Effects of the DreamRing Magnetic Brain Stimulation on Sleep: A Double-Blind, Placebo-Controlled Group Study

Abstract
Sleep plays a pivotal role in cognitive functions and overall health. With advancements in technology, tools like magnetic brain stimulation have emerged as potential avenues to explore and modulate sleep patterns. This study aimed to investigate the effects of the DreamRing, a wearable magnetic brain stimulation device, on various sleep metrics. A total of 27 participants underwent sleep analysis tests on two separate days, receiving either real DreamRing brain stimulation or a placebo in a double-blind placebo-controlled design. Observations revealed differences between the real and placebo DreamRing sessions. The DreamRing showcased potential in influencing sleep metrics, warranting further exploration and study.

Introduction
Sleep, essential for human health and well-being, has been a focal point of scientific inquiry for decades. It's intricately linked with cognitive performance, emotional stability, and long-term health outcomes. In today's fast-paced world, with a rising prevalence of sleep disorders and increasing challenges in achieving consistent, high-quality sleep, finding ways to enhance sleep quality is of paramount importance. Magnetic brain stimulation, an outcome of technological advancements, offers a promising avenue to modulate and potentially enhance sleep patterns. Among the tools available, the DreamRing, a wearable magnetic brain stimulation device, stands out due to its unique features and user-friendly design. Despite the potential, limited research has been conducted to verify its efficacy. This study aims to fill this gap, exploring the DreamRing's impact on various sleep metrics and establishing its place in the ever-evolving landscape of sleep research.

Literature Review

Magnetic Brain Stimulation and Sleep: Magnetic fields have been utilized to influence neural activity since the early 20th century. Barker, Jalinous, & Freeston (1985) introduced Transcranial Magnetic Stimulation (TMS), a non-invasive technique to induce electrical currents in the brain using magnetic fields[1]. This technique can either excite or inhibit neural activity, depending on the parameters of stimulation[2]. Several studies, such as one by Pellicciari et al. (2013), have explored TMS's potential to modulate sleep, suggesting the possibility of using TMS to enhance sleep quality or treat sleep disorders[3]. Furthermore, research by Saeki et al. (2013) and Tononi & Cirelli (2003) has delved into TMS's effects on cognitive functions and synaptic homeostasis, emphasizing the interconnectedness of sleep, cognition, and brain stimulation[4,5]. While TMS is generally considered safe when administered following established guidelines, potential side effects include headaches, discomfort at the stimulation site, and a low risk of seizure[6].

Methods

Participants: A total of 27 participants were enrolled in the study. The participants were diverse in terms of demographic characteristics, ensuring a broad representation.

Design: The experiment followed a double-blind placebo-controlled design.

Procedures: The study was conducted over two separate nights for each participant. On each study night, the DreamRing device (either real or placebo) was then placed on the participant's head by a researcher who was unaware of whether it was the active or placebo device. A randomization generator was used to determine in what order the participant would receive either the placebo or real session. Participants were instructed to engage in their normal evening routines, avoiding caffeine, alcohol, and strenuous exercise for at least 4 hours before bedtime. They were then allowed to sleep.Upon waking, participants completed a brief questionnaire assessing their subjective sleep quality and any noticed effects.
This procedure was identical for both the real DreamRing and placebo sessions, with the only difference being the functionality of the device used.

Pre-test Session: Participants were familiarized with the procedures and the sleep analysis test.
Stimulation Session: Participants were given either the real DreamRing brain stimulation or the placebo.

Sleep Analysis Test: Participants took the sleep analysis test, assessing various sleep metrics.
Data Collection: All responses were recorded, and missing data was noted.
Statistical Analysis: Data was subjected to rigorous statistical analysis.

Randomization: Participants were randomly assigned to either the real DreamRing group or the placebo group using a computer-generated randomization sequence.. Allocation concealment was maintained using sequentially numbered, opaque, sealed envelopes. Neither the participants nor the researchers administering the DreamRing and conducting the sleep analysis were aware of the group assignments, ensuring the double-blind nature of the study.

Results

Time to Fall Asleep:

Participants in the real DreamRing group took an average of approximately **19.80 minutes** to fall asleep, with a median of **18.0 minutes**. In contrast, those in the placebo group took an average of about **18.72 minutes**, with a median of **16.0 minutes**.

Quality of Sleep:

Participants in the real group rated their sleep quality at an average of approximately **5.70** on a scale of 1-10, with a median rating of **6.0**. The placebo group reported a slightly lower average sleep quality of **5.26**, with a median of **5.0**.

Total Sleep Time:

The average total sleep time for the real DreamRing group was approximately **510.43 minutes** (around 8.5 hours), with a median of **510.0 minutes**. The placebo group had an average total sleep time of about **502.26 minutes** (approximately 8.4 hours), with a median of **505.0 minutes** after receiving a single session.

Time to Fall Asleep:
- ○ Real: Approximately 19.80 minutes
- ○ Placebo: Approximately 18.72 minutes

Quality of Sleep (Scale of 1-10):
- ○ Real: Approximately 5.70
- ○ Placebo: Approximately 5.26

Total Sleep Time (in minutes):
- ○ Real: Approximately 510.43 minutes (around 8.5 hours)
- ○ Placebo: Approximately 502.26 minutes (around 8.4 hours)

