Sleep quality mediates the effect of social media use on immune function and physical health

Grace Connor and Phil Reed

Swansea University, UK

Corresponding author: Grace Conner,
Department of Psychology,
Swansea University,
Singleton Park,
Swansea, SA2 8PP, UK.
e-mail: 850925@swansea.ac.uk

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Abstract

A large proportion of individuals report feeling addicted to social media, but research into the physical implications of social media use is limited. This study examined 81 participants (aged 18 – 64), and explored their social media use (Bergan Social Media Addiction Scale), immune function (Immune Function Questionnaire), physical health (Physical Health Questionnaire), diet (Diet and Behavioural Scale), activity level (International Physical Activity Questionnaire Short Form), sleep (Brief Version of the Pittsburgh Sleep Quality Index), and depression and anxiety levels (Hospital Anxiety and Depression Scale). Higher levels of social media addiction were related to worse immune function, and worse physical health, but sleep quality mediated the relationship in both cases. These results suggest that disrupted sleep as a result of social media addiction could be responsible for reduced immune function and worse physical health, and chronic inflammation could explain the poor sleep and reduced immunity and physical health relationship.

Keywords: social media addiction; immune function; physical health; sleep

Social media use has demonstrated a year-by-year growth, and, since 2020, an extra 1 million people report using social media platforms, bringing the estimated worldwide usage to 4.9 billion in 2023. Evidence suggests that individuals spend approximately 2:35 hours daily on social media a day (Ruby, 2023). The rise social media usage from 2019 may be attributed to the impact of the Covid-19 pandemic that limited chances to socialise other than through digital means (Chaturvedi et al., 2021, Sasaki et al., 2020, Squire, 2021). Current research also shows rising numbers of people reporting social media addiction (Li et al., 2021; Onukwuli et al., 2023). In one study, 40% of online users aged 18-22 stated they felt addicted to social media (Dixon, 2022), with users reporting the uncontrollable need to use social media, and devoting so much time to it that it impacted other areas of their lives (Hilliard, 2023). This rise in social media use and reported social media problematic usage strengthens the argument for fully understanding that the impact social media can have on all aspects of physical and psychological health.

Social media addiction may be regarded as a compulsive-impulsive spectrum disorder, where individuals excessively make use of social media platforms, and experience withdrawal if unable to access it (Block, 2008; Reed, 2023; Reed & Haas, 2023). In addition, individuals often experience negative repercussions from their internet use, such as social isolation (Block, 2008; Dalvi-Esfahani et al., 2019). The psychological impact of social media has been widely researched, with studies finding many positives and negatives associated with its use (Keum et al., 2022). Uhls et al. (2017) found that teenagers using social media experienced increased social support, self-esteem, and social capital, and 90% of adolescent users stated they used social media to connect with friends every day to make and maintain friendships. Keum et al. (2022) reported that while students who spent more time on social media experienced greater life satisfaction and social connectedness, they also reported more depression, anxiety, anger, loneliness, and distress. This pattern is in line with

previous findings, which indicate that frequent social media usage is associated with greater risk of anxiety and depression (Gao et al., 2020; Zhao & Zhou (2020).

Despite the large amount of research on psychological and social impacts, research into the physical repercussions is limited. Reed et al. (2015) noted a relationship between higher problematic internet use and worsened immune function. Reed et al. (2015) suggested the relationship may be explained by cortisol and sympathetic nervous system activation which suppress the immune system, but exactly how excessive digital use impacts health is unclear. In this regard, lifestyle factors affected by problematic social media use may exert an impact on physical health.

High levels of social media use negatively impact sleep (Fung et al., 2021), diet (Byun et al., 2021), and exercise (Islam et al., 2020), and these behaviours have adverse effects on health (Booth et al., 2012; Lee & Park, 2015; Lueke & Assar, 2022; Tanaka et al., 2002). It may be the social media use relationship with poor immune function is mediated by social media impacts on lifestyle. Individuals who spend more time on social media are less likely to engage in physical activity, and individuals who are obese use social media more than healthy individuals, possibly due to a more sedentary lifestyle (Islam et al., 2020). Fung et al. (2021) noted increased social media use resulted in significantly reduced physical activity. For people struggling with problematic social media usage, reduced physical activity could impact overall level of health and immune functionality.

