Blocking the Blues at Night

Effect of Swannies Blue Light Blocking Glasses on Sleep

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Executive Summary

In this product validation study, we tested if use of Swannies Blue Light Blocking Glasses would improve sleep in a sample of 30 S+ by ResMed users whose objective sleep data indicated difficulty falling asleep and/or insufficient deep sleep. Participants were instructed to wear Swannies every evening before bed in their homes for a 4-week period.

Across the 29 participants who consistently tracked their sleep with the S+ by ResMed, there were 696 nights of tracked sleep (24 nights per person on average) before they started using Swannies, and 621 nights (21 nights per person on average) during which participants wore Swannies in the evening and then tracked their sleep at night.

Self-report data collected before and after use of the product revealed that using Swannies led to statistically significant improvements in many aspects of perceived sleep: Increased sleepiness at bedtime (+33%), reduced time to fall asleep (-11 minutes), reduced amount of time awake during the night (-24 minutes), improved ability to sleep through the night (+34%), improved overall sleep quality (+36%), and improvement in feeling rested in the morning (+37%). In addition, self-report data collected every morning during the product use period showed significant increases across nights in participants' perceptions of how well they slept each night (+14%) and how refreshed they felt each morning (+18%).

Looking at the objective sleep data, collected using SleepScore technology by ResMed, we found statistically significant improvements in metrics related to deep sleep: Time spent in deep sleep increased in both absolute and relative terms, with participants spending 59 minutes on average in deep sleep before using Swannies (approximately 13% of sleep) and 63 minutes on average (approximately 14% of sleep) while using Swannies. Related to this, participants had an average Body Score of 72 before using Swannies and 74 while using Swannies, a 3% increase.

On the user experience side, participants' responses were very favorable: 90% of users said it was easy to make wearing the glasses part of their nightly routine, and 90% of users felt the glasses were comfortable. Many users commented that wearing Swannies reduced eye strain and helped them relax. In addition, 73% of users said they would recommend Swannies to their close friends and family, and 80% planned to continue to use Swannies after completion of the study.

In summary, this study found that Swannies can improve sleep, and this was seen in both self-report data and objective sleep data. Most participants (73%) reported that Swannies improved their sleep. In addition, objective sleep data revealed that Swannies use resulted in participants getting more deep sleep during the month they used Swannies compared to the month before they used Swannies. This likely can be explained by Swannies blocking blue light, hence not suppressing the naturally occurring melatonin release. Deep sleep is the stage of sleep that is known to be restorative, which can explain why the participants in our study felt significantly more refreshed in the mornings after using Swannies compared to the month before using Swannies.

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Introduction

Using SleepScore technology by ResMed and self-report questionnaires, we conducted a product validation study to test the effectiveness of Swannies in improving sleep. Swannies Blue Light Blocking Glasses, by Swanwick, are designed to improve sleep by filtering out harmful artificial blue light from electronic devices. This prevents blue light-induced decrease in melatonin secretion in the evening and thus helps in maintaining a stable circadian rhythm and sleep pattern. The glasses can also be used to help prevent eye strain.

A growing body of research (see scientific review by Russart & Nelson, 2018) has shown associations between exposure to light at night and negative impacts on health, in part due to suppression of melatonin. For example, links between night work and disease are increasingly being acknowledged; these may be caused by the effects of extended light exposure, circadian disruption, and sleep deprivation (Haus & Smolenksy, 2006; Touitou et al., 2017). Sources of light at night include light pollution in urban areas as well as modern indoor lighting with high intensity and enhanced proportions of blue light. Blue light in particular induces the strongest melatonin inhibition, and exposure to blue light is increasing due to nighttime use of LED lighting and electronic devices (Bonmati-Carrion, et al., 2014). In short, "'brighter and bluer' is not synonymous with 'better'" at night (Gringras et al., 2015).

Professor Chuck Czeisler, a leading scientist in the field of sleep and light, has noted that the use of electric lights at night is disrupting the sleep of more and more people (Czeisler, 2013), and recent studies have documented the impact of light exposure on the quality and architecture of sleep (Wams et al., 2018). Nighttime city and street lights have been linked with altered sleep behavior and impaired sleep satisfaction (Ohayon et al., 2016), and indoor use of light emitting devices at night can suppress melatonin levels and subsequently impact sleep, affecting both falling asleep and the amount of deep sleep (Chang et al., 2015, Chellappa et al., 2013). Both go-to-sleep times and melatonin release can be impacted by levels of home lighting (Burgess & Molina, 2014).

Using Swannies can be a simple solution for reducing exposure to blue light and, in turn, improving sleep. In our study, we examined the effects of 4 weeks of Swannies use on sleep in a group of 30 people. We compared their sleep during 4 weeks without Swannies to their sleep during a 4-week period using Swannies. We tested whether Swannies would improve sleep in the following ways:

Self-report sleep data (comparing *before* Swannies use to *during/after* Swannies use)

a. increase in perceived sleepiness before bed
b. decrease in perceived time to fall asleep
c. decrease in perceived number of awakenings
d. decrease in perceived wake time during the night
e. increase in perceived sleep duration
f. increase in perceived overall sleep quality
g. increase in perception of feeling refreshed in the morning

2. **Objective S+ by ResMed sleep data** (comparing 4-week period *before* Swannies use to 4-week period *while* using Swannies)
    a. decrease in sleep onset latency
    b. decrease in number of awakenings
    c. decrease in wake after sleep onset
    d. increase in deep sleep
    e. increase in total sleep time
    f. increase in SleepScore, Body Score, and Mind Score

Method

Selection of study participants

Selected active users of the sleep monitoring device S+ by ResMed were invited by e-mail to participate in a research study aimed at improving sleep. The invitation was sent to active S+ users with sleep onset latency of greater than 30 minutes on 8 or more nights in the 4 weeks prior to recruitment into the study and/or a relatively low amount of deep sleep reflected in a below average Body Score (a metric related to deep sleep), based on their SleepScore Labs S+ by ResMed sleep data.

