# THE RELATIONSHIP BETWEEN PROBLEMATIC SCREEN USE, PSYCHOLOGICAL, BEHAVIORAL, AND PHYSIOLOGICAL VARIABLES IN COLLEGE STUDENTS

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THE RELATIONSHIP BETWEEN PROBLEMATIC SCREEN USE, PSYCHOLOGICAL, BEHAVIORAL, AND PHYSIOLOGICAL VARIABLES IN COLLEGE STUDENTS (106 pp.)

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This study examined the relationships between problematic screen use, psychological, behavioral, and physiological variables in 43 healthy college students. Data were collected using validated surveys, bioelectrical impedance to measure body fat, and a smartphone application to assess heart rate variability. Results showed significant positive relationships between smartphone, social media, and internet addiction, as well as between problematic screen use and body fat percentage. In other words, participants with higher levels of problematic screen use also had higher levels of body fat. The study also identified smartphone addiction as a potential mediator between body fat and perceived stress and demonstrated associations with depression and stress. These findings suggest that limiting screen time could promote weight loss and mental health.

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# CHAPTER I

## INTRODUCTION

Internet addiction can be defined as the excessive use of digital technology leading to physiological or psychological impairment (American Phycological Association, 2023). In the modern age, internet use, including computers, smartphones, and tablets, has become a fundamental requirement for college students. Numerous studies have indicated a high prevalence of internet addiction in this population, affecting over a quarter of college students surveyed (Lim et al., 2021; Matar Boumosleh & Jaalouk, 2017). Because college students exhibit a high prevalence of internet addiction, they may face an increased risk of experiencing its adverse effects.

While internet addiction may initially seem medically irrelevant, previous research has established its association with several adverse health and behavioral outcomes in college students. These include reduced levels of physical activity (Saffari et al., 2022; Alaca et al., 2020), greater sedentary behavior (Barkley & Lepp, 2016; Peltzer, Pengpid, & Apidechkul, 2014), increased rates of sleep disturbances (Maurya et al., 2022; Wang et al., 2021; Sonawane et al., 2019; Abdulah et al., 2018; Li, Lepp, & Barkley, 2015), a higher prevalence of anxiety, stress, and depression (Bueno-Brito et al., 2024; Al Saigh et al., 2022; Unsar et al., 2020; Maglunog & Dy, 2019; Alhassan et al., 2018; Lepp, Barkley, & Li, 2017; Matar Boumosleh & Jaalouk, 2017), and increased body fat percentage (Domoff et al., 2020; Kim et al., 2015). Additionally, internet addiction has even been linked to alterations in heart rate variability, with lower frequencies and unfavorable low/high frequency ratios observed in college students with internet addiction (Zhang et al., 2023; Lin et al., 2022; Zhang & Xu, 2022). These findings suggest that internet addiction may not be as non-threatening as it appears.

Internet usage inherently promotes a sedentary lifestyle and is a fundamental aspect of college life. For example, previous studies found a negative relationship between smartphone addiction and physical activity levels in female university students, indicating that internet addiction is associated with reduced physical activity (Saffari et al., 2022). There is also evidence that internet addiction and total smartphone use predicts increases in sedentary behavior (Barkley & Lepp, 2016; Peltzer, Pengpid, & Apidechkul, 2014). Additionally, smartphone addiction has been positively associated with increased body fat percentage (Domoff et al., 2020). Decreases in physical activity and increases in sedentary behavior and body fat percentages have been independently associated with increased risk for all-cause mortality, including heart disease (Stingl-Zúñiga et al., 2023; Li et al., 2022; Salinas-Rodgriguez et al., 2022; Zeng et al., 2012). However, the detrimental effects of internet addiction extend beyond physical activity, sedentary behavior, and body fat percentage.

Another consequence associated with internet addiction is sleep disturbance. Research shows a positive correlation between excessive smartphone use, a major component of internet addiction, and sleep disturbances (Maurya et al., 2022; Wang et al., 2021; Sonawane et al., 2019; Abdulah et al., 2018; Li, Lepp, & Barkley, 2015). This association has been identified whether sleep disturbances are subjectively or objectively measured in college students, often through tools like the Pittsburgh Sleep Quality Index. Excessive social media use, a primary reason for smartphone usage, also increases rates of sleep disturbances (Wang et al., 2021; Abdulah et al., 2018), regardless of the specific social media platforms involved.

In addition to the potentially negative behavioral impacts, internet addiction is often linked to numerous psychological variables, anxiety, depression, and stress (Bueno-Brito et al., 2024; Al Saigh et al., 2022; Unsar et al., 2020; Maglunog & Dy, 2019; Alhassan et al., 2018;

Lepp, Barkley, & Li, 2017; Matar Boumosleh & Jaalouk, 2017). This positive association persists whether depression or anxiety is clinically diagnosed or self-reported. Notably, there is a positive correlation between internet addiction and depressive symptoms in college aged adults (Matar Boumosleh & Jaalouk, 2017). This is distinct from findings in older populations, whose elevated rates of internet addiction do not correspond with heightened depressive symptoms (Lim et al., 2021). Moreover, higher levels of internet addiction in college-aged students also predict increased levels of anxiety (Hashemi, 2022; Sewall, Goldstein, & Rosen, 2021; Lepp, Barkley, & Karpinski, 2014). Previous research also suggests smartphone addiction is associated with stress in college students (Bueno-Brito et al., 2024). Finally, internet addiction's impact may extend to HRV, where college students with internet addiction exhibited lower resting HRV frequency power and higher low/high frequency ratios (Zhang et al., 2022), particularly in those with depression (Brugnera et al., 2019; Hartmann et al., 2019; Borrione et al., 2018; Brunoni et al., 2013). These changes in HRV patterns indicate dysfunction in the autonomic nervous system, potentially leading to a reduced ability to regulate vagal tone. Reduced vagal tone has been linked to mood disorders like depression (Hartmann et al., 2019), possibly due to impaired emotional and physiological stress regulation (Chambers & Allen, 2002; Porges, 1995).

Overall, the relationships between internet addiction, including excessive smartphone and social media use, and its potential relationship to physical activity, sedentary behavior, body fat percentage, sleep disturbance, depression, anxiety, stress, and HRV warranted further investigation, especially within a single comprehensive study that examines these variables collectively.

This present study's primary objective was to explore the relationships between internet addiction and physical activity, sedentary behavior, sleep disturbance, depression, anxiety, stress,

body fat percentage and HRV among college students. While assessments of the relationship between internet addiction to HRV and depression were previously examined in a single study (Zhang et al., 2022), this work has recently been retracted due to indication of systemic manipulation of the publication process (International, 2023). Therefore, there are presently no studies we are aware of, that were not withdrawn, that have assessed these potentially important relationships. Our study aimed to contribute potentially valuable insights to the existing literature, shedding light on previously unconfirmed relationships between internet addiction and physical activity, sedentary behavior, body fat percentage, sleep disturbance, stress, depression, anxiety, and HRV in a single study. Understanding these potential relationships in college students is important for discerning the associated negative consequences and formulating targeted interventions based on the most salient variables. This study surveyed participants on internet addiction, smartphone/social media use, physical activity levels, sedentary behavior, sleep disturbances, stress, anxiety, and depression symptoms. Height was measured using a stadiometer, while body fat percentage was assessed through bioelectrical impedance. HRV was then assessed through a single data collection session using the Polar H10 heart rate monitor at rest. We hypothesized that internet addiction severity among college students would be associated with lower levels of physical activity, increased sedentary behavior, increased body fat percentage, sleep disturbances, stress, anxiety, and depression symptoms, as well as aberrant HRV patterns (measured via EliteHRV normative data values).

Additionally, the study's secondary objective was to investigate whether smartphone addiction acts as a mediator in the relationship between stress and depression to HRV and body fat percentage. Previous research has indicated smartphone addiction is positively associated with stress and depression (Bueno-Brito et al., 2024; Matar Boumesleh & Jaalouk, 2017). Prior

investigations also have suggested smartphone use is positively associated with body fat percentage and abnormal HRV (Tonacci et al., 2019). Given body fat percentage and HRV patterns potential predictive power for all-cause mortality, understanding whether smartphone addiction mediates the potential relationship between HRV, and body fat percentage may hold significant therapeutic potential (Zeng et al., 2012). Alleviating smartphone addiction's potentially adverse effects on HRV and body fat percentage through addiction-targeted treatments may not only be meaningful for cardiovascular health but also for mental health, as smartphone addiction may potentially mediate the relationship between stress and depression. Thus, the second hypothesis posited that smartphone addiction would mediate the relationship between stress and depression to HRV and body fat percentage.

# CHAPTER II

## REVIEW OF LITERATURE

Internet addiction is characterized by the excessive use of the internet and associated technologies, including cellphones, laptops, tablets, and desktop computers (American Psychological Association, 2023). The term 'internet use' encompasses a wide range of activities, such as using social media, web-browsing, watching videos, online gaming, and the use of a variety of software applications (apps). Excessive use becomes problematic when individuals utilize the internet to an extent that adversely affects their lives. A separate phenomenon, smartphone addiction, is characterized specifically by excessive use of a smartphone that causes unfavorable health and behavioral outcomes (Ratan et al., 2021). Smartphone addiction is also known as problematic cell/smartphone use. Another separate phenomenon is social media addiction, also known as social media use disorder, which is characterized by excessive and compulsive use of social media (including but not limited to Facebook, Instagram, TikTok, and X) that causes an adverse impact on a user's life (Cheng et al., 2022). Excessive use of all of these different types of technology (internet, smartphone, and social media) is the cause and therefore related to their addiction classifications, though terminology may differ throughout the literature. Since the main method of use is digital technology for these addiction measures, we theorize they are all related in some way. For purposes of this paper, all of these terms will either be named separately, or put into the same category under the term "problematic screen use".

This problematic screen use is associated with numerous undesirable side effects, such as reduced levels of physical activity (Saffari et al., 2022; Alaca et al., 2020), greater sedentary behavior (Barkley & Lepp, 2016; Peltzer et al., 2014), increased rates of sleep disturbances (Maurya et al., 2022; Wang et al., 2021; Sonawane et al., 2019; Abdulah et al., 2018; Li, Lepp, &

Barkley, 2015), a higher prevalence of anxiety, stress, and depression (Bueno-Brito et al., 2024; Al Saigh et al., 2022; Hashemi et al., 2022; Okasha et al., 2022; Unsar et al., 2020; Maglunog & Dy, 2019; Alhassan et al., 2018; Lepp et al., 2017; Matar Boumosleh & Jaalouk, 2017), increased body fat percentages (Domoff et al., 2020; Kim et al., 2015) and unfavorable changes in heart rate variability (Zhang et al., 2022; Lin et al., 2022; Zhang & Xu, 2022). These outcomes contribute to a decline in the quality of life and an elevated risk of all-cause mortality (Stingl-Zúñiga et al., 2023; Li et al., 2022; Salinas-Rodgriguez et al., 2022). Considering the widespread use of technology among college students (traditionally aged 18-25), they emerge as a particularly vulnerable group susceptible to internet addiction (Lim et al.,2021; Matar Boumosleh & Jaalouk, 2017).

## Problematic Screen Use and Anxiety

Internet addiction has been suggested to be associated with anxiety in several studies. For example, a study of 212 Iranian university students showed a significant association between cell phone overuse and students' stress ($r = 0.212$, $p = 0.002$), anxiety ($r = 0.193$, $p = 0.005$), and depression ($r = 0.153$, $p = 0.026$) (Hashemi et al., 2022). These results were similar to research which categorized Turkish university students as smartphone non-users ($n = 71$), low smartphone users ($n = 121$), and high smartphone users ($n = 127$). The high smartphone use group exhibited greater depression, anxiety, and daytime dysfunction scores compared to the low smartphone use and smartphone non-user groups. Positive correlations were also observed between Smartphone Addiction Scale scores and depression levels, anxiety levels, and certain sleep quality scores (Demirci, Akgonul, & Akpinar, 2015).

Another study on 1,300 Egyptian university students demonstrated that 59% were smartphone addicts, with no gender difference. Positive associations were observed between

smartphone addiction and anxiety ($\chi^2 = 142.753$, $p < 0.001$), and sleep disturbance ($\chi^2 = 209.645$, $p < 0.001$) (Okasha et al., 2022). Overall, the findings from the literature suggest a potential association between smartphone overuse and anxiety in university students, emphasizing the need for monitoring those with high smartphone addiction for anxiety (Hashemi et al., 2022; Okasha et al., 2022; Demirci, Akgonul, & Akpinar, 2015). However, anxiety is not the only mental health concern that may be associated with internet addiction.

## Problematic Screen Use and Depression

Numerous studies have indicated a connection between internet addiction and depression. A previous study on 935 Saudi Arabian adults observed that the highest rates of internet addiction were linked to the most elevated levels and severity of depression, particularly within the youngest age group (18 to 35 years) (Alhassen et al., 2018). These findings underscore the importance of focusing on younger adult populations, who may be disproportionately affected by internet addiction and its association with depression as we know this group is among the heaviest users of smartphones (Lim et al., 2021; Matar Boumosleh & Jaalouk, 2017).

Another study on 688 American university students noted that approximately 49% of the participants self-reported excessive smartphone use, while ~20% indicated symptoms of depression (Matar Boumesleh & Jaalouk, 2017). Alarmingly, more than 35% of the participants reported sleeping less than 4 hours per night, attributing it to excessive smartphone use (greater than 5 hours on weekdays) and experiencing fatigue due to late-night smartphone usage. Researchers concluded that depression scores were significantly and positively associated with smartphone addiction ($r = 0.229$, $p < 0.001$), as evidenced by multiple regression analyses ($R^2 = 0.229$) (Matar Boumesleh & Jaalouk, 2017). These findings underscore the elevated prevalence of internet addiction and depression among young adults, especially college students.

