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What is The Biological Mechanism of Nightmares?

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ABSTRACT

In this paper, we sought to understand what the biological mechanism of nightmares so that we could learn how to overcome and improve our quality of sleep. Previous research has predicted an increase in nightmares by variables such as sugar consumed prior to sleeping, an increase in serotonin levels, and frontal alpha asymmetry. In our correlational study, we tested the strength of these relationships by examining naturalistic daily changes in their variables longitudinally over a period of one week. We measured food by grams of sugar consumed prior to sleeping, serotonin levels by hours spent waking vs. sleeping, Frontal Alpha Asymmetry by frontal alpha cortical waves during resting wakefulness using a Muse headband, and nightmares by using the modified Differential Emotions Scale (see Appendix A). Data pooled across participants did not find nightmares were significantly correlated with any of the three predictor variables measured. These results suggest that those who seek to decrease nightmares should attempt to do so via methods other than manipulating sugar intake or hours of sleep. The biological cause of nightmares requires further research to be determined.

1. Introduction

1.1 Research Problem

Nightmares can alter the quality of sleep, causing a lack of motivation and difficulty focusing, and ultimately can directly affect our health. After a nightmare, confusion, anxiety, and even depression can appear the next day. Also, sleep is one of the most important elements that help people stay alert during the daytime. Poor quality of sleep due to a nightmare can lower one's performance in study and work. Fear experienced during a nightmare may cross over into waking life and increase anxiety surrounding the specific frightening elements of the nightmare. (E.g., a nightmare about snakes may increase the fear of real snakes.) Our goal of this research was to understand the causes of nightmares so that we can avoid having nightmares, decrease anxiety, and improve quality of sleep.

1.2 Literature Review

One factor previously found to predict an increase in nightmares is the type of food eaten prior to sleeping. For example, in a correlational study by Nielsen & Powell (2015), researchers surveyed 396 students to find out which foods they noticed had the greatest effect on the content of their dreams over the past two weeks. Participants were asked to complete a combination of seven

questionnaires and scales. Their sleep quality scale used a Likert Scale from one to four ("rarely" to "almost always") and included statements such as, “I wake up easily due to noise,” and, “Poor sleep gives me headaches.” Their three-factor eating questionnaire included questions such as, “When I feel really upset, I want to eat,” and, “How often do you feel hungry?” An intuitive eating scale included questions such as, “I trust my body to tell me when to stop eating,” and, “I use food to help me soothe my negative emotions.” A diet quality questionnaire included questions such as, “Yesterday, did you eat any of the following sweets: cakes, cookies, biscuits…?” and, “Yesterday, did you eat any of the following vegetables: carrots, pumpkin, or sweet potatoes that are orange inside…?” An eating behavior questionnaire used a Likert Scale from one to five ("strongly disagree" to "strongly agree") and included statements such as, “If I miss a meal I get irritable,” and, “I enjoy tasting new foods.” A perceived food-dependent dreaming questionnaire used “...three binary (yes/no) and three open-ended questions. Two binary questions asked whether participants had ever noticed foods that led to disturbing dreams or bizarre dreams while a third asked whether they had noticed if eating late at night had affected their sleep or dreams (Nielsen & Powell, 2015). Lastly, researchers used a dream characteristics questionnaire that consisted of seven items assessing four aspects of disturbing dreams: “recall frequency, clarity, realism, and color” (Nielsen & Powell, 2015). Participants noted dairy products were the most likely to create bizarre dreams, followed by sugary foods and spicy foods. Based on these results, the researchers suggested four possible causes of the correlations noted: food-specific effects (specific foods actually do affect dream content), food-induced distress (specific foods cause irritation to certain individuals, affecting dream content and or/sleep processes), folklore influences (belief that certain foods will affect dream content causes people to notice confirming examples or to be more likely to have bizarre dreams), and causal misattributions (a lack of internal awareness leads people to look for external causes for their dreams).