Using an online questionnaire, we further assessed the user's eligibility and interest in the study. After receiving this information, SleepScore Labs phoned the potential participants to verify their responses and screen them further, applying the following inclusion criteria: residents of the United States interested in wearing glasses to block blue light; exposed to regular light at night (e.g., bright environments, laptop, or tablet use); between the ages of 25-65 (allowing up to 75 if in good health). Given that our goal was to test the product in a sample of healthy users, we excluded people experiencing medical problems that adversely affect sleep and people using medications that affect sleep. Similarly, we excluded recreational drug users and people who reported having 3 or more drinks on 4 or more nights per week. Other exclusion criteria included being a shift worker, having a child at home under 12 months old, and planning to travel across multiple time zones or be away from home for more than 7 days (before and during use of the Swannies).

To protect privacy, eligibility was checked by asking participants if they met *any* of the medical exclusion criteria listed above, rather than asking them to share which specific criteria might apply to them personally.

Thirty people were recruited for participation. All of them signed and submitted a Study Participation Agreement prior to beginning the study.

Study design and procedures

A non-counterbalanced, pre-post study design was implemented. Mixed methods (quantitative and qualitative self-report data as well as objective sleep data) were used.

Swanwick provided each participant with two pairs of Swannies Blue Light Blocking Glasses. Participants were given the choice of receiving either two Classic pairs, two Fitovers (to be worn over prescription glasses or reading glasses), or one of each. This was done to help increase compliance with the study protocol.

Objective sleep data were collected by having participants use their S+ by ResMed sleep monitoring device to track their sleep at home every night. The pre-product use period consisted of 4 weeks during which participants were asked to use their S+ by ResMed every night as usual to track their sleep. During this pre-product use period, participants had not yet received the Swannies.

The product use period consisted of 4 weeks during which participants completed 3 requirements: wore Swannies in the evening, used the S+ by ResMed at night to track sleep, and completed a brief questionnaire the following morning. The brief daily questionnaire served as both a compliance check and a reminder. In addition, participants received a text message each evening at 8:00 p.m. (in their own time zones), reminding them to put on their Swannies. The study was executed from February 26, 2018 to April 22, 2018, which included the switch to Daylight Savings Time (DST, March 10 to 11). Note that excluding nights affected by the switch to DST did not change significant results in the objective sleep data. Results reported reflect all 8 weeks of objective data.

In addition to the brief daily questionnaires that were sent each morning during the product use period, participants completed two longer surveys: a pre-product use sleep experience questionnaire prior to receiving Swannies, and a final sleep experience questionnaire at the end of the product use period. The study timeline is displayed in Figure 1 below.

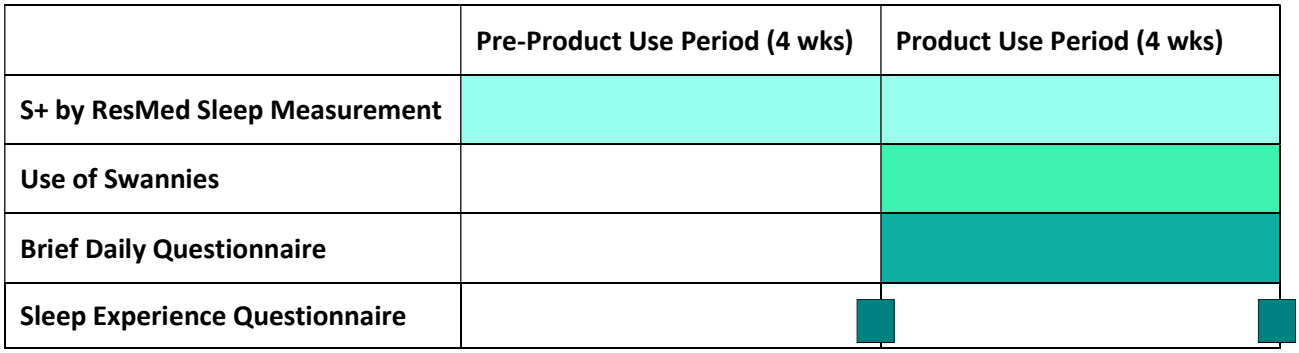

Figure 1: Study timeline.

Instructions to participants

Participants were provided with the following instructions:

- Put on your **Swannies every night** when it gets dark outside and keep them on until you go to sleep. Using them for this length of time will be most effective, because blue light comes from many sources – computers, smartphones, TVs, and modern home lighting.
    - At the very least, wear your Swannies for **90 minutes** before you go to sleep.
    - If you need to turn on lights during the night (ex. to use the bathroom) try to remember to put on your Swannies first.

- We sent you two pairs to make it easier for you to wear them every night. You might want to keep one pair near your door and the other pair on your nightstand. Or, if you carry a bag, you might want to keep one pair in your bag and the other pair at home. Both pairs are for your personal use only.

In addition, participants were reminded to continue to track their sleep using S+ in their habitual way each night.

Measures

For this study, both self-report and objective sleep data were collected.

Self-report data were collected using SurveyMonkey. The sleep experience questionnaire that was administered before product use included items assessing demographics and household situation, perceived sleep during the past month, sleep concerns, lighting in the home, and use of electronics. Most of the questions were quantitative (scales, checklists, multiple choice) and some were qualitative (open-ended).

In the sleep experience questionnaire administered at the end of the product use period, questions from the pre-product use questionnaire were repeated, to allow us to examine change in participants' responses before and after use of Swannies. Additionally, the post-product use sleep experience questionnaire included quantitative and qualitative questions about users' experiences and opinions regarding the product.

A brief questionnaire was sent each morning during the product use period. These daily questionnaires checked compliance during the previous night and functioned as a reminder for the upcoming night. Participants were asked whether they wore Swannies the previous night. If yes, they were asked what time they put them on and took them off. If no, they were asked to explain why. They also were asked whether and for how long they used a computer or tablet the previous night. They were instructed not to use screen filters when using these types of electronics during the study period.