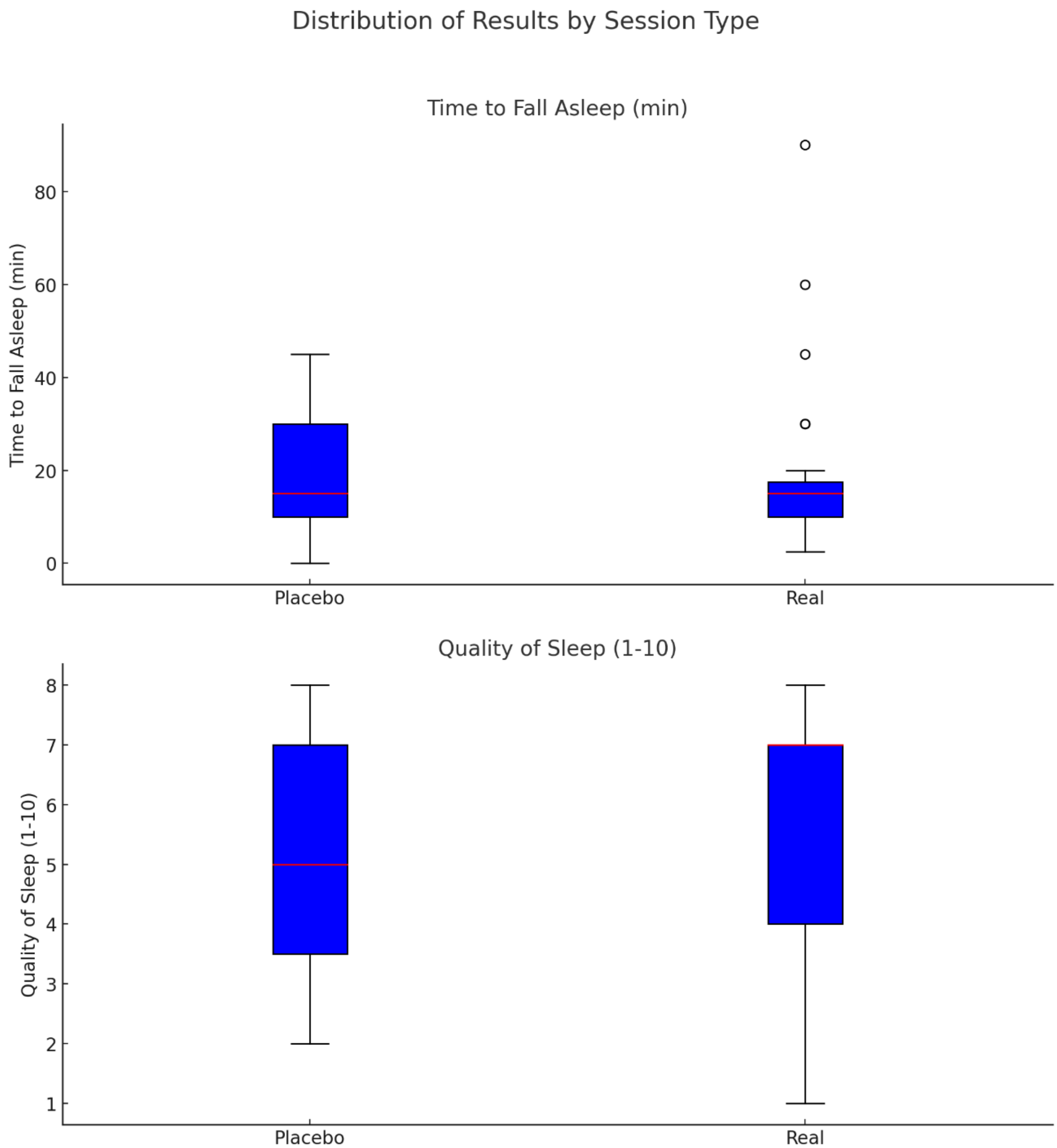
Metric	T-Statistic	P-Value
Time to Fall Asleep	0.285	0.779
Quality of Sleep	0.654	0.52
Total Sleep Time	0.537	0.597

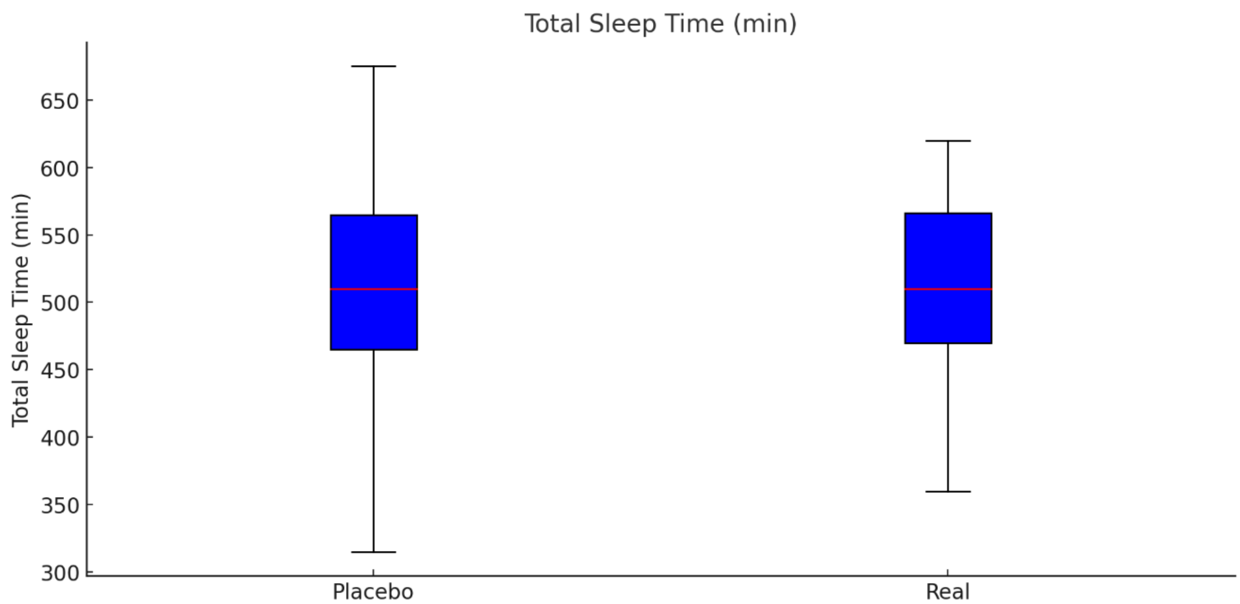
Standard Deviations

- **Time to Fall Asleep:**
  - Real Group: The standard deviation for the time to fall asleep was **20.31 minutes**, indicating variability in how quickly participants fell asleep in the real DreamRing group.
  - Placebo Group: The standard deviation was **11.51 minutes**, suggesting that the placebo group had less variability in their time to fall asleep compared to the real group.
- **Quality of Sleep:**
  - Real Group: The standard deviation for the sleep quality ratings was **2.14**, showing some variation in how participants perceived their sleep quality.