Another factor previously found to predict intensity of nightmares is serotonin. For example, in an experimental study by Pace-Schott et al. (2001), researchers measured the effects of two antidepressant Selective Serotonin Reuptake Inhibitors (SSRIs), paroxetine and fluvoxamine, on psychologically normal participants. In a double-blind experiment, participants were first measured for seven days at baseline, then were randomly assigned treatment with either paroxetine or fluvoxamine for 19 days. After the treatment they were measured for five days of acute discontinuation of the drugs. Participants’ sleep was measured with the Nightcap ambulatory sleep monitor, which they wore every night during the baseline seven days, the initial phase of treatment, and acute discontinuation. From the sleep monitor, researchers recorded REM eyelid movement density and REM latency. Each morning participants recorded the dreams they recalled and scored each line of these reports for its emotional content on a five-point scale using six emotions (fear/anxiety, anger, sadness, shame, joy/elation, and affection/erotic). Participants then completed a questionnaire regarding sleep quality and dream features, which featured seven questions on a five-point Likert scale rating dreams for memorability, visual vividness, amount of sound, amount of movement, emotional intensity, meaningfulness, and strangeness. The

subjective dream reports were typed up by an assistant and scored for content (bizarreness, fictive movement, and visual nouns) by three judges who were blind to participant identity.

Researchers found that while dream recall and REM sleep both decreased during SSRI treatment, intensity of dreams increased both during steady state drug treatment and acute discontinuation. Dreams were most bizarre during acute discontinuation for participants who had received fluvoxamine. Based on these results, researchers concluded that the increased brain arousal associated with aminergic SSRIs may contribute to dream intensity participants experienced while under SSRI treatment.

A third factor previously found to predict an increase in nightmares is Frontal Alpha Asymmetry (FAA). For example, in an experimental study by Sikka et al. (2019), over two nights in the lab researchers awakened participants every five minutes during REM sleep and had them orally report their dream content. Participants then rated their dream affect using a Likert scale, the modified Differential Emotions Scale (mDES), which included questions such as, "What is the most stressed, nervous, or overwhelmed you felt?" and, "What is the most joyful, glad, or happy you felt?" Two external judges read the dream reports and rated the affect expressed in the reports using the same Likert scale. Participants also rated their affect before going to sleep. Researchers used EEG to measure participants' brain activity during resting wakefulness and REM sleep. They recorded Frontal Alpha Asymmetry; that is, the difference in alpha power between right and left frontal cortical regions. Based on previous studies, decreased alpha power in the left frontal area/increased alpha power in the right frontal area has been found to predict both trait and state anger. In the Sikka et al. study, both the EEG measurements and the dream reports showed that increased alpha power in the right frontal region while sleeping also predicted anger experienced in dreams. They also found that FAA experienced in a resting wakeful state predicted dream anger. The only other dream affect predicted by FAA was Hate/Distrust/Suspicion, which researchers considered to be highly related to anger. Based on these results, the researchers suggested that dreaming and waking anger are similar in how they are expressed through brain activity, and that people who experience more alpha power in the right frontal cortex while waking are more likely to experience anger in subsequent dreams.

1.3 Hypotheses

Based on the above literature review, we predicted the following hypotheses:

- Hypothesis #1: If sugar intake increases then nightmares will tend to increase.
- Hypothesis #2: If serotonin level increases then nightmares will tend to increase.
- Hypothesis #3: If right frontal cortical region alpha waves increase during sleep then nightmares will tend to increase.

2. Methods

2.1 Participants

The three authors of this paper served as the participants in its studies. The participants ranged in age from 22 to 36 years old, with an average age of 27 years, and included two females. The participants were all undergraduate students at Camosun College who completed the current studies as an assignment for Psyc 215

("Biopsychology") and were grouped together due to their mutual interest in nightmares.

2.2 Materials and Procedures

We first performed a correlational study to concurrently test all our hypotheses by examining naturalistic daily changes in their variables longitudinally. Each participant kept a study journal with them at all times over this study's one-week period in order to record self-observations of the following three variables: (1) sugar consumed, (2) serotonin levels, (3) right frontal cortical region alpha waves.

Food Consumption - To measure how the type of food consumed prior to sleeping affects dreams, for 11 days participants used a journal to record the food they consumed prior to sleeping and the dreams they could recall the next morning. Prior to sleeping they recorded the grams of sugar in the last food they consumed before sleeping. The next morning, within 10 minutes of waking, they recorded in their journal what they could recall from their dreams that night and rated their dream affect using the modified Differential Emotions Scale (see Appendix A for a complete list of items used in this questionnaire).