The daily questionnaire also asked about sleep during the previous night. A scale ranging from 0-100 (0 being *Not well at all*, 100 being *Extremely well*) was used to measure participants' perceptions of how well they felt they slept, regardless of their S+ data. A similar scale was used to ask how refreshed they felt when they woke up that morning (0 being *Not at all refreshed*, 100 being *Extremely refreshed*).

Objective sleep data were collected using the S+ device by ResMed, a non-contact monitor designed to unobtrusively and objectively measure sleep at the user's home. The S+ provides standard annotated sleep stage data and commonly used sleep metrics such as time to fall asleep (sleep onset latency), number of awakenings, start and end of sleep sessions, and total sleep time.

Validity of these sleep measurements has been shown multiple times, and Zaffaroni and colleagues (2018) recently concluded that the non-contact device showed good performance compared to the "gold standard" sleep measurement technique of polysomnography.

The amount of time spent in light sleep, deep sleep, and REM sleep (all in minutes) together add up to total sleep time. Wake after sleep onset describes the total number of minutes a person is awake after falling asleep for the first time and before waking up prior to getting up. The total time in bed describes the time between getting in and out of bed (from "lights out, start S+ session" to "lights on, stop S+ session").

With these measures, sleep efficiency and sleep maintenance can be calculated. Sleep efficiency (in %) is calculated by dividing total sleep time by time in bed. Sleep efficiency of 85% and higher is considered to reflect good sleep quality (Ohayon et al., 2017). Sleep maintenance (in %) describes the ability of staying asleep once asleep, taking into account waking up too early (before getting out of bed) and/or struggling to get back to sleep (but not the time it takes to fall asleep initially) and is calculated by dividing total sleep time by the sum of the duration of all sleep stages, including wake, after initially falling asleep.

Also, all four relative stage durations (%Light, %Deep, %REM, and %Wake) were calculated by dividing stage duration by the sum of the duration of all sleep stages, including wake, after initially falling asleep.

In addition to the traditional sleep metrics described above, the S+ by ResMed provides three sleep scores: SleepScore, Body Score, and Mind Score. These are normalized 100-point sleep quality scales, based on proprietary algorithms, using scientific averages for a user's age and gender (Ohayon et al., 2004). SleepScore is defined by six sleep parameters and can be regarded as a general sleep quality scale. Mind Score reflects the amount of REM sleep, which is known to play an important role in creative thinking, problem solving, and emotional processing. Body Score reflects the amount of deep sleep, which is considered restorative sleep and is linked to the perception of feeling well-rested the next day.

Data Analyses

We used Excel to analyze the quantitative self-report data. Descriptive statistics and one-tailed, paired-sample *t*-tests were conducted. We used an alpha level of .05.

Objective sleep data and items from the daily questionnaire were analyzed in MLwiN using multilevel regression analyses, taking into account the nested structure of the data (nights within subjects). We used an alpha level of .05.

Both descriptive results and statistically significant results are addressed in the report. The tables in the report give a broader overview of the findings, including non-significant differences.

Results

Analyses of the self-report data included all 30 participants. Objective data analyses included 29 participants; 1 participant was excluded due to limited nights of S+ by ResMed recordings.

As explained above, to increase compliance, each participant received two pairs of Swannies and could choose which style(s) would be best for them. Close to half the participants (*n* = 13, 43%) got both pairs in the Classic style, 6 people got both pairs in the Fitover style, and 11 people got one of each style.

On average, during the product use period, participants used Swannies for 76% of the nights.

Demographics

Of the 30 participants, 16 were women (53%), and 14 were men (47%). Participants' ages ranged from 26 to 71, with an average age of 51. Most participants were White/Caucasian (*n* = 22, 74%). In addition, 3 people were Latino/Hispanic (10%), 2 were African American (7%), 1 was Asian or Pacific Islander (3%), and 1 was Native American (3%). One of the participants indicated that they preferred not to answer (3%).

Participants were asked about their household composition. Most participants reported living with a partner and/or child(ren) (*n* = 20, 67%). In addition, 7 reported living alone (23%), 2 lived alone but had a partner or child(ren) regularly sleeping at their home (7%), and 1 participant lived with unrelated roommates (3%).

Most participants were employed full-time or part-time (*n* = 20, 68%). Twenty percent (*n* = 6) were retired. Two were students (6%). The remainder (*n* = 2, 6%) were unemployed or unable to work. Half of the participants (*n* = 15, 50%) had a college degree or higher, and 11 people (37%) had an associate degree or some college. For 4 participants (13%), the highest level of education was a high school degree. Annual household income before taxes varied considerably, ranging from less than $25,000 (*n* = 4, 13%) to $200,000 or more (*n* = 2, 7%). Ten participants (33%) reported income in the $25,000 - $75,000 range, and 6 participants (20%) reported income in the $75,000 - $125,000 range. Four participants (14%) had income in the range of $175,000 - $199,000. Several participants (13%) declined to answer the income question.

Home environment and sleep before using Swannies

Prior to starting to use Swannies, participants were asked about their home environment, sleep-related habits, and sleep experiences.

The majority of participants (63%) described themselves as being an evening person, 30% identified as a morning person, and the rest (7%) described themselves being neither an evening nor a morning person.

On average, most participants (83%) reported using a computer or tablet every night. The remainder reported using these types of electronics 2 to 6 evenings per week. Two-thirds reported never using screen dimming software, and 17% used it often or sometimes; 10% percent reported always using screen dimming software, and 7% reported using it very often.

When asked about the level of darkness in their bedroom while sleeping, one-third of the participants reported no light, 64% reported a little, and one person reported some light. Among those who reported that there was light in their bedroom during sleep, there was an equal split between electronics and outside light as the primary source. To reduce light in the bedroom when sleeping, some participants used one or more of the following solutions: blinds (28%), blackout shades (21%), and/or curtains (19%). Four people (9%) reporting using an eye mask. Some noted that they did not use any of those solutions or used other solutions; for example, one person commented that they put a pillow or blanket over their head.