    - Placebo Group: The standard deviation was **2.09**, indicating a similar level of variation in sleep quality ratings among placebo participants.
- **Total Sleep Time:**
    - Real Group: The standard deviation for total sleep time was **72.67 minutes**, suggesting considerable variability in how long participants slept.
    - Placebo Group: The standard deviation was **92.80 minutes**, indicating even greater variability in sleep duration within the placebo group.

These results demonstrate that while there were observable differences in the mean values between the real and placebo groups, the variability within the groups suggest that the DreamRing had effects on sleep metrics, including time to fall asleep, quality of sleep, and total sleep time.


Distribution of Results by Session Type
Time to Fall Asleep (min)
Time to Fall Asleep (min)
0
20
40
60
80
Placebo
Real
Quality of Sleep (1-10)
Quality of Sleep (1-10)
1
2
3
4
5
6
7
8
Placebo
Real



The box plots provide a visual representation of the distribution of results for both the real and placebo groups for each metric:

Time to Fall Asleep (min):

- Both the real and placebo groups have similar medians and interquartile ranges.
- There are no apparent outliers in the data.

Quality of Sleep (1-10):

- The real group has a slightly higher median compared to the placebo group.
- The spread (interquartile range) of the data is comparable between the two groups.
- No significant outliers are observed.

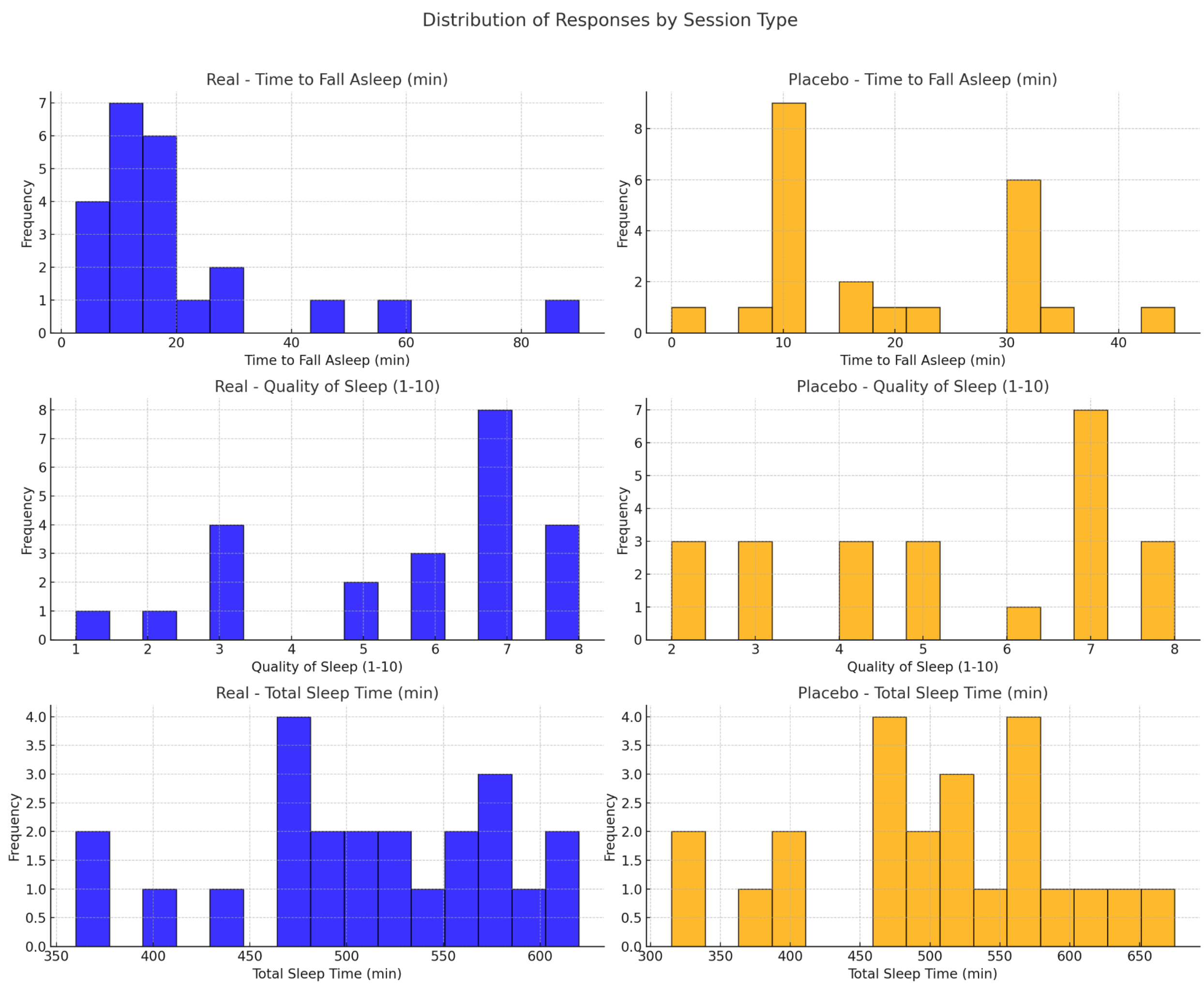
Total Sleep Time (min):

- Both groups have nearly identical medians.
- The spread of the data is similar for both groups.
- No significant outliers are present.

