

Research Article

Positive Effects of a Weighted Blanket on Insomnia

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OPEN ACCESS**Abstract**

Insomnia is a common occurrence and can have a negative impact on physiological, psychological and social well-being. There is a need for simple, effective solutions to increase sleep quality. It has been suggested that weighted blankets and vests can provide a beneficial calming effect, especially in clinical disorders. Hence, we aimed to investigate the effects of a chain weighted blanket on insomnia, using objective and subjective measures. Objectively, we found that sleep bout time increased, as well as a decrease in movements of the participants, during weighted blanket use. Subjectively, the participants liked sleeping with the blanket, found it easier to settle down to sleep and had an improved sleep, where they felt more refreshed in the morning. Overall, we found that when the participants used the weighted blanket, they had a calmer night's sleep. A weighted blanket may aid in reducing insomnia through altered tactile inputs, thus may provide an innovative, non-pharmacological approach and complementary tool to improve sleep quality.

Keywords

- Sleep
- Insomnia
- Treatment
- Pressure
- Touch
- Blanket

ABBREVIATIONS

ANOVA: Analysis of Variance; ASD: Autism Spectrum Disorders; BMI: Body Mass Index; ISI: Insomnia Severity Index; KSS: Karolinska Sleepiness Scale; PSG: Polysomnography; REM: Rapid Eye Movements; Karolinska Sleepiness Scale; TST: Total Sleep Time; VAS: Visual Analog Scale; WASO: Wake after Sleep Onset

INTRODUCTION

According to most epidemiological studies, up to a third of the population in industrialized countries suffers from poor sleep [1-5]. This problem affects all categories of people from teenagers to the elderly, and is increasing due to modern lifestyles and the associated stressors, especially in cities. The impairment of sleep has short- and long-term effects. It can lead to depression, burn-out, psychosomatic disorders and addictions, as well as other serious health problems (e.g. metabolic, cardiovascular) [3,4,6,7]. It can affect professional lives (e.g. loss in productivity, poor judgments, accidents, inadequate emotional reactions), with great economic consequences. It can also have a negative impact on social and family life. Pharmacological and behavioral (e.g. cognitive, relaxation) methods are commonly used to treat sleep disorders. However, drugs are often addictive or have side effects, and psychological/behavioral methods require long treatment sessions and it may take time to achieve satisfactory results. Hence, there is a need for additional, simpler methods to promote and maintain better sleep.

The application of deep pressure, through for example weighted vests and blankets, has been reported to produce a calming and relaxing effect in clinical conditions such as autism spectrum disorders (ASD), attention-deficit hyperactivity disorder, and pervasive developmental disorders [8-15]. Applying deep pressure has been shown to be beneficial for children with high levels of anxiety or arousal [16] and deep pressure touch may also alleviate anxiety (e.g. in dental environments and bipolar disorder [17,18]). There are also anecdotal reports suggesting that the elderly who suffer from anxiety and dementia may find relief from deep pressure touch and many nursing homes are experimenting with weighted blankets.

A weighted blanket that is more than 10% of a person's body weight has been found to provide beneficial, calming effects [19]. Most of the research on weighted blankets has focused on their use in children with clinical disorders, such as ASD. However, the majority of these studies do not probe sleep objectively. To our knowledge only one study has systematically investigated the use of a weighted blanket during bedtime and this was in children with ASD and severe sleep problems, using some objective measures. The study found no increase in the total sleep time; however, the blanket was favored by both the children and their parents [20].

There is a need for systematic studies into the potential benefits of weighted blankets for sleep, especially for adults and those with insomnia. Hence, the aim of the present study was to investigate whether the use of a weighted blanket may have a

positive impact on adults with sleeping problems, mainly chronic insomnia.

