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Smartphone Ecological Momentary Assessment: Adherence, Stress, and Sleep Study

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Abstract

It is known that lack of sleep correlates with more stress throughout the day. In this unique study, we utilize participants smartphones to complete surveys through a hyperlink via text message. The use of smartphones could help because stress and sleep can only be measured at a moment's notice. A sample of 8 participants were assessed for Pittsburgh Sleep Quality Index (PSQI), Perceived Stress Scale (PSS), College Student's Stressful Event Checklist (CSSEC) along with their height, weight, and blood pressure at baseline. Next, participants were asked to respond to five scheduled surveys over the next two days where they completed records about food and drink intake, exercise, and questions from the Perceived Stress Scale 4 (PSS4) and Positive and Negative Affect Scale (PANAS). Our results indicated that reported sleep and the PSS at baseline were indirectly and strongly related with a coefficient correlation of -0.82. This suggests that less sleep results in a higher PSS score. There is little research done on smartphone ecological momentary assessment where participants answer can answer questions about stress and sleep, we can implement so much more stress factors for future research seeing that this is just a pilot study.

Key Words: Pittsburgh Sleep Quality Index, Perceived Stress Scale, College Student's Stressful Event Checklist, Ecological Momentary Assessment, REDCap

Smartphone Ecological Momentary Assessment;
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Stress is a nationwide public health concern that is affecting health of many people. Everyone has experienced stress in one way or another. There is a trend between stress and the consumption of high-calorie and high-fat foods. “38% of adults say they have overeaten or eaten unhealthy foods in the past month because of stress” (“Stress and Eating,” 2013). In fact, when the body is stressed, fat is stored more compared to less when the body is relaxed (Björntorp, 2001). America is already known for its high obesity rates and now known for being stressed. Daily stress and the disruption of sleep may be leading to changes in salivary amylase and potentially impacting eating patterns or digestion of food. Ultimately, such changes may lead to risk for overweight/obesity, cardiometabolic risk, or changes in blood glucose.

Salivary amylase is an enzyme that breaks down the starches in your food into simple sugars. Salivary amylase can be impacted by many factors like gender, age, sleep, exercise, mood, and stress. It can fluctuate throughout the day with high and low concentrations of salivary amylase in the mouth as it is a fast-reacting stress system and changes in autonomic balance as a response to stress (Rohleder & Nater, 2008). In the Rohleder and Nater, 2008, review, for example, the circadian rhythm of salivary amylase activity has a strong decrease after waking up and gradually increases with peaks and valleys in the late afternoon when examined on 17 healthy subjects (Rohleder & Nater, 2008). Also, when tested on association of content type diets and salivary amylase, the carbohydrate-based diet showed a significantly higher amylase concentration compared to the protein balanced diet population (Rohleder & Nater, 2008). Thus, it is possible that salivary amylase may link stress to food intake, particularly carbohydrate intake.

Sleep is a vital part of our everyday life and is recommended to make up a third of our day. Lack of sleep can cause many types of health risks and can also lead to stress. To show how sleep impacts stress, young and older adults were tested in Schwarz's Sleep Deprivation study. Participants were randomized in four conditions, 1) normal night sleep and a Placebo Trier Social Stress Test (TSST), 2) normal night sleep and TSST, 3) sleep deprivation and Placebo-TSST, and 4) sleep deprivation and TSST. Five saliva samples were taken after waking up from sleep, taking the TSST, filling out questionnaires, and conducting cognitive tests (Schwarz et al., 2018). The results found that stress levels were higher in sleep deprived participants at baseline compared with non-sleep deprived individuals. Alpha amylase significantly increased in response to the TSST and decreased thereafter as compared to the Placebo-TSST group. It was found that sleep deprivation causes an increase in cortisol and subjective stress in sleep deprived compared to rested participants (Schwarz et al., 2018). Changes in sleep patterns generally increase stress. There is still much more needed research on the impact of different types of stressors and sleep manipulation to better understand acute psychosocial stress.

In moments of stress, people find something to depend on to relieve their stress. For many people, this dependence can be on food. Stress is a key factor in the development of addiction and high levels of stress changes eating habits and increases consumption of highly palatable foods (HP) that increases dependence (Sinha & Jastreboff, 2013). In this review, Sinha and Jastreboff uncovered a significant positive association between uncontrollable stressful events and adiposity, BMI, and weight gain. This relationship becomes worse when the subjects are already overweight. In a study with a sample of 588 participants, subjects with high numbers of stressful events and chronic stressors over their lifetime were more likely to use excessive alcohol use, be a smoker, and have a higher BMI after controlling for age, race, gender, and

socioeconomic status (Sinha & Jastreboff, 2013). With great consumption of highly palatable foods; carbohydrates, fat metabolism, insulin sensitivity, and appetite hormones influence reward regions and increases salience of highly palatable foods and makes you want increase food intake. This can happen with type two diabetics and insulin resistant individuals which is no good because stress affects glucose levels as well. This domino effect that stress puts on an individual goes to show that it is not easy to overcome. The body tries to overcome the stress by allowing large amounts of unhealthy food into your body and is rewarding this behavior by doing so. Interventions should be a next step to research to combat obesogenic eating patterns and prevent further weight gain all due to stress.

In another study, 125 newly detected diabetes mellitus (NDDM) subjects and 125 normal glucose tolerance (NGT) subjects were compared. Stress was assessed through questionnaires like the perceived stress scale (PSS) that measures how much stress an individual may have in one's life. It was found that systolic blood pressure and diastolic blood pressure were found to be significantly higher in NDDM subjects compared to NGT subjects (Siddiqui & Madhu, 2015). Salivary alpha amylase was similar between the two groups; however, it showed a significant correlation with the PSS and PSS scores were significantly high in NDDM subjects (Siddiqui & Madhu, 2015). It is interesting that PSS scores were higher with type 2 diabetes and PSS and PSS has a significant correlation with salivary alpha amylase. It is something that the researchers did not go into further detail about but should be researched further.