While smartphones significantly contribute to internet addiction and are linked with depression, the specific role of social media in this association should not be overlooked. The literature shows social media use as a primary reason for excessive smartphone use (Lim et al., 2021), highlighting a potential interplay between internet addiction, social media, and depression. This relationship has been explored in previous studies throughout the literature. For example, a previous study on 347 Pilipino university students used validated survey instruments to assess the possible associations between Facebook use and depression (Maglunog & Dy, 2019). The results indicated that participants spent an average of 212 minutes per day on Facebook, with over a quarter exceeding 250 minutes daily. Frequent Facebook activities included sending private messages, chatting, and viewing videos. Among the participants, about 46% indicated experiencing depression. Researchers observed a positive correlation between frequency of Facebook visits ($r = 0.305$, $p < 0.05$), number of minutes spent on Facebook ($r = 0.423$, $p < 0.05$), and levels of depression (Maglunog & Dy, 2019). This study suggests there may be a positive relationship between excessive social media use and depression in college students. It's important to note that social media is an umbrella term encompassing more than just Facebook, such as, Instagram, X (formally known as Twitter), TikTok, Snapchat, and YouTube.

In a similar study on 105 Emirati university students, researchers observed moderate levels of problematic social media use were present in the study's participants. Nearly half of the students ($N = 44$; 41.9%) reported having depressive symptoms. Those with greater depression scores predicted elevated social media addiction. Through stepwise linear regression analysis that adjusted for age, academic discipline, gender, university level, social media application used, and social media addiction score, depression emerged as the exclusive predictor of

problematic social media use (OR = 1.1, p = 0.005). This highlights the potentially significant influence of social media on the severity of depression among university students (Al Saigh et al., 2022).

Research consistently shows a relationship between internet addiction and depression across different groups. Studies on smartphone use in Saudi Arabia and American university students highlight how younger adults, especially college students, are more prone to and potentially negatively impacted by excessive internet use (Alhassen et al., 2018; Matar Boumesleh & Jaalouk, 2017). Social media use among this population is linked to higher depression levels (Maglunog & Dy, 2019), with a study in Abu Dhabi suggesting that depression is tied to problematic social media use, a form of internet addiction (Al Saigh et al., 2022). This consistent evidence underscores the need to recognize and address the possible relationship between internet addiction and depression, especially among younger people and college students.

## Problematic Screen Use and Stress

Previous research has demonstrated internet addiction has been associated with stress. For example, Bueno-Brito et al. (2024) examined the potential association between smartphone addiction and stress on 212 Mexican nursing students. Using validated and reliable addiction and mental health instruments, author observed high rates of smartphone addiction (38%) and stress (39%) in their sample. There were also significant positive associations between smartphone addiction and stress ($r = 0.36$; $p < 0.001$). These results demonstrate that users with smartphone addiction had higher rates of stress levels, showing the potential negative impact of smartphone addiction on mental health assessed via stress (Bueno-Brito et al., 2024).

In a similar study on 433 Turkish university students, researchers observed positive associations between internet use and stress (Unsar et al., 2020). Through numerous validated survey instruments and correlations analysis, authors observed a significant positive association between daily internet use (min) and stress ($r$ = .156; $p$ = 0.001), as well as weekly internet use (hours) and stress ($r$ = .124; $p$ = 0.010). Students that were freshman had higher rates (45%) of internet addiction compared to seniors (9.2%), which may suggest addiction targeted interventions should be implemented as early as possible for incoming college students. In conclusion, several studies observed a significant association between internet addiction and stress, further highlighting the potential negative impact of internet addiction on mental health (Bueno-Brito et al., 2024; Unsar et al., 2020).

## Problematic Screen Use and Sleep

In addition to anxiety, stress, and depression, existing evidence suggests that internet addiction may also be associated with sleep disturbances. One study conducted on 16,292 Indian adolescents and young adults demonstrated that 18% of adolescents and 31% of young adults reported using smartphones for three or more hours per day (Maurya et al., 2022). Notably, these same participants also reported a greater incidence of sleep disturbances in the last 15 days. Additionally, the rate of sleep problems was elevated among adolescents and young adults with low levels of physical activity. The data demonstrated that using a smartphone for more than two hours a day increased the risk of sleep problems by 1.55 times for adolescents and 1.48 times for young adults. In summary, excessive smartphone use was prevalent among adolescents and young adults, and higher usage (coupled with lower levels of physical activity) was associated with a greater likelihood of sleep problems compared to lower levels of use (Maurya et al., 2022).

Additional evidence on 220 Indian university students reported an inverse relationship between internet addiction and both subjectively and objectively assessed measures of sleep quality (Sonawane et al., 2019). Objective sleep quality was evaluated using the Fitbit Charge 2, while validated survey items were used to assess subjective sleep quality and internet addiction. Investigators identified 120 participants with high smartphone usage and 134 with poor sleep quality. Notably, students addicted to smartphones exhibited significantly worse objectively measured sleep quality than their non-addicted counterparts. Users with greater smartphone addiction levels had greater self-reported sleep disturbances ($r = 0.509$, $p < 0.001$) than users who were not addicted to their smartphones. The authors hypothesized that the potentially negative effects from smartphone use on sleep may be attributed to bright light exposure, electromagnetic radiation, or both. Moreover, smartphone-addicted users objectively experienced more awake time after sleep onset and reported increased lethargy and inactivity due to poor sleep quality (Sonawane et al., 2019). This study replicates previous findings (Maurya et al., 2022), providing additional insight through objective sleep measures that align with subjective sleep reports in individuals with smartphone addictions.

Furthermore, several studies support the association between internet addiction and sleep quality, particularly concerning excessive social media use, which is a primary driver for (Maurya et al., 2022; Wang et al., 2021; Sonawane et al., 2019; Abdulah et al., 2018). In one study of 286 Saudi Arabian medical students, investigators observed a significant majority (90%) of participants reported daily usage of Twitter/WhatsApp, with 30% dedicating at least three hours to these platforms each day (Abdulah et al., 2018). Notably, most students engaged with Twitter/WhatsApp during the evening, and 30% exhibited poor sleep quality. The highest prevalence of poor sleep quality was observed among individuals spending more than 4 hours

daily on Twitter/WhatsApp (Abdulah et al., 2018). As social media is considered part of internet addiction, this study aligns with the previous findings (Sonawane et al.,2019), which measured internet addiction using smartphones. Similar outcomes were replicated when focusing on Facebook use rather than Twitter/WhatsApp (Wang et al., 2021).

Regarding another study on 277 Taiwanese university students, researchers observed nearly half (48%) of users spent at least an hour on Facebook after logging in, 30% were consistently logged in, and 36% actively used Facebook for 3 to 5 hours at a stretch (Wang et al., 2021). Alarmingly, over 50% of participants reported poor sleep quality, and even one hour of daily Facebook use was associated with poor sleep. Investigators concluded that a significant and positive correlation ($OR = 1.05$, $p < 0.05$) existed between sleep quality and Facebook addiction, with 30% of participants exhibiting addictive tendencies. These outcomes align with previous research (Abdulah et al.,2018), that investigated Twitter/WhatsApp instead of Facebook.

Additionally, a study in India revealed that adolescents and young adults spending more than two hours a day on smartphones had a higher likelihood of reporting sleep problems (Maurya et al., 2022). Another study with college students in India found that those addicted to smartphones had worse sleep compared to non-addicted peers, indicating a possible positive relationship between smartphone addiction and poor sleep quality (Sonawane et al., 2019). This is similar to research involving Saudi Arabian medical students which showed an association between excessive use of Twitter and WhatsApp, considered part of internet addiction, and poor sleep quality (Abdulah et al., 2018). Similar outcomes were observed in a study with Taiwanese university students, where poor sleep quality was significantly and positively correlated with Facebook addiction (Wang et al., 2021). In summary, these studies collectively suggest that internet addiction, particularly through social media and smartphones, might contribute to sleep

problems, shedding light on the relationship between internet use and sleep quality. The lack of sleep observed throughout the literature may be a contributor to depression in individuals with internet addiction as well.

### Problematic Screen Use and Physical Activity and Sedentary Behavior

Recent research has suggested a relationship between smartphone use, physical activity, and sedentary behavior (Fennel et al., 2019). The study aimed to evaluate how 423 adults aged 18 to 80 years use their cell phones in different situations (sitting, standing, or being physically active) and explore the relationship between cell phone use, physical activity, and sedentary behavior. Users reported an average daily cell phone use of 239 minutes, with 81% typically using the device while sitting. The findings indicated a positive association between cell phone use and sedentary behavior, as well as the interaction between physical activity and sedentary behavior (referred to as the "active couch potato" phenomenon). Higher cell phone users engaged in more sedentary time compared to lower users, but there were no significant differences between high and moderate users or between low and moderate users. Additionally, cell phone use was negatively associated with age and showed no correlation with physical activity or gender (Fennel et al., 2019).

Previous investigations also have shown smartphone use to be associated with sedentary behavior but the relationship to physical activity is less clear (Barkley et al., 2016). In one study on 236 college students, researchers observed a positive association ($\beta = 0.23$, $p < 0.05$) between smartphone use and sedentary behavior, particularly among high users who engaged in significantly more sedentary activities than moderate and low smartphone users. However, their study found no correlation between smartphone use and overall physical activity levels (Barkley et al., 2016).

While these studies did not show a relationship between smartphone use and physical activity levels, similar studies have shown cell phone use as having an impact on exercise intensity. For example, a study on 226 United States university students demonstrated self-reported smartphone use averaged 380 minutes per day, with 87% occurring while sitting and 70% for leisure (Barkley & Lepp, 2016). Smartphone use showed a positive association with sedentary behavior ($\beta = 0.30$, $p < 0.001$) but was again not associated with overall physical activity. However, as smartphone use increased, the likelihood of using the device during moderate ($p = 0.006$) and mild ($p < 0.001$) intensity exercise also rose. This is problematic as smartphone use during physical activity may reduce the intensity of that activity (Barkley & Lepp, 2016; Rebold et al., 2015). The results suggest that smartphone use tends to be a sedentary leisure behavior. Moreover, frequent use increases the likelihood of using it during exercise, potentially reducing exercise intensity (Barkley & Lepp, 2016).

Smartphone use is not only associated with exercise intensity but also to cardiorespiratory fitness. A previous study on healthy college students demonstrated a significant negative association ($\beta = -0.25$, $p = 0.047$) between smartphone use and cardiorespiratory fitness, even after accounting for sex, self-efficacy for exercise, and percent body fat (Lepp et al., 2013). High-frequency smartphone users were more likely to forgo physical activity opportunities for sedentary smartphone use, while low-frequency users cited active peer connections as a motivation for physical activity. The study suggests that, similar to traditional sedentary behaviors, high smartphone use may disrupt physical activity and diminish cardiorespiratory fitness (Lepp et al., 2013).

While some research failed to report an association between self-reported total smartphone use and physical activity a more recent study of 50 college students reported a

negative correlation ($r = -0.25$) between objectively measured daily smartphone use and steps (Smith-Ricketts et al., 2022). Mixed model regression confirmed the significance of this relationship ($F = 3.65$, $p = 0.00019$) (Smith-Ricketts et al.,2022). It is possible that the different methods of assessment, subjective versus objective measures, may explain these equivocal findings regarding the relationship between smartphone use and physical activity.

The relationship between smartphone use and physical activity may also differ if measures of smartphone addiction is swapped for measures of total smartphone use (Saffari et al., 2022). For example, a study on 391 Chinese female university students demonstrated significant association between smartphone addiction and reduced physical activity levels ($OR = 0.11$, $p = 0.003$). Investigators concluded that excessive smartphone use might contribute to lower physical activity levels compared to non-excessive users (Saffari et al., 2022). Further, recent research on 215 Turkish university students reported that approximately 25% of the subjects were internet addicted (Alaca, 2020). This group exhibited significantly ($p < 0.05$) lower levels of physical activity compared to individuals who were not addicted to the internet. These findings suggest that internet addiction may be associated with lower levels of physical activity (Alaca, 2020).

While these studies (Saffari et al., 2022; Alaca, 2020) demonstrate a potential connection between smartphone use and addiction to physical activity levels, neither study specifically evaluated social media use, which might impact smartphone use and, consequently, internet addiction. A different study on 163 Turkish adults (average age 34.75±6.02 years) observed social media addiction was higher in individuals with lower physical activity levels (Alime et al., 2021). Further research examining 100 Turkish university students also assessed physical

activity and social media addiction (Tosum et al., 2020). The study demonstrated a negative correlation ($r = -0.864$, $p < 0.001$) between physical activity levels and social network addiction.

Internet addiction may also predict sedentary behavior. A recent study on 31,954 Chinese high school students reported 6% of students met the criteria for internet addiction, 73% exhibited high levels of sedentary behavior, and 72% had low physical activity (Han et al., 2021). In their multivariate analysis, investigators reported that participants with low physical activity ($OR = 1.22$, $p < 0.001$) and high sedentary behavior ($OR = 1.72$, $p < 0.001$) were 1.99 times more likely to be classified as internet addicted compared to their counterparts with high physical activity and low sedentary behavior (Han et al., 2021). These findings suggest an association between internet addiction and both low physical activity and increased sedentary behavior.

Prior evidence indicates that cell phone use predicts sedentary behavior (Lepp & Barkley, 2019). However, the relationship between cell phone use and physical activity is not as clear (Barkley, Lepp, & Salehi-Esfahani, 2016; Lepp et al., 2013). A better understanding is needed as physical activity and low sedentary behavior may be beneficial for decreasing symptom severity of depression and anxiety and increasing sleep quality. This relationship is also important to understand as excessive cell phone use and internet are associated with an increased incidence of depression (Al Saigh et al., 2022; Maglunog & Dy, 2019; Alhassan et al., 2018; Lepp, Barkley, & Li, 2017; Matar Boumosleh & Jaalouk, 2017), anxiety (Hashemi et al., 2022; Okasha et al., 2022; Demirci, Akgonul, & Akpinar, 2015) and poorer sleep quality (Maurya et al., 2022; Wang et al., 2021; Sonawane et al., 2019; Abdulah et al., 2018; Li, Lepp, & Barkley, 2015).