MATERIALS AND METHODS

Intervention

There are several weighted blankets on the market. For this study we used a new type of chain-weighted blanket (Somna AB, Stenkullen, Sweden), currently used both in nursing homes for the elderly and in patients with ASD. The weight is provided by a metal chain construction, which is evenly distributed throughout the blanket and provides constant tactile stimulation across the body. The participant can choose to sleep with the chain or the padding side of the blanket closest to their body (hence provide a different sensation). They can also use an additional quilt, either over or under the blanket. The blanket is weighted without being thick, and the fabric is such that the blanket does not particularly provide additional warmth. Three weights were available (6, 8 or 10 kg) and the participants could select the most comfortable one. The majority of the participants in the present study selected the 8 kg blanket.

Study design

A repeated-measures study was undertaken in two clinical sites in Sweden, over the course of a year. For each participant, the study lasted 4 weeks. There was no control group, as the participants were their own control, with baseline pre-test and post-test measures. The study was approved by the Ethical Committee of the Sahlgrenska Academy in Gothenburg and was conducted according to the Declaration of Helsinki. Written, informed consent was obtained from all the participants before taking part and they were paid for their time. Prior to undertaking the study, an effect size analysis was conducted to ascertain the approximate number of participants required for significant effects. This was based on statistical analyses from objective and subjective results of a previous pilot study on 5 participants. Cohen's *d* was used to calculate an effect size of 0.75, with a power of 0.8 (ratio 4:1 between type 1: type 2 errors); a minimum of 26 participants was required to gain statistical differences. Hence, we aimed to recruit 30 participants to account for drop-out and technical failures, due to the complexity of the study and its design.

Study population

The inclusion criteria were: participants' of genders, aged 20-66, complaining of chronic insomnia, which was defined as difficulties in falling asleep and/or maintaining sleep for several nights a week (> 3 days) for more than 3 months, and having feelings of not being refreshed when waking up in the morning. If they were on medication upon entering the study, this was continued throughout the trial period. Otherwise they had to be healthy. The exclusion criteria were presence of illnesses or newly discovered problems (<6 months), for example, sleep apnea, untreated metabolic disorders or high blood pressure. The participants should not have changed any medication in the prior 4 weeks to commencing the study.

Participants were selected by advertising at the sleep clinics and through leaflets on boards. A total of 33 healthy participants

complaining of chronic insomnia were recruited for the study; 31 completed the protocol (11 men, 20 women). For further details about the participants, see Table 1. Prior to the study, the participants also completed various questionnaires covering environmental and lifestyle factors, including their health status, irregularity in sleep-wake patterns and life style, variability of sleep during the weekend, the presence of any sleep phase delay or advance, their perception of sleep quality, and if they used any medication.

The level of insomnia per participant was determined according to the 7-item Insomnia Severity Index (ISI) [21], which assesses the nature, severity, and impact of insomnia in their life. Each question is rated from 0 (no problem) to 4 (severe problem), with the total possible score being 28. A score of less than 7 reflects no clinically significant insomnia, 8-14 being sub-threshold insomnia, while 15-21 represents moderate insomnia and a score greater than 22 indicate severe insomnia. The 8-item Epworth Sleepiness Scale [22] was used to reflect any daytime consequences of insomnia (i.e. daytime sleepiness). This consisted of a questionnaire with answers ranging from 0 (no chance of dozing) to 3 (high chance of dozing) to give a total out of 24 points.

Procedures

After screening and consent, the eligible participants slept for a week in their habitual environment, which consisted the pre-test baseline period. The following test period followed consisted of two consecutive weeks during which the participant used the weighted blanket every night. They pre-selected a blanket weight, but if they felt that it was too light or heavy, they could change it after no more than two nights into the test. The participant returned the blanket after these two test weeks and slept for one more week in their ordinary, habitual conditions (post-test period).

Methods for studying sleep patterns

The trial design included both objective (physiological) and subjective (self-report) measures.

OBJECTIVE MEASURES

Continuous actigraphy (Actiwatch; Cambridge Neurotechnology Ltd, Cambridge, UK) and comprehensive polysomnography (PSG) recordings, in the participants' own home, were obtained.