So much information can be gathered through a cell phone that it is being implemented into research studies more and more. Ecological momentary assessment is a phrase used to describe participants recording data via smartphone for research purposes. In a study about ecological momentary assessment, participants were asked to complete assessments on mobile

application four times daily for 6 months. Ethnic minority mothers were given Samsung smartphones to complete assignments on the pilot test mobile application. Participants tracked sleep, stress, mood, food intake, hunger, and exercise through cellular ecological momentary assessment (CEMA). It was seen that the CEMA were more likely to be completed in the morning and decreased as the day went on (Comulada et al., 2018). Over 6 months' time, there is a noticeable decrease in CEMA compliance over the study period (Comulada et al., 2018). The study also utilized photographic food records (PFR) in which participants were instructed to take a picture of every meal for 6 months. PRF adherence was lower on the weekends and decreased more rapidly in early months and higher PFR adherence was found being used more by older participants (Comulada et al., 2018). The study found that over 6 months, adherence dropped but did not hit no adherence. Participants who recorded PFR for more than a day were more likely to be obese versus normal- to overweight participants and have higher blood pressure (Comulada et al., 2018). The researchers recommend that CEMA and PFR is not a preferred method for capturing data over a long period time, but it is something to consider for variations in populations and temporal characteristics (Comulada et al., 2018). It is safe to say that short term assessments may work better for ecological assessments as participants do not have to commit most of their time into filling out questionnaires and taking pictures of food. In the future, researchers would like to see how cellular ecological momentary assessments could be used in research. With the rise in smartphone technology, it is almost unavoidable to utilize them in research assessments.

In this study, participants will track food and fluid intake, exercise, and stress behavior through the administration of surveys via text message. At the end of each survey, participants will have to provide a saliva sample to capture fluctuation in salivary amylase throughout the day

and determine if stress has a relation with amylase levels. This project will look at a subset of data. Specifically, we will look at adherence to the protocol, and the impact of sleep on stress levels from survey responses. It is hypothesized that with the use of smartphone ecological momentary assessment, participants adherence to surveys will decrease. In other words, participants, on average will complete 80% of the daily surveys. It can also be hypothesized that stress has a strong impact on sleep, specifically with a significant correlation between the hours of sleep and the Perceived Stress Scale. It can be hypothesized that the PSQI will positively correlate with the College Students Stressful Event Checklist (CSSEC). Sleep length will negatively correlate with the Global PSQI score, in other words the less you sleep, unhealthier your sleep quality will be.

My role in this study as a research assistant of Dr. Jeanne McCaffery was to learn the Research Electronic Data Capture (REDCap). At the start of fall semester 2018, I was introduced to REDCap. It was very new to me and if I was interested in doing any sort of Institutional Review Board (IRB) approved study, I had to learn quickly. I started with watching long tutorial videos and using the REDCap's interface myself. Numerous times, I spoke with the IT department at University of Connecticut Health. I also integrated Twilio so we could send the surveys via text message. Fast forward to the middle of spring semester 2019, I had made over 1,600 fields for the surveys and I was ready to send out surveys to future participants.

Ultimately, we were approved by the IRB in late March, allowing me to run participants for three weeks. This was an amazing experience that not everyone gets to do. Along the way I enhanced my knowledge in excel and SPSS Statistical Software. Everything mentioned here was to show my efforts in the process of writing my honors thesis. Please refer to appendix A for a sample of the surveys.

Methods

Research Design

In our research to determine how much stress alters salivary amylase activity, the research design is an observational, within-subjects design, wherein participants will track their stress levels, eating, physical activity and salivary amylase five times per day over two days. No treatments will be offered, and all participants will undergo the same protocol. We anticipate the protocol taking participants one week to complete.

The study is comprised of six stages: recruitment, screening, informed consent, baseline assessment, daily surveys and saliva samples and follow-up assessment. Phone screens and baseline assessments are easily rescheduled. The follow-up assessment is completed via smart phone so no researcher contact is necessary. Once the daily surveys are initiated, it is difficult to repeat these as they are time sensitive. However, if a survey is missed, participants can participate in the next one. This research study was approved by the Institutional Review Board at the University of Connecticut, Protocol #: H18-268.

Participants

The research criteria included an age range from 18-50 years old to capture a wide range of adulthood. Inclusion criteria suggests participants must weigh at least 110 pounds and have a smartphone with internet and texting capability in order for participants to receive surveys via text messages. Potential participants less than 18 years of age are excluded as parental involvement would be necessary for the protocol and the protocol is somewhat complex and potentially challenging to adhere to. Participants older than 50 years old are excluded as many will have major medical illness or take medications that would interfere with salivary amylase. Participants are not excluded based upon gender, race or ethnicity.

Every attempt will be made to keep participants in the study once enrolled. However, participants will be removed from the study if they request to be removed. If participants do not respond to 50% of the daily surveys on any given day, they will be contacted by the researcher and reminded to complete the surveys for the remaining days. If participants show patterns of non-compliance (e.g., responding with the same response to every question, reporting food intake substantially below nutritional requirements, e.g., 1800 calories), they will also be contacted by the researcher for feedback and ideas to help with compliance. Participants were compensated for their efforts, $3 for each survey completed for a potential total of $30 and was transferred through the University of Connecticut's Husky Buck's.

The research team will recruit from the UCONN community, including but not limited to UCONN faculty and students, Storrs and the surrounding communities. Ads will be placed on the Daily Digest and flyers will be posted around the University of Connecticut and in Downtown Storrs.