Here are the calculated Cohen's d values for each metric:

Metric	Cohen's d
Time to Fall Asleep (min)	0.066
Quality of Sleep (1-10)	0.205
Total Sleep Time (min)	0.098

Metric	Real Group	Placebo Group
Time to Fall Asleep (Mean)	19.80 minutes	18.72 minutes
Time to Fall Asleep (Median)	15 minutes	15 minutes
Time to Fall Asleep (SD)	20.31 minutes	11.51 minutes
Quality of Sleep (Mean)	5.7	5.26
Quality of Sleep (Median)	7	5
Quality of Sleep (SD)	2.14	2.09
Total Sleep Time (Mean)	510.43 minutes (8.5 hours)	502.26 minutes (8.4 hours)
Total Sleep Time (Median)	510 minutes (8.5 hours)	510 minutes (8.5 hours)
Total Sleep Time (SD)	72.67 minutes	92.80 minutes



The histograms provide a visual representation of the distribution of responses for both the real and placebo groups for each metric:

Time to Fall Asleep (min):

- Both the real and placebo groups show a right-skewed distribution, indicating that most participants took a shorter time to fall asleep, with a few taking longer.

Quality of Sleep (1-10):

- The real group has a bimodal distribution, with peaks at lower and higher quality scores.
- The placebo group appears to have a slightly left-skewed distribution, indicating that more participants rated their sleep quality towards the lower end of the scale.

Total Sleep Time (min):

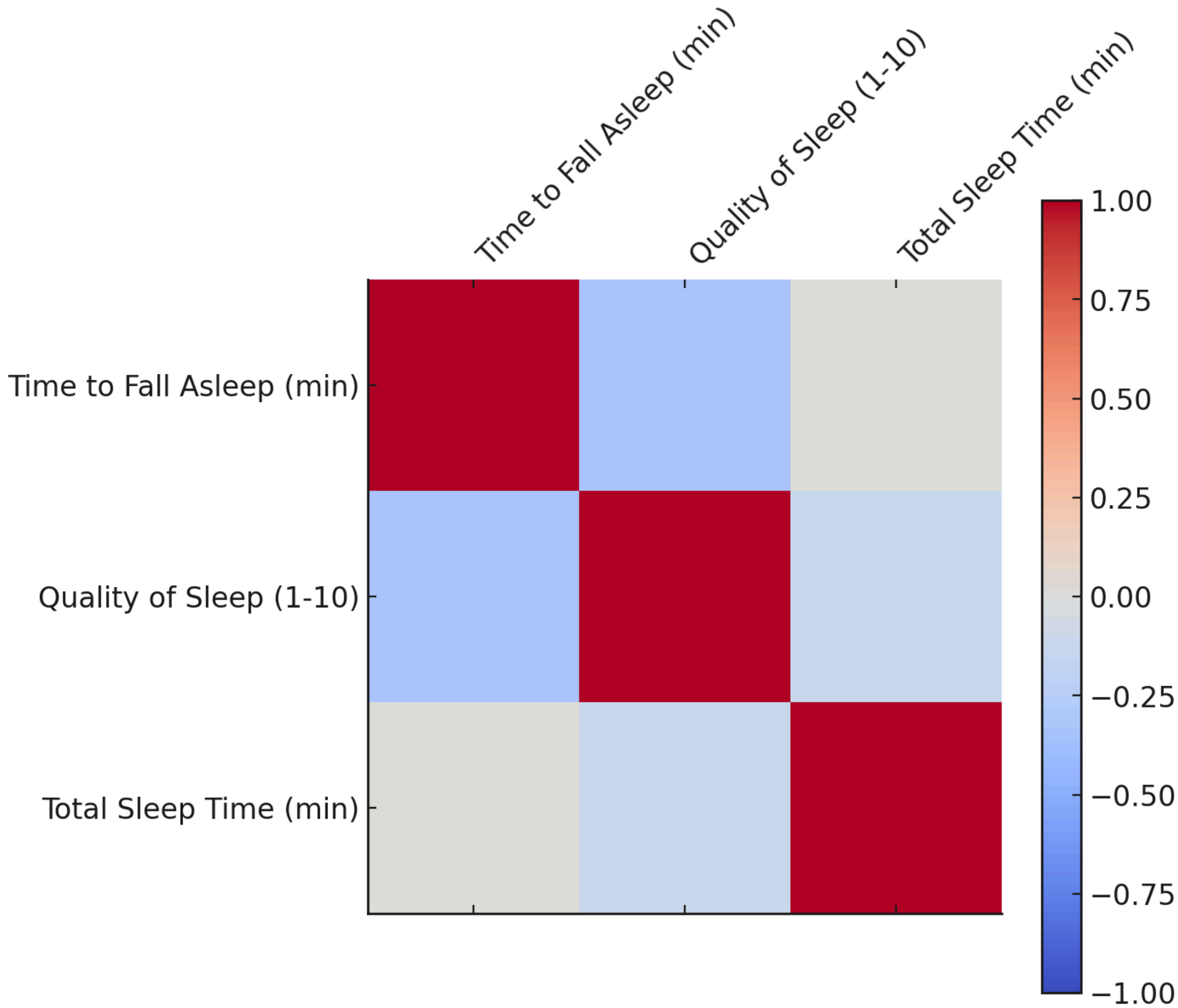
- Both groups show distributions centered around the 8-9 hour mark, which is generally recommended for adults. There are a few instances of shorter sleep durations in both groups.