The actigraphy watch consisted of an accelerometer that was worn on the same wrist continuously during the 4 week period. Data were stored in the watch unit. Analyses of patterns and frequencies of movements were done by validated algorithms for the recognition of basic sleep-wake patterns. The participants' time-to-bed and waking-up time were reported in their sleep diaries, which defined their sleep periods. The main analyses were conducted on these sleep periods. The variables analyzed included sleep latency, assumed sleep, total wake time, sleep fragmentation index, number of bouts of immobile time and their frequency, as well as the number of sleep bouts and their duration. We did not want to interfere with the ordinary lifestyle and activities of the participants, though we recommended that

Table 1: Details about the participants.

Characteristic	Number	Mean ± SD	Range
Age (all)	31	47 ± 14 years	21-66 years
Males	11	49 ± 15 years	25-60 years
Females	20	43 ± 13 years	21-66 years
BMI (all)	31	25.8 ± 5.2	19.6-45.4
Males	11	27.1 ± 2.9	23.9-30.8
Females	20	25.4 ± 5.8	19.6-45.4
ISI(all)	31	20 ± 5	5-28
Males	11	19 ± 4	11-23
Females	20	20 ± 6	5-28
Epworth(all)	31	6 ± 4	0-12
Males	11	6 ± 3	2-12
Females	20	6 ± 4	0-11
Weight of blanket/weight of participant	31	19% ± 7	12% -38%
Question	No	Occasionally/Yes	Often
Do you take sleep medication?	66%	21%	14%
Do you have an irregular sleep cycle?	66%	21%	14%
Is your sleep different at the weekend?	48%	34%	17%
Do you have a phase delay with sleep?	90 %	10%	
Do you do shift work?	93%	7%	

Abbreviations: BMI: Body Mass Index; ISI: Insomnia Severity Index

they avoid major irregularities, if it meant a large variation in their sleep-wake pattern e.g. going to bed late and getting up late during the weekend. For participants that showed these large irregularities in their routine (defined as exceeding 2 hours deviation for 2 or more days), we restricted the analysis to 5 continuous days/nights for both the pre-test and the test period, which typically did not include weekends where the larger sleeping deviations tended to occur.

The PSG was measured using a 23 channel ambulatory polygraph that recorded electroencephalography (electrical brain activity), electromyography (muscle activity), electrooculography (eye movements), electrocardiography (heart beat), respiratory activity and oxygen content in the blood (pulse oximetry), while a sensor pad, placed under the sheets, recorded body movements and positions during the night (Biosaca; Swedsleep AB, Gothenburg, Sweden). Two comprehensive PSG recordings were completed at home, for each participant: one during the first pre-test (no weighted blanket) week and one at the end of the third week (test period, with the weighted blanket). PSG analysis was done using the REM Logic software (Embla Systems LLC).

Further to conventional PSG analysis a validated automatic system for analyzing body movements [23] was used (U-sleep; Swedsleep AB, Gothenburg, Sweden). Based on the sensor pad it detected specific movements and classified them into four groups according to their duration (from < 5 s to >15 s), representing jerks or twitches, minor or major adjustments, and turns in the bed. The total number and duration of each of these measures were calculated, as well as the distribution per recording hour, with an emphasis on the next-to-last hour prior to waking up. The following measures were gained: wake after sleep onset (WASO; in mins), total sleep time (TST), sleep efficiency, sleep latency, latency to deep sleep and rapid eye movements (REM), number of awakenings, amount of deep sleep and REM, arousal

index, number of stage shifts, of sleep cycles, deep and REM sleep, average deep sleep period, and sleep spindles index.

Subjective measures

During the whole experimental period, the participants filled in a sleep/day diary reporting daytime behavior and sleep perception together, with any comments about their night's sleep and any environmental changes of importance. Each morning, they also reported their 'sleep quality' in a visual analog scale (VAS; with the end-anchors 'Very good' and 'Very bad'), as well as on the Karolinska Sleepiness Scale (KSS; 1= very alert to 9 = very sleepy) [24].