REDCap

Study data were collected and managed using REDCap electronic data capture tools hosted at University of Connecticut Health. REDCap (Research Electronic Data Capture) is a secure, web-based application designed to support data capture for research studies, providing 1) an intuitive interface for validated data entry; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources (Harris et al., 2009).

REDCap will be used to capture data using scheduled surveys in participants own smartphone device. Twilio is a communications platform that will be used to allow to send and

receive text messages through REDCap. Collection and storage of real research data and/or Personally Identifiable Information (PII), Protected Health Information (PHI), or any other type of sensitive data will be kept using REDCap's production server. A full REDCap survey can be found in Appendix A

Twilio

Twilio is a third-party application that assists REDCap to be able to send text messages to research participants mobile phones. REDCap's mobile communication options are made possible with Twilio's integration within the REDCap's interface (Somers, n.d.). Most of the study management occurs in REDCap, for example, scheduling survey invitations, setting up reminders if a survey was not completed on time, and immediately sending surveys. All of this is done through REDCap and Twilio runs in the background to ensure that text messages are being sent along with the surveys.

Measures

Assessments were taken in our lab in Koons Hall at the University of Connecticut with a minimum of two CITI trained, biosafety trained, and IRB approved research assistants. One assistant would take measurements of the subjects while the other subject would record the information into REDCap. Assessments include height, weight, blood pressure, and the baseline survey on their personal smartphone.

Anthropometric measures:

Height: Participant will remove shoes and hair ornaments, jewelry, buns, or braids from the top of the head that interfere with the measurement. The participant will stand erect against the backboard with the body weight evenly distributed and both feet flat on the stadiometer platform and will look straight ahead. Once positioned, the stadiometer is lowered so the headpiece rests

firmly on top of the participant's head, with enough pressure to compress the hair. Standing height will be recorded in inches. Repeat height measurement.

Weight: A digital scale will be used to weigh participants. Participants wear light clothing without shoes and are asked to remove objects such as cell phones, wallets, and toys from their pockets. Participants will stand in the center of the scale platform with hands at their sides and looking straight ahead. Weight is recorded in kilograms. Repeat weight measurement.

Blood pressure: The proper cuff size must be used to avoid under- or over-estimation of BP. The participant is seated, legs uncrossed, in a quiet room, with the elbow and forearm resting comfortably on the armrest of the Blood Pressure measurement chair (or table), with the palm of the hand turned upward. The area to which the cuff is to be applied must be free of clothing. The lower edge of the cuff is placed about 1 inch above the natural crease across the inner aspect of the elbow with the palm of the participants hand turned upward, making sure the long edges of the cuff lie on top of each other as the cuff is wrapped around. Blood Pressure is recorded as systolic and diastolic Blood Pressure in mmHg. Wait 1 minute and repeat the measurement for a total of three times.

Saliva samples: We will collect a total of 11 saliva samples from each participant; one sample in baseline and 10 samples during the 2 days of the study. Participants will use the drool method into a salivette to collect a minimum of 0.5 mL of saliva. Saliva samples are pre-labeled with their subject ID number and day and time that saliva was sampled. A cooler will be administered to research participants along with an ice pack to keep saliva samples cool throughout the day.

Research participants will store saliva samples in their personal freezers overnight until the study is finished. Then, we schedule a cooler drop off time where participants find the most convenient for themselves. Saliva samples will be stored in the freezer overnight until we have time to review them. We collect saliva to characterize diurnal patterns of salivary amylase and differences in salivary amylase as they relate to stress, eating and activity.

Questionnaires

Our collection of demographic data and our questions about eating, physical activity, sedentary behavior from the daily surveys did not come from pre-existing sources and are provided in detail. For the full REDCap protocol, please see Appendix A.

Surveys

Baseline assessment:

Collection of demographic data:

- What is your Gender?
- What is your Age?
- How would you describe your race?
- How would you describe your ethnicity?
- What is the highest degree or level of school you have completed?
- What is your estimated household income?

Perceived stress scale (PSS)

The Perceived Stress scale is a stress assessment and will serve as a tool to understand how different situations affect feelings and perceived stress. The questions in the scale will ask about the feelings and thoughts during the last month and ask participants to indicate how often they

felt or thought a certain way. Baseline PSS will consist of 10 questions, each question is worth a value from 0-4 points, perceived stress score will be determined at conclusion of assessment Cohen, Kamarck, & Mermelstein, 1983).

College Student's Stressful Event Checklist (CSSEC)

The College Student's Stressful Event Checklist was modified from the Holmes-Rahe Stress Inventory to apply to college students. It consists of 32 potential stress producers. It ranks and assigns scores to each potential stress producers. Participants will check off the stress events that happened in their life and add up the stress scores in the end. The higher the stress score the more likely one is to have illness within the coming year (Holmes &Rahe, 1967).

The Pittsburgh Sleep Quality Index (PSQI)

The Pittsburgh Sleep Quality Index measures the quality and patterns of sleep in adults. Participants will self-report their sleep through the measurement of seven domains: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. These measurements will differentiate "good" from "poor" sleep. Can be used as initial and ongoing measurements if needed. Scoring of these answers are based on a 0-3 scale, where 3 is negative extreme on the Likert Scale and a global sum of >5 indicates a poor sleeper. Numerous studies have shown that using the PSQI in a variety of adult populations internationally have supported high validity and reliability. Scores range from 0 to 21, where higher scores denote unhealthier sleep (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989).

Daily surveys:

Perceived Stress Scale 4 (PSS4)

The PSS-4 will be part of the 5 daily assessments, consisting of 4 questions. Each question is worth a value from 0-4. Questions in this scale will ask about your feelings and thoughts during the past three hours or right now. Higher scores are correlated to more stress (Cohen, Kamarck, & Mermelstein, 1983).