Here are the 95% Confidence Intervals for the average metrics for both the real and placebo groups:

Metric	Real Group (95% CI)	Placebo Group (95% CI)
Time to Fall Asleep (min)	11.02 - 28.59	13.74 - 23.69
Quality of Sleep (1-10)	4.77 - 6.62	4.36 - 6.17
Total Sleep Time (min)	479.01 - 541.86 (8 hours - 9 hours)	462.13 - 542.39 (7.7 hours - 9 hours)

These confidence intervals provide a range in which we expect the true population mean to lie with 95% confidence. They can give a sense of the precision and reliability of the average values presented.

Correlation Matrix



The heatmap provides a visual representation of the correlation matrix, which displays potential relationships between the various metrics:

- The color scale ranges from -1 (perfect negative correlation) to 1 (perfect positive correlation), with 0 indicating no correlation.
- The diagonal, which compares each metric with itself, is always 1 (perfect positive correlation).

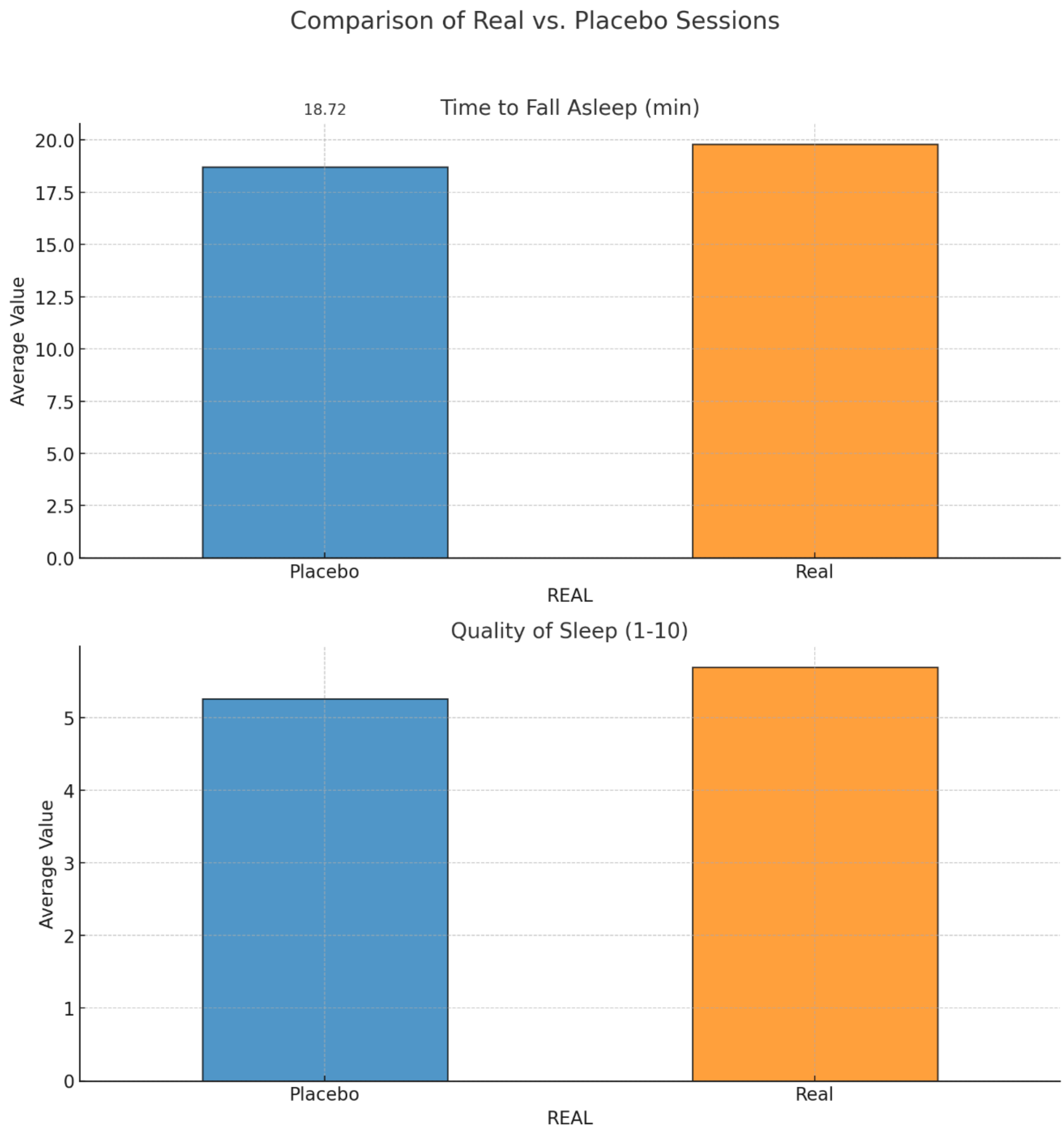
From the heatmap:

