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The Role of Higher Protein Diets in the Regulation of Mood and Sleep in Patients with Metabolic Syndrome

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The Role of Higher Protein Diets in the Regulation of Mood and Sleep in Patients with Metabolic Syndrome

An Honors Thesis submitted in partial fulfillment of the requirements for Honors Studies in Biology

By

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Introduction

Metabolic Syndrome is becoming a more prevalent health issue within the United States, currently affecting 22% of adults (Capuron et al., 2008). Several factors contribute to the diagnosis of Metabolic Syndrome, including obesity, high levels of triglycerides, elevated blood pressure, and low high-density lipoprotein cholesterol. Metabolic Syndrome puts those who have it at an increased risk for numerous diseases, such as type 2 diabetes, cardiovascular disease, and cancer (Jennings et al., 2007).

Several studies have shown that Metabolic Syndrome plays a negative role in sleep and mood of those with the disease. Individuals with Metabolic Syndrome often have poor sleep quality, which could contribute to worsening of the risk factors associated with the disease (Hung et. al 2013). Metabolic Syndrome has also been linked to obstructive sleep apnea and is prevalent in those with the disease (Parish et al., 2007). There is also evidence that short sleep duration and poor sleep quality are associated with obesity, one of the risk factors for Metabolic Syndrome (Jennings et al., 2007).

Individuals with Metabolic Syndrome are more susceptible to symptoms of certain psychological disorders, such as depression (Capuron et al, 2008). An additional study has shown that out of the patients diagnosed with bipolar disorder, 49% of them were obese, which is an indicator of Metabolic Syndrome. The same study also showed that the factors of Metabolic Syndrome negatively impacted the patient's emotional well-being, physical health, quality of life, and self-esteem (Fagiolini et al., 2005).

One method that has been shown to help those with Metabolic Syndrome has been higher protein diets. Higher protein diets have been shown to improve markers of Metabolic Syndrome by reducing fasting blood glycose levels, improving post meal insulin response, and reducing cholesterol levels (Layman & Baum, 2005). In addition, higher protein diets increase weight loss in those with metabolic syndrome, which in turn improves their sleep duration and sleep quality (Zhou et al., 2016). Research also shows that those with high protein diets experience less sleep disorders, such as insomnia, than those with low protein diets (Jennings et al., 2007).

The **objective** of this study is to determine the role of higher protein diets on the regulation of mood and sleep in patients with Metabolic Syndrome. The **hypothesis** for the study is that a higher protein diet will create a better quality of sleep for the individuals and lengthen their sleep duration, as well as create an increase in the emotional well-being of the individuals through increased weight loss and improved regulation of blood glucose control.

Materials and Methods

<u>Participant Recruitment and Consent</u>**.** A total of eleven participants (male and female, 18+ years) with Metabolic Syndrome (characterized by participant having three or more of the following measurements: abdominal obesity, triglyceride level over 150 mg/dl, HDL cholesterol < 40 mg/dl in men and 50 mg/dl in women, systolic blood pressure of 130 mm Hg or diastolic blood pressure of 85 mm Hg, and/or fasting glucose > 100 mg/dL) were recruited to participate in the study. Participants also had to be consuming a lower protein diet (less than 20% of total calorie intake) before enrolling in the study. Ethical approval for the study was obtained from the Institutional Review Board at the University of Arkansas. Written consent was obtained from all individuals who participated in the study.

There were three phases of the recruitment plan. In *Phase 1* of the recruitment, we advertised for participants using the University digital newspaper, which is distributed to all faculty, staff, and students on a daily basis. We advertised on the Center for Human Nutrition website and with the local newspaper and public radio station. We also advertised using flyers within the Food Science Department. Finally, we used social media (E.g., Facebook, Twitter, and Instagram) and relied on word-of-mouth. *Phase 2* of recruitment involved a phone screening. All information will be kept confidential. Individuals who had food allergies, diet restrictions, recently dieted (past 3 months), were taking medication that could impact cholesterol or glucose metabolism, or had any other diet-related conditions that would prevent them from consuming a high protein diet, were excluded from the study. In addition, individuals who used illicit drugs or abuse alcohol, were pregnant or breastfeeding were also excluded from the study at the time. *Phase 3* was the final stage of recruitment, which was an in-person screening. Height and weight and baseline cardiometabolic markers were confirmed at this time using a Cholestech LDX Analyzer (Columbus, OH). The consent forms were also explained and signed at this time.