All but one person did not use any special lighting or light bulbs to help them sleep or wake up. Over half of participants (56%) reported that LEDs were among the most commonly used light bulbs in their home. Other responses included CFL (19%) or incandescent (17%) bulbs, and 3 people were unsure what type of bulbs they had. When asked about the level of light at home in the evening, over half of participants (57%) answered not bright/not dim. The rest answered somewhat dim (27%), somewhat bright (13%), or bright as daylight (3%).

Specific sleep concerns identified by participants during the month prior to using Swannies are shown in Figure 2. The most commonly experienced concerns were taking too long to fall asleep at night (27%) and waking up too often during the night (20%). The next most commonly experienced concerns were not feeling rested when waking up in the morning (17%) or throughout the day (15%). Several participants had a hard time falling asleep again after waking during the night (11%) or had problems with waking up too early in the morning (7%). Other concerns (2%) included little deep sleep and falling asleep early in the day.

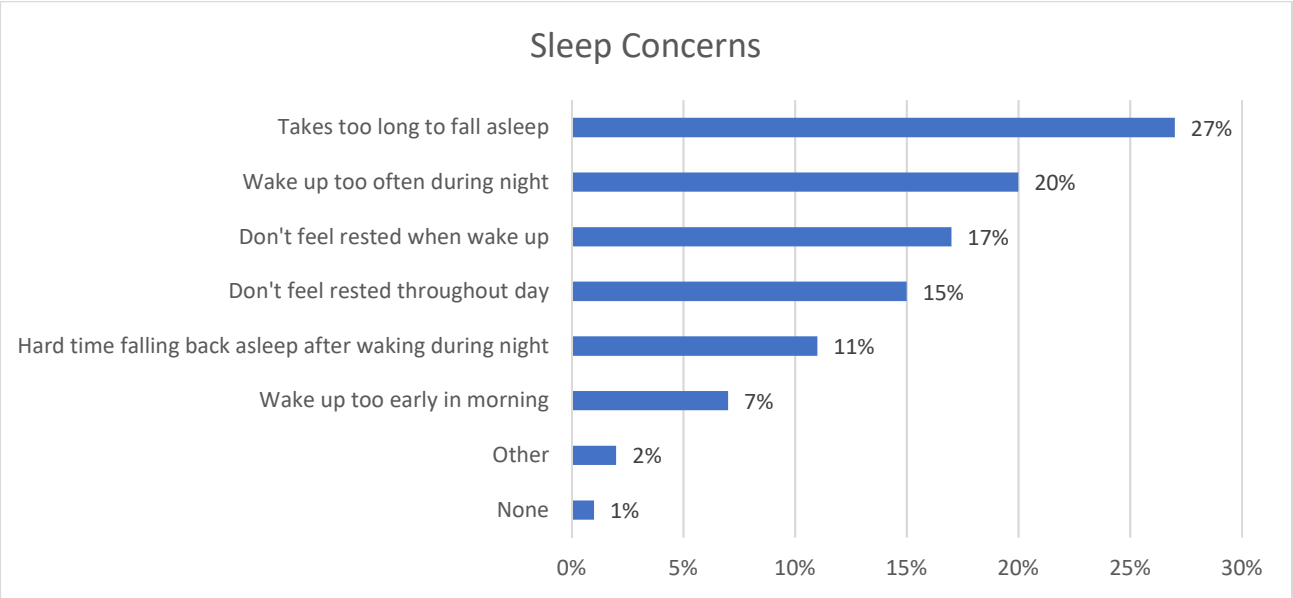

Figure 2: Perceived sleep concerns during month prior to product use.

Looking at the experience of sleep across the night, we first asked participants how sleepy they usually felt when they went to bed. On a scale from 0 (*Not sleepy at all*) to 100 (*Extremely sleepy*), participants' average for the prior month was 52. Overall, participants reported that they did *not* sleep well: On a scale from 0 (*Poor*) to 100 (*Excellent*), participants rated their sleep quality during the prior month as 48 on average. When asked how well they were able to sleep through the night without waking up, participants' average for the prior month was only 34 on a scale from 0 (*Not well at all*) to 100 (*Extremely well*). Finally, on a scale from 0 (*Not at all rested*) to 100 (*Extremely rested*), participants' average level of feeling rested in the morning during the prior month was 45. In the next section of this report, these pre-product use averages will be compared to the corresponding post-product use averages. Summarizing these responses, we can conclude that the participants did not experience their sleep as being very good overall.

Effects of Swannies on self-reported sleep

Over the course of the study, participants reported wearing Swannies for an average of 157 minutes each night (*SD* = 46.25).

The sleep experience questionnaire administered at the end of the 4-week product use period repeated questions from the pre-product use questionnaire (prior to Swannies use), allowing us to examine perceived change. Participants reported the following significant improvements when comparing sleep before using Swannies to after using Swannies for 4 weeks: 33% increase in feeling sleepy before bed ($p < .001$), 36% increase in overall sleep quality ($p < .001$), 34% increase in perception of how well they slept through the night without waking up ($p = .007$), and a 37% increase in feeling rested in the morning ($p < .001$). As shown in Figure 3, all the pre-product use average ratings were either around or below the mid-point (50), whereas all the average ratings for the product use period were above 50.