At the end of the study the participants reported their subjective feelings about using the weighted blanket in an 8-item VAS questionnaire, containing specific questions about their sleep with the blanket (Table 2), where lower scores indicated more favorable feelings towards the weighted blanket. Two further questions were asked: (i) 'Which side of the blanket is closest to your body most of the time?' and (ii) 'Did you use something else as a cover, in addition to the weighted blanket?' These were to assess how the participants used the weighted blanket.

Data analysis

Statistical studies were made using SPSS (version 22; IBM, Armonk, NY) and Prism (version 6; Graph Pad, La Jolla, CA) where significant differences of p<0.05 were accepted. All the analyses have been conducted on normalized data, as most of the variables were not normally distributed. Hence, parametric, interval statistics were carried out on the actigraphy, PSG and U-sleep measures and repeated-measures analysis of variance (ANOVA) tests were used. We compared the pre- and post-test data with the weighted blanket data for each variable using Bonferroni post-hoc corrected-significance tests, which controlled for multiple comparisons. It was not always possible

Table 2: The participants rated their subjective feelings about sleep with the weighted blanket using a visual analog scale for questions 1-8.

	Score between	1	10
1	How do you find sleep with the weighted blanket?	Comfortable	Uncomfortable
2	How is your experienced sleep quality, as compared to having no weighted blanket?	Better	Worse
3	How do you find sleep with regard to the extra weight the blanket adds?	Not difficult	Awkward
4	Is it difficult to move with the weighted blanket?	Not at all	Very
5	Does the blanket affect your temperature in bed?	Not at all	Very
6	Is it easier to settle down to sleep with the blanket?	Very	Not at all
7	Does the blanket give you a sense of security?	Very	Not at all
8	How do you feel in the morning with the blanket?	More rested	More tired

to include all of the participants per measure due to issues such as technical problems. The effects of confounding variables, such as the participant's gender, age, use of medication, were tested as covariates. As the behavioral measures were based on questionnaires, non-parametric, ordinal tests were used for the analysis.

Additional analyses were conducted on a sub-set of participants who rated the weighted blanket favorably, which was based on their subjective assessment scores, where lower scores indicated a higher liking. The criteria for exclusion (participant who disliked the blanket) were defined as a mean score on questions 1-8 of more than 5, a maximum score of 8 or more, and scores of 8 or more on more than two questions.

RESULTS

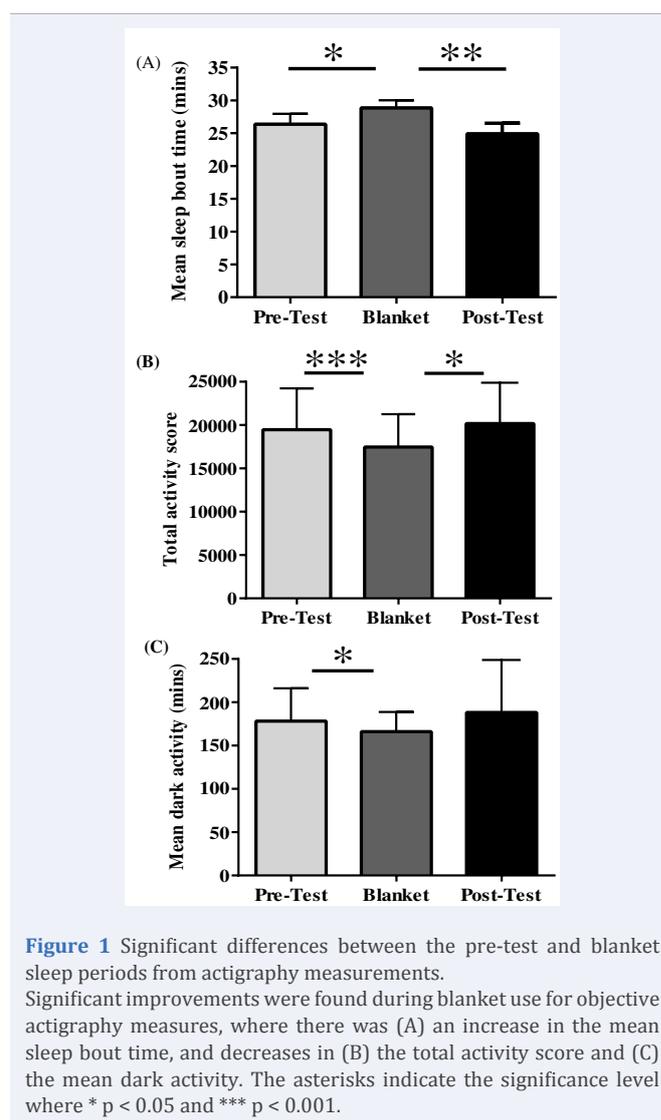
The mean ISI score for all the participants was 19.5 (± 5.3 SD), which indicated insomnia of moderate severity (see Table 1 for further details). The mean Epworth score was 6.1 (± 3.7 SD) indicating that the participants had minor issues with sleepiness in the daytime, with further details in Table 1.