Serotonin - To measure how serotonin levels affect the presence of nightmares, for 11 days participants used a journal to record the number of hours they were awake during the day. This was because serotonin levels increase during waking. On the other hand, serotonin levels decrease during sleep, so participants were also asked to record the number of hours they were asleep during the night.

Frontal Alpha Asymmetry - To measure FAA, we used an EEG device, the Muse headband. Participants wore the headband during resting wakefulness for two minutes in each recording, measured for 11 days. Both left and right frontal alpha waves were recorded. FAA measurements were compared with participants' reported dream affect to see whether resting wakefulness activity in the frontal cortex had a relationship to participants' dream affect.

Nightmares - To measure nightmares, we used the Modified Differential Emotions Scale (see Appendix A). Participants recorded any dreams they remembered in a journal each morning and then rated their dream affect using the Modified Differential Emotions Scale. We calculated our score by adding together the score of all questions recorded by each participant.

2.3 Statistical Analyses

To assess the strength and statistical significance of associations between variables predicted by our three hypotheses, we performed Pearson product-moment correlations of their predictor variables sugar intake, serotonin levels, and right frontal cortical alpha waves with their outcome variable (increase in nightmares). For testing Hypothesis #1, we correlated sugar intake with an increase in nightmares. For testing Hypothesis #2, we correlated serotonin levels with an increase in nightmares. For testing Hypothesis #3, we correlated right frontal cortical alpha waves with an increase in nightmares. We performed all the above correlations separately for each participant as well as using data pooled across all the participants. For the correlations using pooled data, in addition to using the raw data, we also performed correlations after we had first transformed the data from each participant into *z*-scores in order to standardize differences in averages and variability seen between the participants in their data and thus make them more comparable. A correlation coefficient was considered statistically significant if the probability of its random occurrence (*p*) was

< .05 (i.e., less than 5% of the time expected by chance alone).

3. Results

This study did not find statistical significance for the correlation of nightmares with any of the three variables measured (see Table 1). Sugary foods did not exhibit any correlation to nightmares, either in pooled raw data (r = -0.05, p = 0.83; see Figure 1) or pooled standardized data (r = 0.32, p = 0.15; see Figure 2). The association between serotonin and nightmares was not significant for either pooled raw data (r = -0.16, p = 0.48; see Figure 3) or pooled standardized data (r = 0.24, p = 0.29; see Figure 4). Right frontal alpha did not correlate significantly with nightmares in pooled raw data (r = 0.09, p = 0.72; see Figure 5) or pooled standardized data (r = 0.10, p = 0.69; see Figure 6). Although it did not reach statistical significance, sugar showed the strongest correlation, with the pooled standardized data at p = 0.32.

4. Discussion

4.1 Summary of Results

Based on previous research, we hypothesized that increases in three variables would be followed by an increase in nightmares: the amount of sugar consumed prior to sleeping (Hypothesis #1), an increase in serotonin levels during waking (Hypothesis #2), and an increase in right frontal cortical alpha waves (Hypothesis #3). Data pooled across participants in our correlational study did not support the predicted relationships. The result suggests that increased levels of sugar, serotonin, and right frontal cortical region alpha waves did not affect participants' level of nightmares.

4.2 Relation of Results to Past Research

Our correlational study failed to confirm the relationship between the amount of sugar consumed prior to sleeping and an increase in nightmares reported by previous research. Nielsen and Powell (2015) found that an increase in the amount of sugar consumed prior to sleeping increased the chances of having a nightmare. One way our correlational study differed from that of Nielsen and Powell (2015) is that we did not record the kind of sugar being consumed: processed, refined, or natural. In previous research, refined sugar was found to have the highest correlation with an increase in nightmares. We recommend that future studies record not only the amount of sugar consumed but the type of sugar being consumed, which can allow researchers to measure results more precisely.

Our correlational study failed to confirm the relationship between serotonin levels during waking and an increase in nightmares reported by previous research. An increase in serotonin had previously been found to correlate with an increase in nightmares (Pace-Schott et al., 2001). Participants in the original study were given SSRIs to increase serotonin, whereas we measured serotonin increase due to wakefulness versus sleeping. Our serotonin manipulation may not have been strong enough to create significant results.