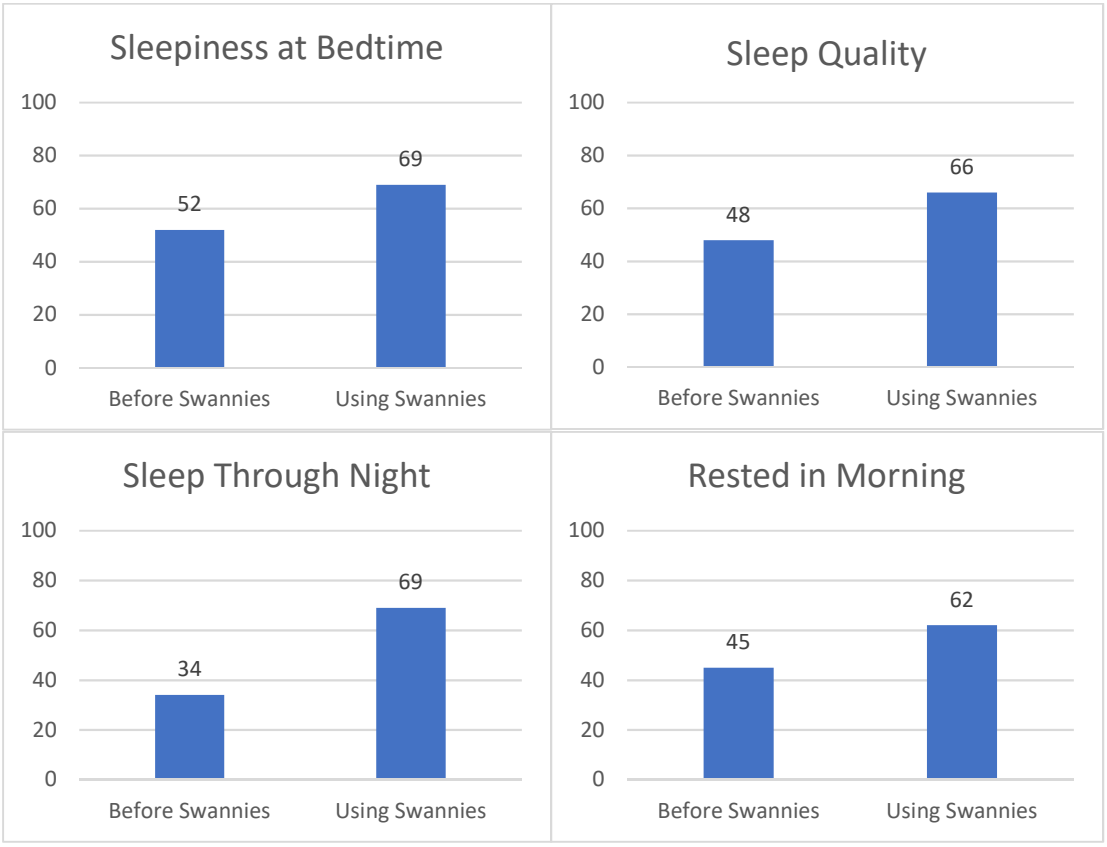

Figure 3: Perceived sleep improvements, based on comparison of ratings provided before product use to ratings provided after product use.

Although there was no notable change in perceived sleep duration before versus during product use, there were significant improvements in participants' perceptions of how long it took them to fall asleep (p = .046) and their awareness of being awake during the night (p = .006). Compared to the month before Swannies use, participants reported, on average, an 11-minute decrease in time to fall asleep, as well as a 24-minute decrease in number of minutes they were awake during the night. See Figure 4.

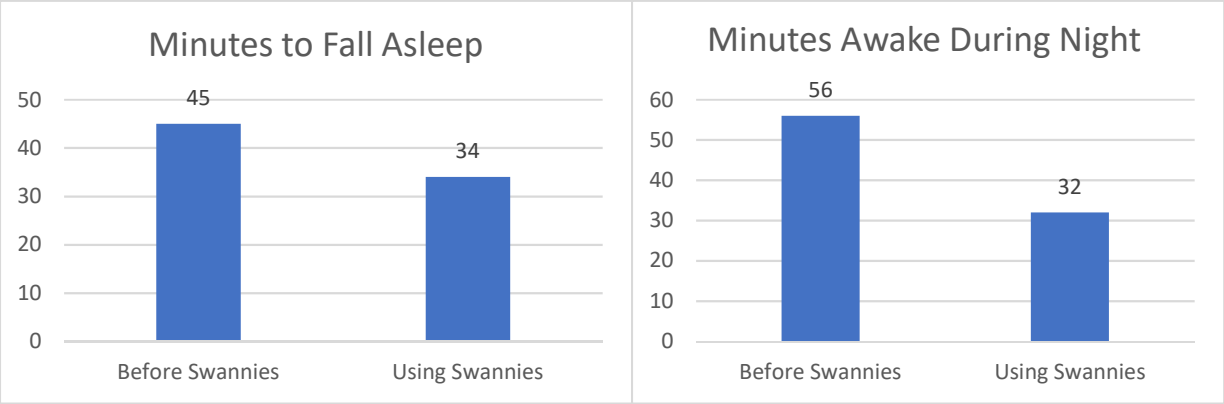

Figure 4: Perceived time to fall asleep and perceived wake duration before versus during product use.

Each morning during the product use period, participants rated on a scale of 0-100 how well they felt they slept last night (0 being *Not well at all*, 100 being *Extremely well*). Using multilevel analyses, we found that across all nights of product use, average daily sleep quality showed a significant 14% improvement, increasing from 57 on the first night to 65 on the last night ($p < .0001$). Similarly, participants rated on a scale of 0-100 how refreshed they felt each morning (0 being *Not at all refreshed*, 100 being *Extremely refreshed*). Across all nights of product use, average daily rating of feeling refreshed showed a significant 18% improvement, from 56 on the first night to 66 on the final night ($p < .0001$).

To measure the perceived effectiveness of Swannies in a single, simple question, participants were asked at the end of the study to reply *yes* or *no* as to whether they felt that Swannies improved their sleep. As shown in Figure 5, 73% replied yes.