## Problematic Screen Use and Body Fat Percentage

While there are numerous studies demonstrating the relationship between internet addiction and physical activity and sedentary behavior, previous research has demonstrated internet addiction may also be associated with body fat (Domoff et al., 2020; Kim et al., 2015). For example, a previous study on 110 Chinese international students in Korea observed a negative association between smartphone addiction and muscle mass ($r$ = -0.245; $p$ = 0.001), and a positive association between smartphone addiction and fat mass ($r$ = 0.435; $p < 0.001$). Muscle mass and fat mass were assessed using bioelectrical impedance. In conclusion, participants with smartphone addiction had higher levels of fat mass and lower levels of muscle mass.

Additionally, a study in the American Midwest on university students observed a significant positive association between smartphone addiction and body fat percentage ($r$ = 0.22; $p < 0.05$), as well as between smartphone addiction and dysregulated eating ($r$ = 0.53; $p < 0.01$). Smartphone addiction was also positively associated with emotional dysregulation ($r$ = 0.29; $p <$ 0.01). These results suggest smartphone addiction is positively associated with increased body fat percentage, as well as emotional dysregulation. Further research may be warranted to better understand the relationship between smartphone addiction, body fat percentage, and mental health as suggested by these prior investigations (Domoff et al., 2020; Kim et al., 2015).

## Problematic Screen Use and All-Cause Mortality

Given that internet addicted individuals are more prone to sedentary behavior, they might be at a heightened risk of all-cause mortality (Stingl-Zúñiga et al., 2023; Li et al., 2022; Salinas-Rodgriguez et al., 2022). For example, researchers conducted an analysis on data from the Chilean National Health Survey, involving 5834 respondents aged 20 to 96 years, with a median age of 51 years (Stingl-Zúñiga et al., 2023). The authors estimated that physical inactivity and

sedentary behavior might have contributed to up to 10% of all deaths in Chile in 2018. Similarly, previous investigations observed comparable results in an older adult population (mean age of 67.5 years) of 2404 individuals from the World Health Organization Study on global AGEing and adult health in Mexico (Salinas-Rodríguez et al., 2022). Their findings demonstrated that participants with low physical activity levels and high sedentary behavior experienced increased mortality and disability rates, along with a lower quality of life. In a cohort of 17,265 Chinese individuals from the Rural Chinese Cohort Study, researchers also identified a significant dose-response relationship ($HR = 1.11$, $p < 0.05$) between sedentary time and all-cause mortality after a 6-year follow-up period (Li et al., 2022).

## Heart Rate Variability

Heart rate variability is the fluctuation in the amount of time between each consecutive heartbeat, referred to as interbeat intervals (McCraty & Shaffer, 2015). The differences in interbeat intervals are non-linear and mathematically chaotic (Goldberger, 1991). Heart rate variability offers insight into the regulation of the autonomic nervous system, specifically the balance of sympathetic and parasympathetic drives (Yugar et al., 2023). While excessively low heart rate variability is associated with increased mortality, cardiac risk, and autonomic dysfunction, excessively high heart rate variability is seen in disease states such as atrial fibrillation in older individuals (Stein et al., 2005). High-normal resting heart rate variability in healthy individuals, however, is associated with comparatively better executive function such as attention and emotional processing (McCraty & Shaffer, 2015).

The most accepted method of deriving heart rate variability is root mean square of successive R-R interval (R-R intervals refer to the time between consecutive R waves on an electrocardiogram) is the principal metric for assessing heart rate variability. It is calculated by

first determining the time difference between consecutive heartbeats in milliseconds (Shaffer & Ginsberg, 2017). Subsequently, each of these values is squared and averaged, and the square root of the total is calculated. A larger root mean of successive R-R interval difference indicates a greater heart rate variability (Shaffer & Ginsberg, 2017).

The two main time frames used to measure heart rate variability are 24-hours or short-term (5 minutes). 24-hour measurements may provide more insight into the effects of circadian rhythm on autonomic system function than short-term measurements, but short-term data are still shown to provide significant insight into overall autonomic function (Karemaker, 2009). Heart rate variability represents the relationship between sympathetic and parasympathetic drives: this relationship is dynamic, complex, and not "zero sum". For example, parasympathetic drive can increase, decrease, or remain the same in the setting of changes in sympathetic drive (Billman et al., 2015). Short-term measurements are also representative of regulatory mechanisms such as the baroreceptor reflex that controls blood pressure based on negative-feedback and changes in vascular tone (Gavirtz et al., 2016). Specifically, when an individual inhales, their heart rate increases, and blood pressure also increases about 5 seconds later. Baroreceptors, which sense changes in blood pressure, fire more rapidly due to the blood pressure increase. This increase in firing causes a drop in blood pressure (via vasodilation) and heart rate, observed after exhaling (Lehrer & Vaschillo, 2008). The baroreflex is what makes this speeding up and slowing down of the heart possible. The complex adjustments of the autonomic nervous system, which involve the baroreflex, heart rate, and blood pressure, contribute to the variability in time fluctuations between R-R intervals observed during heartbeats (Vaschillo et al., 2002).

## Problematic Screen Use, Heart Rate Variability, and Cardiovascular Risk

Low heart rate variability is associated with disease and mental health disorders (Tiwari et al., 2021). Recent evidence suggests as an individual's internet addiction increases, their resting heart rate variability decreases below normal values, possibly contributing to negative health implications (Zhang et al., 2022). The negative association has been observed in numerous populations, from school-aged children to college students. In a study where 240 Chinese school-aged children were recruited, researchers administered the Chinese Internet Addiction Scale (26 item scale that is scored from 26 to 104) and used spectral analysis to measure heart rate variability (Lin et al., 2022). The results of the cross-sectional study showed internet addicts (Chinese Internet Addiction Scale score greater than 63) having a significantly lower high frequency percentage, higher low frequency percentage, and lower total frequency power compared to children who were not addicted to the internet. Authors concluded internet addiction was associated with lower heart rate variability compared to normal values, overall exhibiting autonomic dysregulation (Lin et al., 2022). Similar results were observed in another study on 46 college students from China, where internet addicted individuals were found to have significantly lower heart rate variability than students who were not addicted to the internet (Zhang & Xu, 2022). While researchers have speculated that poor sleep quality and depression may play a role in this relationship, the mechanism remains unknown (Zhang et al., 2022; Lin et al., 2014). However, researchers have hypothesized that reduced parasympathetic activity (beyond normal values) may be caused by short sleep durations in individuals with internet addiction (Spiegelhalder et al., 2011). The higher sympathetic activity (beyond normal values) in internet addicted individuals may be caused by the increased rates of depression and anxiety observed in this population (Williams, 2015).

The relationship between heart rate variability and internet addiction may be especially concerning due to heart rate variability also having a negative relationship with cardiovascular disease (Kuboto et al., 2017). For example, results from a study with 9,744 participants (aged 45 to 64) without baseline cardiovascular disease, recruited from numerous United States communities, showed an inverse relationship between heart rate variability and cardiovascular incidence. Participants were followed over a 24-year period, from 1989 to 2013, with heart rate variability being collected throughout the study. Cardiovascular incidence rates increased with reduced rates of heart rate variability. Researchers concluded reduced heart rate variability may be associated with an increase in cardiac events due to autonomic dysfunction, which may trigger conditions such as high blood pressure, increased inflammation, impaired cerebral blood flow, and therefore an increase in cardiac events that was observed during the study (Kuboto et al., 2017). An increase in autonomic dysfunction (observed through reduced heart rate variability) has previously been shown to lead to an increase in cardiovascular risk factors, which increases the risk of cardiovascular incidents (Gezer et al., 2022; Samora et al., 2023). Since the United States has a university population where about 25% is addicted to the internet, this population may be at risk for decreased heart rate variability and possibly an increase in cardiovascular events in the future.

## Heart Rate Variability and Depression

Researchers have recently observed a relationship between heart rate variability and depression (Borrione et al., 2018). In an exploratory study, 118 depressed Brazilian hospital patients had their heart rate variability collected via electrocardiography, using root mean square of successive differences for the time-domain. The frequency-domain recordings consisted of low frequency (0.04 to 0.15 Hz), high frequency (0.15 to 0.4 Hz), and low/high frequency ratio.

Results from a multiple linear regression showed depressive symptoms predicted low frequency and low/high frequency ratio. These recent exploratory results show there is an association between depression and heart rate variability (Borrione et al., 2018), which are similar to the results observed in previous studies using root mean of successive differences to measure heart rate variability (Borrione et al., 2013)

While exploratory research has demonstrated a relationship between heart rate variability and depression, further research has shown a deeper insight into this relationship (Hartmann et al., 2019). For example, 127 (62 depressed and 65 control) individuals were recruited for a study that investigated heart rate variability as a possible indicator of clinical state depression. After initial measurements of heart rate variability and depression were recorded, participants were given an antidepressant medication for the duration of the study. Results showed significant differences ($F = 15.029$, $p < 0.001$) in baseline heart rate variability between groups. Depressed individuals had lower high frequency power compared to the control group. After treatment with antidepressants, the depressed group experienced lower depression symptom severity and improved heart rate variability that was no longer significantly different from the control group. These results indicate heart rate variability is linked to depression symptom severity and therefore could be used a bio marker in depression diagnostics, however, further research needs conducted to confirm this relationship (Hartmann et al., 2019).

Even though there is evidence supporting the relationship between heart rate variability and depression, the mechanism behind this relationship remains unclear. Researchers have theorized heart rate variability dysfunction potentially leading to a reduction in vagal tone (Hartmann et al., 2019; Borrione et al., 2018). There is evidence vagal tone has been used as an indicator of treatment response in depression (Chambers & Allen, 2002). These associations

between vagal tone, depression, and heart rate variability may exist due to vagal tone's physiological stress index utility (Porges 1995). Heart rate variability and emotional regulation also have been shown to share similar neural networks in the brain (Williams, 2015). Overall, there is a body of evidence in the literature showing a negative association between heart rate variability and depression.

## Heart Rate Variability and Anxiety

Low heart rate variability has been associated with psychological disorders such as anxiety (Tomasi et al., 2024; Chalmers et al., 2014; Gorman & Sloan, 2000). Previous research on 240 Canadians observed the association between anxiety and heart rate variability (Tomasi et al., 2024). Investigators split their sample into an experimental anxiety group (n = 120) or into a control group where individuals did not have anxiety (n = 120). Anxiety was assessed using validated survey items while resting heart rate variability was assessed using a wearable device for 5 minutes. Researchers observed a significant difference in resting heart rate variability between the two groups ($F = 1.182$; $p = 0.011$), with greater anxiety symptom severity being significantly associated with lower resting heart rate variability ($r = -0.17$; $p = 0.02$). Anti-anxiety medication use did not significantly impact this association (Tomasi et al., 2024).

While anxiety and heart rate variability appear to be associated, the mechanism behind this potential relationship is not fully understood (Chalmers et al., 2014; Gorman & Sloan, 2000). The current theory is a reduction in vagal tone causing the nervous system to not be able to inhibit feelings, such as panic and worry, and increased heart rate. These prolonged heightened states, and a lack of ability to reduce them, appear to cause high basal levels of cortisol, further lowering vagal tone (Chalmers et al., 2014). Impaired vagal function may also be increasing

rates of anxiety (also lowering heart rate variability), as causation between the relationship of anxiety and heart rate variability is not currently known (Tomasi et al., 2024).

## Heart Rate Variability, Physical Activity, and Sedentary Behavior

Previous evidence links heart rate variability to physical activity. For example, one study on 3,328 British male adults demonstrated low frequency power increased with moderate ($p < 0.05$) and vigorous ($p < 0.01$) physical activity (Rennie et al., 2003). Similar trends were observed with high frequency power for vigorous ($p < 0.01$) but not moderate ($p = 0.32$) physical activity. Overall, heart rate variability increased with increasing physical activity intensity (Rennie et al., 2003).

Another study on 66 sedentary middle-aged Spanish adults demonstrated significant improvements in heart rate variability after a 12-week training program (Navarro-Lomas et al., 2022). Participants were randomly assigned to either a control (no exercise), combination (resistance and aerobic), endurance only, or resistance only group. Significant differences were found between all experimental groups for root mean square of successive difference ($F = 6.428$, $p = 0.001$) pre to post training. There was no change in the control group over time. Since the control group had no significant differences pre to post exercise program, researchers concluded that exercise, regardless of modality, is shown to improve heart rate variability (Navarro-Lomas et al., 2022).

Recent research also suggests heart rate variability may be negatively impacted by sedentary behavior. One study on 96 Brazilian young adult women who were physically active showed significantly greater root mean square of successive differences ($p < 0.0001$) and smaller frequency/high frequency ratio ($p < 0.0001$) during mental stress and at rest than women who were sedentary (Zaffalon Júnior et al., 2018). Authors concluded sedentary behavior reduces

autonomic function at rest and during mental stress. Previous evidence demonstrates low heart rate variability being associated with depression (Zhang et al., 2022; Lin et al., 2022; Zhang & Xu, 2022). Low heart rate variability is also associated with sedentary behavior (Zaffalon Júnior et al., 2018), while higher heart rate variability is associated with physical activity (Navarro-Lomas et al., 2022; Rennie et al., 2003). Therefore, physical activity and exercise may have an antidepressant effect due in part to the increases in heart rate variability (Philippot et al., 2022).

## Need for Research

Current research gaps exist in understanding the behavioral, psychological, and physiological responses associated with internet addiction. The college population, given its heavy reliance on the internet (Lim et al., 2021; Matar Boumosleh & Jaalouk, 2017), faces an elevated risk of addiction. This heightened risk is linked to various adverse behavioral effects, including potentially decreased physical activity (Saffari et al., 2022; Alaca et al., 2020), increased sedentary behavior (Barkley & Lepp, 2016; Peltzer, Pengpid, & Apidechkul, 2014), and sleep disturbances (Maurya et al., 2022; Wang et al., 2021; Sonawane et al., 2019; Abdulah et al., 2018; Li, Lepp, & Barkley, 2015). All of which may contribute to a greater prevalence of anxiety, stress, depression, and increased body fat percentages in internet addicted college students (Bueno-Brito et al., 2024; Al Saigh et al., 2022; Domoff et al., 2020; Unsar et al., 2020; Maglunog & Dy, 2019; Alhassan et al., 2018; Lepp, Barkley, & Li, 2017; Matar Boumosleh & Jaalouk, 2017; Kim et al., 2015).