Our correlational study failed to confirm the relationship between right frontal cortical alpha waves and an increase in nightmares reported by previous research (Sikka et al., 2019). Unlike the original study, we did not take EEG measurements close to sleeping, which may have resulted in less overlap between resting wakefulness

and dream states. We also did not measure EEG while participants were asleep, relying instead only on the mDES for our definition of nightmares. Therefore, we could not see the correlation between waking and sleeping right frontal cortical alpha waves, which may have given us more significant results.

4.3 Implications of Results

Our study did not find statistical significance for any of the three variables measured: sugar consumed prior to sleeping, serotonin levels during waking, and right frontal cortical alpha waves. Data was collected throughout an 11-day period. Even though this amount of time gave our correlational study statistical power, the lack of statistical significance may have been due in part to our small sample size.

We originally wanted to understand the biopsychological causes of nightmares to prevent their frequency. Our correlational study did not find statistical significance. From our research, it appears that neither amount of sugar consumed prior to sleeping, hours spent awake, nor resting wakeful right frontal alpha waves predict the emotional content of dreams we experience. The results of our correlational study suggest that people experiencing nightmares should not attempt to alter sugar intake or amount of hours awake as a means to decrease nightmares. Further research is needed to gain more understanding of the biopsychological factors of nightmares. This may eventually lead to solutions that will decrease the anxiety and impact on sleep caused by nightmares.

References

Nielsen, T., & Powell, R. A. (2015). Dreams of the rarebit fiend: Food and diet as instigators of bizarre and disturbing dreams. *Frontiers in Psychology, 6*. https://doi.org/10.3389/fpsyg.2015.00047

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Sikka, P., Revonsuo, A., Noreika, V., Valli, K. (2019). EEG frontal alpha asymmetry and dream affect: Alpha oscillations over the right frontal cortex during REM sleep and presleep wakefulness predict anger in REM sleep dreams. *The Journal of Neuroscience*, *39*(24), 4775-4784. doi:10.1523/JNEUROSCI.2884-18.2019

Table 1

Correlations for Study Variables

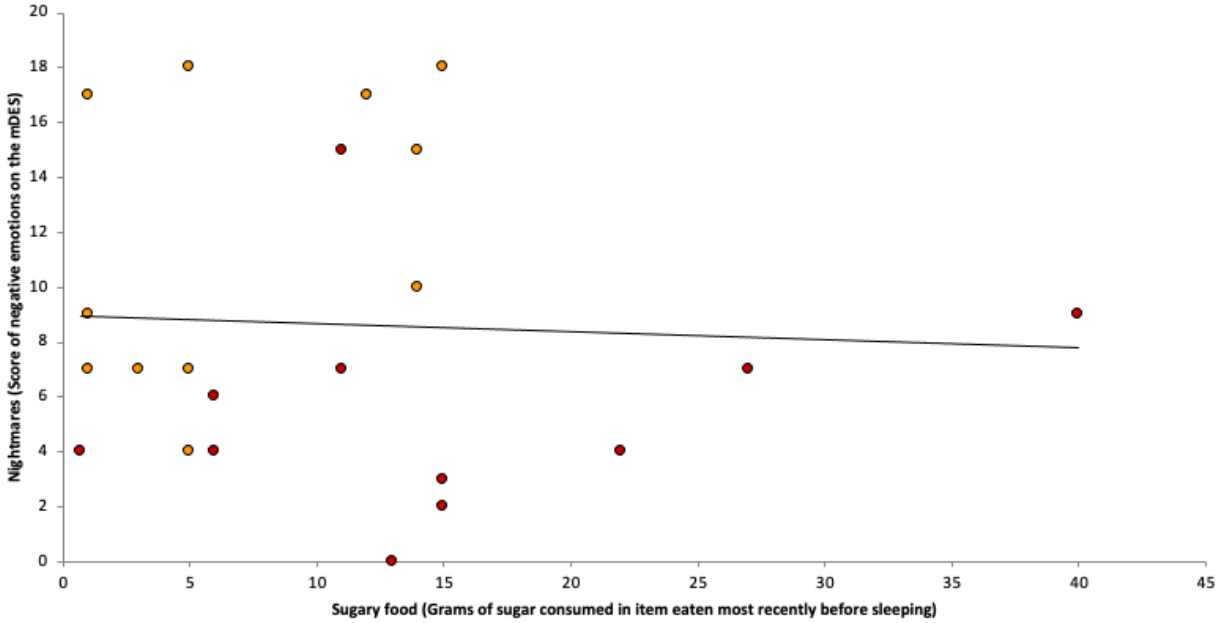
Variables	Participant #1		Participant #2		Pooled raw data		Pooled standardized data	
	r	*n*	*r*	*n*	*r*	*n*	*r*	*n*
Sugar and nightmares	*0.21*	*11*	*0.44*	*11*	*-0.05*	22	0.32	22
Serotonin and nightmares	0.07	11	0.41	11	-0.16	22	0.24	22
Right Frontal Alpha and nightmares	0.42	10	-0.23	10	0.09	20	0.10	20