Study Design. The participants (n=11) were assigned to a dietary treatment that consisted of a higher protein diet with >30% of calories coming from protein. At the beginning of the study, the participants were informed of different foods and meals that would fit within the high protein diet. They were given different tools to allow them to follow the diet easier, such as measuring cups and recipes. Each participant followed the high protein diet for 28 days, and then came back in for measurements and surveys. The study lasted a total of 16 weeks.

Anthropometrics: Measurements were taken on a monthly basis, which was every 4 weeks. Body height was measured to the nearest 0.1 cm using a stadiometer (Detecto, St. Louis, MO) with subjects barefoot, in the free-standing position. Body weight was measured in the fasting state with subjects without shoes to the nearest 0.05 kg using calibrated balance scales (Detecto, St. Louis, MO). Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared. Body composition was measured at the beginning of the intervention using dual x-ray absorptiometry (DEXA), which was to control the energy expenditure measurements to kg of lean mass. Waist-hip ratio (WHR) was calculated by measuring the circumference of the waist (cm) and dividing it by the circumference of the hips (cm).

Assessment of Sleep and Well-being: At the beginning of every 4-week cycle, mood/emotions, sleep, and physical activity were assessed. Sleep was assessed using the Pittsburg Sleep Quality Index (PSQI) and by using an Actigraph monitor to track sleep in real-time. The PSQI involved a questionnaire, and it assessed the overall quality of sleep of the participants. Questions on the questionnaire related to various aspects of sleep, such as sleep efficiency and use of sleeping medication. The Actigraph monitors were issued to each participant, and they tracked the duration of real-time sleep. Mood and emotions were assessed using Profile of Mood States (POMS) questionnaires. POMS assesses six main mood states, which includes tension, depression, anger, vigor, fatigue, and confusion.

Results

Participant Characteristics

The study consisted of a total of eleven participants. **Table 1** shows the participant characteristics, which includes age, sex, weight, height, BMI, WHR, fat mass, and ethnicity. These measurements were taken at the beginning of the study at baseline.

Table 1. Participant Characteristics, n = 11	
Age (yr)	38.2± 10.9
Sex:	
Male	2
Female	9
Anthropometrics: Baseline	
Weight, (kg)	91.6 ± 17.0
Height, (cm)	162.2 ± 7.8
BMI, (kg/m^2)	34.6 ± 5.1
WHR, (WHR)	0.92 ± 0.06
Fat Mass, (%)	46.7 ± 4.5
Ethnicity:	
Caucasian	8
Hispanic	1
Asian	1
African American	1

Anthropometrics

Weight, Body Mass Index, Waist-Hip Ratio

Table 2 shows the average measurements for all of the participants that were recorded throughout the 16-week study. The mean bodyweights of the participants did change over 16 weeks; however, there was not a significant decrease or increase in weight throughout the study ($P > 0.05$). There was not a significant change in the mean BMI measurements throughout the study ($P >0.05$). The figure also includes the mean WHR measurements of the participants, in which there was not a significant change over 16 weeks ($P >0.05$).

Table 2

	Baseline	Week 4	Week 8	Week 12	Week 16
Weight, (kg)	91.6 ± 17.0	90.8 ± 16.6	90.7 ± 17.0	90.8 ± 17.0	91.1 ± 17.1
BMI, (kg/m^2)	34.6 ± 5.1	34.3 ± 4.8	34.2 ± 4.9	34.3 ± 5.0	34.4 ± 5.0
WHR, (W/H)	0.92 ± 0.06	0.91 ± 0.06	0.91 ± 0.06	0.91 ± 0.06	0.90 ±0.06

Table 2. The results from the measurements for mean weight (kg), mean BMI (kg/m^2), and mean WHR (W/H). There was not a significant change in weight throughout the study ($P > 0.05$). Since there was not a significant weight change, that lead to there not being a significant change in BMI or WHR throughout the 16 weeks ($P > 0.05$).