Moreover, internet addiction is associated with adverse changes in heart rate variability (Zhang et al., 2022; Lin et al., 2022; Zhang & Xu, 2022), particularly in individuals with depression (Brugnera et al., 2019; Hartmann et al., 2019; Borrione et al., 2018; Brunoni et al., 2013; Zeng et al., 2012). This combination of increased sedentary behavior, increased body fat

percentage and decreased heart rate variability poses an elevated risk for cardiovascular disease and, consequently, an increased risk of mortality (Stingl-Zúñiga et al., 2023; Li et al., 2022; Salinas-Rodgriguez et al., 2022). While previous research has identified an association between heart rate variability and depression (Brugnera et al., 2019; Hartmann et al., 2019; Borrione et al., 2018; Brunoni et al., 2013), the precise relationship between depression and heart rate variability remains unclear. In addition, there has yet to be a single comprehensive study until now investigating the relationship between these variables. Understanding this relationship in individuals with internet addiction could pave the way for internet addiction to serve as a diagnostic marker for depression, with treatment enhancing heart rate variability, and consequently reducing mortality risk in internet addicted college students.

## Purpose and Hypothesis

The primary objective of this study was to enhance our understanding of the relationship between internet addiction, physical activity, sedentary behavior, sleep disturbances, depression, anxiety, stress, body fat percentage, and heart rate variability among college students, who are at an elevated risk for internet addiction (Lim et al., 2021; Matar Boumosleh & Jaalouk, 2017). A survey was administered to assess these variables, including the objective measurement of physical activity and smartphone use for iPhone users. Body fat percentage will be assessed using bioelectrical impedance. Heart rate variability was measured using a Polar H10 heart rate monitor and the EliteHRV smartphone application. Based on the sedentary nature of internet use and existing research, we hypothesized that the severity of internet addiction among college students will correlate with lower levels of physical activity, increased sedentary behavior, heightened sleep disturbances, symptoms of anxiety, stress and depression, increased body fat percentage, and aberrant heart rate variability patterns.

The secondary aim of this study was to examine whether smartphone addiction mediates the relationship between stress and depression to HRV and body fat percentage. Given the negative associations of smartphone addiction with stress, depression, HRV, body fat percentage, and all-cause mortality (Bueno-Brito et al., 2024; Stingl-Zúñiga et al., 2023; Li et al., 2022; Salinas-Rodgriguez et al., 2022; Domoff et al., 2020; Tonacci et al., 2019; Matar Boumesleh & Jaalouk, 2017; Kim et al., 2015; Zeng et al., 2012), understanding this relationship has significant therapeutic potential. Treatment for smartphone addiction may enhance heart rate variability, decrease body fat percentage, lower levels of stress and depression, and therefore decrease mortality while improving mental health. Accordingly, we hypothesized that smartphone addiction would mediate the relationship between stress and depression, as well as the relationship between HRV and body fat percentage.

# Chapter III

## Methodology

All study procedures were approved by the Kent State University Institutional Review Board (IRB) prior to any recruitment or data collection for this study.

## Specific Aims

The first aim of this study was to assess the relationship between internet addiction and HRV, depression, anxiety, stress, physical activity, sedentary behavior, body fat percentage, and sleep disturbances via laboratory-based assessments, survey items, and data obtained from smartphone applications.

The second aim of this study was to assess if smartphone addiction mediates the potential relationship between stress and depression, as well as the relationship between HRV and body fat percentage. This was a secondary analysis of the data collected from aim 1.

## Participants

To meet the inclusion criteria, individuals had to be a Kent State University student between the ages of 18 to 25 years old and use an Apple iPhone operating iOS version 12 or newer. We had an estimated sample size of 50 participants based on a study by Zhang et al. (2022) that recruited 46 students. This prior study investigated the effects of an exercise intervention program on internet addiction, sleep quality, mood, and HRV. They reported effect sizes for exercise improving sleep quality, depression, internet addiction and HRV that were Cohen's $d \geq 0.75$. Given this effect size, an $\alpha \leq 0.05$ and a power $\geq 0.8$ a sample of 16 would be needed. However, this prior study utilized a combination of experimental and non-experimental methods that somewhat differ from the proposed study which is entirely non-experimental.

Given the design differences, our study obtained a sample ($N = 43$) that exceeded the minimum needed based upon the power calculations ($N = 16$) from the work by Zhang et al. (2022).

## Study Design

The primary investigator recruited students by proposing the study to eligible participants in undergraduate and graduate classrooms. The proposal was be made in front of the classroom at the beginning of class before regular lecturing began. Research flyers with the research team's information as well the general study requirements was also be posted around campus buildings on bulletin boards. All collected information was confidential with any digital materials kept under a passkey and any physical materials locked in the lab only accessible by the primary investigator and the research team. Any student who qualified and agreed to take part in the study came to the laboratory for a single visit where they completed the surveys, as well as had their height, weight, body fat percentage, HRV measures, physical activity, and cell phone use data collected. Informed consent was on the first page of the survey.

Participants completed surveys which assessed physical activity, sedentary behavior, smartphone use, sleep habits, and psychometric variables. They were also asked to complete questions on demographics. Students were asked to first complete the surveys and then had their height and body fat percentage collected via stadiometer and bioelectrical impedance, respectively. They were then instructed to sit quietly for five minutes. Immediately after five minutes of rest, HRV data was collected for five more minutes. They were asked to be part of overall data collection for a total of 45 minutes. After the data collection, one $10 Starbucks gift card was given as payment, at which time participants were finished with the study.

**Objective Physical Activity Step Application**

Average daily steps were collected using the "Health" app on participants' iPhones. This factory installed application estimates the number of steps you have taken throughout the day when your phone is on your person. Yearly trends were collected for the study. Participants opened the app, selected "Steps", then selected either "Y" (yearly) for trends. Validity has been shown when comparing the step tracker application to laboratory and free-living assessments (Duncan et al., 2017).

**Objective Cell Phone Use Application**

Cell phone screen use was assessed via the screen time app also on participants' iPhones. They selected "Settings", then "Screen Time" to access their screen use trends. The most recent seven days (full week) of screen use time was be collected. This app is also factory installed and provides an accurate estimation of screen use (Hodes & Thomas, 2021).

**Body Fat Percentage**

The Body Composition Analyzer Scale (InBody 570) was used to determine body fat percentage. Research has shown the InBody 570 to be a valid and reliable tool when compared to Dual-Energy X-Ray Absorptiometry (McLester et al., 2020). To obtain measurements, participants stood on the scale, held onto the hand electrodes, and followed the on-screen instructions. The device sends electrical currents through the body, measuring impedance across different tissues. These impedance values are then used to estimate body fat percentage.

**International Physical Activity Questionnaire-Short Form (IPAQ-SF)**

Sedentary time was measured using the International Physical Activity Questionnaire-Short Form (IPAQ-SF), a validated and reliable tool across 12 countries (Craig et al., 2003; Booth, 2000). In particular, the assessment focused on the question related to sitting behavior.

Participants self-reported the number of hours and minutes they typically spent sitting on a weekday over the past seven days.

Sedentary behavior questions were structured as follows:

1. During the **last 7 days**, how much time did you usually spend **sitting** on a **weekday**?

   _____ **hours per day**

   _____ **minutes per day**

**Young's Internet Addiction Test-Short Version (IAT-SV)**

The IAT is a 12-item survey used to assess an individual's severity of internet addiction (Young, 1998). Pawlikowski et al. (2012) demonstrated reliability of the IAT in college students. There were significant correlations observed between total internet usage per week and IAT-SV scores ($r = .400$; $p < 0.001$). A two factor ("loss of control/time management and "craving/social problems") analysis also showed significant correlations between IAT-SV scores and "loss of control/time management" ($r = .378$; $p < 0.001$) and "craving/social problems" ($r = .325$; $p < 0.001$). Pawlikowski et al. (2012) repeated these results in four different studies. This suggests that the IAT-SV is a valid and reliable instrument for assessing internet addiction (Pawlikowski et al., 2012). All 12 questions are answered based upon the five-point Likert scale as follows: 1 very rarely; 2 rarely; 3 sometimes; 4 often; and 5 very often. The Likert scale numbers are then summed for all questions for scoring, with a possible 12 to 60 total points. A higher score indicates higher levels of internet addiction. Some examples of the 20 questions were as follows:

1. How often do you find that you stay online longer than you intended?
2. How often do you neglect household chores to spend more time online?

**Social Media Disorder Scale (SMD)**

The SMD is a nine-item survey used to assess an individual's social media addiction severity (Boer et al., 2022). Structural validity was confirmed by a one-factor solution with an eigenvalue greater than 4.57. The one-factor solution also had an ordinal alpha of 0.87, indicating adequate test reliability (Boer et al., 2022). Individuals respond either "yes" or "no" to nine-items, with a score of six or more "yes" responses indicating social media addiction. A score of five or less "yes" responses indicate the individual does not have social media addiction. Some example questions were as follows:

1. During the past year, have you often felt bad when you could not use social media?
2. During the past year, have you tried to spend less time on social media, but failed?

**Smartphone Addiction Scale-10 items (SAS-10)**

The SAS-10 was developed to efficiently measure smartphone addiction (Li et al., 2023). A Rasch analysis resulted in an item reliability of 1.0 and person reliability of 0.76. Significant correlations were observed between SAS-10, the Smartphone Addiction Scale ($r = .917$; $p < 0.001$), Smartphone Addiction Scale-Short Version ($r = 0.840$; $p < 0.001$), and Problematic Mobile Phone Use Questionnaire ($r = 0.596$; $p < 0.001$). These results indicate sufficient reliability and validity of the SAS-10 (Li et al., 2023). All 12 questions are answered based upon the four-point Likert scale as follows: 1 Strongly Disagree; 2 Disagree; 3 Agree; and 4 Strongly Agree. The responses are totaled, with a higher score showing higher levels of addiction. Some examples of the items were as follows:

1. There is nothing other than smartphone use that is fun to do in my life.
2. My life would be empty without my smartphone.

**Pittsburgh Sleep Quality Index (PSQI)**

The PSQI was developed by Buysee et al. (1989) to evaluate sleep disturbance rate and sleep quality over the previous one month using a 19-item questionnaire. Grander et al. (2012) showed the PSQI has criterion validity by observing significant correlations with objective sleep measures. There are seven component scores within the 19 items, including: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The PSQI requires individuals to answer from zero to three, with zero being no level of dysfunction and three being a severe level of dysfunction. Each subcategory is summed with a possible score ranging from zero to 21, with a higher number equating to a worse sleep quality. A question from the sleep quality and use of sleep medication subcategories, respectively, were as follows:

1. During the past month, how long (in minutes) has it usually taken you to fall asleep each night? NUMBER OF MINUTES
2. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")? Not during the past month. Less than once a week. Once or twice a week. Three or more times a week.

**Patient Health Questionnaire-9 Items (PHQ-9)**

The PHQ-9 is a reliable and valid questionnaire designed to measure depression severity of individuals (Kroenke, Spitzer, & Williams, 2001). It uses nine items that are scored on a scale from zero (not at all) to three (nearly every day). Sun et al. (2020) demonstrated significant ($r = 0.610$; $p < 0.001$) construct validity against the Hamilton Depression Scale in hospital patients diagnosed with clinical depression. Pearson correlation analysis also showed a correlation coefficient of 0.737 for test-retest reliability in the same group (Sun et al., 2020). The items are

scored, with a higher score indicating greater depression severity. Example questions are as follows:

1. Little interest or pleasure in doing things
2. Feeling down, depressed, or hopeless

**Generalized Anxiety Disorder-7 Items (GAD-7)**

The GAD-7 is a reliable and valid questionnaire designed to measure anxiety severity in individuals (Dhira et al., 2021). It uses seven items that are scored on a scale from zero (not at all) to three (nearly everyday). Researchers demonstrated significant ($r = 0.69$; $p < 0.01$) construct validity against the Beck Anxiety Inventory in psychiatric patients undergoing treatment for anxiety (Johnson et al., 2019). Other researchers observed a significant Cronbach's $\alpha$ of 0.895, showing the GAD-7 to be reliable (Dhira et al., 2021). The items are summed, and a higher score indicates greater severity of anxiety. Items 1 and 2 from the GAD-7 were as follows:

1. Felling nervous, anxious or on edge
2. Not being able to stop or control worrying

**Perceived Stress Scale-10 Items (PSS-10)**

The Perceived Stress Scale-10 Item (PSS-10) was used to evaluate stress levels. This 10-item questionnaire is a reliable and valid tool for assessing perceived stress over the past month (Cohen & Williamson, 1988). Each item is rated on a five-point Likert scale: 0 (Never), 1 (Almost Never), 2 (Sometimes), 3 (Fairly Often), and 4 (Very Often). To determine the overall stress level, responses are summed, with higher scores reflecting greater perceived stress.

### HRV Data Collection

HRV data was collected using the Polar H10 heart rate monitor and the Elite HRV Pro smartphone application. The Polar H10 heart rate monitor was placed on the participant's upper torso. Schaffarczyk et al. (2022) observed the Polar H10 monitor and Elite HRV as a valid combination when comparing data to an electrocardiogram (ECG) during rest and exercise. Both methods of HRV measurement used root mean square of successive differences (RMSSD) to evaluate HRV. RMSSD is conventionally measured in five minutes and reflects the variance in heart rate between each beat (Shaffer & Ginsberg, 2017). This variance is essentially HRV, along with the changes in frequencies. Elite HRV can collect a selected time of HRV using the smartphone application version, and then is exported to the online application version. The online application version uses Elite HRV software to calculate the RMSSD of the collected data. This allowed for analysis of RMSSD, the main measurement in short term heart rate variability. We then imported the data from Elite HRV to SPSS that was used for analysis. These metrics allowed for an accurate representation of HRV health and were compared between individuals. Females had their HRV data collected during the first seven days of their menstrual cycle (or during placebo if take an oral contraceptive) due to menstrual cycles influencing HRV. During this phase of the menstrual cycle (follicular), HRV is at its greatest (Brar et al., 2015).