Social media use has been found to be negatively correlated with total sleep time (Fung et al., 2021). Nguyen et al. (2022) noted poor sleep quality is associated with excessive internet use. As a loss of sleep quality is directly linked to poor immune function (Lueke & Assar, 2022), sleep may be a mediator for problematic internet use and immune function.

Byun et al. (2021) found longer leisure-related internet use was linked to less healthy dietary habits, including reduced intake of fruit and vegetables, and a higher intake of high density easy to cook meals, such as fast food and instant noodles. Hinojo-Lucena et al. (2019) suggested problematic internet usage leads to sedentarism, which results in a diet of easily accessible junk food over well-balanced meals. Ying Ying et al. (2020) demonstrated that internet addicted adolescents experienced excessive carbonated drink and fast-food intake, and reduced intake of fruit and vegetables. An imbalanced diet results in poor nutrition and a lack of necessary minerals and vitamins which the body needs to continue to function healthily (Shergill-Bonner, 2017). Thus, there is a possibility that diet could mediate the relationship between problematic internet use and immune function.

Although it is important to note that temporal and causal relationships between social media use and physical factors such as health and lifestyle have not been definitively established, and it may well be that there is a bidirectional relationship, much research does assume that a key relationship is that social media use adversely impacts lifestyle and physical factors (Fung et al., 2021; Kulandairaj, 2014; Reed et al., 2023; Zang et al., 2022). The above suggests social media affects lifestyle behaviours, which, in turn, may damage health. This study examines these possibilities by exploring whether the previously noted relationship between social media use and immune function (Reed et al. 2015) was the product of mediating health behaviour factors. To this end, exercise, diet, and sleep, along with anxiety and depression, were examined as potential, mediators of any effects of social media on physical health or immune function. This study used a correlational design to examine sleep, diet, exercise, anxiety and depression as possible mediators, with social media use being investigated as the predictor variable and immune function and health as the outcome variables. Although this design would not necessarily allow strong evidence of causation, given the difficulties in manipulating the variables, mediation analyses remain the

design of choice in the literature (Fung et al., 201; Zang et al., 2022), and provide evidence of the degree of association between social media use and health when the impact of lifestyle factors are controlled.

Method

Participants

Participants were recruited via adverts on social media (via Instagram, Facebook, and WhatsApp) as the study was aimed at those who used social media. The inclusion criteria for the study required participants to be over the age of 18. In total, 92 people completed the study, with 11 participants being excluded due to incomplete surveys. Of the remaining 81 participants, there were 19 male participants, 59 female participants, 2 non-binary participants, and 1 participant who preferred not to disclose their gender. The mean age of participants was 23 years (range = 18 to 64). A priori power analysis conducted using G*Power version 3.1.9.7 suggested the minimum sample size required for 80% power in detecting a medium effect, at a significance criterion $p < .05$, was 55 for a linear multiple regression. Ethical approval was obtained through the University's Department of psychology Research Ethics Committee.

Materials

Bergen Social Media Addiction Scale (BSMAS; Andreassen et al., 2016) is a 6-item measure assessing components of addiction relating to social media. Responses are collected on a 5-point Likert scale, giving a total possible score is 30, with scores of below 12 indicating a normal relationship with social media, 12-18 indicating a problematic relationship, and scores of above 18 indicating an addiction to social media. The scale had good internal reliability for the current sample ($\alpha = .76$).

Immune Function Questionnaire (IFQ; Reed et al., 2015) measures the frequency of symptoms associated with poor immune function. There are 19 statements directly measuring immune function symptoms via a 5-point likert scale, scored 0 to 4. Scores range from 0-97, with higher scores reflecting worse immune function. The measure displayed high internal reliability for the current sample (α = .82). An additional 6 statements are included to measure secondary lifestyle implications resulting from poor immune function, via a 4-point likert scale woth scores ranging 0-3. Two more questions assess participants health related lifestyle choices via smoking and drinking, and a final question assesses participants views of their immune function.