Notes. *r* = correlation coefficient, *n* = number of days sampled.

* $p < .05$.

Figure 1

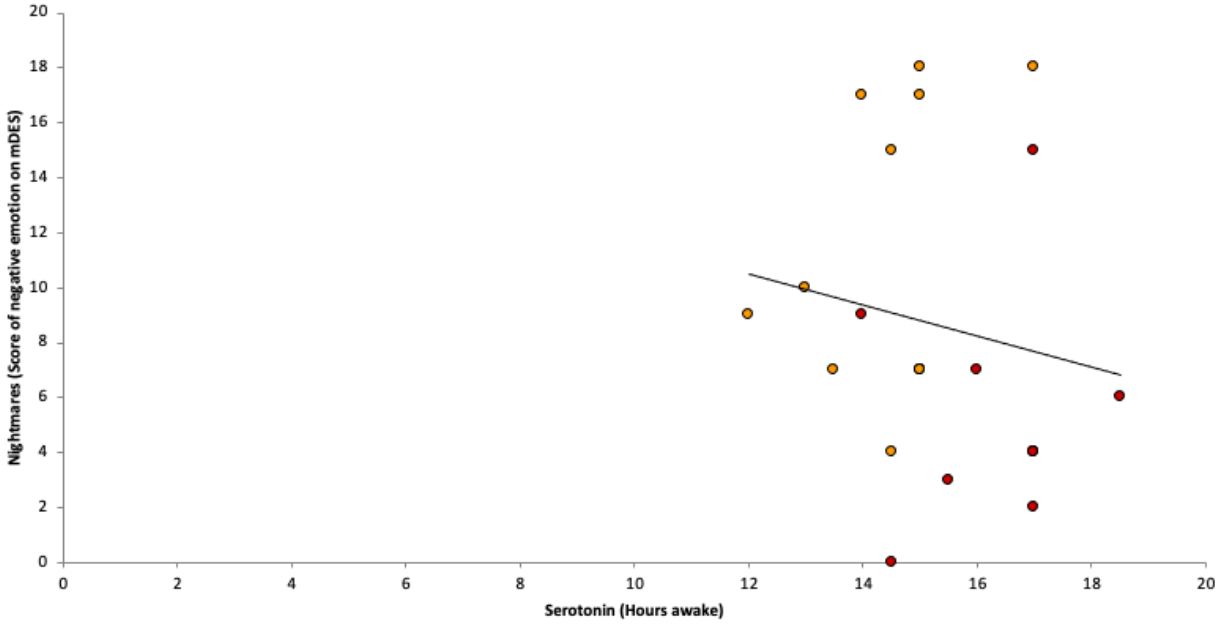
Association Between Sugar and Nightmares Using Pooled Raw Data



Notes. Marker colour differentiates participants: red = participant #1 and orange = participant #2. Some data might not be visible in the figure due to overlapping markers.