## Statistical Analysis

To assess the relationships between internet addiction, social media addiction, smartphone addiction, sleep, smartphone usage, steps, sitting, depression, anxiety, stress, body fat percentage, and HRV, Pearson's correlation analysis was performed using Software Package for Social Sciences (SPSS) Version 29 with an a-priori $\alpha \leq 0.05$ between all the variables.

To address our second aim, we assessed whether smartphone addiction mediated the relationship between stress and depression to percent fat and HRV. To examine whether smartphone addiction mediated the relationships between these variables, we followed the mediation analysis framework outlined by Baron and Kenny (1986). First, Pearson's correlation analyses were conducted to evaluate associations among smartphone addiction, stress, and body fat percentage. Next, a partial correlation analysis was performed to determine whether the relationship between stress and body fat percentage remained significant after controlling for smartphone addiction as a potential mediator. This procedure was then repeated to assess whether smartphone addiction mediated the relationship between depression and body fat percentage. The same approach was applied two more times to examine whether smartphone addiction mediated the relationships between stress and HRV, as well as depression and HRV. All statistical analyses were conducted using SPSS Version 29, with a significance level set at $\alpha \leq 0.05$.

# CHAPTER IV

# PROBLEMATIC SCREEN USE PREDICTS PERCENT BODY FAT IN HEALTHY COLLEGE STUDENTS

## Introduction

Internet addiction is characterized by excessive use of the internet and technologies such as smartphones, laptops, tablets, and desktop computers (American Psychological Association, 2023). It includes activities like social media use, web browsing, video watching, online gaming, and app usage. When this usage negatively impacts daily life, it becomes problematic. Smartphone addiction, or problematic smartphone use, specifically refers to excessive smartphone use that leads to adverse health and behavioral effects (Ratan et al., 2021). Similarly, social media addiction, or social media use disorder, involves compulsive use of platforms like Facebook, Instagram, TikTok, and X, which also negatively affects a user's life (Cheng et al., 2022). While the terminology may vary, all of these addictions are related to excessive use of digital technology. It's theorized that they are interconnected, and for this paper, they will either be discussed separately or grouped under the term "problematic screen use."

Prior evidence suggests smartphone addiction is associated with numerous negative psychological and physical health outcomes (Bueno-Brito et al., 2024; Hashemi et al., 2022; Okasha et al, 2022; Domoff et al., 2020; Lim et al., 2021; Tonacci et al., 2019; Alhassen et al., 2018; Matar Boumosleh & Jaalouk, 2017; Demirci et al., 2015). For example, researchers observed significant positive relationships between smartphone addiction and anxiety in college students (Hashemi et al., 2022; Okasha et al, 2022; Demirci et al., 2015). Numerous studies also indicate a significant positive relationship between smartphone addiction and depression in young adults (Lim et al., 2021; Alhassen et al., 2018; Matar Boumosleh & Jaalouk, 2017). Prior

research also suggests a significant positive association between smartphone addiction and stress (Bueno-Brito et al., 2024). In other words, greater smartphone addiction predicts greater anxiety, depression, and stress.

There is also evidence, albeit limited, of a significant positive relationship between smartphone addiction and measures of adiposity such as body mass index (BMI) and percent body fat (Domoff et al., 2020). Previous investigations have even demonstrated associations between smartphone addiction and poor heart rate variability (HRV) (Tonacci et al., 2019). HRV is the fluctuation in the amount of time between each consecutive heartbeat, referred to as interbeat intervals (McCraty & Shaffer, 2015). These mathematically chaotic and non-linear interbeat intervals known as HRV offer insight into the regulation of the autonomic nervous system, specifically the balance of sympathetic and parasympathetic drives (Yugar et al., 2023; Goldberger, 1991). Researcher have demonstrated poor HRV (i.e. excessively high or low) is predictive all-cause mortality (Talbert et al., 2024; Tsai et al., 2017; Liddell et al., 2016; Schuster et al., 2016; Carney et al., 2001). Taken together, greater smartphone addiction is associated with a greater risk of elevated adiposity and poor HRV.

The previously observed relationships between smartphone addiction and health outcomes may be due in part to relationships between smartphone use and certain health behaviors, including sleep, physical activity, and sitting (Maurya et al., 2022; Smith-Ricketts et al., 2022; Fennel et al., 2019; Sonawane et al., 2019). For example, Maurya et al. (2022) concluded smartphone addiction was significantly and positively associated with sleep problems in adolescents and young adults (Maurya et al., 2022). Similar results were observed in a study on university students (Sonawane et al., 2019). Recent research has suggested a significant negative relationship between smartphone addiction and physical activity in college students

(Smith-Ricketts et al., 2022). Additionally, previous investigations observed a significant relationship between smartphone addiction and sitting in adults (Fennel et al., 2019). In other words, smartphone addiction has been associated with increased sleep problems, decreased physical activity, and increased sitting. These behavioral health outcomes may be impacting the previously mentioned health outcomes associated with smartphone use. For example, increased sleep disturbances have been associated with increased severity of depression, anxiety, and stress and poor HRV (Sajjadieh et al., 2020; Nyer et al., 2013). Previous investigations have even demonstrated associations between poor sleep and increased body fat percentage (Kim et al, 2023). Researchers also observed a positive relationship between decreased physical activity and increased sitting and increased depression, anxiety and higher body fat percentage (Liao et al., 2024; Zhou et al., 2024; Lee & Kim, 2019).

While there is varying evidence supporting the relationship between measures of problematic screen use and health behaviors and outcomes we are not aware of any research that has attempted to assess these all of these aforementioned relationships in a single study focusing on college students. This population is potentially important as they are the first cohort of young adults to have lived in world where smartphones have been ever-present (Talmon, 2019). Therefore, the purpose of this study was to assess the relationship of three separate measures of problematic screen use (internet, social media, and smartphone addiction) to multiple health outcomes (depression, anxiety, stress, body fat percentage, and HRV) and behaviors (sleep, physical activity, and sedentary behavior) in a sample of college students.

## Methods

This study consisted of a sample of 43 ($N$ = 25 females) college students (21.5 ± 18 years old) from Kent State University (Kent, OH, USA). Participants were 18 to 25 years old and used

an Apple iPhone. They attended a single laboratory visit, where they filled out a survey, and their height and body fat percentage was assessed via a stadiometer and bioelectrical impedance (InBody 570), respectively. Informed consent was on the first page of the survey. After completing the surveys, participants were instructed to sit quietly for five minutes. Immediately after five minutes of rest, HRV data was collected for five more minutes. The entire laboratory visit lasted approximately 45 minutes. Upon completion of the study, one $10 Starbucks gift card was given as compensation.

A-priori power analyses were performed based on a similar study that investigated the effects of an exercise intervention program on internet addiction, sleep quality, mood, and HRV (Zhang et al., 2022). They reported effect sizes for exercise improving sleep quality, depression, internet addiction and HRV that yielded a Cohen's $d \geq 0.75$. Given this effect size, an $\alpha \leq 0.05$ and a power $\geq 0.8$ a sample of 16 would be needed. However, this prior study utilized a combination of experimental and non-experimental methods that somewhat differ from the present study, which is entirely non-experimental. Given the design differences, the final sample of $N = 43$ exceeded our power calculation.

**Body Fat Percentage**

Body fat percentage was measured using bioelectrical impedance analysis Body Composition Analyzer Scale (InBody 570). The InBody 570 has been demonstrated to be reliable and valid under very strict hydration, fasting, and exercise conditions when compared to Dual-Energy X-Ray Absorptiometry (McLester et al., 2020). The machine utilizes hand to hand and foot to foot electrical signals to predict body fat percentage.

**Physical Activity**

Physical activity was collected by having participants report their yearly average step count from their iPhones. The "Health" application is factory installed and estimates the number of steps participants have taken throughout the day. Validity has been shown when comparing the step tracker application to laboratory and free-living assessments (Duncan et al., 2017).

**Smartphone Usage**

Smartphone usage was assessed via the screen time application also on participant's iPhones. The most recent seven days (full week) of screen use time was collected. The application is also factory installed and provides an accurate estimation of screen use (Hodes & Thomas, 2021).

**Sitting**

Sitting time was assessed via the International Physical Activity Questionnaire-Short From (IPAQ-SF), which has been shown to be valid and reliable in 12 countries (Craig et al., 2003; Booth, 2000). Specifically, the question that references sitting. Participants were asked to report the number of hours and minutes spent sitting in response to the question: "During the last 7 days, how much time did you usually spend sitting on a weekday?"

**Internet Addiction**

Internet addiction was assessed via Young's Interned Addiction Test-Short Version (IAT-SV). The IAT-SV is 12 questions and has been demonstrated to be reliable in college students (Pawlikowski et al., 2012). All 12 questions are answered based upon the five-point Likert scale as follows: 1 very rarely; 2 rarely; 3 sometimes; 4 often; and 5 very often. The Likert scale numbers are then summed for all questions for scoring, with a possible 12 to 60 total points. A higher score indicated more severe internet addiction.

**Social Media Addiction**

Social media addiction was assessed using the Social Media Disorder Scale (SMD). The SMD is nine-items and has structural validity and test reliability (Boer et al., 2022). Individuals respond “yes” or “no”, with a score of six or more “yes” responses indicating social media addiction. A score of five or less “yes” responses indicate the individual does not have social media addiction. If a participant responded “yes”, their response was coded as a “2”, and “no” responses were coded as a “1”.

**Smartphone Addiction**

Smartphone addiction was assessed via the Smartphone Addiction Scale-10 items (SAS-10). The SAS-10 has been demonstrated to be a reliable and valid method for measuring smartphone addiction (Li et al., 2023). All 10 questions are answered based upon the four-point Likert scale as follows: 1 Strongly Disagree; 2 Disagree; 3 Agree; and 4 Strongly Agree. The responses are totaled, with a higher score demonstrating higher levels of addiction.

**Sleep**

Sleep was assessed using the Pittsburgh Sleep Quality Index (PSQI). The PSQI evaluates sleep disturbance rate and sleep quality over the previous one month using a 19-item questionnaire. Grander et al. (2012) demonstrated the PSQI has criterion validity by observing significant correlations with objective sleep measures (Grander et al., 2012). There are seven component scores within the 19 items, including: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The PSQI requires individuals to answer from zero to three, with zero being no level of dysfunction and three being a severe level of dysfunction. Each subcategory is summed

with a possible score ranging from 0 to 21, with a higher number equating to a worse sleep quality.

**Depression**

The Patient Health Questionnaire-9 Item (PHQ-9) was used to assess depression. The PHQ-9 is a reliable and valid questionnaire designed to measure depression severity of individuals (Kroenke, Spitzer, & Williams, 2001). It uses nine items that are scored on a scale from zero (not at all) to three (nearly every day). A higher score on the PHQ-9 indicates greater depression severity.

**Anxiety**

Anxiety was assessed using the Generalized Anxiety Disorder-7 Item (GAD-7). The GAD-7 is a reliable and valid questionnaire designed to measure anxiety severity in individuals (Dhira et al., 2021). It uses seven items that are scored on a scale from zero (not at all) to three (nearly everyday). Each item score is then totaled. A higher GAD-7 score suggests greater levels of anxiety.

**Stress**

Stress was assessed via the Perceived Stress Scale-10 Item (PSS-10). The PSS-10 is a reliable and valid 10 item questionnaire designed to measure perceived stress in individuals from the past month (Cohen & Williamson, 1988). All 10 questions are answered based upon the five-point Likert scale as follows: 0 never; 1 almost never; 2 sometimes; 3 fairly often; and 4 very often. The Likert scale responses are then summed for all questions for scoring, with a higher score indicating greater perceived stress.

### Heart Rate Variability

HRV data was collected using the Polar H10 chest heart rate monitor and the Elite HRV Pro smartphone application. The Polar H10 chest heart rate monitor combined with the Elite HRV smartphone application has been demonstrated to be a valid and reliable way to collect HRV (Schaffarczyk et al. 2022). The gold standard HRV measurement used is root mean square of successive differences (RMSSD) to evaluate HRV. Females had their HRV data collected during the first seven days of their menstrual cycle (or during placebo if take an oral contraceptive) due to menstrual cycles influencing HRV. During this phase of the menstrual cycle (follicular), HRV is at its greatest (Brar et al., 2015).

## Analytical plan

Pearson's correlation analyses were performed to assess the relationships between internet addiction, social media addiction, and smartphone addiction. Then the relationships between those three variables were assessed across the health behavior (sleep, smartphone usage, steps, and sitting) and health outcomes variables (depression, anxiety, stress, body fat percentage, and HRV) again using Pearson correlation. All analyses were performed via SPSS Version 29 with an a-priori $\alpha \leq 0.05$.

## Results

Means and standard deviations are shown in Table 1. There were large, significant positive effect sizes ($r \geq 0.50$, $p < 0.001$) for the relationships between internet addiction and social media addiction ($r = 0.714$), and smartphone addiction ($r = 0.611$). There was a similarly strong and significant positive relationship between social media addiction and smartphone addiction ($r = 0.656$).