The Physical Health Questionnaire (PHQ; Schat & Kelloway, 2000) assesses physical health via examining the frequency of physical symptoms participants experienced. The scale consists of 14 questions, rated on a 7-point Likert scale. Scores range from 14 to 98, and higher scores reflected worse physical health. The internal consistency of the scale was high within this study (α = .85).

Diet and Behavioural Scale (DABS; Richards et al., 2015) assess participants intake of common dietary variables. There are 29 questions, 18 examine frequency of consumption on a 5-point scale; 11 questions ask about amounts they consumed, and responses are split into 5 percentiles scored 1-5. The scores are combined to create 4 separate scales: junk food scoring 6 to 30; caffeinated soft drinks and gum, scoring 5 to 25; healthy foods, scoring 3 to 15; and hot caffeinated beverages, scoring 4 to 20. For all scales, a higher score indicates a higher intake. The scales showed internal reliability for the current sample between .59 and .78.

International Physical Activity Questionnaire Short Form (IPAQ-TM; Craig et al., 2003) measures active using 7 questions. Multiples of the Resting Metabolic Rate (MRMR)

is calculated for each activity and combined, with higher scores representing more physical activity. The internal reliability for the current sample was α = .42.

Brief Version of the Pittsburgh Sleep Quality Index (B-PSQI; Sancho-Domingo et al., 2021) measures the quality of sleep. The measure comprises 6 questions, measuring 5 different sleep components: sleep efficiency, sleep latency, sleep duration, sleep disturbance, and subjective sleep quality. Overall scores range from 0 to 15, where a higher score indicates worse sleep quality. The internal reliability score for the current sample was α = .61.

Hospital Anxiety and Depression Scale (HADS; Snaith, 2003) measures anxiety and depression. It consists of 14 items (7 anxiety; 7 depression), each question is scored from 0-3. When scoring anxiety and depression separately, scores of 0-7 are considered normal, scores of 8-10 are considered mild, scores of 11-14 are considered moderate, and scores of 15-21 indicate sever anxiety or depression. The internal reliability was α = .80 for anxiety, and α = .76 for depression.

Demographic Questions were included to measure age, gender, and hours spent per week on social media for both personal and work-related use.

Procedure

Participants were recruited via social media. Participants responded to a link posted on social media platforms (Instagram, WhatsApp, and Facebook), where the link was shared alongside a description of the study. Participants were first presented with the information sheet, detailing the aims of the study, and how this data would be used. If participants were happy to proceed, they were directed to the consent form, where they gave informed consent, and declared they were over 18. Participants were then shown the first questions on general demographics, followed by the Bergen Social Media Addiction Scale, Immune Function

Questionnaire, Hospital Anxiety and Depression Scale, Brief Pittsburgh Sleep Quality Index, The Diet and Behaviour Scale, Physical Health Questionnaire, International Physical Activity Questionnaire – Short Form. There was no time limit to complete these questions, allowing candidates to spend time to think through their answers. Participants were able to withdraw from the study without penalty at any time. After answering all the questions appropriately participants were then shown the debrief sheet where candidates were told that the survey was investigating social media addiction and its effect on immune function and provided links to outside support and contact details for the researchers.

Data Analysis

All variables were checked for outliers and normality of distribution, and, in all cases, were found to be acceptable for inclusion in parametric analysis. Initially relationships between the predictor (SMA) and outcomes (immune function, and health) were assessed using Pearson correlations, as were the relationships between the predictor (SMA) and outcomes (immune function, and health) with the potential mediators (sleep quality, activity, healthy eating, junk food consumption, anxiety, and depression). On the basis of these analyses, and the a priori assumptions about potentially important variables, outlined in the literature review above, mediation models using PROCESS v3.5 (Hayes, 2013) for SPSS (v.26), employing 5000 bootstrap samples, were conducted.

Results

The mean hours per day spent on social media for personal use reported by participants was 2.81 (± 2.10; range = 0 – 12), and this was .29 (± .49; range = 0 – 2) for professional purposes. The mean score for social media addiction levels (SMA) was 16.37 (± SD = 4.49). On the basis of the scale cut-offs: 14% of participants indicated normal use of

social media (score < 12); 54% of participants indicated problematic use (score = 12 – 18); and 32% of participants indicated and social media addiction (scores > 18).