Figure 2

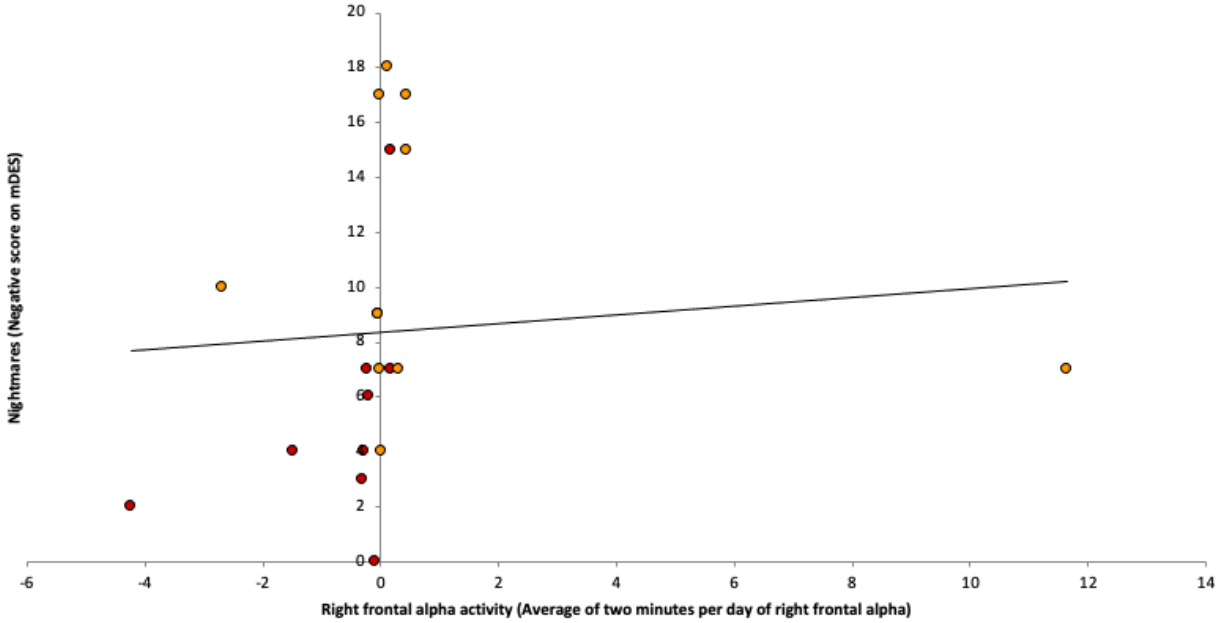
Association Between Serotonin and Nightmares Using Pooled Standardized Data



Notes. Marker colour differentiates participants: red = participant #1 and orange = participant #2. Some data might not be visible in the figure due to overlapping markers.

Figure 3

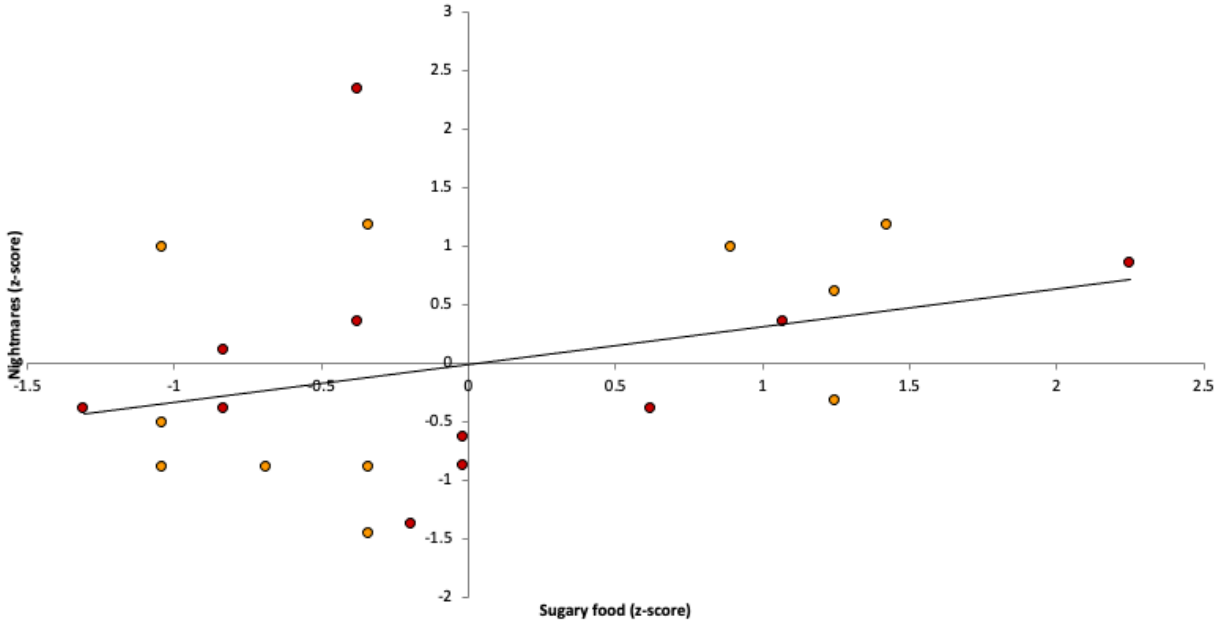
Association Between Right Frontal Alpha and Nightmares Using Pooled Raw Data