**Table 1**

*Mean and Standard Deviations of Variables*

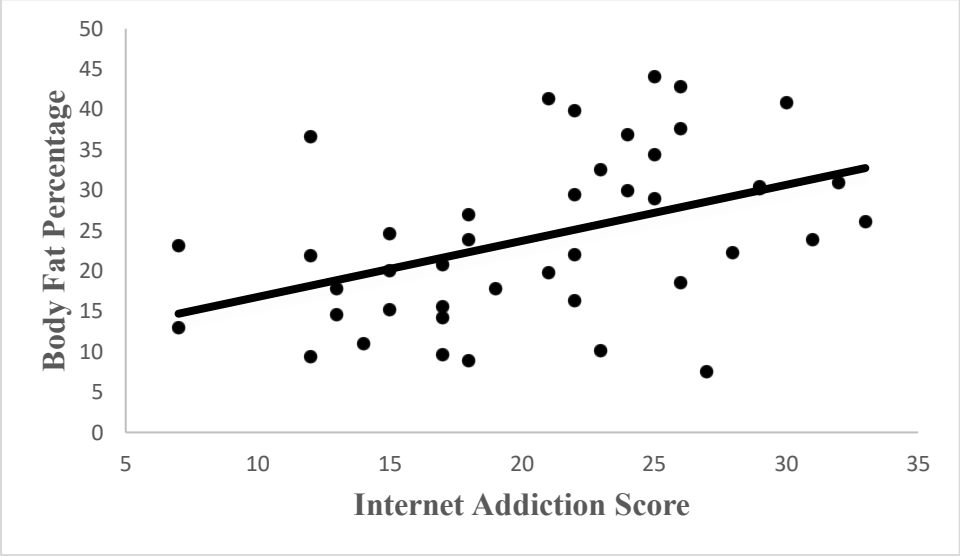
| **Variable (*N* = 43)** | **Mean** | **SD** |
|---|---|---|
| Internet Addiction | 20.74 | 6.59 |
| Smartphone Addiction | 24.83 | 9.02 |
| Social Media Disorder | 16.27 | 1.43 |
| Body Fat Percentage | 24.23 | 10.32 |
| Sleep | 4.48 | 2.76 |
| Depression | 5.83 | 2.76 |
| Anxiety | 6.74 | 5.38 |
| Stress | 16.27 | 6.62 |
| HRV (milliseconds) | 57.53 | 44.27 |
| Smartphone Usage (minutes per day) | 347.41 | 133.45 |
| Steps | 6908.39 | 2591.37 |
| Sitting (minutes per day) | 487.37 | 408.22 |

Means and standard deviations of various screen-based addiction measures and health and behavioral outcomes.

There was a significant positive correlation between internet addiction and body fat percentage ($r = 0.443$, $p = 0.003$), demonstrating participants with greater internet addiction had higher body fat percentage (shown in Figure 1). Sleep, depression, anxiety, stress, HRV, smartphone usage, steps, and sitting were not significantly associated with internet addiction ($r \leq 0.223$, $p \geq 0.150$).

**Figure 1**

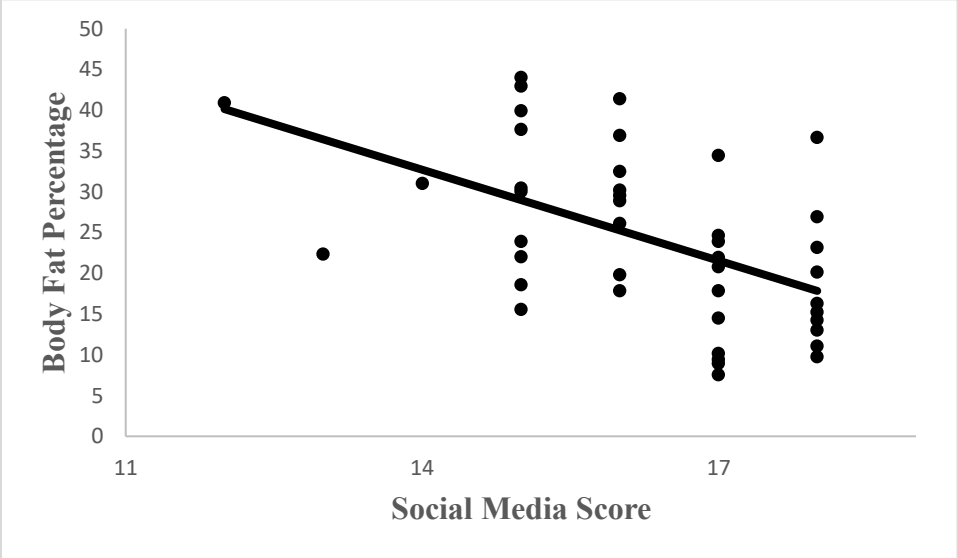
*Correlation Between Internet Addiction Score and Body Fat Percentage*




There was a significant negative correlation between social media addiction and body fat percentage ($r = -0.517$, $p < 0.001$). Regarding the social media addiction assessment, a higher score meant lower levels of addiction. These results demonstrate participants with greater social media addiction had higher body fat percentage (shown in figure 2). Sleep, depression, anxiety, stress, HRV, smartphone usage, steps, and sitting were not significantly associated with social media addiction ($r \leq 0.284$, $p \geq 0.065$).

**Figure 2**

*Correlation Between Social Media Addiction and Body Fat Percentage*




There was a significant positive correlation between smartphone addiction and depression ($r = 0.339$, $p = 0.026$), stress ($r = 0.363$, $p = 0.017$), and body fat percentage ($r = 0.434$, $p = 0.004$), demonstrating participants with greater smartphone addiction had greater severity of depression, higher levels of perceived stress, and higher body fat percentage (shown in Figure 3, 4, and 5, respectively). Sleep, anxiety, HRV, smartphone usage, steps, and sitting were not significantly associated with smartphone addiction ($r \leq 0.277$, $p \geq 0.072$).

**Figure 3**

*Correlation Between Smartphone Addiction and Depression*

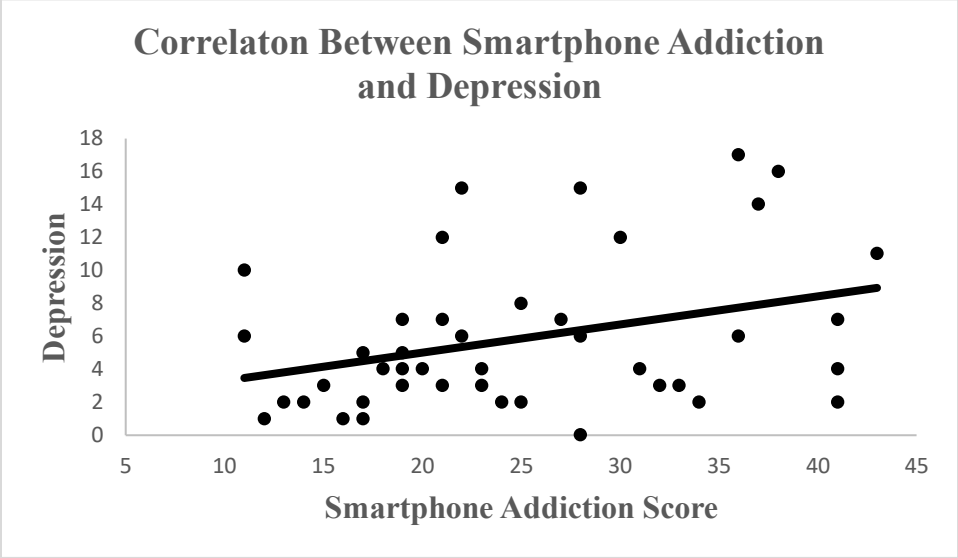


**Figure 4**

*Correlation Between Smartphone Addiction and Stress*

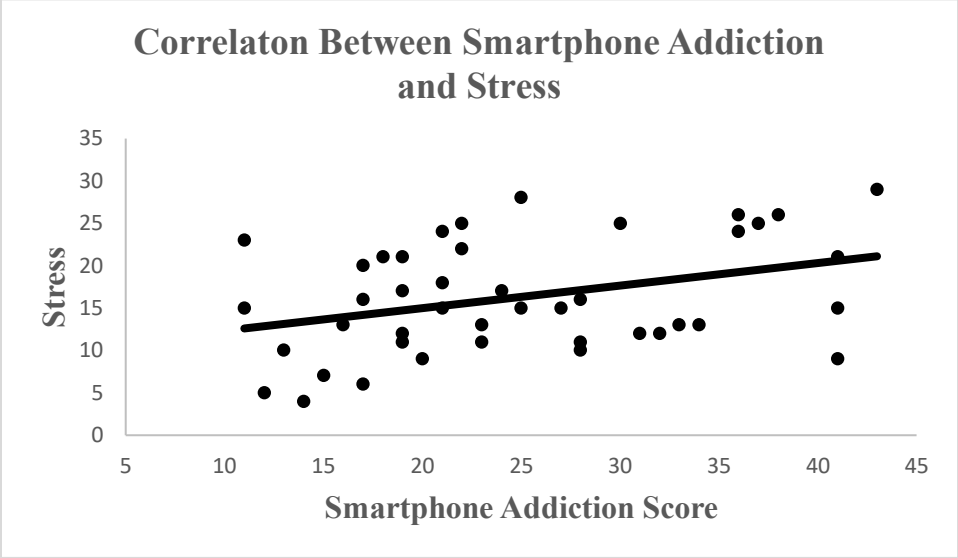
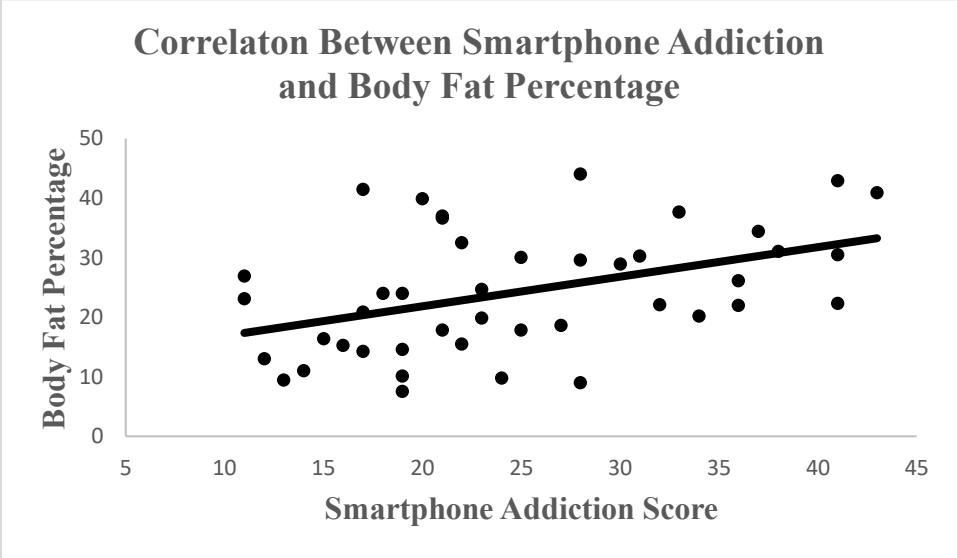


**Figure 5**

*Correlation Between Smartphone Addiction and Body Fat Percentage*




## Discussion

In this paper we assessed the ability of three correlated measures of problematic screen use to predict a variety of health behaviors and outcomes. Presently we noted positive relationships between all three problematic screen use measures and body fat percentage. Additionally, smartphone addiction was positively associated with depression severity and perceived stress. Taken together these findings suggest that participants who reported greater problematic screen use scores had greater body fat percentage as well as greater depression severity and perceived stress. There were no significant relationships between measures of problematic screen use and any of the other measures of health behaviors nor health outcomes assessed currently.

The relationship between each of the problematic screen use measures and body fat percentage is supported by previous research (Ayyiliz & Sahin, 2022; Azizi et al., 2024; Domoff et al., 2020). For example, Domoff et al reported a significant positive relationship between addictive smartphone use and percent fat in adolescents (Domoff et al., 2020). Additionally, while not assessing percent fat, others have similarly reported positive relationships between body mass index (BMI) and internet addiction as well as social media addiction (Aziz et al., 2024; Ayyildiz & Sahin, 2022). These findings are also similar to research that has consistently reported that excessive television viewing is predictive of both greater adiposity in a range of ages (Staiano et al., 2013; Dunstan et al., 2005). Therefore, the current findings further add to this existing evidence that excessive screen use is predictive of greater risks for obesity and excess body fat accumulation. The current research expands upon this evidence as it represents the first evidence of the ability of social media addiction and internet addiction to predict bodyfat. Furthermore, this is the first study we are aware of to assess the ability of these specific screen use measure to predict percent bodyfat in a sample of college students. This sample is of particular interest as they represent the first generation of young adults to grow up in a world where smartphones were always present (Talmon, 2019). Therefore, the current study contributes to filling these existing gaps in the literature.

The relationship between smartphone addiction, depression severity, and perceived stress is also similar to previous research (Bueno-Brito et al., 2024; Matar Boumosleh & Jaalouk, 2017). For example, Matar Boumosleh & Jaalouk (2017) reported a significant positive relationship between smartphone addiction and depression in university students (Matar Boumosleh & Jaalouk, 2017). In a similar study on university students, researchers observed a positive relationship between smartphone addiction and depression as well as smartphone

addiction and stress (Bueno-Brito et al., 2024). These previous findings suggest that smartphone addiction is positively associated with depression severity and perceived stress, which aligns with the findings of our present study.

While the relationship between smartphone addiction, depression and stress is supported by previous research, notably, prior evidence also suggests body fat percentage is associated with depression and stress (Dewi et al., 2021). One study demonstrated a positive relationship between body fat and depression, as well as body fat and stress in university students (Dewi et al., 2021). In other words, students with higher body fat percentages had higher rates of depression and stress. Previous evidence suggests there is a relationship between problematic screen use and sleep, anxiety, HRV, smartphone usage, steps, and sitting (Fennel et al., 2019; Hashemi et al., 2022; Lin et al., 2022; Maurya et al., 2022; Saffari et al., 2022), however, we did not observe these relationships in our present investigation. These previous findings are equivocal. For example, one of our previous studies reported a relationship between smartphone use and steps (Smith-Ricketts et al., 2022), however, we did not observe a significant relationship between smartphone use and steps in our present study. Given that these relationships, including our own findings, seem to be equivocal, further research is needed to clarify the context in which these relationships may occur.

