audiotape at a comfortable volume; (3) use earphones or not, as preferred; (4) listen to the other side of the tape if not asleep after the first side; (5) do not worry about turning off the music, but just let it play. The investigator did not give tapes or instructions to the control group, but said that later they would receive a music tape that might help them to sleep; they were told that before this, it was important to report their sleep patterns for 3 weeks.

The PSQI score used to screen for eligibility was also used as the pretest for participants who enrolled. Three post-test measures of sleep quality were obtained on the PSQI at the end of Week 1, Week 2 and Week 3. Three weeks is a recommended period of time for observing sleep patterns (Roehrs *et al.* 1994, Walsh *et al.* 1994), and the effects of a new intervention on sleep quality (Hoch & Reynolds 1986, Wang 1997).

During the study period, the investigator telephoned all participants twice a week. Those in the music group were asked whether they had listened to the music each night, and those in the control group were assessed and encouraged not to use music at bedtime. All participants in the control group reported that they did not use music at bedtime and family members confirmed this. The investigator visited all participants each week to measure sleep, and collect sleep logs. Graphs made from the sleep logs were returned later that day.

Ethical considerations

The study was approved by the institutional review board of the university and hospital, and conformed to the Declaration of Helsinki. All participants gave verbal informed consent at the first home visit. Taiwanese elders are not comfortable with signing their names because they consider this a legal act. The community leaders introduced the investigator to their neighbours, friends and relatives either in person or by telephone, and the investigator scheduled a home visit and conducted the study.

Data analysis

Potential confounding covariates were assessed with Pearson's, Point Biserial, and Spearman's correlations. Independent *t*-tests were used to compare the groups on pretest PSQI. The test the hypotheses, repeated measures analysis of covariance (RM-ANCOVA) was used to determine group differences in global PSQI scores. *Post hoc t*-tests with Bonferroni correction were used to determine group differences in global PSQI scores at each weekly post-test. Mann–Whitney tests were used to determine group differences in each sleep component across the four time points and also at each weekly post-test.

Results

Description of participants

Participants' ages ranged from 60 to 83 years (67 ± 5 years) and they were born either in Taiwan ($n = 39$, 65%) or China. The majority were married ($n = 49$, 82%), not employed ($n = 39$, 65%) and most lived with a spouse and adult children ($n = 42$, 70%). Fifty-two (87%) had completed at least grade school (6 years) and, although four (7%) had no formal education, they could read calendars and numbers. Those included:

- were 60 years of age and older;
- had normal cognitive function (Short Portable Mental Status Questionnaire) (Pfeiffer 1975);
- were Taiwanese or Chinese speaking;
- reported ability to hear radio or TV easily without a hearing aid;
- had poor sleep, i.e. >5 points on the PSQI (Buysse *et al.* 1989);
- did not show sleep apnoea on the ESS, i.e. had <16 points (Johns 1991); and did not attribute sleep problems to environmental factors, such as mattress, temperature, light, or noise.

Those excluded:

- had a medical diagnosis of Parkinson's or Alzheimer's disease, major depressive disorder, asthma, seizures, or a primary sleep disorder;
- used hypnotics, sedatives, antidepressants, anticholinergics, antihistamines, tranquilizers, or melatonin for sleep;
- meditated or did relaxation in the evening within 30 minutes before bedtime; or consumed caffeine over 1·4 mg/kg within 10 hours before bedtime.

The investigator interviewed the person and their family to obtain this information. Only one member of a couple living in the same household was permitted to participate in the study.

Pretest scores

At the pretest (first home visit), global PSQI scores ranged from 6 to 16 in the music group, and 6 to 15 in the control group (Table 1), indicating substantial difficulty sleeping that was more than double the five points needed for inclusion in the study and nearly two-thirds of the 18 points possible. Scores improved steadily in the music group by Week 3, but remained consistently poor in the control group.