OBJECTIVE MEASURES

Actigraphy

The actigraphy was used to determine variables about sleep metrics; therefore only the sleep period was analyzed, with the time-in-bed adjusted according to each participant's sleep diary. Actigraphy was obtained from 27 participants, from a total of 26 different measures, although some of these measures were seemingly redundant (e.g. immobility expressed in minutes compared to immobility as a percentage of time). Significant differences were found in comparing the pre-test period to the test period with the weighted blanket. Specifically, the mean sleep bout time (in mins) significantly increased ($p = 0.035$), when using the weighted blanket. Furthermore, the total activity score during the time in bed ($p < 0.001$) and the average dark activity (activity during the night) ($p = 0.032$) significantly decreased, during weighted blanket use. These measures are shown in Figure 1.

There was an effect on the results from one of the covariates, where significant decreases were found for the sleep latency ($p=0.010$) and time-in-bed ($p=0.009$) during use of the weighted blanket, if the participant used medication. The further analysis on the participants that liked using the blanket ($n = 19$ subjects



included) showed no further additional significant differences in the results.

The post-test actigraphy period was compared to both the pre-test and weighted blanket periods. Due to participant drop-out, only 22 participants completed the post-test, as compared to the 27 who completed the pre-test and weighted blanket periods. There were no significant differences between the pre- and post-

test measures. There was significant decrease between using the weighted blanket and the post-test periods for the mean sleep bout time in mins ($p = 0.003$), and significant increases in the total activity score ($p = 0.018$) and mean activity score ($p = 0.015$).

PSG

A total of 25 participants completed both PSG tests during the pre-test stage and while using the weighted blanket. PSG is a state-of-the-art measure for sleep studies, but the participants often reported that it was disturbing, due to the equipment required. Only one measure gave significant difference during the weighted blanket test, as compared to the pre-test: the spindles index significantly decreased ($p = 0.003$). However considering only the 21 participants (out of the 25 who completed the PSG, i.e. 84%) who liked the blanket, WASO was decreased significantly ($p = 0.004$) and TST increased significantly with the blanket ($p = 0.016$). The effect of confounding variables on the PSG measures was sought, where an effect of gender was found, but this was only for the sleep spindles measure. Here, females had a higher spindles index during use of the weighted blanket, as compared to males ($p = 0.024$).

Movement analysis

The U-sleep data consisted of 6 measures collected from 23 of the 25 participants who completed the PSG (in 2 subjects there were technical problems with the sensor pad). The mean movements decreased in the next-to-last hour prior to waking up, both in duration ($p = 0.001$) and in number ($p = 0.075$). No significant effects were found for the confounding variables on the U-sleep measures. A further analysis was run using only the subjects that liked using the weighted blanket ($n = 15$). Here, the number of movements in the next-to-last hour prior to waking up now showed a very significant decrease ($p < 0.001$), during blanket use.