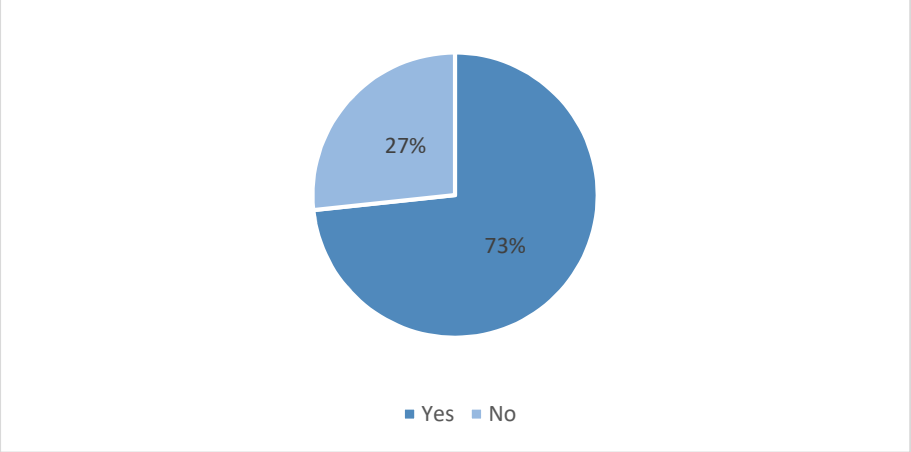

Figure 5: Perception of whether Swannies improved overall sleep.

A similar question was asked at the end of the study regarding perceived sleep onset. As shown in Figure 6, 63% of participants reported that Swannies helped them fall asleep faster.

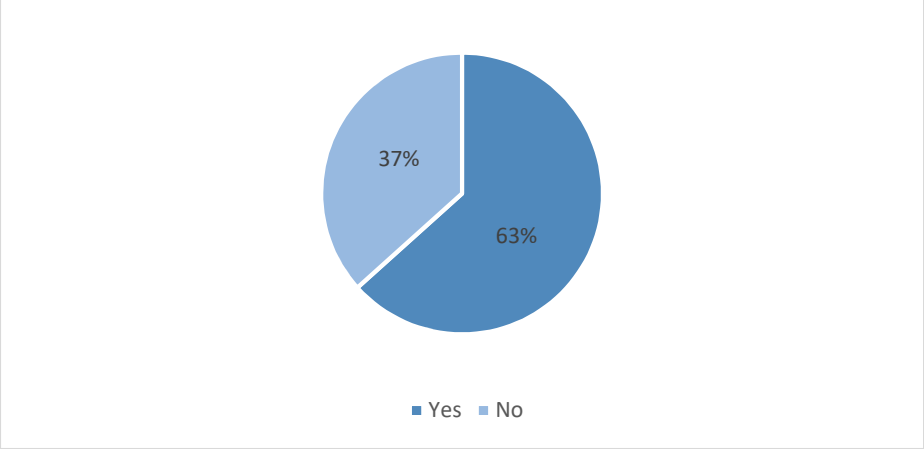

Figure 6: Perception of whether Swannies improved ability to fall asleep faster.

Effects of Swannies on objectively-measured sleep

In total for the 29 participants, there were 1317 nights of objective sleep data: 696 nights during which participants tracked their sleep before using Swannies, and 621 nights during which participants both tracked their sleep and used Swannies. The number of nights a participant tracked in the pre-product use period ranged from 11 to 28, with a mean of 24 nights. The number of nights in the product use period ranged from 7 to 28, with a mean of 21 nights.

To test whether the perceived sleep improvements would be observed in objectively-measured sleep (using S+ by ResMed), we compared participants' sleep during the full pre-product use period (before using Swannies) with their sleep during the full product use period (while using Swannies). Table 1 shows the results.

The main findings in the objective data included statistically significant improvements in metrics related to deep sleep. Specifically, Body Score significantly increased (p = .027). Prior to using Swannies, participants had an average Body Score of 72. While using Swannies, participants had an average Body Score of 74, which translates to a 3% increase. Time spent in deep sleep significantly increased in both absolute (p = .019) and relative (p = .005) terms, with participants spending 59 minutes on average in deep sleep before using Swannies (approximately 13% of sleep) and 63 minutes on average (approximately 14% of sleep) while using Swannies.

Table 1. Objective sleep and multilevel regression results comparing pre-test period to test period (*n* = 1317 nights).

	Observed		Estimated		
	Pre-test Period	**Test Period**	**Constant**	**beta**	**p-value**
SleepScore (0-100)	75.81	76.72	75.93	1.23	0.15
Mind Score (0-100)	77.78	77.50	78.24	-0.27	0.77
Body Score (0-100)	**72.39**	**73.96**	**72.25**	**1.69**	**0.03**
Total sleep time (minutes)	392.72	389.46	394.02	-5.29	0.31
Sleep onset latency (minutes)	36.75	37.00	35.98	0.92	0.56
Number of awakenings	6.49	6.33	6.59	-0.18	0.24
Wake after sleep onset (minutes)	72.73	70.23	72.16	-2.83	0.31
Light (minutes)	260.70	254.89	261.67	-7.46	0.06
REM (minutes)	72.66	71.64	73.17	-1.09	0.54
Deep (minutes)	**59.36**	**62.93**	**59.18**	**3.83**	**0.02**
% Light sleep	55.73	55.11	56.00	-0.64	0.17
% REM sleep	15.53	15.47	15.61	0.04	0.90
% Deep sleep	**13.12**	**13.90**	**12.97**	**1.01**	**0.01**
% Wake after sleep onset	15.62	15.52	15.42	-0.48	0.42

Note. For pre-test period and test period, each average was calculated by averaging nights across participants, and then averaging those participants' averages to a single simple average, listed under *Observed* in the table. Test period scores represent averages from all nights during the test period in which participants had both objective sleep data and reported wearing the Swannies glasses. Listed under *Estimated* are the outcomes of the multilevel regression analyses. Regression model was as follows: $Sleepmeasure_{ij} = Const_{0ij} + B*TestPeriod_{ij}$; TestPeriod coded as 0 for the observations prior to Swannies, and 1 for nights during the test period in which participants recorded objective data and reported wearing Swannies. Nights during the test period in which participants did not have objective data or did not report wearing Swannies were not included in analyses. Betas represent the modeled difference from pre-test to test period in each measure's units. Bold indicates statistical significance ($p < .05$) for the multilevel regression model.