Assessment of Sleep and Well-being

Pittsburgh Sleep Quality Index (PSQI)

Figure 1 displays the mean results with standard deviation from the PSQI global scores. The mean score represents the quality of sleep overall that the participants were experiencing throughout the study. The results show that there was a significant decrease in the mean global scores ($P < 0.05$). A higher mean score would indicate that the participants were experiencing an overall poor sleep quality; therefore, since there was a significant decrease, the overall sleep quality of the participants improved.

Figure 1

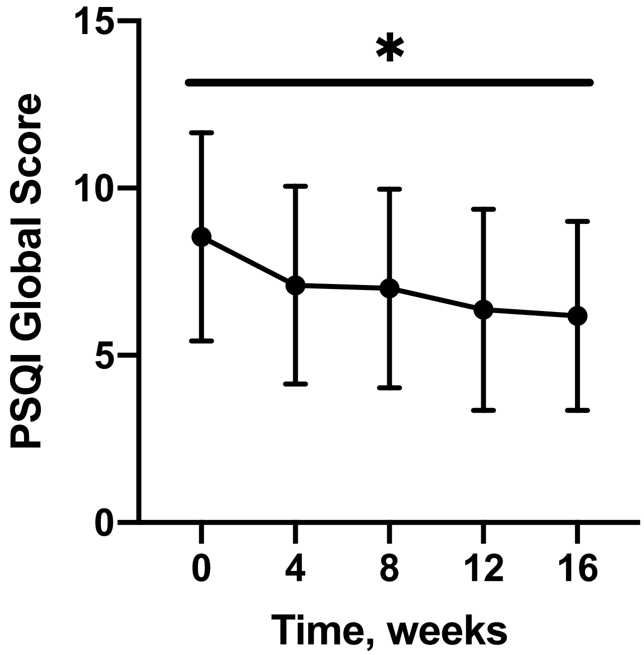

Figure 1. The mean values with standard deviation for the Pittsburg Sleep Quality Index global scores at each 4-week interval for a total of 16 weeks. The graph shows a significant decrease in the mean PSQI global scores, with the baseline week being the highest score and Week 16 being the lowest score ($P<0.05$).

Profile of Mood States (POMS)

Figure 2 displays the mean results from the Total Mood Disturbance Scores with standard deviation of the participants throughout the 16-week study. The POMS questionnaire was administered to each participant at the beginning of every 4-week cycle. The questionnaire asks questions about six mood states which includes Tension, Depression, Anger, Vigor, Fatigue, and Confusion. The total score takes into account all of the mood states. The equation used for the total mood disturbance scores is summing all of the mood states and then subtracting vigor. **Figure 2** shows that although there was a decrease in the mean total mood disturbance score throughout the study, there was not a significant decrease ($P > 0.05$). **Figure 3a** shows the mean results from the mood state Tension scores with standard deviation. There was a significant decrease in the mood state tension throughout the study, which would indicate that the participants moods improved in regard to feelings of tension ($P < 0.05$). The mood state Depression is shown in **Figure 3b**. There was not a significant decrease or increase in the mood state depression ($P > 0.05$). **Figure 4a** shows the mean results for the mood state anger with standard deviation. The results indicated that there was not a significant increase or decrease in the mood state anger throughout the study ($P > 0.05$). The mean results with standard deviation for the mood state fatigue are shown in **Figure 4b**. The results showed that there was not a significant change in the mean scores for the mood state fatigue during the study ($P > 0.05$). **Figure 5a** portrays the mean results with standard deviation for the scorings of the mood state confusion. The results showed that there was not a significant change in the mood state confusion ($P > 0.05$). The mood state vigor is shown in **Figure 5b**. The results show that there was not a significant change in the mood state vigor throughout the study ($P > 0.05$). Overall, the only significant change in regard to the profile of mood states was the mean results for the mood state tension.