Comparability of groups

Using *t*-tests, there were no significant pretest differences between the music and control groups in age, state anxiety, trait anxiety, depressive symptoms, and physical activity.

Table 1 Pittsburgh Sleep Quality Index: means by group and time

Time points	Music ($n = 30$)		Control ($n = 30$)			
	Mean	SD	Mean	SD	t	95% CI
Pretest	10·97	2·61	10·20	2·82	1·09	−0·67 to +2·17
Week 1	8·40	3·07	10·13	2·78	−2·29*	−3·25 to −0·21
Week 2	7·73	3·15	10·17	2·73	−3·20*	−3·96 to −0·91
Week 3	7·13	3·19	10·07	2·75	−3·81*	−4·47 to −1·39

*$P < 0·01$.

Using χ^2 tests, there were no differences in those with or without a bedtime routine, herbal tea consumption, after-lunch napping, or pain. The majority (63%) took a nap after lunch ranging from 20 to 60 minutes (43 ± 14 minutes). In addition, χ^2 tests indicated that there were no significant group differences in demographic factors: gender, cultural background, marital status, education, employment, and relatives living in the home. No participants reported using alcohol or other behavioural interventions to improve sleep.

At pretest, there were no group differences in global sleep quality (PSQI). However, on two sleep components the music group had significantly poorer scores: shorter sleep duration ($z = 3{\cdot}01$, $P < 0{\cdot}05$) and more daytime dysfunction ($z = 2{\cdot}10$, $P < 0{\cdot}05$). Three variables were related to global sleep quality at one or more time points: depressive symptoms ($r = 0{\cdot}35$–$0{\cdot}38$), herbal tea consumption ($r = 0{\cdot}28$–$0{\cdot}30$), and after-lunch napping ($r = 0{\cdot}29$–$0{\cdot}31$). These were used as covariates, along with pretest global sleep scores ($r = 0{\cdot}46$–$0{\cdot}85$), when analysing the PSQI.

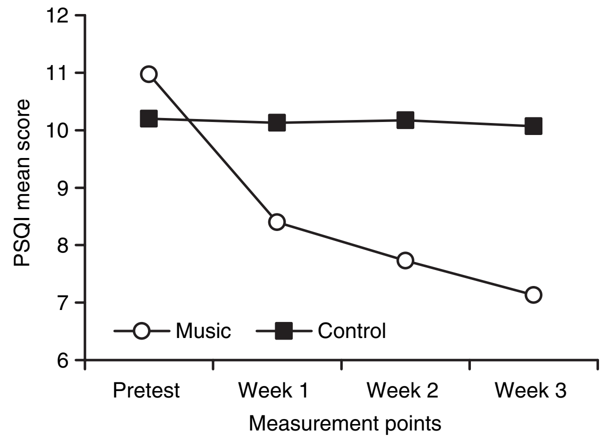

Figure 2 Pittsburgh Sleep Quality Index data from the pretest until Week 3.

Sleep quality outcomes

The music intervention was effective in improving sleep not only on the global PSQI score, but also on five of the six component subscales of the PSQI across three time points. In the music group, there were significant improvements, with a small to medium effect size in both global and perceived sleep quality, sleep latency, sleep duration, sleep efficiency and daytime dysfunction.

Global sleep quality

While controlling for pretest PSQI, depressive symptoms, herbal tea consumption, and after-lunch napping, repeated measures ANCOVA indicated a significant difference in global PSQI scores for group [$F(1, 54) = 40{\cdot}75$, $P < 0{\cdot}001$], time [$F(1{\cdot}60, 86{\cdot}49) = 3{\cdot}65$, $P < 0{\cdot}05$] and the interaction of group and time [$F(1{\cdot}60, 86{\cdot}49) = 4{\cdot}17$, $P < 0{\cdot}01$]. The interaction indicated that the effect of music was different among the three time points; global sleep quality in the music group improved the most between the pretest and Week 1, but continued to improve at Weeks 2 and 3 (Table 1, Figure 2), with 43% of the variance in PSQI scores across time associated with the music intervention. Sleep quality remained the same in the control group. *Post hoc* t-tests (adjusted alpha = 0·017) showed that the music group had significantly better PSQI scores than the control group at each point: Week 1, $t(58) = -2{\cdot}29$, $P < 0{\cdot}01$, Week 2, $t(58) = -3{\cdot}20$, $P < 0{\cdot}01$, and Week 3, $t(58) = -3{\cdot}81$, $P < 0{\cdot}01$. One-way analysis of variance indicated no significant post-test differences in PSQI scores among the six types of music at Week 1, Week 2, or Week 3.