Figure 1 about here

Figure 1 shows Pearson correlations between social media addiction (SMA), hours/day social media for personal use (personal) and work use (work), immune function (IFQ), and physical health (PHQ), along with scatterplots showing 95% confidence intervals, and distributions for each variable. These data reveal positive correlations between SMA and with hours per day social media for personal use, $r = .241$, $p = .030$; a positive correlation between SMA score and poorer physical health, $r = .252$, $p = .025$; and a positive correlation between poorer physical health and worse immune function, $r = .579$, $p < .001$.

Figure 2 about here

Figure 2 shows the Pearson correlations between the potential mediators (sleep quality, activity, junk food consumption, health eating habits, anxiety, and depression), along with scatterplots showing 95% confidence intervals, and distributions for each variable. There were positive correlations between poorer sleep quality and anxiety, $r = .356$, $p < .001$, and depression, $r = .331$, $p = .003$; negative correlations between healthy eating and anxiety, $r = -.240$, $p = .036$, and depression, $r = -.268$, $p = .011$; and a positive correlation between anxiety and depression, $r = .484$, $p < .001$.

Table 1 about here

Table 1 shows the Pearson correlations between social media addiction (SMA), immune function (IFQ), and physical health (PHQ), with each of the potential mediator variables (sleep quality, activity, healthy eating, junk food consumption, anxiety, and depression). There were positive correlations between higher SMA and both greater anxiety and greater depression; worse immune function and each of poorer sleep quality, greater anxiety, and greater depression; and between worse physical health and poorer sleep quality, more junk food consumption, greater anxiety, and greater depression.

The mediator variables for further analysis were selected on the basis of their relationship with SMA, IFQ, and PHQ. On this basis, sleep quality, anxiety and depression were selected for further analysis to determine whether they mediated the relationship between SMA levels and immune function, and SMA levels and physical health. Although sleep did not correlate significantly with SMA, it was retained as a potential mediator due to its status in the previous literature, and also as the significance of a correlation is not necessarily the only indicator of whether it reflects an important relationship (especially as a potential mediator).

Figure 3 about here

The top panel of Figure 3 shows a moderation analysis for social media addiction as the predictor, immune function as the outcome, and anxiety, depression, and sleep quality as mediators. There were positive associations between SMA and each of the mediators, but only a positive association between poor sleep quality and worse immune function. The direct effect of SMA on immune function was not significant (effect = -.089; lower:upper values = -.572:.394). There was a significant indirect effect of SMA on immune function mediated by sleep quality (effect = .130; .028:.339), but no mediated relationship through either anxiety (effect = .110; -.086:.352) or depression (effect = .090; -.105:.334).

The bottom panel of Figure 3 shows a moderation analysis for social media addiction as the predictor, physical health as the outcome, and anxiety, depression, and sleep quality as mediators. There were positive associations between SMA and each of the mediators, and positive associations between poor sleep quality and worse physical health, and worse anxiety and worse physical health. The direct effect of SMA on physical health was not significant (effect = -.003; -.594:.589). There was a significant indirect effect of SMA on physical health mediated by sleep quality (effect = .182; .072:.445), and anxiety (effect = .340; .028:.717), but not depression (effect = .223; -.035:.615).

Discussion

The current study investigated the relationship between social media addiction levels and immune function and physical health, to build on findings of a link between internet addiction and reduced immune function (Reed et al., 2015), whilst examining the role of lifestyle variables including diet, exercise, sleep, anxiety, and depression. The key finding was that sleep mediated the relationships between social media use and both poor physical health and poor immune function, the former was also mediated by anxiety. Although there was no direct relationship between social media use and physical health or immune function, the relationship became significant when sleep acted as a mediator. Whilst these findings do not provide evidence for the hypothesis that problematic internet use increases nervous system and cortisol activation, which, in turn, impacts immune function (Reed et al., 2015), they suggest increased social media use decreases sleep duration and quality (as well as increasing anxiety) and these have a detrimental effect upon the general health and immune function.