Figure 2

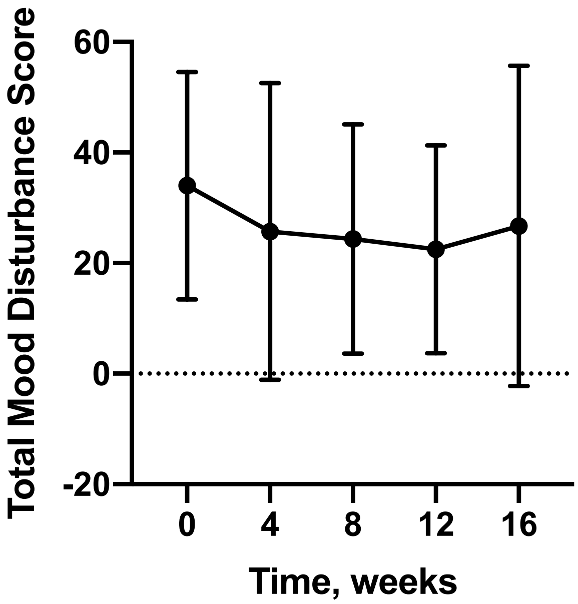

Figure 2. The mean total mood disturbance scores with standard deviation taken at each 4-week time interval for a total of 16 weeks. Although the graph shows that the baseline week score was higher than the Week 16 score, there was not a significant decrease in the score throughout the study.

Figure 3a

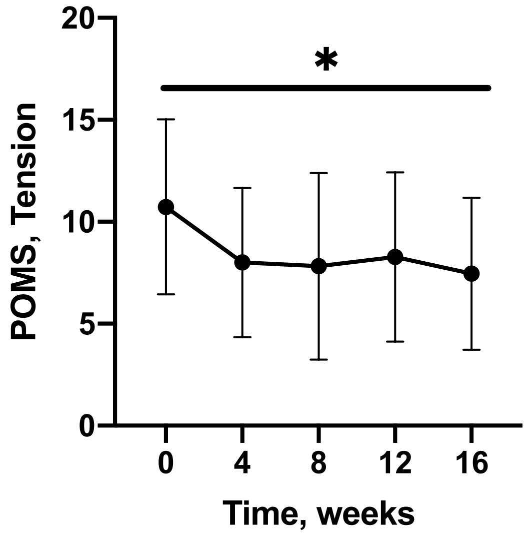

Figure 3b

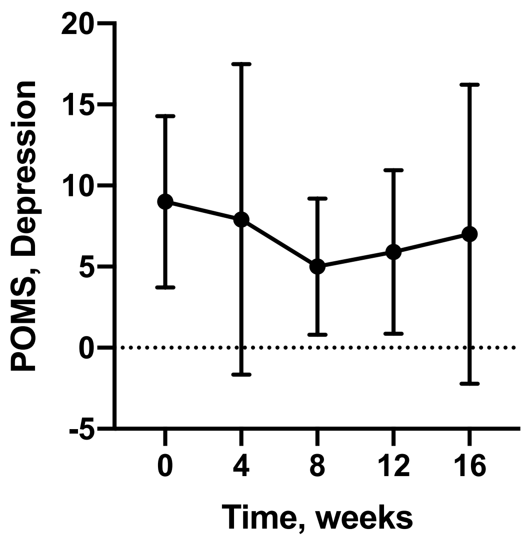

Figure 3. Mean mood states scores with standard deviation at each 4-week interval for a total of 16 weeks. Figure 3a shows a significant decrease in tension throughout the study (P<0.05). Figure 3b shows a decrease in depression throughout the study, but the decrease was not significant.