At each time point, the effect of music on global sleep quality was supported by correlations with the sleep log kept by all participants each morning upon awakening. Weekly mean log variables were strongly and positively correlated with weekly PSQI scores [$r = 0{\cdot}67$ (bedtime); $r = 0{\cdot}89$–$0{\cdot}99$ (sleep onset latency); $r = 0{\cdot}90$–$0{\cdot}99$ (rising time); $r = 0{\cdot}95$–$0{\cdot}99$ (hours asleep) and 1·00 (pain), $P < 0{\cdot}001$).

Component scores

In addition, the music group had significantly better scores on five of the six components of sleep quality over 3 weeks (Table 2). Mann–Whitney tests were used with change scores (pretest minus Week 3 scores). Music resulted in improved perceived sleep quality, shorter sleep latency, longer sleep duration, better sleep efficiency, and less daytime dysfunction, but did not reduce sleep disturbance.

On four sleep quality components, *post hoc* Mann–Whitney tests showed that the music group slept significantly better than controls at all three weekly time points: better perceived sleep quality, less sleep latency, greater sleep efficiency, and less daytime dysfunction. On one component, sleep duration, improvement took a little more time and significance did not occur until Weeks 2 and 3. Sleep disturbance was not improved (Table 2).

Music mastery and autonomic response

All those in the music group achieved a satisfactory mastery score for the use of music at the first visit, with two practice periods needed for the majority ($n = 18$, 60%). In addition, mean heart rates were 75·5 ± 5·0 beats/minute before

Table 2 Sleep quality components ($n = 60$)

	Change scores				Mann–Whitney *U*-test				
	Music		Control		Overall group difference		Weekly group difference		
Sleep quality components	Mean†	SD	Mean	SD	z	P	Week 1	Week 2	Week 3
Perceived sleep quality	−0·93	0·91	0·000	0·00	−4·98	0·000	***	***	***
Sleep latency	−0·90	0·92	0·000	0·00	−4·58	0·000	***	***	***
Sleep duration	−0·33	0·61	−0·003	0·18	−2·57	0·010	–	*	**
Sleep efficiency	−0·70	0·79	−0·006	0·25	−3·94	0·000	**	**	***
Sleep disturbance	−0·17	−0·38	−0·006	0·45	−1·38	0·168	–	–	–
Daytime dysfunction	−0·76	0·73	−0·003	0·32	−4·72	0·000	***	***	***

–, not significant.
*$P < 0·05$; **$P < 0·01$; ***$P < 0·001$.
†Mean change scores = pretest minus Week 3.

Table 3. Examples of music selections on the tapes

Style	Selection	Tape or CD	Artist
Chinese Orchestra	Folk Music	Chinese Orchestra	Shanghai Chinese Traditional Orchestra
Synthesizer	Selection #1	Comfort Zone	Steven Halpern
Harp	Gnossienne #5	Fresh Impressions	Georgia Kelly
Piano	Gigi	Nadia's Theme	Roger Williams
Orchestra	Symphony #6	Beethoven	Cleveland Orchestra
Jazz	When Joanna Loved Me	Easy Living	Paul Desmond

Examples of the music used are presented. Researchers who wish to replicate the study may create their own tapes or contact the first author for the Chinese Orchestra tape and the second author for the others.

listening to music and significantly lower at 74·7 ± 5·0 beats/minute after ($t = 6·6$, $P = 0·001$). Respiratory rates were 15·2 ± 1·8 breaths/minute before music and significantly fewer, 14·7 ± 1·8 breaths/minute after ($t = 6·2$, $P < 0·001$). These observations suggested that they mastered the technique of relaxing to the sedative music and there were effects on the autonomic nervous system.