Subjective measures

The sleep quality and KSS measures were obtained from 29 participants. There were decreases in both of these measures, meaning a better subjective sleep quality (sleep quality: decreased from 5.9 (pre-test) to 5.5 (during blanket use), $p = 0.005$; KSS decreased from 5.8 (pre-test) to 5.5 (during blanket use), $p = 0.068$). The post-test values showed no significant differences with either the pre-test or weighted blanket periods (both the sleep quality and KSS were 5.6). No significant effects were found for the confounding variables on the KSS or sleep quality measures, nor were any further differences found when only the participants that liked using the blanket ($n = 20$) were analyzed.

In Figure 2, the subjective assessment of using the weighted blanket showed that overall, the participants liked sleeping with the blanket ($p = 0.035$), found easier to settle down to sleep ($p = 0.032$) and reported a much better quality of sleep ($p = 0.004$), feeling more refreshed in the morning ($p = 0.045$). They were not disturbed by the weight of the blanket ($p = 0.012$) and in fact, felt a sense of security ($p = 0.042$). Furthermore, the weighted blanket did not affect their temperature in bed. The majority of participants (63%) preferred the padding side of the blanket to be closest to their body during sleep. The majority also just used

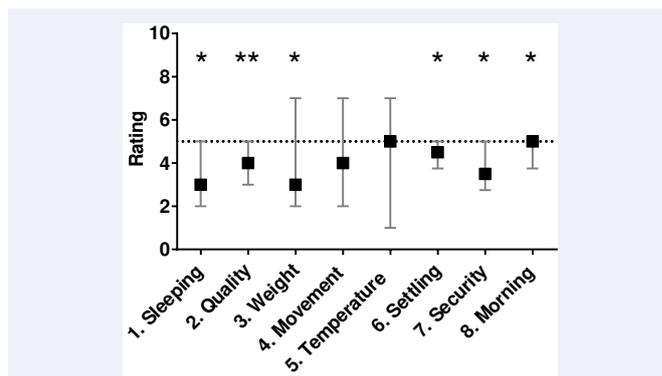


Figure 2 Ratings of subjective feelings about sleep with the weighted blanket. Each participant rated their feelings on VASs for eight items (numbered 1-8, see questions in Table1), where lower numbers are more favorable ratings towards the weighted blanket. The dotted line indicates the level between liking and disliking. The asterisks indicate the questions where there were significant decreases under the dotted line (i.e. significant liking), * $p < 0.05$, ** $p < 0.01$.

the weighted blanket (63%), as compared to 30% who used an additional quilt under the blanket and 7% who used a quilt over the blanket.

DISCUSSION

In the present study, a chain weighted blanket was found to be effective at improving sleep quality in recognized insomniacs, both in parameters measured objectively and subjectively. The impact was more pronounced objectively when the participants reported having a positive experience of using the weighted blanket and if they used sleep medication. No adverse effects of using the weighted blanket were found.

Weighted blankets providing a 'cocooning' feeling and are often recommended for young patients with ASD and in the care of agitated elderly people. However, to our knowledge this is the first scientific study on the effect of weighted blankets in insomniacs. The ISI results validated that the selected group had mild-to-moderate insomnia and their Epworth scores, expected to be low in this group of subject, though within the normal range, were also a little elevated (mean = 6, indicating some tendency for daytime consequences), meaning that the blanket could be beneficial for general insomnia and potentially also for mild sleep problems. Based on sensory integration, it has been suggested that deep pressure and consistent sensory input, such as provided by a heavy weight on the body, can reduce physiological levels of arousal [25]. A crucial point is that the weight should not be too light or heavy, and the weight must be evenly distributed throughout the fabric to provide constant tactile stimulation distributed across the body, which the current weighted blanket design provided.