Positive and Negative Affect Scale (PANAS)

This scale consists of several words that describe different feelings and emotions. Participants must read each item and then list the number from the scale below next to each word. 1-Very Slightly or Not at All, 2-A Little, 3-Moderately, 4-Quite a Bit, and 5-Extremely. Indicate to what extent you feel this way right now, that is, at the present moment. 10 words are positive and 10 words are negative. Of the 20 words from this questionnaire, 5 words will be utilized to index positive and negative emotion during the daily surveys, 3 negative and 2 positives. Positive and negative words are added up separately with high scores representing higher levels of positive or negative affect (Watson, Clark, & Tellegan, 1988).

Other daily survey questions

Surveys were sent for two days at 9 A.M., 12 P.M., 3 P.M., 6 P.M., and 9 P.M. Questions about food and drink intake along with a description of the serving size and where it was consumed were asked in the daily surveys. Questions about physical activity; type of exercise and how long it was performed were also asked. Refer to appendix A for a sample of the surveys.

Data Analysis

We are looking at adherence of survey completion and will utilize REDCap to determine the record status of each of the subjects and their surveys. Survey responses will be exported to SPSS Statistical Software where we will calculate mean, standard deviation, and correlation coefficient (r) to analyze our data, they are the most well-known pieces of information to describe trending data.

For participants that were not able to complete a survey, we conducted a mean replacement for missing data. We were missing two data points and in order to fill the missing data, we took the average of the other data points for that day. Doing this estimates what participants would have potentially answered based on their other responses.

Because we have a small sample size of eight, we will be applying the Cohen effect size. With a small sample size, we cannot determine significance of our data and we are not looking at statistical significance since this is an exploratory study (Ellis, 2009).

Results

The potential participant count for this study was 12 subjects that completed the phone screen. A phone screen about demographics and inclusion and exclusion criteria was conducted for the twelve. Two subjects were ineligible due to being under the 110 pounds inclusion criteria. Two more subjects never showed up to the baseline meeting to obtain measurements, for a total of 4 phone screened subjects that did not make it into the study. Therefore, 8 subjects have completed the study from start to finish.

Table 1 contains descriptive statistics at baseline assessment. The sample of 8 consisted of more females than males, mostly Caucasians, and mostly non-Hispanics. The average systolic and diastolic blood pressures and average heart rate were within normal range. They are also

considered normal body mass index (BMI) based on their average height and weight calculation. Our sample was considered moderately stressed based on the average of the PSS measured at baseline. Our sample was considered severely stress based on the average score of the CSSEC. The average Global PSQI scores were in the middle of the range with an average hour of sleep just over 7.

Baseline

There were some interesting outcomes in this study. There is a strong, indirect correlation, as seen in Figure 1, between hours of sleep reported at baseline and the PSS at baseline. A correlation of -0.82 suggests that the more hours of sleep an individual has, the less stressed they are. With a correlation coefficient of 0.82, according to the Cohen interpretation of effect size, the effect size is very large when looking at a small sample size (Ellis, 2009).

The Scatter plot in Figure 2 depicts an indirect, intermediate relationship between hours of sleep reported at baseline and the CSSEC at baseline. The correlation coefficient is -0.33 suggesting that the less sleep you have, the higher stress score you will have. If we look at the Cohen effect size, this gives us a medium effect size for our small sample (Ellis, 2009).

The relationship between the Global PSQI score and the CSSEC showed a direct but weak relationship with a correlation of 0.25. A direct relationship makes sense because higher Global PSQI Scores denote a poorer sleep quality.

There was an unexpected result between the Global PSQI Score and hours reported of sleep. The correlation coefficient between the Global PSQI Score and the hours of sleep reported is 0.33. This is a direct, intermediate relationship suggesting that more hours slept will result in a higher PSQI score. A higher PSQI score denotes unhealthier sleep quality. It should also be

reminded that hours slept at baseline is a recall of participants own knowledge of when they usually go to bed and wake up. Refer to Figure 3 for a scatterplot of this relationship.

Because blood pressure is known to increase when stressed, it would be interesting to see the results compared to stress scales. Systolic blood pressure has a correlation coefficient of 0.153 compared to the PSS which is direct and weak, and a correlation of -0.168 compared to the CSSEC which is indirect and weak. Diastolic blood pressure has a correlation coefficient of -0.08 compared to the PSS which is indirect and weak, and a correlation of 0.22 compared to the CSSEC which is direct and weak.

Day 1

Looking at the hours slept in day 1 compared to the average negative PANAS score, the correlation is indirect and weak at -0.22. This makes sense because the less hours off sleep obtained, the more negative you will feel throughout the day.

Hours slept in day 1 compared to the average PSS4 does not represent the data with a direct and intermediate relationship of 0.52 correlation, as we do not expect more hours of sleep to relate with stress. If we look at the Cohen effect size, this gives us a large effect size (Ellis, 2009). Refer to figure 4 for a scatterplot of this relationship.

Day 2

Looking at the hours slept in day 2 compared to the average negative PANAS score, the correlation represents a direct and weak value of 0.09. Hours slept in day 2 compared to the average PSS4 portrays a direct and intermediate relationship of 0.29. Compared to day one, this correlation dropped down enough to where the Cohen effect size is now small (Ellis, 2009).

Hours slept in day 2 compared to the average PSS4 has a direct and intermediate relationship of 0.29 correlation. We expect the correlation to be negative because more hours of sleep should not correlate with more stress.

Baseline and Day1

Baseline hours of sleep reported is different than what is slept for day 1. With a correlation of 0.16, it is direct and weak relationship.

Baseline hours of sleep reported compared to PSS4 from day 1 survey exhibited a -0.29 correlation, indirect and intermediate relationship. The direction of the correlation is correct because the less hours of sleep results in a higher PSS4 score or being more stressed.