Responders vs. non-responders

Participants were considered 'responders' to music if their total PSQI post-treatment scores dropped into normal range (≤5). At the end of the study, nearly half of those in the music group responded to the intervention and became good sleepers ($n = 14$, 47%), while the other 16 (53%) were still poor sleepers. Although not different on demographic or confounding variables, responders had better sleep at the pretest, with lower global sleep quality scores ($M = 9·5$) than poor sleepers ($M = 12·25$, $t(28) = -3·37$, $P = 0·02$). Pretest scores were also significantly lower for good sleepers on three of the six components of sleep quality: perceived sleep quality, sleep latency, and sleep efficiency ($P < 0·05$). Further, the relaxation response to sedative music may have also occurred differently between those who became good sleepers compared with those who did not. Although equal at pretest, after the introductory music started, respiratory rates became significantly lower in the good sleepers ($M = 13·86 \pm 1·51$ respirations/minute), than in the poor sleepers ($M = 15·38 \pm 1·75$, $t = -2·53$, $P = 0·01$), but there was no difference in heart rate. More study is needed on responders to music used for sleep.

Clinical significance

The magnitude of difference between groups was clinically significant (Table 1, Figure 2) and indicated 35% improvement overall in the music group, shown as the slope of sleep scores (Figure 2). The greatest improvement occurred in the first week (26%) and there was no change over time in the control group. Increasing effects over time were supported by the delayed effect on sleep duration (Weeks 2 and 3). The weekly group differences indicated 17%, 24%, and 29%

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better sleep each week respectively in the music group. The length of treatment needed for maximum effects was not determined because a plateau was not reached.

Discussion

Older adults who used sedative music as therapy for 45 minutes at bedtime for 3 weeks had better global sleep quality and also better individual components of sleep quality over time than those who did not. The exception was sleep disturbance. In addition, those who used music had better global sleep quality at each of the weekly time points and better scores on four components: better perceived sleep quality, sleep latency, sleep efficiency, and less daytime dysfunction. There was also a delayed effect for sleep duration by Weeks 2 and 3, and an increasing dose effect on overall sleep quality from the pretest until Week 3 (Figure 2).

Despite a meaningful clinical improvement in many participants, over half of those who improved were still poor sleepers after three weeks. These findings are comparable with the review in which Lacks and Morin (1992) found that insomniacs have substantial improvement in response to cognitive-behavioural interventions, but the majority do not become good sleepers. In our study, those with a milder sleep problem were more likely to respond.

Our findings were similar to those in the three previous studies that used qualitative (Mornhinweg & Voignier 1995), quasi-experimental (Levin 1998), or experimental (Zimmerman *et al.* 1996) approaches. In the experimental study, music was used in the afternoon rather than at bedtime when sleep was measured. All six types of music in our study were used at bedtime and were found useful for sleep; the six types were similar in their effects. All those who received music reported listening to it every night, and family members verified this information. The Chinese orchestra tape has not been tested before, but the remainder of the music used has been found effective for pain in postoperative studies (Good 1995, Good & Chin 1998, Good *et al.* 1999).

Although Hoch and Reynolds (1986) have suggested that three weeks are needed to observe a new intervention for sleep quality, others have found effects after 3-day (Zimmerman *et al.* 1996) and 2-week periods (Levin 1998). In the present study, a 45-minute tape of music every night at bedtime, along with brief instructions for relaxation, improved global sleep quality after only 1 week, and the effect continued to increase for two more weeks. The daily sleep log showed good agreement with weekly recall for the PSQI. As a plateau did not emerge (Figure 2), the possibility of greater improvement with a longer intervention period remains unknown.