There are a number of explanations regards the mechanisms behind the association of social media addiction and sleep. Individuals who excessively use social media may sleep

less because they are using social media instead of sleeping, or as they struggle to fall asleep, resulting in less hours sleep per night. Electronic devices used to access social media emit blue light, which is on the short wavelength spectrum, and which can impacting melatonin production and disrupt natural circadian rhythms (Heo et al., 2017; Tähkämö et al., 2018). This may explain how social media usage can negatively impacts sleep. Alternatively, social media use may increase arousal, making it harder to relax. Social media usage prior to sleep attempts could result in individuals taking longer to fall asleep due to increased arousal levels (Harbard et al., 2016). Finally, individuals may engage with social media when they would otherwise be asleep, thus reducing the amount of sleep, as they sacrifice sleep in favour of social media use (Scott & Woods, 2018).

The relationship between sleep and the immune system is strongly evidenced. The immune system uses cytokines to coordinate immune responses; and natural killer cells, T cells and B cells, to target pathogens and carry out the immune response. Sleep deprivation has been linked to a decline in killer cell activity, making the immune system less active and hence reducing immunity (Motivala & Irwin, 2007). Over a prolonged period, the effects of sleep deprivation progress from reduced immunity to impacting an individual's physical health. Sleep deprivation causes excessive stress on the body, which results in a stress response that increases pro-inflammatory cytokine levels, increasing inflammatory activity in the body, often described as chronic low-grade inflammation (Besedovsky et al., 2011). This response is enhanced by high levels of cortisol from the stress response (Kuna et al., 2022; Vgontzas et al., 2004).

Future research could focus on the causes of the negative impact of sleep on immune function and physical health. Previous research provides possible explanations as to how sleep mediates social media use with immune function and physical health (Fung et al., 2021; Nguyen e al., 2022). For example, use of social media has been found to reduce levels and

quality of sleep (Fung et al., 2021; Nguyen et al., 2022). In turn, poor sleep quantity and quality has been found to produce worse immune function (Lueke & Assar, 2022). This possible chain may form the basis for future research with a longitudinal component to develop testable hypotheses, which could be used to work on a solution for reducing the impact social media has on health.

There are limitations to this study which need to be noted. The sample was recruited online, which means it may not be fully representative of the population, as the sample would have not collected anyone who did not use social media. However, social media users were the target population, and the sample did have a wide age range and a mix of male and female participants. A larger sample size may also help explore these associations with a greater degree of confidence, although power assumptions were met. It should also be acknowledged that this study was a correlational one, so cause and effect cannot be established. It could be that lifestyle factors and health impact social media use, rather than the other way around, or that there exists a bidirectional relationship between these factors. However, evidence suggests that the relationship from social media use to lifestyle and physical factors is a key one in this regard (Fung et al., 2021; Kulandairaj, 2014; Zang et al., 2022). Certainly, studies that have manipulated social media use as an independent variable have noted impacts on health (Reed et al., 2023). Nevertheless, future longitudinal research is recommended to fully assess the sleep-mediated relationship of social media use and immune function and physical health.

In summary, this report established a link between higher levels of social media addiction and poor immune function and physical health. However, this link was largely mediated by sleep. It was suggested that blue light, arousal, and increased social media engagement, could be responsible for decreased sleep, and poor immune function and health

could be explained by reduced immune responses and chronic inflammation. Further research into both these areas could build on the findings this paper has established.

References

Andreassen, C. S., Billieux, J., Griffiths, M. D., Kuss, D. J., Demetrovics, Z., Mazzoni, E., & Pallesen, S. (2016). The relationship between addictive use of social media and video games and symptoms of psychiatric disorders: A large-scale cross-sectional study. *Psychology of Addictive Behaviors*, *30*(2), 252–262. https://doi.org/10.1037/adb0000160

Besedovsky, L., Lange, T., & Born, J. (2011). Sleep and immune function. *Pflügers Archiv - European Journal of Physiology*, *463*(1), 121–137. https://doi.org/10.1007/s00424-011-1044-0

Block, J. J. (2008). Issues for DSM-V: Internet addiction. *American Journal of Psychiatry*, *165*(3), 306–307. https://doi.org/10.1176/appi.ajp.2007.07101556

Booth, F. W., Roberts, C. K., & Laye, M. J. (2012). Lack of exercise is a major cause of chronic diseases. *Comprehensive Physiology*, *2*(2), 1143–1211. https://doi.org/10.1002/cphy.c110025