Baseline hours of sleep reported compared to average negative PANAS score from day 1 survey portrayed a -0.23 correlation, indirect and weak relationship. The direction of the correlation is correct because the less hours of sleep results in a higher average negative PANAS score or being more stressed.

One significant value that came about was the hours slept for day 1 and the CSSEC at baseline. It has a correlation of -0.81 which suggests an indirect and strong relationship. According to the Cohen effect size, this represent a very large effect size (Ellis, 2009). Please refer to Figure 5 for a scatter plot about this relationship.

The relation between hours slept in day 1 and the PSQI showed a 0.025, direct and weak correlation between the two variables.

Baseline and Day 2

Baseline hours of sleep reported is different that what is slept for day 2. With a correlation of 0.33, a direct and intermediate relationship, a little better than what was slept for day 1.

Baseline hours of sleep reported compared to PSS4 from day 2 survey exhibited a -0.38 correlation, indirect and intermediate relationship. The direction of the correlation is correct because the more hours of sleep results in a lower PSS4 score or being less stressed. Please refer to Figure 6 for a scatter plot about this relationship.

Baseline hours of sleep reported compared to average negative PANAS score from day 2 survey portrayed a 0.115 correlation, direct and weak relationship. The direction of the correlation is incorrect because this is saying that the more hours of sleep results in a higher average negative PANAS score or being more stressed, which is not usually the case.

Baseline hours reported is still different to what the hours slept for day 2 were. The correlation is 0.33 which is a direct and intermediate relationship. This shows that what the participants report about sleep does not reflect actual sleep.

The relation between hours slept in day 1 and the PSQI showed a -0.134, an indirect and weak correlation between the two variables.

Discussion

Adherence

It was hypothesized that participants will adhere to responding to 80% of the daily surveys. Among eight participants, forty daily surveys were administered and only two were missed making the adherence 95%. It was thought that adherence to survey completion was going to be difficult as college students would be busy with class and assignments. But, with access to a smartphone and $3 incentive per daily survey completed, it was not difficult. With a higher adherence than expected, survey administration via text message is a great tool for obtaining data from college students.

Hours Slept and PSS

It was hypothesized that stress has a strong impact on sleep, specifically with hours slept and the Perceived Stress Scale. Our results showed there was a strong, indirect correlation between hours of sleep reported at baseline and the PSS at baseline. A correlation of -0.82 suggests that the more hours of sleep an individual has, the less stressed they are. This ties in with our hypothesis because it shows that there is a strong relationship between the two variables. According to the Cohen interpretation of effect size, the effect size is very large when looking at a small sample size (Ellis, 2009).

PSQI Total Score and CSSEC

It was hypothesized that the PSQI will positively correlate with the College Students Stressful Event Checklist (CSSEC). The Global PSQI score and the CSSEC showed a direct but weak relationship with a correlation of 0.25. It is positive, however it is a small Cohen effect size because of the small correlation coefficient (Ellis, 2009). Because hours of sleep relates to PSQI, I want to mention the correlation coefficient of hours slept reported at baseline and the CSSEC at baseline which is -0.33 suggesting that the less sleep you have, the higher stress score you will have. If we look at the Cohen effect size, this gives us a medium effect size for our small sample (Ellis, 2009).

PSQI Vs. Hours Slept

It was hypothesized that sleep length will negatively correlate with the Global PSQI score, in other words the less you sleep, unhealthier your sleep quality will be. The correlation coefficient between the Global PSQI Score and the hours of sleep reported is 0.33. This is a direct, intermediate relationship suggesting that more hours slept will result in a higher PSQI score. A higher PSQI score denotes unhealthier sleep quality.

Baseline and Daily Surveys

Baseline in relation to Day 1 had some values that shared what were expected. For example, hours reported at baseline compared to PSS4 and negative PANAS showed an indirect relationship that was expected because less hour of sleep correlate with more stress or more hours of sleep with less stress. The same was founded for day2 and baseline, except the negative PANAS scale direction which was direct in saying that more sleep means more stress or less sleep means less stress, which is not the case. Then again, this is baseline data compared to daily survey data, which does not go together.

Day 1 and Day 2

There was a lot of variation between day 1 and day 2. First, hours slept between day 1 and day 2 had a correlation of 0.49, direct and intermediate. The average PSS4 scores between day 1 and day 2 had a correlation of 0.33, direct and intermediate. Lastly, the average negative PANAS scores between day 1 and day 2 had a correlation of 0.182, direct and weak. There were no strong relationships that showed similarities between the two days. This suggests that these participants had variation in their stress levels throughout the day for both days.

Strengths

A strength of this study was the surprising result that 95% of the surveys via smartphone were completed. This means that smartphone ecological momentary assessment is a great tool to use when capturing data from subjects outside of lab. The use of scheduled surveys and reminders really helped participants complete surveys. It is about making the participants comfortable and the researchers doing the complicated work in the background to make things run smoothly. Along with this, every participant was able to provide a saliva sample after each survey completed. An incentive was used ($3 per survey completion) to increase the likelihood

that each participant will complete each survey. Were also proud that REDCap worked so well the first time we tested it to its limits.

Weaknesses

A possible limitation we are unsure that if participants gave saliva samples at the correct time range. They may have sampled everything all at one time. We will find out eventually when we look at salivary amylase and see if they exhibit a normal activity curve with relation to time of day.

Another limitation of the study was that we had countless prospective participants interested in the study, but we were limited with resources. We could only schedule four participants at a time because we only had four coolers to contain the saliva in. This prevented us from obtaining more subjects because participants had the coolers for two days and we had to schedule a time where it was most convenient for them to drop off the coolers.

Another limitation in the study was having outliers, it is hard to take out outliers with only eight people in the study. It would skew our data greatly, but with a greater sample size it could be possible to exclude outliers.