Figure 4a

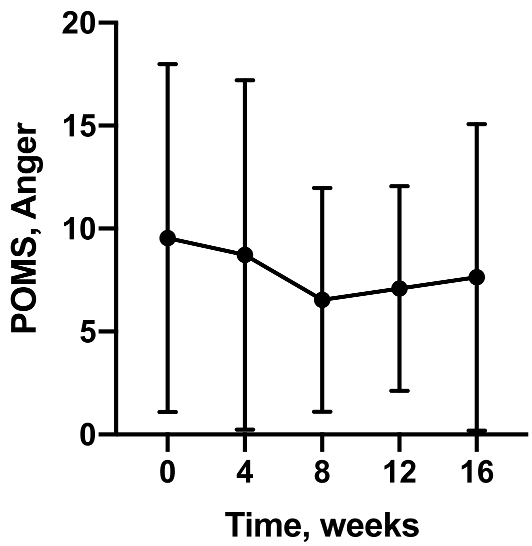

Figure 4b

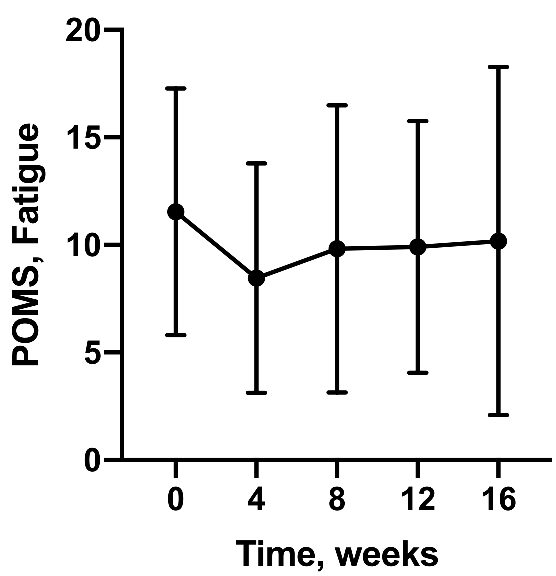

Figure 4. Mean mood states scores with standard deviation at each 4-week interval for a total of 16 weeks. Figure 4a shows a decrease in anger throughout the study, but the decrease was not significant. Figure 4b shows a decrease in fatigue, but the decrease was not significant.

Figure 5a

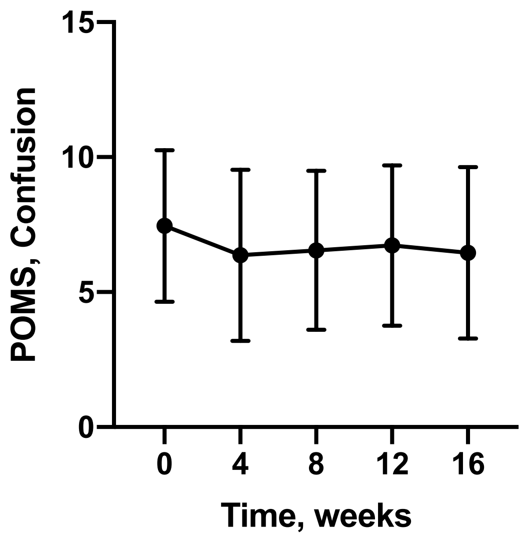

Figure 5b

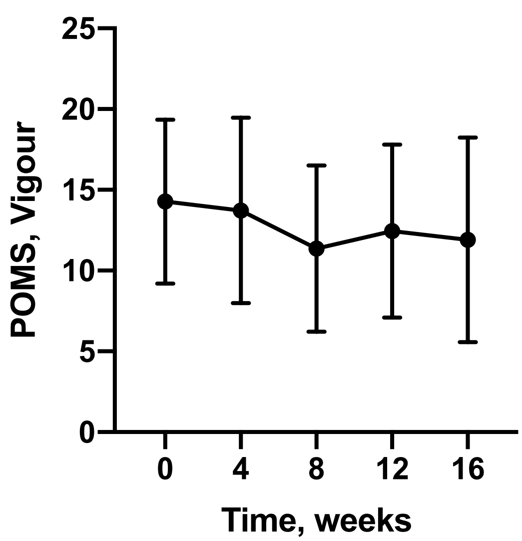

Figure 5. Mean mood states scores with standard deviation at each 4-week interval for a total of 16 weeks. Although Figure 5a shows a decrease in confusion throughout the study, the decrease was not significant. Figure 5b shows that the decrease in vigor was not significant.