Notes. Marker colour differentiates participants: red = participant #1 and orange = participant #2. Some data might not be visible in the figure due to overlapping markers.

Figure 4

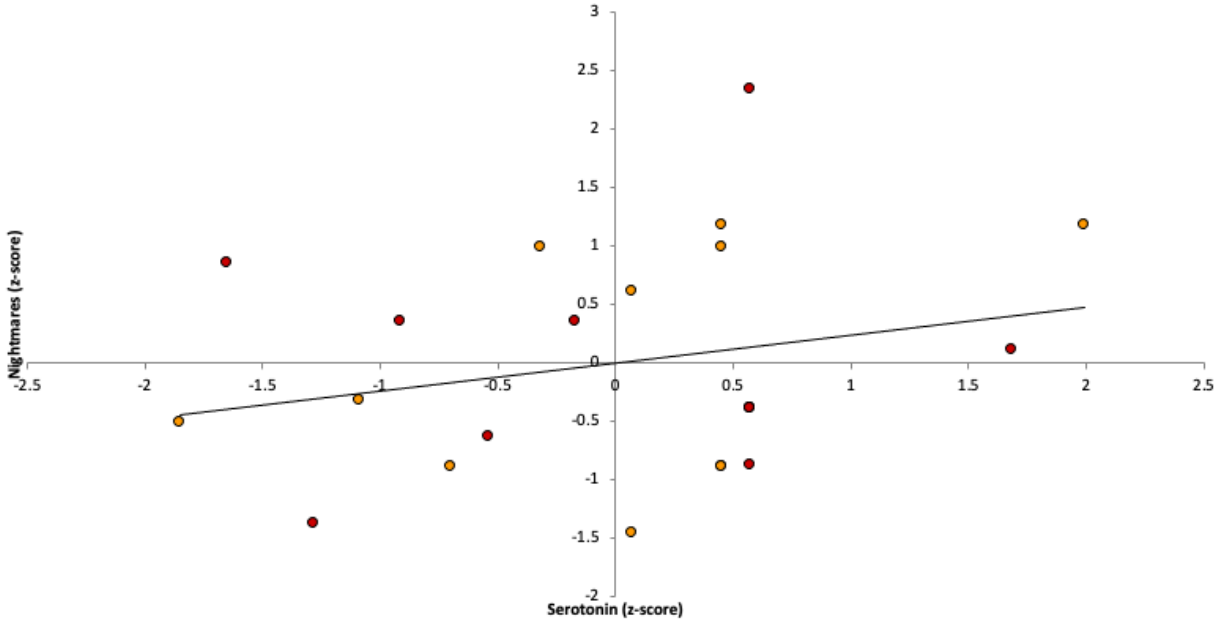
Association Between Sugar and Nightmares Using Pooled Standardized Data



Notes. Marker colour differentiates participants: red = participant #1 and orange = participant #2. Some data might not be visible in the figure due to overlapping markers.