While this investigation provides novel information regarding the potential relationships between problematic screen use and health and behavioral outcomes, it is not without limitations. The sample consisted only of students from a single university in the American Midwest. While we feel it is important to understand these relationships in samples like this one it limits our ability to generalize our results to other populations. Also, our study was non-experimental research, which does not allow us to infer causal relationships between

problematic screen use measures and our outcome variables. Finally, while we did use some objective measures, such as percent body fat percentage and steps, several measures were self-reported and therefore we cannot rule out bias. These subjective measures may also help explain our equivocal findings. Further research should be conducted in the future to help confirm potential causal relationships between problematic screen use and health and behavioral outcomes, as well as to conduct studies using objective measures and experimental methods in a more diverse sample. For example, a future investigation could recruit participants that are 18 to 65 years of age and then separate them into two groups. One group would have their smartphone use, internet use, and social media use restricted, while the other group would be able to use this screen-based technology as much as they would like.

This study adds to the growing body of evidence that problematic screen use may predict undesirable health behaviors and outcomes. This study is the first we are aware of to establish a positive relationship between social media addiction, internet addiction, and body fat percentage. Further, while there is evidence of a positive relationship between smartphone addiction and percent bodyfat in adolescents the current study is the first to report this relationship in a sample of college students. The results also provide additional evidence of concerning relationships between problematic screen use and depression and stress in college students. In conclusion, there is mounting evidence of the associations between problematic smartphone use and negative health outcomes. While this evidence is largely non-experimental and causation cannot be inferred, users who experience screen-based addiction may want to be mindful of their usage and consider taking steps to limit their screen use to possibly help to mitigate the potential negative health behaviors and outcomes associated with problematic screen use.

# CHAPTER V

# SMARTPHONE ADDICTION'S MEDIATING ROLE BETWEEN STRESS AND PERCENT BODY FAT IN HEALTHY COLLEGE STUDENTS

## Introduction

There is ample evidence supporting the link between psychological and physical health (Morse et al., 2024; Attar et al., 2021; Borrione et al., 2018; Olive et al., 2017). For example, Borrione et al. (2018) observed a significant positive association between depression and abnormal heart rate variability (HRV) (i.e., either high or low) in adults (Borrione et al., 2018). HRV refers to the variation in time between successive heartbeats, known as interbeat intervals (McCraty & Shaffer, 2015). These complex, non-linear fluctuations provide valuable insight into autonomic nervous system regulation, particularly the balance between sympathetic and parasympathetic activity (Yugar et al., 2023; Goldberger, 1991). Researchers have observed a similar significant positive association between stress and abnormal HRV in young adults (Attar et al., 2021). An abnormal HRV predicts cardiovascular disease (Kuboto et al., 2017). Prior evidence also demonstrated a significant positive association between depression (Olive et al., 2017) as well as stress (Morse et al., 2024) and body fat percentages.

There are a variety of behaviors that may be detrimental to psychological and physical health. Emerging evidence has indicated that excessive and/or compulsive (henceforth problematic) smartphone use may be such a behavior (Bueno-Brito et al., 2024; Domoff et al., 2020; Tonacci et al., 2019; Matar Boumesleh & Jaalouk, 2017). For example, smartphone use has been positively associated with both stress and depression (Bueno-Brito et al., 2024; Matar Boumesleh & Jaalouk, 2017) in university students. Prior research also suggests a positive relationship between smartphone use and body fat percentage in adolescents as well as a positive

association between smartphone use and body mass index (BMI) (Domoff et al., 2020). Additionally, researchers observed a positive relationship between smartphone use and abnormal HRV in adults (Tonacci et al., 2019). Taken together these findings suggest that individuals with more problematic smartphone use may have elevated stress, depression, percent fat, BMI, and abnormal HRV.

Given these findings it stands to reason that problematic smartphone phone use could contribute to both worsening mental and physical health. The present study examined that possibility by assessing the ability of problematic smartphone use to mediate relationships between measures of psychological and physical health. We hypothesized that smartphone addiction would act as a mediator for relationships between both stress and depression to HRV and percent bodyfat.

## Methods

This investigation involved a group of 43 ($N = 25$ females) college students (21.5 ± 18 years old) from an American Midwest University. To be eligible, participants had to be between the ages of 18 and 25 years old and use an Apple iPhone. Each participant completed one laboratory session, during which they answered a survey, and their height and body fat percentage were measured using a stadiometer and bioelectrical impendence, respectively. Participants then rested for five minutes, and HRV data was immediately collected for an additional five minutes. The total duration of the laboratory session was approximately 45 minutes.

A-priori analyses were conducted based on a comparable study that examined the impact of an exercise intervention program on internet addiction, mood, and HRV (Zhang et al., 2022). This study reported effect sizes for improvements in depression, internet addiction and HRV of ≥

Cohen's $d = 0.75$. Based on this effect size, an $\alpha \leq 0.05$ and a power $\geq 0.8$ a sample size of 16 was calculated to be sufficient. This earlier study employed a mix of experimental and non-experimental methods, which differs from the entirely non-experimental approach used in the present investigation. Considering these design differences, the final sample of $N = 43$ was selected to exceed the power calculation.

Participants completed validated survey instruments evaluating screen-based addiction and various psychometric measures. They also provided demographic information. Following this, body fat percentage and HRV were measured. Informed consent was obtained prior to the survey being administered. At the conclusion of the study, each participant received a $10 Starbucks gift card as compensation.

**Body Fat Percentage**

Body fat percentage was assessed using bioelectrical impedance analysis (InBody 570). The InBody 570 has been shown to be both reliable and valid when compared to Dual-Energy X-Ray Absorptiometry (McLester et al., 2020). The device employes electrical signals transmitted through the hands and feet to estimate body fat percentage.

**Smartphone Addiction**

Smartphone addiction was evaluated using the 10-item Smartphone Addiction Scale (SAS-10). The SAS-10 has been established as a reliable and valid tool for assessing smartphone addiction (Li et al., 2023). Each of the 10 questions is rated on a four-point Likert scale as follows: 1 (Strongly Disagree), 2 (Disagree), 3 (Agree), and 4 (Strongly Agree). The total score is calculated, with higher scores indicating greater levels of addiction.

### Depression

Depression was assessed using the 9-item Patient Health Questionnaire (PHQ-9), a well-established and validated tool for measuring depression severity (Kroenke et al., 2001). Each of the nine items is rated on a scale from zero (not at all) to three (nearly every day). Higher total scores reflect greater severity of depressive symptoms.

### Stress

Stress levels were measured using the 10-item Perceived Stress Scale (PSS-10), a validated and reliable questionnaire designed to assess perceived stress over the past month (Cohen & Williamson, 1988). Each of the 10 items is rated on a five-point Likert scale: 0 (Never), 1 (Almost never), 2 (Sometimes), 3 (Fairly Often), and 4 (Very Often). Scores are obtained by summing the responses, with higher totals indicating greater perceived stress.

### Heart Rate Variability

HRV data was measured after five minutes of rest via the Polar H10 chest heart rate monitor in conjunction with the Elite HRV Pro smartphone application. This combination has been shown to be a reliable and valid method for measuring HRV (Schaffarczyk et al., 2022). The primary HRV metric used was the root mean square of successive differences (RMSS). For female participants, HRV measurements were taken during the follicular phase of their menstrual cycle or placebo for birth control pills to account for the influence of hormonal fluctuations on HRV. HRV tends to be highest during this follicular phase of the cycle (Brar et al., 2015).

## Analytical plan

We utilized Baron and Kenny's (1986) methods for testing our potential mediator, smartphone addiction, on any potential relationship between stress and depression to percent fat and HRV. First, Pearson's correlation analyses were performed to test the relationship between

smartphone addiction, stress and body fat percentage. Then, a partial correlation was performed to assess the relationship between stress and body fat percentage after controlling for smartphone addiction as the potential mediator. Barron and Kenny's method was repeated a second time to test if smartphone addiction mediated a hypothesized relationship between depression, and body fat percentage. The process was then repeated two more times assessing if smartphone addiction mediated potential relationships between stress and HRV and then depression and HRV. All analyses were performed using SPSS Version 29 with $\alpha \leq 0.05$.

## Results

The results of the investigation were separated by the three tests of mediation that were conducted.

### Body Fat Percentage to Stress

There were moderate, positive significant correlations between stress and smartphone addiction ($r = 0.363$, $p = 0.017$), smartphone addiction and body fat percentage ($r = 0.434$, $p = 0.004$), and stress and body fat percentage ($r = 0.323$, $p = 0.034$).

After controlling for smartphone addiction via partial correlation the relationship between stress and body fat percentage was no longer significantly correlated ($r = 0.198$, $p = 0.21$). This is evidence that smartphone addiction mediated the relationship between stress and body fat percentage.

### Body Fat Percentage to Depression

After replacing measures of stress with depression in the analysis, there were positive significant correlations between depression and smartphone addiction ($r = 0.339$, $p = 0.026$) and, as mentioned above, bodyfat percentage and smartphone addiction ($r = 0.434$, $p = 0.004$). There was not a significant correlation between depression and body fat percentage ($r = 0.121$, $p =$

0.44). Because there was not a significant correlation between bodyfat percentage and depression, no partial correlation analysis was necessary.

**HRV to Stress and Depression**

Further correlation analysis between smartphone addiction, stress, and HRV revealed no significant relationships between HRV and smartphone addiction ($r$ = -0.118, $p$ = 0.45), or HRV and stress ($r$ = -0.163, $p$ = 0.296). When replacing stress for depression, there were again no significant relationships between HRV and depression ($r$ = -0.090, $p$ = 0.566) or HRV and the other variables as mentioned above. No partial correlations were conducted since there were no initial correlations between HRV and the other variables.

## Discussion

Presently there were no relationships between HRV and stress, depression, or smartphone addiction. This is different from previous research that has identified relationships among these variables. Conversely, percent bodyfat was associated with both stress and smartphone addiction. Furthermore, there was evidence that smartphone addiction mediated the relationship between percent body fat and stress. While prior research has reported significant relationships between smartphone addiction and bodyfat percentage and stress this is the first we are aware to assess the potential role of smartphone addiction as a mediator of this relationship.

Recent investigations concluded higher levels of smartphone addiction were associated with higher body fat percentage and greater stress levels (Bueno-Brito et al., 2024; Domoff et al., 2020). Previous evidence also suggests higher levels of smartphone addiction are associated with lower levels of physical activity, increased sedentary behavior, increased eating disorders, as well as increased fast food and carbonated soft drink consumption (Jeong et al., 2023; Wang et al., 2023). Based on this previous evidence, it’s reasonable to conclude smartphone addiction could

mediate the relationship between body fat percentage and stress in addicted users as our study indicates. Increased food consumption combined with decreased physical activity and increased sedentary behavior associated with smartphone addiction may help explain the increased body fat percentage observed in our study. Using a smartphone excessively may also lead to stress, which could be also driving the increased food intake (Lopuszanska-Dawid et al., 2022).

Previous research has shown HRV is related to depression and stress (Attar et al., 2021; Borrione et al., 2018; Hartmann et al., 2019). These findings indicate excessively high or low HRV is associated with greater severity of depression and stress. However, in the present sample of healthy college students most participants exhibited normal HRV (i.e., nether high or low). This lack of abnormality in HRV may have made it difficult to see any relationships between this variable and depression or stress in our study. Future research may be warranted that examines a sample including a wider age range, which may have a greater prevalence of abnormal HRV. This would be similar to the samples observed in previous research where HRV was associated with depression and stress (Attar et al., 2021; Borrione et al., 2018; Hartmann et al., 2019).

While this investigation provides novel information regarding the potential mediating effect of smartphone addiction on the relationship between body fat percentage and stress, it is not without limitations. The sample consisted only of students from a single university in the American Midwest. This specific sample limits our ability to generalize our results to other populations. Also, as mentioned above, this young and healthy population is less likely to have poor cardiovascular health, limiting the range of HRV in our sample. Lastly, our study was non-experimental research, which limits our ability to establish causal relationships between smartphone addiction measures and our outcome variables. Future research should use more experimental methodology on a more diverse sample. For example, a future investigation could

recruit participants that are 18 to 65 years of age and then separate them into two groups. One group would have their smartphone use restricted, while the other group would be able to use their smartphones as much as they would like.

This present study is the first we are aware of to identify smartphone addiction as a possible mediator of an observed positive relationship between body fat percentage and perceived stress. While HRV has been associated with stress and depression in prior research, we did not observe these results in our investigation. These different results may be due to the participants in our study, which were recruited from a young and healthy population. In conclusion, because it mediated the relationship between body fat percentage and stress, restricting smartphone use may represent a target for behavioral interventions designed to promote weight loss and enhance mental health. Future research examining such an intervention is warranted as it would allow for a better understanding of the causal impact problematic smartphone use may have upon both physical and mental health.

# CHAPTER VI

## SUMMARY

Internet addiction, characterized by excessive digital technology use causing psychological or physiological harm (APA, 2023), is prevalent among college students. The current college student population is the first to grow up in a world where access to technology such as smartphones has been ever present (Talmon, 2019), which may make them more vulnerable to addiction. Currently, no single study exists that assess the negative health and behavioral outcomes previously associated with addiction. Therefore, the first purpose of this study was to examine associations between three forms of screen-based addiction (internet, social media, and smartphone addiction) and various health outcomes (depression, anxiety, stress, body percentage, and HRV) and behaviors (sleep, physical activity, and sedentary behavior) in college students. The second aim of this study was to assess if smartphone addiction mediates the relationship between percent body fat and HRV to depression and stress.