Byun, D., Kim, R., & Oh, H. (2021). Leisure-time and study-time internet use and dietary risk factors in Korean adolescents. *The American Journal of Clinical Nutrition*, *114*(5), 1791–1801. https://doi.org/10.1093/ajcn/nqab229

Chaturvedi, K., Vishwakarma, D. K., & Singh, N. (2021). Covid-19 and its impact on education, social life and mental health of students: A survey. *Children and Youth Services Review*, *121*, 105866. https://doi.org/10.1016/j.childyouth.2020.105866

Craig, C. L., Marshall, A. L., Sjöström, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J. F., & Oja, P. (2003). International Physical Activity Questionnaire: 12-Country Reliability and Validity. *Medicine & Science in Sports & Exercise*, *35*(8), 1381–1395. https://doi.org/10.1249/01.mss.0000078924.61453.fb

Dalvi-Esfahani, M., Niknafs, A., Kuss, D. J., Nilashi, M., & Afrough, S. (2019). Social media addiction: Applying the DEMATEL approach. *Telematics and Informatics*, *43*, 101250.

Dixon, S. (2022). *U.S. Social Media Addiction by age group 2019*. Statista. https://www.statista.com/statistics/1081292/social-media-addiction-by-age-usa/

Fung, X. C. C., Kwok, C., Leung, P. Y., & Poon, K. Y. (2021). The effects of internet gaming and social media use on physical activity, sleep, quality of life, and academic performance among university students in Hong Kong: A preliminary study. *Asian Journal of Social Health and Behavior*, *4*(1), 36-44. https://doi.org/10.4103/shb.shb_81_20

Gao, J., Zheng, P., Jia, Y., Chen, H., Mao, Y., Chen, S., Wang, Y., Fu, H., & Dai, J. (2020). Mental health problems and social media exposure during COVID-19 outbreak. *PLOS ONE*, *15*(4), e0231924. https://doi.org/10.1371/journal.pone.0231924

Harbard, E., Allen, N. B., Trinder, J., & Bei, B. (2016). What's keeping teenagers up? Prebedtime behaviors and actigraphy-assessed sleep over school and Vacation. *Journal of Adolescent Health*, *58*(4), 426–432. https://doi.org/10.1016/j.jadohealth.2015.12.011

Hayes, A. F. (2013). Introduction to mediation, moderation, and conditional process analysis: A regression-based approach. *Guilford Press*.

Heo, J.-Y., Kim, K., Fava, M., Mischoulon, D., Papakostas, G. I., Kim, M.-J., Kim, D. J., Chang, K.-A. J., Oh, Y., Yu, B.-H., & Jeon, H. J. (2017). Effects of smartphone use with and without blue light at night in healthy adults: A randomized, double-blind, cross-over, placebo-controlled comparison. *Journal of Psychiatric Research*, *87*, 61–70. https://doi.org/10.1016/j.jpsychires.2016.12.010

Hilliard, J. (2023, April 3). *Social Media Addiction*. Addiction Center. https://www.addictioncenter.com/drugs/social-media-

addiction/#:~:text=Social%20media%20addiction%20is%20a%20behavioral%20addiction%20that%20is%20characterized,impairs%20other%20important%20life%20areas.

Hinojo-Lucena, F.-J., Aznar-Díaz, I., Cáceres-Reche, M.-P., Trujillo-Torres, J.-M., & Romero-Rodríguez, J.-M. (2019). Problematic internet use as a predictor of eating disorders in students: A systematic review and meta-analysis study. *Nutrients*, *11*(9), 2151. https://doi.org/10.3390/nu11092151

Islam, Md. S., Sujan, Md. S., Tasnim, R., Ferdous, Most. Z., Masud, J. H., Kundu, S., Mosaddek, A. S., Choudhuri, M. S., Kircaburun, K., & Griffiths, M. D. (2020). Problematic internet use among young and adult population in Bangladesh: Correlates with lifestyle and online activities during the COVID-19 pandemic. *Addictive Behaviors Reports*, *12*, 100311. https://doi.org/10.1016/j.abrep.2020.100311

Keum, B. T., Wang, Y.-W., Callaway, J., Abebe, I., Cruz, T., & O'Connor, S. (2022). Benefits and harms of social media use: A latent profile analysis of emerging adults. *Current Psychology*, *42*, 23506–23518. https://doi.org/10.1007/s12144-022-03473-5

Kulandairaj, A.J. (2014). Impact of social media on the lifestyle of youth. *International Journal of Technical Research and Applications*, *2*(8), 22-28.