There are many weighted blankets and vests on the market with different designs, for example, those with metal chains or covers filled with small plastic balls or pellets. Chain covers and ball quilts may provide different sensations (e.g. tactile, thermal insulation) and have different weights, which need to be adapted individually, as some patients may be more sensitive to stimulation, thus requiring a lesser-weighted blanket. The

effectiveness of a weighted blanket has been found to relate to the mass of a person, where a blanket that weighs more than 10% of the person's body is more beneficial [19]. All of the participants in the current study had a weight of blanket/participant ratio of more than 12% (see Table 1). The longitudinal chain construction of the present weighted blanket may adjust well to the participant's body, where an even weight is delivered over the body from the whole blanket surface, with the longitudinal chain construction adding further pressure points that fluctuate with minor movements producing a stroking-like effect.

There are limitations to the current study design, which include a lack of a control group, the long duration of the study, some missing data, and the inability to provide a placebo weighted blanket. The participants represented their own control (pre- and post-test measures) in our cross-over design and a control group would only have been necessary if the goal was to compare different types of blankets. However, in some tests, we had reduced numbers of participants (e.g. in the PSG), particularly due to technical issues with this equipment-intensive technique. As we calculated that we needed at least 26 participants for significant effects prior to the study, we conducted the study on 31 participants, which allowed for some issues and participant drop-out (which occurred mainly at the week 4 post-test stage). Giving a weighted blanket to control participants without insomnia would have been less meaningful, unless we were interested in looking at a possible negative impact of the blanket. However, the strengths of our design include the use of combined objective and subjective assessments using different, independent methods, and the use of a pre- and post-test baseline.

PSG is the golden standard to study sleep, but it can be cumbersome, disturbing and is limited to a few nights, hence not representative of the subject's habitual night sleep. The PSG did show some beneficial effects of blanket use, including the TST and WASO that were significantly improved in the 21 participants reporting a subjective positive impact of the blanket. Regarding the significant decrease in the spindles index, this may reflect the responsiveness of the brain to stimuli, where a decreased amount suggests a 'loss of contact' with the external environment, hence working as a filter and enhancing sleep continuity [26]. The movement (U-sleep) analysis was based on recordings from the PSG pad; however, the first sleep hours can be disturbed by the PSG. Hence, we used the 'next to last hour' measure to assess sleep, since the last hour is often characterized by a shallow sleep. The participants showed a decrease of movements this next to last hour, which represented a quieter, more restful sleep. Therefore the combination with actigraphy made for a more comprehensive evaluation of the effects of using the weighted blanket over time. The actigraphy showed a number of objective improvements in sleep, including a decrease in movements and an increase in the length of sleep bouts.

Overall, these measures suggest the additional pressure stimulation from the weighted blanket provided a calming effect on the participants, by decreasing agitation and increasing the quality of their sleep. This was demonstrated through a decrease in movements during sleep with the weighted blanket, which were increased in the pre- and post-test periods, and also the subjective increased in sleep quality (measured by the VAS)

and KSS (which is a validated instrumental scale). Although these subjective measures are possibly less clinically relevant, it is important to consider the psychological effects of using the weighted blanket (cf. [20]), for example, having a positive attitude. Weighted blankets and deep pressure touch may work well for insomniacs, both through psychological means (e.g. calming and 'cocooning', releasing anxiety [27]) and physiological means (e.g. tactile input that decreases activity of the sympathetic nervous system [28]). As increased sympathetic arousal likely affects sleep quality negatively, reducing it may aid sleep.

CONCLUSION

The weighted chain blanket used in the present study had a positive impact on sleep, both objectively and subjectively, where a number of physiological and behavioral measures were improved during weighted blanket use. When the participants used the weighted blanket, they had a calmer night's sleep, with a decrease in movements. Subjectively, they believed that using the blanket provided them with a more comfortable, better quality, and more secure sleep. In conclusion, a weighted blanket may aid in reducing insomnia through increased tactile and proprioceptive inputs, may provide an innovative, non-pharmacological approach and complementary tool to improve sleep quality.

CONFLICT OF INTEREST

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