Future Research

This was a pilot study to really test out and see how well we could use REDCap to gather data. For future research, we would continue with our study, add the salivary amylase values into our data and compare them with the PSS, CSSEC, PSQI, PSS4 and hours slept. To capture more stressful factors during the daily surveys, it would be great to obtain blood pressure from a 24-hour monitor in connection with completing the surveys. Of course, make our sample much bigger, we will start the study much earlier in the school semester to gather as many eligible participants as we can.

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Table 1

Table 1. Baseline Descriptive Statistics		
Variable		**Total**
		% or Mean (SD)
Sample Size		8.0
Age (Years)		20.0
Gender		
	Male	12.5
	Female	87.5
Race		
	AA	12.5
	White	50.0
	Asain	37.5
Ethnicity		
	Hispanic	12.5
	Non-Hispanic	87.5
Height (cm)		163.74 (9.25)
Weight (lbs)		138.17 (24.68)
BMI		23.49 (4.24)
Systolic Blood Pressure (mmHg)		100.13 (12.98)
Diastolic Blood Pressure (mmHg)		66.88 (9.20)
Hours Slept Baseline		7.13 (1.64)
Pittsburgh Sleep Quality Index Baseline (PSQI)		11.25 (2.05)
Perceived Stress Scale Baseline (PSS)		21.13 (3.09)
College Students Stressful Event Checklist Baseline(CSSEC)		360.13 (144.02)