Kuna, K., Szewczyk, K., Gabryelska, A., Białasiewicz, P., Ditmer, M., Strzelecki, D., & Sochal, M. (2022). Potential role of sleep deficiency in inducing immune dysfunction. *Biomedicines*, *10*(9), 2159. https://doi.org/10.3390/biomedicines10092159

Lee, H., & Park, H. (2015). Correlations between poor micronutrition in family members and potential risk factors for poor diet in children and adolescents using Korean National Health and Nutrition Examination Survey Data. *Nutrients*, *7*(8), 6346–6361. https://doi.org/10.3390/nu7085286

Li, Y., Sun, Y., Meng, S., Bao, Y., Cheng, J., Chang, X., Ran, M., Sun, Y., Kosten, T., Strang, J., Lu, L., & Shi, J. (2021). Internet addiction increases in the general population during

COVID-19: Evidence from China. *The American Journal on Addictions*, *30*(4), 389–397. https://doi.org/10.1111/ajad.13156

Lueke, N. A., & Assar, A. (2022). Poor sleep quality and reduced immune function among college students: Perceived stress and depression as mediators. *Journal of American College Health*, 1–8. https://doi.org/10.1080/07448481.2022.2068350

Motivala, S. J., & Irwin, M. R. (2007). Sleep and immunity. *Current Directions in Psychological Science*, *16*(1), 21–25. https://doi.org/10.1111/j.1467-8721.2007.00468.x

Nguyen, C. T., Yang, H.-J., Lee, G. T., Nguyen, L. T., & Kuo, S.-Y. (2022). Relationships of excessive internet use with depression, anxiety, and sleep quality among high school students in northern Vietnam. *Journal of Pediatric Nursing*, *62*, 91-97. https://doi.org/10.1016/j.pedn.2021.07.019

Onukwuli, V. O., Onyinye, E. N., Udigwe, I. B., Umeh, U. M., Enebe, J. T., & Umerah, A. T. (2023). Internet addiction during the COVID-19 pandemic among adolescents in Southeast Nigeria and implications for adolescent care in the post-pandemic era: A cross-sectional study. *SAGE Open Medicine*, *11*. ttps://doi.org/10.1177/20503121231152763

Reed, P. (2023). Impact of social media use on executive function. *Computers in Human Behavior*, *141*, 107598.

Reed, P., & Haas, W. (2023). Social media use as an impulsive 'Escape From Freedom'. *Psychological Reports*, 00332941231171034.

Reed, P., Fowkes, T., & Khela, M. (2023). Reduction in social media usage produces improvements in physical health and wellbeing: An RCT. *Journal of Technology in Behavioral Science*, *8*(2), 140-147.

Reed, P., Vile, R., Osborne, L. A., Romano, M., & Truzoli, R. (2015). Problematic internet usage and immune function. *PLOS ONE*, *10*(8), e0134538. https://doi.org/10.1371/journal.pone.0140692

Richards, G., Malthouse, A., & Smith, A. (2015). The diet and behaviour scale (DABS): Testing a new measure of food and drink consumption in a cohort of secondary school children from the South West of England. *Journal of Food Research*, *4*(3), 148-161. https://doi.org/10.5539/jfr.v4n3p148

Ruby, D. (2023). S*ocial Media Users — Global Demographics (2023)*. DemandSage. https://www.demandsage.com/social-media-users/

Sancho-Domingo, C., Carballo, J. L., Coloma-Carmona, A., & Buysse, D. J. (2021). Brief version of the Pittsburgh Sleep Quality index (B-PSQI) and measurement invariance across gender and age in a population-based sample. *Psychological Assessment*, *33*(2), 111–121. https://doi.org/10.1037/pas0000959