User experiences with Swannies

At the end of the study, participants were given the opportunity to share their experiences and express their opinions about the product and its features. As an overall summary question, participants were asked how much they like Swannies on a scale from 0 (*I don't like them at all*) to 100 (*I like them a lot*). The average rating was 70.

Participants were asked how many nights it had taken them to get adjusted to using Swannies. The most common response was that it took only 1 night (*n* = 8, 27%). Two-thirds of respondents got used to wearing the glasses after a total of 4 nights or fewer. However, 6 participants (20%) indicated that they never got used to them. One person attributed this to the fact that they typically do not wear any glasses, and another felt that the glasses bothered their eyes. One person explained that they "love color" and disliked Swannies' tint.

Table 2 provides insight into user experiences and opinions. Overall, participants' responses were very favorable. Of note, 90% of users said it was easy to make wearing the glasses part of their nightly routine, and 90% of users felt the glasses were comfortable. However, users' experiences were split as to whether wearing the glasses made it difficult to see in dimly lit rooms.

Table 2. User experiences and opinions.

Evaluation of positive statements regarding Swannies	**Yes**	**No**
It was easy to fit using the glasses into my nightly routine.	90%	10%
The glasses were comfortable to wear.	90%	10%
My eyes were less strained when using electronics while using the glasses.	73%	27%
The orange tint of the glasses helped me relax at night.	63%	37%
I think the glasses look good on me.	57%	43%
Evaluation of unfavorable statements regarding Swannies	**Yes**	**No**
It was difficult to remember to wear the glasses at night.	17%	83%
It was difficult to read text on paper or electronic screens while using the glasses.	17%	83%
The orange tint of the glasses was unpleasant to look through.	23%	77%
I did not like how the orange tint of the glasses distorted color while watching TV or using other electronics.	40%	60%
The glasses made it difficult to see in dimly lit rooms.	47%	53%

To better understand what participants liked and did not like, we asked open-ended questions. Examples of what was liked best are shown in Table 3, sorted by themes that emerged from the comments. Participants appreciated a variety of aspects about Swannies, including blue light blocking functionality and comfort.

Table 3: Best-liked aspects of Swannies.

Theme	**Selected favorable responses**
Blue light blocking	*The Swannies glasses did help block out the blue light from my iPhone and computer.*
	The blocking of light on my electronics.
	The functionality to block blue light which I think has negatively affected my sleep.
	The way they cut out the light and didn't strain my eyes.
Strain reduction	*It reduces my eye and brain strain.*
	I really felt like when using a screen, particularly watching television, my eyes endured a lot less stress. I also felt myself getting sleepy like I would "normally" when not engaged in screen viewing.
	The tint of the glasses were very comforting to my eyes.
Relaxation	*Felt very relaxing at the end of the day wearing the glasses. Very soothing.*
	Helps me to relax.
	Relaxing while watching television at night.
	They did seem to help me relax before sleep.
Sleep	*Much better sleep!*
	I think they helped my sleep. I never used others so can't compare.
	They fit well, are comfortable, and most of all they really work to improve my sleep quality!
Comfort	*They were comfortable and did not obstruct my vision. It was easy to forget that I was wearing them.*
	The comfort, even though it's another layer over my glasses.
	Comfortable.
Cleaning	*I liked that they came with a cleaning cloth, this was nice because I found them difficult to see out of when they were smudged.*
Design	*I like that they have a fit over design.*
	The style and comfort.
	Very easy to wear over my regular glasses.

Examples of least favorable aspects of the product are presented in Table 4, sorted by themes we identified. Many participants commented on how the glasses changed their vision, such as their ability to identify colors. In contrast, 6 participants reported there was nothing they disliked about Swannies, including one person who wrote “I love them” in the comment box.

Table 4: Least-favorable aspects of Swannies.

Theme	**Selected unfavorable responses**
Not suitable for all activities	*I felt they were unpleasant in any non-electronic screen activity such as cooking or reading. The tint made it harder to see things.*
	I had to take them off occasionally or use a supplemental light when taking dogs outside or in cases where there was not enough light available.
	The tint wasn't unpleasant, but it meant some tasks, that rely on color had to be delayed.
Effects on vision	*They ruined TV watching for me. Also affected my vision.*
	The filtering out of the color blue - when shopping online I had to take them off to see the actual color of the item I wanted to buy.
	They made it difficult to identify colors of actual objects that were blue and green, not just on the computer or tv screens.
	Everything looked sepia to me like I was watching a black and white movie.
	They really changed colors of things I was looking at.
	The first 2 nights it felt like the glasses distorted the color while watching TV. The third day and forward I got used to the glasses and hardly even noticed any distortion.
	Harder to see color accurately.
Style/Size	*My wife made fun of me for how they look lol.*
	Smaller frames and metal might have been nicer.
	The frame is too small and doesn't cover sides at all, it looks ugly and sits on the nose somewhat uncomfortably.
	They did not really cover enough or block out light from the sides.
	I have a small face, and don't look that great in large -frame glasses.
	They make me look like Jeff Goldblum.
Other	*I left the glasses on a wooden nightstand and after a day the black plastic left a mark.*

When asked if they would continue to use Swannies after the study, 80% of participants answered positively (see Figure 7). One particularly enthusiastic person wrote, “Yes every single night! I just can’t imagine doing without them as this has proved to me that the Swannies do absolutely improve the quality of my sleep in every aspect!” In addition to sleep improvement, reasons to continue wearing Swannies included “relaxed my mind” and “the tint of the glass is comforting to my eyes.” On the other hand, one person commented, “They didn’t seem to do much for me. Maybe if I notice a worsening in my sleep I may try them again.”