Figure 1

PSS at Baseline and Hours of Sleep at Baseline

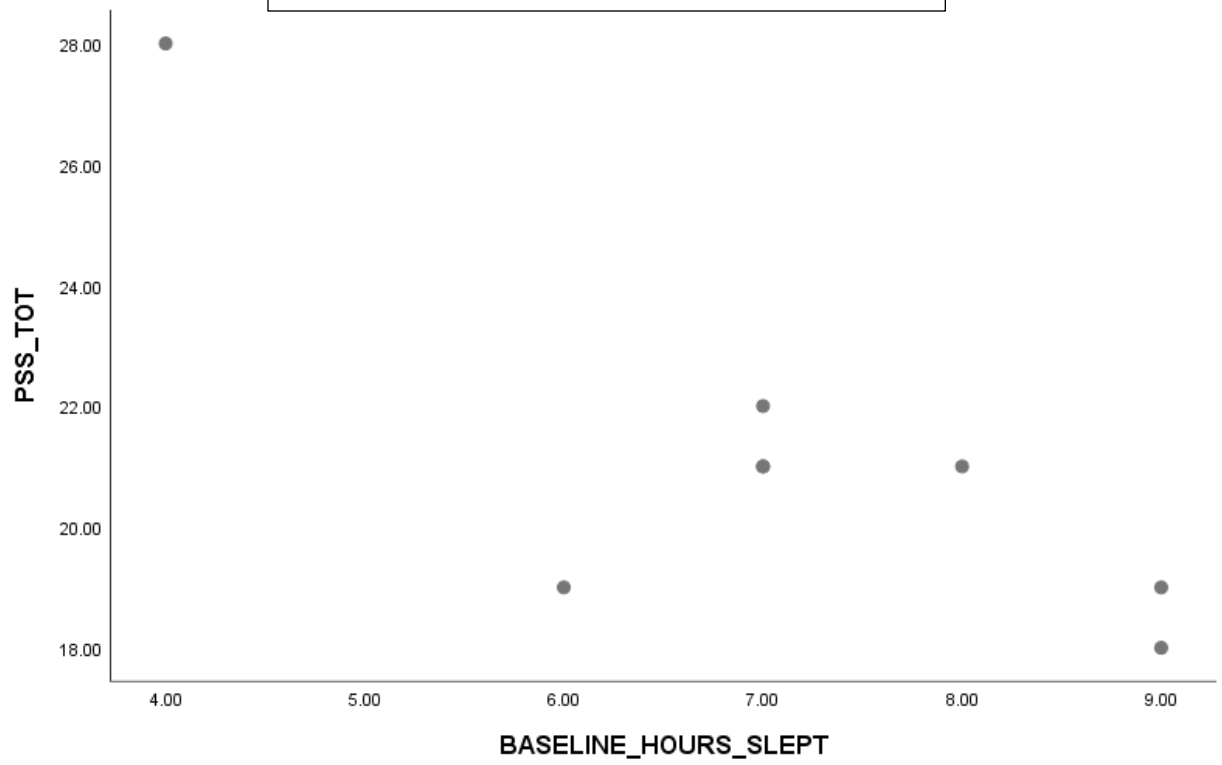

Figure 2

CSSEC at Baseline and Hours of Sleep at Baseline

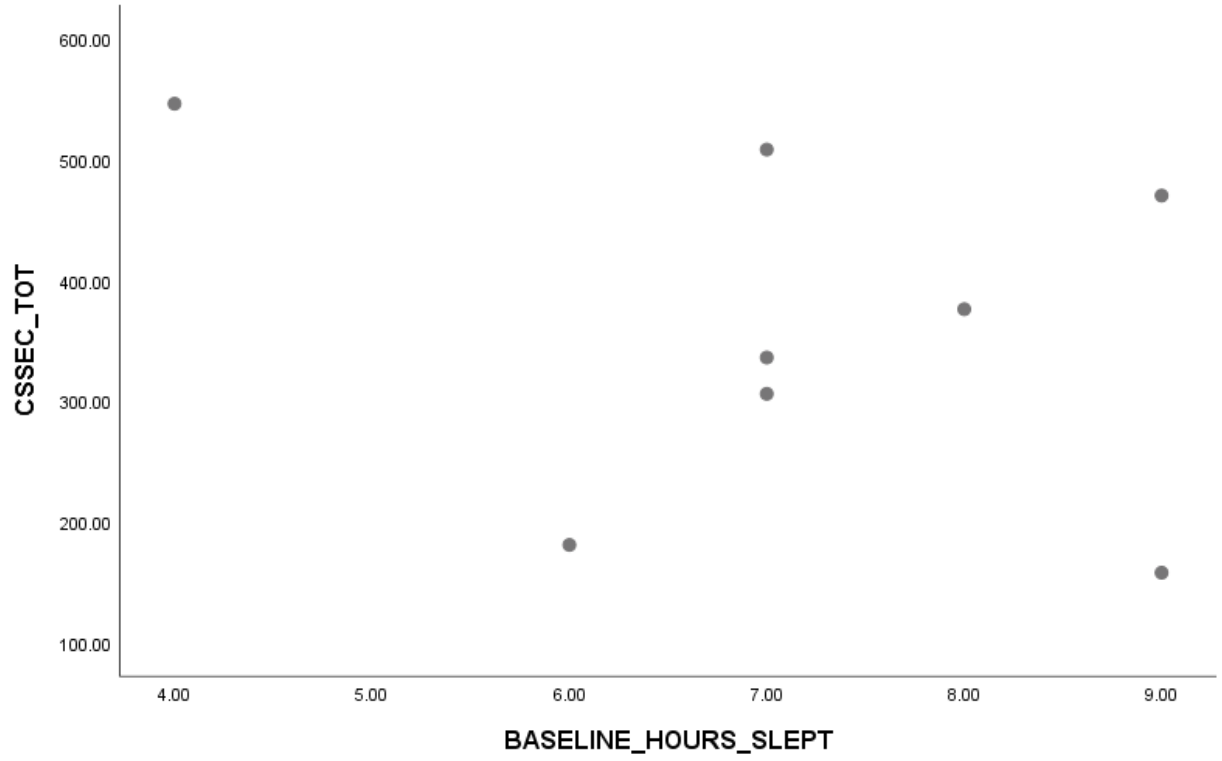

Figure 3

Global PSQI Score at Baseline and Hours Slept at Baseline