Discussion

Results from this study show that consuming a higher protein diet may improve sleep quality and better emotional well-being in regard to feelings of tension, which supports our hypothesis. These findings suggest that individuals with metabolic syndrome can improve their sleep quality and feel less tense by consuming a diet higher in protein.

The results from the study showed that the body weight of the participants did not significantly change throughout the study. Since the body weights of the individuals did not change significantly, there was also no significant change in BMI or WHR. Results from other literature show that a decrease in weight leads to better sleep quality and changes in mood (Alfaris et al., 2015). A study that included women who were in the early stages of metabolic syndrome and type 2 diabetes showed that a high protein diet led to weight loss, which opposed our findings (Te Morenga et al., 2011). Another study that included participants with metabolic syndrome showed that a high protein diet leads to a reduction in WHR, which also opposes the results from our study (Campos-Nonato et al, 2017). It is possible that if the individuals in our study had a decrease in weight, that it could contribute to a further improvement in quality of sleep and emotional well-being.

Data showed that there was a significant decrease in the PSQI global score throughout the study. One study, that also involved the PSQI, showed that those who with metabolic syndrome reported poor sleep quality and had high PSQI scores, which agree with the findings in this study (Okubo et al., 2014). The PSQI scale takes into account an individual's sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of medication, and daytime dysfunction (Buysse et al., 1988). A decrease in the scoring indicates that the overall sleep quality of the participants improved. These findings suggest that a higher protein diet is correlated with better sleep quality in patients with metabolic syndrome. This study correlates with other current literature, which suggest that a high protein diet can lead to longer sleep duration and a better quality of sleep in individuals who are obese, which is a factor of metabolic syndrome (Willi et al., 1998). Another study showed that in increase in protein intake can lengthen the sleep duration of individuals, which also supports the findings in our study (Grandner et al., 2013). Current literature, along with this study, suggests that a diet high protein can lead to an overall better quality of sleep.

In regard to mood, the results from the POMS questionnaire showed that overall, there was no significant change in mood states. The POMS questionnaire looks at six mood states that are identifiable and can be measured, which includes tension, depression, anger, vigor, fatigue, and confusion. The only significant change was the mood state tension, which showed to decrease throughout the study. Tension encompasses multiple feelings, such as anxiety, worry, and being on edge. This data correlates with current studies that also used the POMS questionnaire to evaluate the moods of the participants. These studies also found that the emotional well-being of obese adults improved after consuming a high protein diet (Breymeyer et al., 2016). Another study that involved participants who were obese and had type 2 diabetes, which are both factors of metabolic syndrome, also showed an increase in emotional well-being after consuming a high protein diet (Watson et al., 2018). In contrast, one study showed that after consuming a high-protein meal, the moods of the participants did not improve (Lemmens et al., 2011). The findings in our study suggest that a higher protein diet may improve the mood state tension, but more data is needed to show a correlation between a high protein diet and an overall increase in emotional well-being in patients with metabolic syndrome.

Even though the results supported the hypothesis that a higher protein diet creates better sleep quality and improves emotional well-being in individuals with metabolic syndrome, the study still had limitations. One of the main limitations of the study was that there were only eleven participants. Since there were certain parameters that the participants had to meet, it was difficult to find individuals that qualified. If the study implemented more recruitment and had another cycle of participants, then the number of individuals could have possibly increased. More data on a larger number of participants would help to strengthen the conclusions of the results. Additionally, further research could be done on participants without metabolic syndrome to see if higher protein diets still play a role in the regulation of mood and sleep. This study focused on individuals with metabolic syndrome specifically; therefore, it cannot be concluded that a high protein diet improves sleep and emotional well-being in those without metabolic syndrome.

As metabolic syndrome continues to increase throughout the world, it is important for individuals to maintain healthy diets and lifestyle practices. With those who have metabolic syndrome, it is suggested that changing to a high protein diet can lead to better physical and mental health. According to this study, consuming a high protein diet leads to a better quality of sleep and can even improve emotional well-being in regard to tension in those with metabolic syndrome.

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