Figure 5

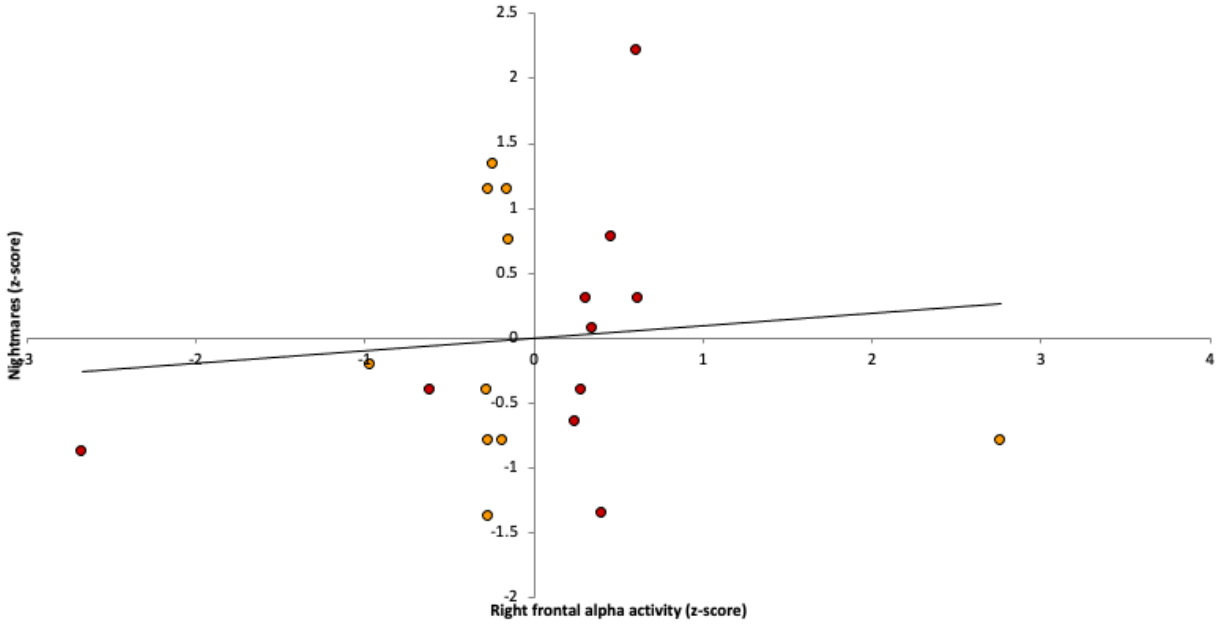
Association Between Serotonin and Nightmares Using Pooled Standardized Data



Notes. Marker colour differentiates participants: red = participant #1 and orange = participant #2. Some data might not be visible in the figure due to overlapping markers.

Figure 6

Association Between Right Frontal Alpha and Nightmares Using Pooled Standardized Data



Notes. Marker colour differentiates participants: red = participant #1 and orange = participant #2. Some data might not be visible in the figure due to overlapping markers.

Appendix A

Modified Differential Emotions Scale (mDES)

Instructions:

Please think back to how you have felt during the past 24 hours. Using the 0-4 scale below, indicate the greatest amount that you've experienced each of the following feelings.

0 = Not at all, 1 = A little bit, 2 = moderately, 3 = Quite a bit, and 4 = Extremely

___1. What is the most amused, fun-loving, or silly you felt?

___ 2. What is the most angry, irritated, or annoyed you felt?

___3. What is the most ashamed, humiliated, or disgraced you felt?

___4. What is the most awe, wonder, or amazement you felt?

___5. What is the most contemptuous, scornful, or disdainful you felt?

___6. What is the most disgust, distaste, or revulsion you felt?

___7. What is the most embarrassed, self-conscious, or blushing you felt?

___8. What is the most grateful, appreciative, or thankful you felt?

___9. What is the most guilty, repentant, or blameworthy you felt?

___ 10. What is the most hate, distrust, or suspicion you felt?

___11. What is the most hopeful, optimistic, or encouraged you felt?

___12. What is the most inspired, uplifted, or elevated you felt?

___13. What is the most interested, alert, or curious you felt?

___14. What is the most joyful, glad, or happy you felt?

___15. What is the most love, closeness, or trust you felt?

___16. What is the most proud, confident, or self-assured you felt?

___17. What is the most sad, downhearted, or unhappy you felt?

___ 18. What is the most scared, fearful, or afraid you felt?

___19. What is the most serene, content, or peaceful you felt?

___20. What is the most stressed, nervous, or overwhelmed you felt?