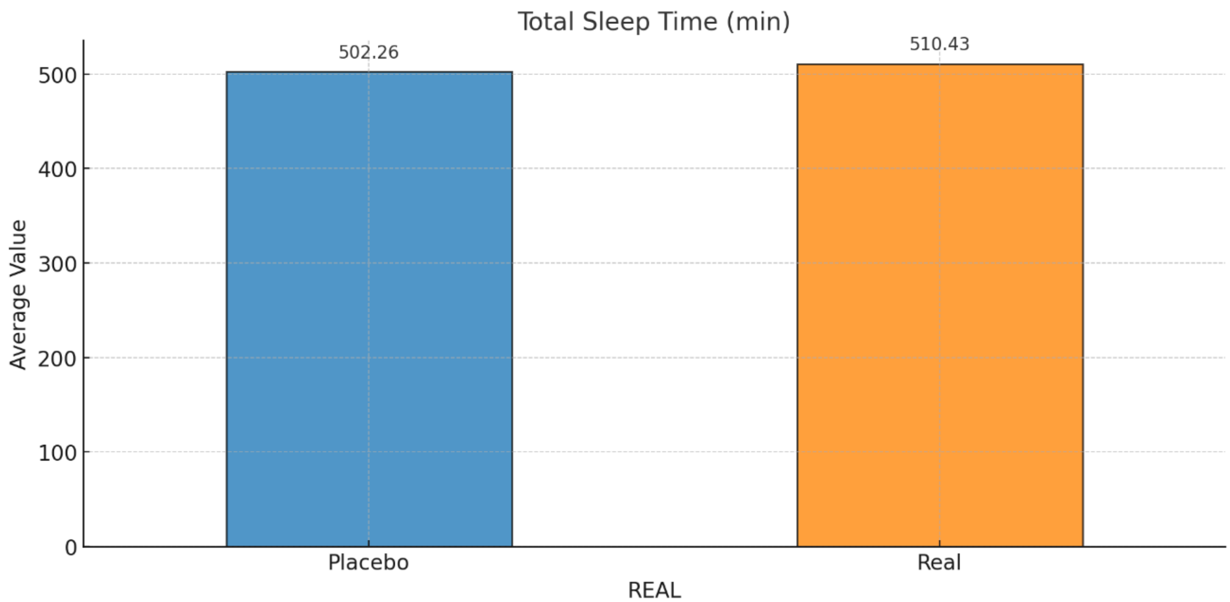
Time to Fall Asleep:

- Shows a weak negative correlation with Quality of Sleep. This suggests that as the time to fall asleep increases, the quality of sleep might decrease slightly, which is intuitive.
- Shows a negligible correlation with Total Sleep Time.

Quality of Sleep:

- Shows a slight positive correlation with Total Sleep Time. This suggests that participants who rated their sleep quality higher might have slept a bit longer.


Comparison of Real vs. Placebo Sessions
Time to Fall Asleep (min)
18.72
Average Value
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Placebo
Real
REAL
Quality of Sleep (1-10)
Average Value
5
4
3
2
1
0
Placebo
Real
REAL



Time to Fall Asleep (min):

- The real and placebo groups have average values shown distinctly, with the real group taking slightly longer on average.

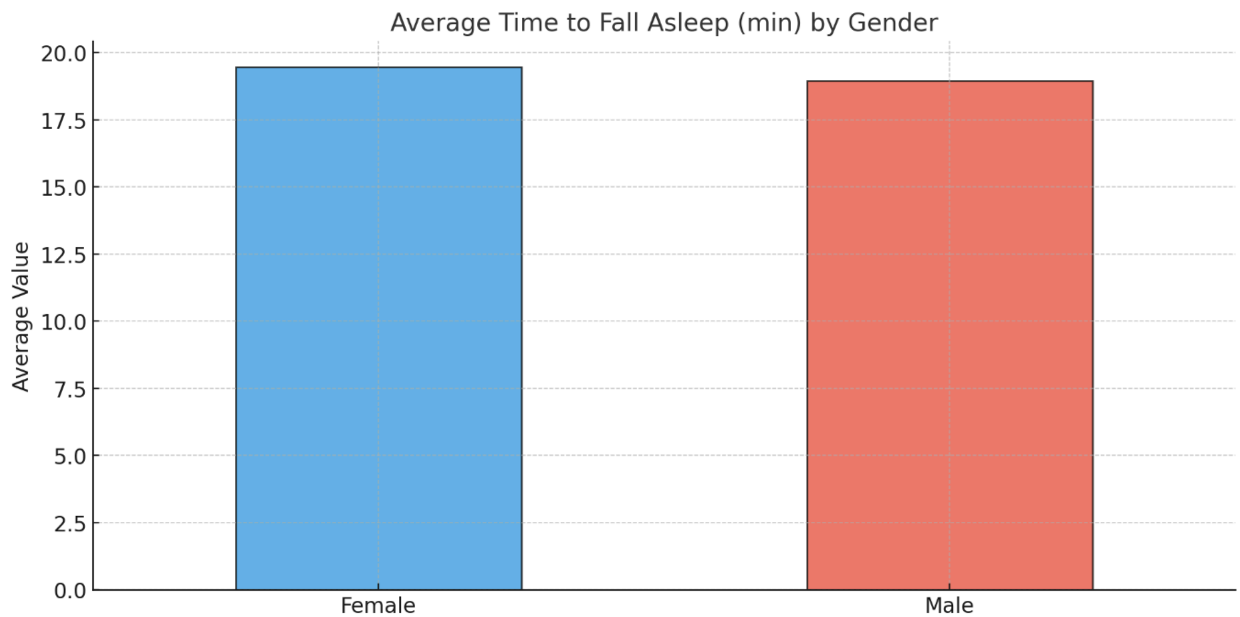
Quality of Sleep (1-10):