The results can be explained by the psychophysiological theory that sleep quality can be improved by relaxing the body with sedative music which decreases circulating noradrenaline (Gerra *et al.* 1998) that is related to sleep onset (Irwin *et al.* 1999). The timing of the intervention at bedtime, brief instruction and feedback, and use of music for 45 minutes may have facilitated relaxation as the person fell asleep (Kaempf & Amodei 1989, Steelman 1990, Updyke 1990, White 1992).

Limitations

First, the convenience sample limited generalization of the results to older people who are healthy, medication-free, cognitively normal, and with no primary sleep disorders. Because participants lived in one city, generalization to other older populations may be limited, but still possible with culturally appropriate music, as the results were because of the intervention and not due to the community-living situation or cultural group. Secondly, the self-report measure of sleep was used without objective verification. Thirdly, the 3-week study period precludes any conclusion about maintenance of sleep improvements over time. Fourthly, a Hawthorne effect may have occurred due to awareness of participation in a study. Fifthly, blinding of the participants was not possible and blinding of the data collector was not practical, and this is a potential source of bias. Sixthly, although there were no significant differences between the music and control groups in demographic or most sleep-related variables, pretest differences on some components of sleep quality could be due to failure of randomization. Finally, a single nurse-researcher provided the music intervention, raising the possibility of treatment bias.

Future research

We recommend that researchers continue to explore the components of sleep quality, in addition to global PSQI. Also recommended is testing the intervention for more than 3 weeks to determine when beneficial effects reach a plateau, or whether continued use of music for sleep would be effective for those who do not become good sleepers in 3 weeks or for those with PSQI scores >10 points.

The next step would be to verify the effect of music on sleep with home-based polysomnography or a wrist-actigraph. Poor sleepers tend to underestimate sleep duration and sleep efficiency, and to overestimate sleep latency (Adam *et al.* 1986, Lacks & Morin 1992), although other

What is already known about this topic

- Three preliminary studies have found that music has beneficial effects on sleep.
- Soft music has been found to reduce pain and induce relaxation, which can reduce neuroendocrine and sympathetic nervous system effects on anxiety, heart and respiratory rates and blood pressure.

What this paper adds

- Music intervention at bedtime improved sleep quality weekly for 3 weeks.
- Music intervention at bedtime also improved the components of sleep quality: shorter sleep latency, less daytime dysfunction, longer sleep duration, greater perceived sleep quality and greater sleep efficiency.
- The effectiveness of the music intervention was dose-related.

researchers report consistency between subjective and objective estimates of sleep (Morin *et al.* 1993, Kramer *et al.* 1999). Body temperature is another physiological indicator of sleep, because the circadian rhythms of both sleepiness and thermoregulation are parallel (Glotzbach & Heller 1991). Investigators could use a non-invasive thermistor to measure skin temperature changes at bedtime and during the night to objectively confirm subjective effects.

More research is needed to document the effectiveness of music on sleep quality in other populations such as medically ill, hypnotic-dependent, frail, or institutionalized older adults. In addition, study of musical interventions is needed for specific sleep disorders such as sleep onset insomnia or sleep maintenance insomnia. A crossover design might decrease the error term. Researchers and practitioners who wish to use sedative music for sleep can find tapes or CDs of soft music similar to these examples (Table 3) in public libraries and music stores or can contact us for further information.

Conclusions

Our findings contribute to knowledge about the effectiveness of soft slow music used as therapy on sleep quality in community-dwelling older people. Music is pleasant and safe and can be used therapeutically for insomnia in older people. The intervention is quick and easy to learn, is low cost, and could be used readily by nurses.

Author contributions

H.-L.L: conception, design, data collection, data analysis, interpretation, MG: supervision, technical support, statistical advice, developer of Western music tapes. Both authors have participated in the research, the analysis and the writing of the manuscript.

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