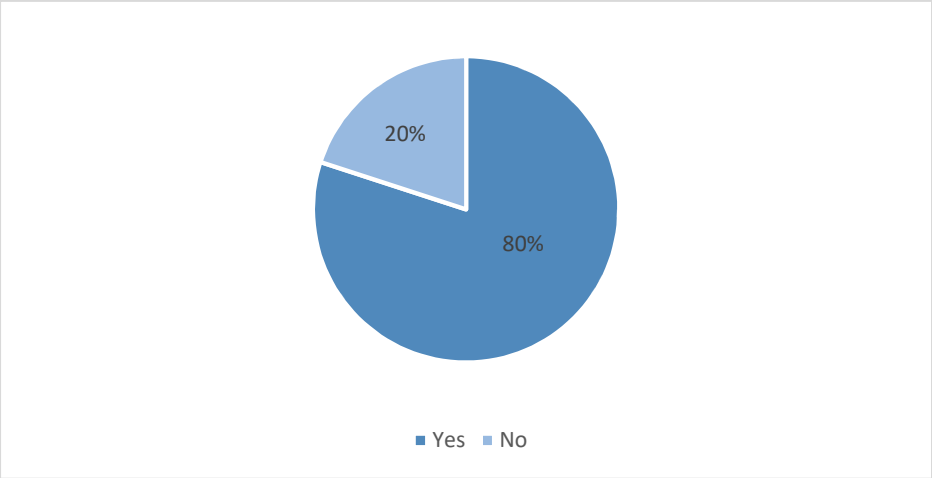

Figure 7: Intent to continue to wear Swannies in the future.

Finally, participants were asked if they would recommend Swannies to close friends or family. As shown in Figure 8, 73% of participants said yes. One participant who replied yes commented, “REALLY made a difference in my sleep & generally how I felt during the day.” Another wrote, “I believe everyone could benefit from using them.”

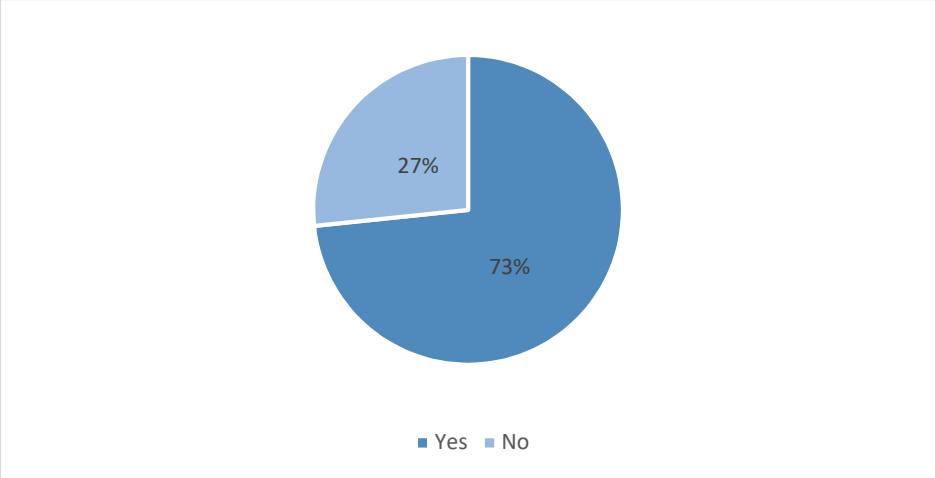

Figure 8: Recommendation of Swannies to close friends and family.

Conclusion & Discussion

We tested if Swannies would improve sleep in a sample of 30 S+ by ResMed users whose objective sleep data indicated difficulty falling asleep and/or insufficient deep sleep. The product was tested in participants' own homes over multiple nights. This way of testing has the advantage of providing insight into the effectiveness of the product under real-life conditions and hence yielding more ecologically valid results.

Using Swannies resulted in significantly improved sleep, as experienced by the participants. Specifically, Swannies led to 33% perceived improvement in sleepiness at bedtime, 11-minute perceived improvement in time to fall asleep, 24-minute perceived improvement in amount of time awake during the night, 34% perceived improvement in ability to sleep through the night, 36% perceived improvement in overall sleep quality, and 37% perceived improvement in feeling rested in the morning. In addition, self-report data collected every morning during the product use period showed significant improvement across nights in participants' perceptions of how well they slept each night (14% increase over the course of the product use period) and how refreshed they felt each morning (18% over the course of the product use period).

To test if these self-report findings would be accompanied by similar findings in the objective sleep data, we compared the 696 total nights (24 per person on average) that participants tracked their sleep using S+ by ResMed before using Swannies with the 621 nights (21 per person on average) during which participants tracked their sleep while using Swannies. We found statistically significant improvements in metrics related to deep sleep: Time spent in deep sleep significantly increased in both absolute and relative terms, with participants spending 59 minutes on average in deep sleep before using Swannies (approximately 13% of sleep) and 63 minutes on average (approximately 14% of sleep) while using Swannies. Related to this, participants had an average Body Score of 72 before using Swannies and 74 while using Swannies, a 3% increase.

Overall, 73% of users felt that Swannies improved their sleep. In addition to sleep improvement, many users commented that wearing the glasses reduced eye strain and helped them relax. Notably, 90% of users said it was easy to make wearing the glasses part of their nightly routine, and 90% of users felt the glasses were comfortable. Eighty percent of participants intended to continue to use Swannies after completion of the study, and 73% of users said they would recommend Swannies to their close friends and family.

In sum, this study found that Swannies can improve sleep, and this was seen in both self-report data and objective sleep data collected using SleepScore technology by ResMed. Participants felt that Swannies improved many different aspects of their sleep, and objective data revealed that Swannies use resulted in participants getting more deep sleep during the month they used Swannies compared to the month before using Swannies. This likely can be explained by Swannies blocking blue light and therefore preventing suppression of naturally occurring melatonin release. Deep sleep is the stage of sleep that is known to be restorative, which can explain why the participants in our study felt significantly more refreshed in the mornings after using Swannies compared to the month before using Swannies.

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