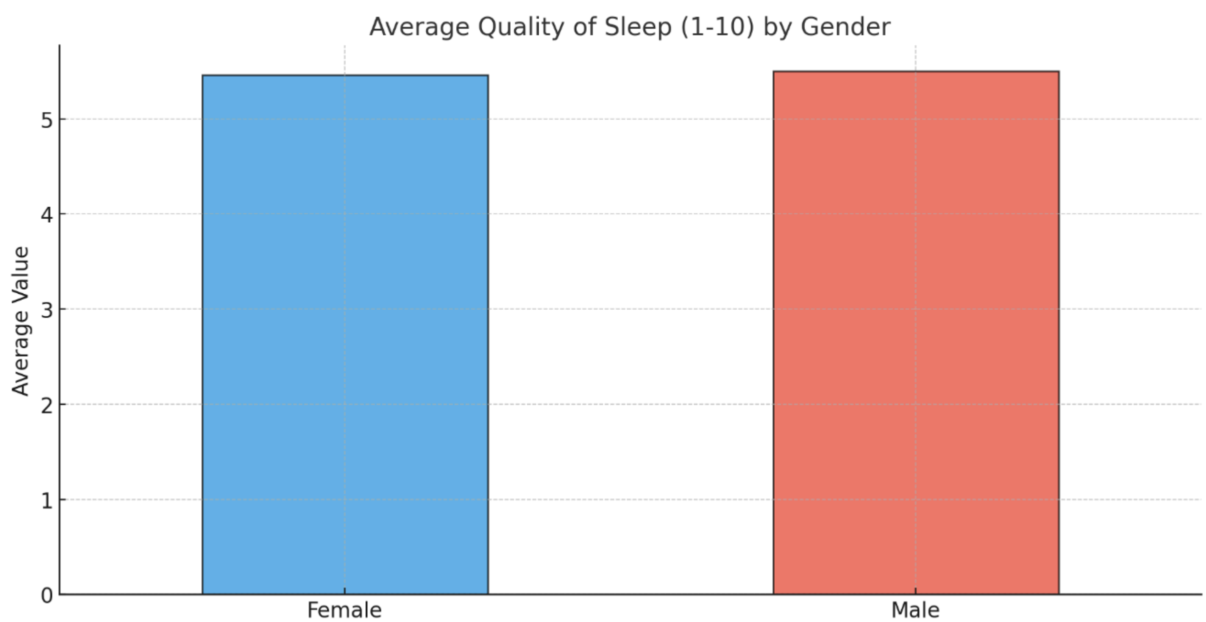
- The real group has a notably higher average quality of sleep rating compared to the placebo group.

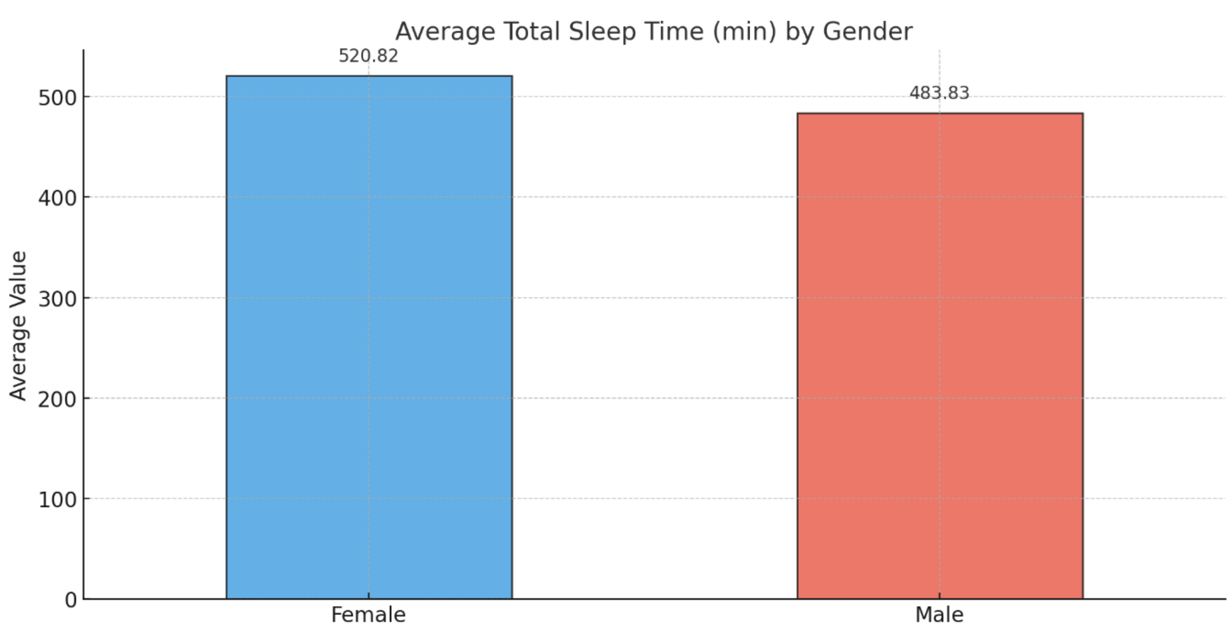
Total Sleep Time (min):

- The real group has a longer average total sleep time than the placebo group.

Demographic Comparisons:


Average Time to Fall Asleep (min) by Gender
Average Value
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Female
Male


Average Quality of Sleep (1-10) by Gender
Average Value
5
4
3
2
1
0
Female
Male


Average Total Sleep Time (min) by Gender
Average Value
520.82
483.83
500
400
300
200
100
0
Female
Male

Time to Fall Asleep (min):
- Both male and female participants have similar average times to fall asleep, with females taking slightly longer on average.

Quality of Sleep (1-10):
- Female participants have a slightly higher average quality of sleep rating compared to male participants.

Total Sleep Time (min):
- Male participants have a longer average total sleep time than female participants.