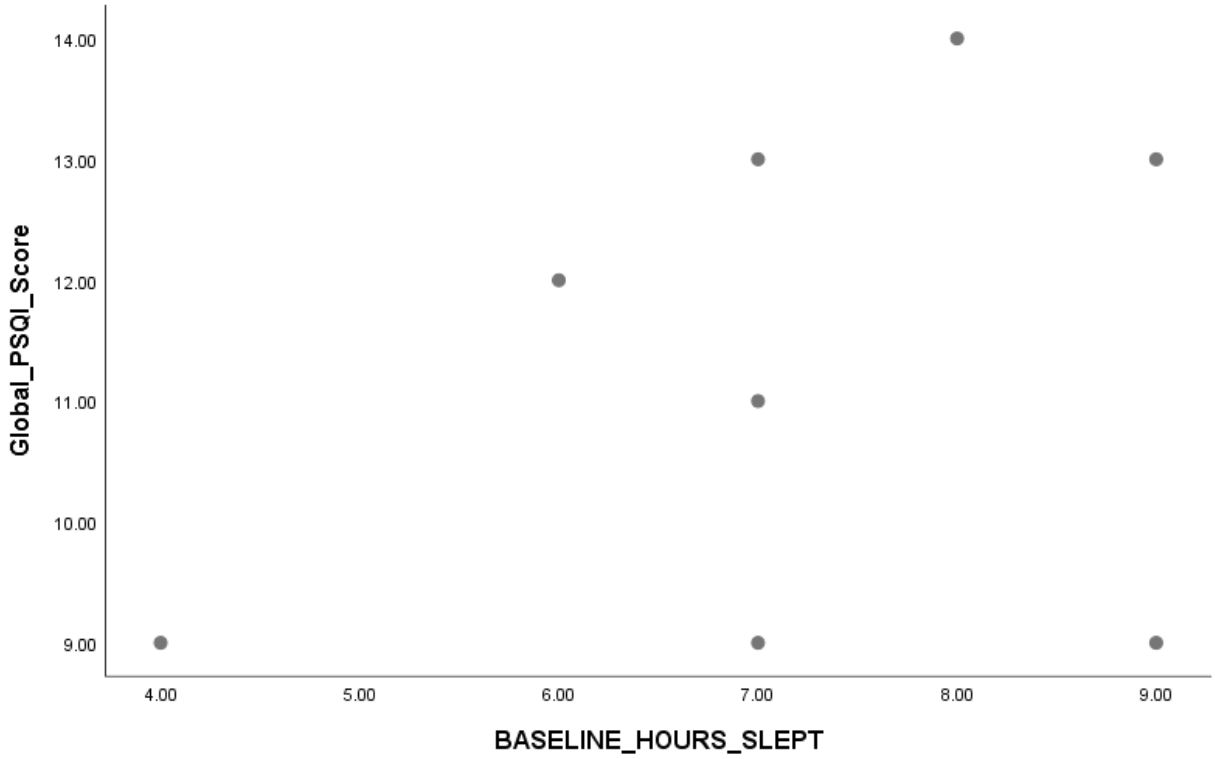

Figure 4

Average PSS4 at Day 1 and Hours Slept at Day 1

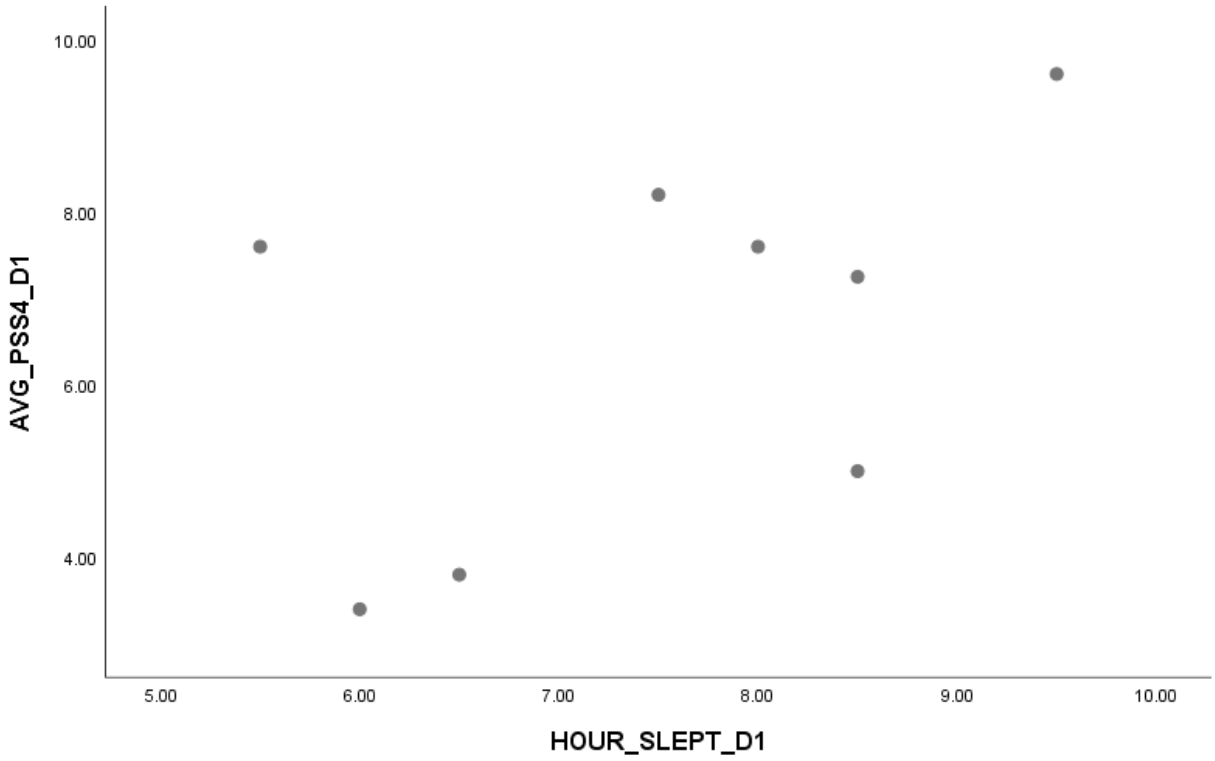

Figure 5

CSSEC at Baseline and Hours Slept at Day 1

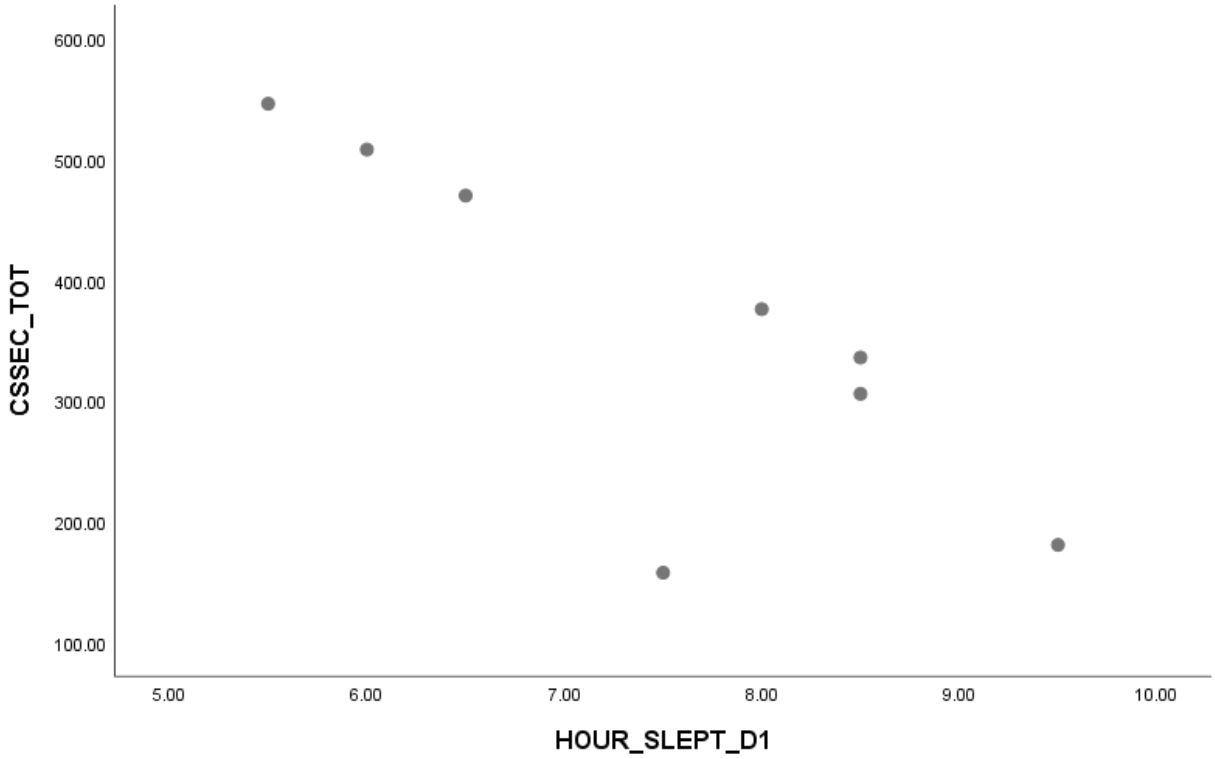

Figure 6

Average PSS4 at Day 2 and Hours of Sleep at Baseline