This study adds to the growing body of evidence that screen-based addiction is linked to negative health behaviors and outcomes. It is the first to establish a positive association between social media and internet addiction with body fat percentage and to confirm the relationship between smartphone addiction and higher body fat in college students. Additionally, this study identifies smartphone addiction as a potential mediator between body fat percentage and perceived stress. While previous research has linked HRV with stress and depression, we did not observe this association, likely due to our young, healthy sample. These findings reinforce the connection between screen-based addiction, depression, and stress, emphasizing its impact on student health. Given its mediating role, reducing smartphone use may be a valuable strategy for

promoting weight loss and improving mental health. As screen-based addiction continues to rise, individuals should be mindful of their usage and consider limiting screen time to mitigate potential negative health effects.

# APPENDICES

# APPENDIX A

# INFORMED CONSENT

# APPENDIX A
# Informed Consent

## Informed Consent to Participate in a Research Study

**Study Title:** The Relationship Between Problematic Screen Use, Psychological, Behavioral, and Psychological Variables in College Students

**Principal Investigator:** Dr. Jacob Barkley

**Co-Investigators:** David Kohan, Adam Jajtner, PhD, Megan Maggee, PhD, Andrew Lepp, PhD

You are being invited to participate in a research study. This consent form will provide you with information on the research project, what you will need to do, and the associated risks and benefits of the research. Your participation is voluntary. Please read this form carefully. It is important that you ask questions and fully understand the research in order to make an informed decision. You will receive a copy of this document to take with you.

**Purpose:**
The primary purpose of this investigation is to enhance our understanding of the relationship between internet addiction, physical activity, sedentary behavior, sleep disturbances, depression, anxiety, and heart rate variability among college students, who are at an elevated risk for internet addiction.

## Procedures

To be included in this study, you must be a Kent State University student between the ages of 18 and 25 years old and be an Apple iPhone user. If you are eligible, you will come to the Applied Exercise Physiology Laboratory in the School of Health Sciences at Kent State University for a single visit. You will be asked to refrain from alcohol, caffeine, and exercise for 24 hours leading up to your scheduled visit. Upon arrival, you will be asked to provide informed consent.

You will be asked to self-report demographic information, including gender, race, ethnicity, age, and year in school. You will also be asked to complete surveys on stress, depression, anxiety, smartphone use, internet addiction, social media use, and sleep. Screen use and steps from you iPhone will also be requested. Depression history and current medication use will be asked as well.

You will also be asked to wear a Polar H10 heart rate monitor for a total of 10 minutes at rest while having your heart rate variability recorded. Heart rate variability will be recorded using a smartphone and requires no effort from you. If you are a female, then you will be asked to schedule your visit during the first 7 to 14 days of your menstrual cycle, or during the placebo week if taking an oral contraceptive. The entire visit will take approximately 30 minutes.

## Benefits

This research will not benefit you directly. However, your participation in this study will help us to better understand previously unconfirmed relationships between internet addiction and physical activity, sedentary behavior, sleep disturbance, depression, anxiety, and heart rate variability in a single study. Understanding these potential relationships in college students is important for discerning the associated negative consequences and formulating targeted interventions based on the most important variables.

## Risks and Discomforts

The overall risk to you is minimal. Some of the survey questions may cause psychological discomfort as they will ask you about mental health. You may ask to see the questions before deciding whether or not to participate in the study.

## Privacy and Confidentiality

All collected information will be confidential with any digital materials kept under a passkey and any physical materials locked in the lab only accessible by the primary investigator and the research team. Participants will be given a number upon arriving for their visit. Any physical and digital data with identifying participant information will be destroyed after 5 years.

Your study related information will be kept confidential within the limits of the law. Any identifying information will be kept in a secure location and only the researchers will have access to the data. Research participants will not be identified in any publication or presentation of research results; only aggregate data will be used.

Your research information may, in certain circumstances, be disclosed to the Institutional Review Board (IRB), which oversees research at Kent State University, or to certain federal agencies. Confidentiality may not be maintained if you indicate that you may do harm to yourself or others.

## Future Research

Your de-identified information will not be used or shared with other researchers.

## Compensation

You will receive a $10 Starbucks gift card upon completion of your visit.

## Voluntary Participation

Taking part in this research study is entirely up to you. You may choose not to participate or you may discontinue your participation at any time without penalty or loss of benefits to which you

are otherwise entitled. You will be informed of any new, relevant information that may affect your health, welfare, or willingness to continue your study participation.

**Contact Information**

If you have any questions or concerns about this research, you may contact Dr. Jacob Barkley at jbarkle1@kent.edu or David Kohan at dkohan@kent.edu. This project has been approved by the Kent State University Institutional Review Board. If you have any questions about your rights as a research participant or complaints about the research, you may call the IRB at 330-672-2704.

**Consent Statement and Signature**

I have read this consent form and have had the opportunity to have my questions answered to my satisfaction. I voluntarily agree to participate in this study. I understand that a copy of this consent will be provided to me for future reference.

_____ _____

**Participant Signature** **Date**

# APPENDIX B

# SURVEY INSTRUMENTS

# APPENDIX B
## Survey Instruments

### The international Physical Activity Questionnaire-Short Version

**The last question is about the time you spent sitting on weekdays while at work, at home, while doing course work and during leisure time. This includes time spent sitting at a desk, visiting friends, reading traveling on a bus or sitting or lying down to watch television.**

4. During the last 7 days, how much time in total did you usually spend *sitting* on a **week day?**

**____ hours _____ minutes**

### Young's Internet Addiction Test-Short Version

Answer the following questions on the Likert scale:

Liker Scale: 0=Does not apply
1=Rarely
2=Occasionally
3=Frequently
4=Often
5=Always

1. Do you feel preoccupied with the internet (think about previous online activity or anticipate the next online session)? _____

2. Do you feel the need to use the internet with increasing amounts of time to achieve satisfaction?_____

3. Have you repeatedly made unsuccessful efforts to control, cut back, or stop internet use?_____

4. Do you feel restless, moody, depressed, or irritable when attempting to cut down or stop internet use?_____

5. Do you stay online longer than originally intended?_____

6. Have you jeopardized or risked the loss of a significant relationship, job, educational or career opportunity because of the internet?_____

7. Have you lied to family members, therapists, or others to conceal the extent of involvement with the internet? _____

8. Do you use the internet as a way of escaping from problems or of relieving a dysphoric mood (e.g., feelings of helplessness, guilt, anxiety, depression)?_____

9. Do you feel more comfortable with your online friends than with your real-life friends?_____

10. Do you feel that life without the internet would be boring, empty, and joyless?_____

11. Do you find yourself compulsively using the internet even when it is not really needed?_____

12. Do you find yourself obsessively thinking about your online activity or anticipate your next online session when offline?_____

**Social Media Disorder Scale (SMD Scale)**

Please answer the question by thinking of your experience with using social media (e.g., WhatsApp, SnapChat, Instagram, Twitter, Facebook, Google+, Pintrist, forums, weblogs) in past year. Answer the questions as honestly as possible.

During the past year have you…

1. Regularly found that you can't think of anything else but the moment you will be able to use social media again? Yes/No

2. Regularly felt dissatisfied because you want to spend more time on social media? Yes/No

3. Often felt bad when you could not use social media? Yes/No

4. Tried to spend less time on social media, but failed? Yes/No

5. Regularly neglected other activities (i.e. hobbies, sports, homework) because you wanted to use social media? Yes/No

6. Regularly had arguments with others because of your social media use? Yes/No

7. Regularly led to your parents or friends about the amount

of time you spend on social media? Yes/No

8. Often used social media to escape from negative feelings?
Yes/No

9. Had serious conflict with parents, brother, sister (friends,
relationships etc.) because of your social media use?
Yes/No

**Smartphone Addiction Scale-10 Items**

Directions: Please circle a number (1 through 6) of how you much you agree with each statement.

| | Items | Strongly disagree | Disagree | Weakly disagree | Weakly agree | Agree | Strongly agree |
|---|---|---|---|---|---|---|---|
| 1 | Missing planned work due to smartphone use | 1 | 2 | 3 | 4 | 5 | 6 |
| 2 | Having a hard time concentrating in class, while doing assignments, or while working due to smartphone use | 1 | 2 | 3 | 4 | 5 | 6 |
| 3 | Feeling pain in the wrists or at the back of the neck while using a smartphone | 1 | 2 | 3 | 4 | 5 | 6 |
| 4 | Will not be able to stand not having a smartphone | 1 | 2 | 3 | 4 | 5 | 6 |
| 5 | Feeling impatient and fretful when I am not holding my smartphone | 1 | 2 | 3 | 4 | 5 | 6 |
| 6 | Having my smartphone in my mind even when I am not using it | 1 | 2 | 3 | 4 | 5 | 6 |
| 7 | I will never give up using my smartphone even when my daily life is already greatly affected by it | 1 | 2 | 3 | 4 | 5 | 6 |
| 8 | Constantly checking my smartphone so as not to miss conversations between other people on Twitter or Facebook | 1 | 2 | 3 | 4 | 5 | 6 |
| 9 | Using my smartphone longer than I had intended | 1 | 2 | 3 | 4 | 5 | 6 |
| 10 | The people around me tell me that I use my smartphone too much | 1 | 2 | 3 | 4 | 5 | 6 |

## PITTSBURGH SLEEP QUALITY INDEX

**INSTRUCTIONS:**
The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. Please answer all questions.

1. During the past month, what time have you usually gone to bed at night?

   BED TIME _____

2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?

   NUMBER OF MINUTES _____

3. During the past month, what time have you usually gotten up in the morning?

   GETTING UP TIME _____

4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

   HOURS OF SLEEP PER NIGHT _____

***For each of the remaining questions, check the one best response. Please answer all questions.***

5. During the past month, how often have you had trouble sleeping because you . . .

a) Cannot get to sleep within 30 minutes

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

b) Wake up in the middle of the night or early morning

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

c) Have to get up to use the bathroom

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

d) Cannot breathe comfortably

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

e) Cough or snore loudly

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

f) Feel too cold

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

g) Feel too hot

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

h) Had bad dreams

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

i) Have pain

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

j) Other reason(s), please describe_____

_____

How often during the past month have you had trouble sleeping because of this?

Not during the past month_____ Less than once a week_____ Once or twice a week_____ Three or more times a week_____

6. During the past month, how would you rate your sleep quality overall?

Very good _____

Fairly good _____

Fairly bad _____

Very bad _____

7. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

8. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

| Not during the past month_____ | Less than once a week_____ | Once or twice a week_____ | Three or more times a week_____ |
|---|---|---|---|

9. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

| | |
|---|---|
| No problem at all | _____ |
| Only a very slight problem | _____ |
| Somewhat of a problem | _____ |
| A very big problem | _____ |

## Patient Health Questionnaire

| **Over the last 2 weeks, how often have you been bothered by any of the following problems?** *(Use "✔" to indicate your answer)* | **Not at all** | **Several days** | **More than half the days** | **Nearly every day** |
|---|---|---|---|---|
| **1.** Little interest or pleasure in doing things | 0 | 1 | 2 | 3 |
| **2.** Feeling down, depressed, or hopeless | 0 | 1 | 2 | 3 |
| **3.** Trouble falling or staying asleep, or sleeping too much | 0 | 1 | 2 | 3 |
| **4.** Feeling tired or having little energy | 0 | 1 | 2 | 3 |
| **5.** Poor appetite or overeating | 0 | 1 | 2 | 3 |
| **6.** Feeling bad about yourself — or that you are a failure or have let yourself or your family down | 0 | 1 | 2 | 3 |
| **7.** Trouble concentrating on things, such as reading the newspaper or watching television | 0 | 1 | 2 | 3 |
| **8.** Moving or speaking so slowly that other people could have noticed? Or the opposite — being so fidgety or restless that you have been moving around a lot more than usual | 0 | 1 | 2 | 3 |
| **9.** Thoughts that you would be better off dead or of hurting yourself in some way | 0 | 1 | 2 | 3 |

**If you checked off any problems, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?**

| **Not difficult at all** | **Somewhat difficult** | **Very difficult** | **Extremely difficult** |
|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ |

# GAD-7 Anxiety

| Over the last two weeks, how often have you been bothered by the following problems? | Not at all | Several days | More than half the days | Nearly every day |
|---|---|---|---|---|
| 1. Feeling nervous, anxious, or on edge | 0 | 1 | 2 | 3 |
| 2. Not being able to stop or control worrying | 0 | 1 | 2 | 3 |
| 3. Worrying too much about different things | 0 | 1 | 2 | 3 |
| 4. Trouble relaxing | 0 | 1 | 2 | 3 |
| 5. Being so restless that it is hard to sit still | 0 | 1 | 2 | 3 |
| 6. Becoming easily annoyed or irritable | 0 | 1 | 2 | 3 |
| 7. Feeling afraid, as if something awful might happen | 0 | 1 | 2 | 3 |

If you checked any problems, how difficult have they made it for you to do your work, take care of things at home, or get along with other people?

| Not difficult at all | Somewhat difficult | Very difficult | Extremely difficult |
|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ |

# Perceived Stress Scale

## Instructions:

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate how often you felt or thought a certain way.

In the last month, how often have you...

| | | Never | Almost Never | Sometimes | Fairly Often | Very Often |
|---|---|---|---|---|---|---|
| 1 | been upset because of something that happened unexpectedly? | **0** | **1** | **2** | **3** | **4** |
| 2 | felt that you were unable to control the important things in your life? | **0** | **1** | **2** | **3** | **4** |
| 3 | felt nervous and "stressed"? | **0** | **1** | **2** | **3** | **4** |
| 4 | felt confident about your ability to handle your personal problems? | **4** | **3** | **2** | **1** | **0** |
| 5 | felt that things were going your way? | **4** | **3** | **2** | **1** | **0** |
| 6 | found that you could not cope with all the things that you had to do? | **0** | **1** | **2** | **3** | **4** |
| 7 | been able to control irritations in your life? | **4** | **3** | **2** | **1** | **0** |
| 8 | felt that you were on top of things? | **4** | **3** | **2** | **1** | **0** |
| 9 | been angered because of things that were outside of your control? | **0** | **1** | **2** | **3** | **4** |
| 10 | felt difficulties were piling up so high that you could not overcome them? | **0** | **1** | **2** | **3** | **4** |

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