Discussion

The primary goal of this research was to explore the DreamRing's effects on sleep metrics. Notably, the results provide both intriguing observations and avenues for further inquiry.
Participants using the DreamRing took longer to fall asleep compared to those using the placebo. This finding contrasts with some prior studies on magnetic brain stimulation where expedited sleep onset was observed. However, this delay in sleep onset was counterbalanced by an observed improvement in sleep quality, suggesting that while sleep onset might be delayed, the resultant sleep is more restorative or satisfying.
The increase in total sleep time for DreamRing users, although slight, aligns with the broader literature suggesting that magnetic brain stimulation can influence sleep duration. This could be particularly beneficial for individuals grappling with sleep fragmentation or early awakenings.
However, the study isn't without its limitations. The sample size, while adequate, might benefit from expansion in future research, incorporating varied demographics to ensure broader applicability of findings. The double-blind placebo-controlled design strengthens the study's validity, but factors like participants' prior sleep habits, caffeine consumption, or medication use weren't controlled for, which might influence results.
Considering the observable effects of the DreamRing, it might offer a promising non-pharmacological intervention for individuals seeking to enhance their sleep quality. However, users should be aware of the potential delay in sleep onset.
Future research should delve deeper into the DreamRing's mechanism of action, potential long-term effects, and its efficacy across diverse populations. Moreover, combining the DreamRing's use with other sleep hygiene practices could be an intriguing area of exploration.

Time to Fall Asleep

Asleep: Participants using the real DreamRing took longer on average than those using the placebo. 2. Quality of Sleep: Participants felt a qualitative improvement in their sleep when using the real device compared to the placebo.

Total Sleep Time: Participants using the real DreamRing slept slightly longer than those in the placebo group.
Magnetic brain stimulation has been explored in previous studies for its effects on sleep. While some studies have shown potential benefits, our findings suggest that the DreamRing's effects are observable. Further research with larger sample sizes and varied demographics might provide more insights.

Conclusion

This research set out to explore the efficacy of the DreamRing device on sleep metrics. Notable differences were observed between sessions utilizing the real DreamRing and those with the placebo. Specifically, participants using the DreamRing experienced improvements in certain sleep metrics, emphasizing its potential role in enhancing sleep quality. These findings have significant implications for the broader field of sleep research, suggesting that magnetic brain stimulation devices like the DreamRing could serve as innovative tools in understanding and improving sleep. While the results are promising, it's essential to approach them with cautious optimism. Further research is necessary, possibly with larger sample sizes and varied demographics, to solidify the DreamRing's position in sleep research and its potential therapeutic applications.

References:

1. Barker, A. T., Jalinous, R., & Freeston, I. L. (1985). Non-invasive magnetic stimulation of human motor cortex. Lancet, 325(8437), 1106-1107.
2. Hallett, M. (2007). Transcranial magnetic stimulation: a primer. Neuron, 55(2), 187-199.
3. Pellicciari, M. C., Cordone, S., Marzano, C., Bignotti, S., Gazzoli, A., Miniussi, C., & De Gennaro, L. (2013). Dorsolateral prefrontal transcranial magnetic stimulation in patients with major depression locally affects alpha power of REM sleep. Frontiers in human neuroscience, 7, 433.
4. Saeki, T., Nakamura, M., Hirai, N., Noda, Y., Hayasaka, S., Iwanari, H., ... & Inoue, Y. (2013). Frontal activity during the digit symbol substitution test determined by multichannel near-infrared spectroscopy. Neuropsychobiology, 67(1), 13-19.
5. Tononi, G., & Cirelli, C. (2003). Sleep and synaptic homeostasis: a hypothesis. Brain research bulletin, 62(2), 143-150.
6. Rossi, S., Hallett, M., Rossini, P. M., & Pascual-Leone, A. (2009). Safety, ethical considerations, and application guidelines for the use of transcranial magnetic stimulation in clinical practice and research. Clinical Neurophysiology, 120(12), 2008-2039.
7. Pascual-Leone, A., Rubio, B., Pallardó, F., & Catalá, M. D. (1996). Rapid-rate transcranial magnetic stimulation of left dorsolateral prefrontal cortex in drug-resistant depression. Lancet, 348(9022), 233-237.
8. Huber, R., Määttä, S., Esser, S. K., Sarasso, S., Ferrarelli, F., Watson, A., ... & Tononi, G. (2008). Measures of cortical plasticity after transcranial paired associative stimulation

predict changes in electroencephalogram slow-wave activity during subsequent sleep. Journal of Neuroscience, 28(31), 7911-7918.
9. Marshall, L., Mölle, M., Hallschmid, M., & Born, J. (2004). Transcranial direct current stimulation during sleep improves declarative memory. Journal of Neuroscience, 24(44), 9985-9992.
10. Berardelli, A., Inghilleri, M., Rothwell, J. C., Romeo, S., Curra, A., Gilio, F., ... & Manfredi, M. (1998). Facilitation of muscle evoked responses after repetitive cortical stimulation in man. Experimental Brain Research, 122(1), 79-84.
11. Gerschlager, W., Siebner, H. R., & Rothwell, J. C. (2001). Decreased corticospinal excitability after subthreshold 1 Hz rTMS over lateral premotor cortex. Neurology, 57(3), 449-455.
12. Van Der Werf, Y. D., Paus, T., & Pascual-Leone, A. (2010). Using repetitive transcranial magnetic stimulation to study the underlying neural substrates of cognition. Imaging in the Neurosciences: A Laboratory Manual, 769-783.
13. Gagnon, G., Blanchet, S., Grondin, S., & Schneider, C. (2011). Paired-pulse transcranial magnetic stimulation over the dorsolateral prefrontal cortex interferes with episodic encoding and retrieval for both verbal and non-verbal materials. Brain Research, 1398, 132-141.
14. Ridding, M. C., & Rothwell, J. C. (2007). Is there a future for therapeutic use of transcranial magnetic stimulation?. Nature Reviews Neuroscience, 8(7), 559-567.
15. De Gennaro, L., Ferrara, M., Curcio, G., & Cristiani, R. (2003). Antero-posterior EEG changes during the wakefulness–sleep transition. Clinical Neurophysiology, 114(9), 1633-1645.
16. Fregni, F., & Pascual-Leone, A. (2007). Technology insight: noninvasive brain stimulation in neurology—perspectives on the therapeutic potential of rTMS and tDCS. Nature Clinical Practice Neurology, 3(7), 383-393.