Sasaki, N., Kuroda, R., Tsuno, K., & Kawakami, N. (2020). Workplace responses to Covid-19 associated with Mental Health and work performance of employees in Japan. *Journal of Occupational Health*, *62*(1), e12134. https://doi.org/10.1002/1348-9585.12134

Schat, A. C., & Kelloway, E. K. (2000). Effects of perceived control on the outcomes of workplace aggression and violence. *Journal of Occupational Health Psychology*, *5*(3), 386–402. https://doi.org/10.1037/1076-8998.5.3.386

Scott, H., & Woods, H. C. (2018). Fear of missing out and sleep: Cognitive behavioural factors in adolescents' nighttime social media use. *Journal of Adolescence*, *68*(1), 61–65. https://doi.org/10.1016/j.adolescence.2018.07.009

Shergill-Bonner, R. (2017). Micronutrients. *Paediatrics and Child Health*, *27*(8), 357–362. https://doi.org/10.1016/j.paed.2017.04.002

Snaith, R. P. (2003). *Health and Quality of Life Outcomes*, *1*(1), 29. https://doi.org/10.1186/1477-7525-1-29

Squire, K. D. (2021). From virtual to participatory learning with technology during COVID-19. *E-Learning and Digital Media*, *19*(1), 55–77. https://doi.org/10.1177/20427530211022926

Tähkämö, L., Partonen, T., & Pesonen, A.-K. (2018). Systematic review of light exposure impact on human circadian rhythm. *Chronobiology International*, *36*(2), 151–170. https://doi.org/10.1080/07420528.2018.1527773

Tanaka, H., Taira, K., Arakawa, M., Masuda, A., Yamamoto, Y., Komoda, Y., Kadegaru, H., & Shirakawa, S. (2002). An examination of sleep health, lifestyle and Mental Health in junior high school students. *Psychiatry and Clinical Neurosciences*, *56*(3), 235–236. https://doi.org/10.1046/j.1440-1819.2002.00997.x

Uhls, Y. T., Ellison, N. B., & Subrahmanyam, K. (2017). Benefits and costs of social media in adolescence. *Pediatrics*, *140*(Supplement_2), S67-S70. https://doi.org/10.1542/peds.2016-1758e

Vgontzas, A. N., Zoumakis, E., Bixler, E. O., Lin, H.-M., Follett, H., Kales, A., & Chrousos, G. P. (2004). Adverse effects of modest sleep restriction on sleepiness, performance, and inflammatory cytokines. *The Journal of Clinical Endocrinology & Metabolism*, *89*(5), 2119–2126. https://doi.org/10.1210/jc.2003-031562

Ying Ying, C., Awaluddin, S. M., Kuang Kuay, L., Siew Man, C., Baharudin, A., Miaw Yn, L., Sahril, N., Omar, M. A., Ahmad, N. A., & Ibrahim, N. (2020). Association of Internet Addiction with Adolescents' Lifestyle: A National School-Based Survey. *International Journal of Environmental Research and Public Health*, *18*(1), 168. https://doi.org/10.3390/ijerph18010168

Zhang, J., Marino, C., Canale, N., Charrier, L., Lazzeri, G., Nardone, P., & Vieno, A. (2022). The effect of problematic social media use on happiness among adolescents: The mediating role of lifestyle habits. *International Journal of Environmental Research and Public Health*, *19*(5), 2576.

Zhao, N., & Zhou, G. (2020). Social media use and mental health during the COVID-19 pandemic: Moderator role of disaster stressor and mediator role of negative affect. *Applied Psychology: Health and Well-Being*, *12*(4), 1019–1038. https://doi.org/10.1111/aphw.12226

Table 1: Pearson correlations between personal social media addiction, immune function (IFQ), physical health (PHQ), and the potential mediator variables.

	Sleep	Activity	Healthy	Junk	Anxiety	Depression
SMA	.172	.149	-.212	.138	.421***	.404***
IFQ	.433***	.038	-.155	.050	.287**	.270**
PHQ	.556***	.161	-.116	.216*	.508***	.456***

*p<.05; **p<.01; ***p<.001

Figure 1: Pearson correlations between social media addiction (SMA), hours/day social media for personal use (personal) and work use (work), immune function (IFQ), and physical health (PHQ), along with scatterplots showing 95% confidence intervals, and distributions for each variable.

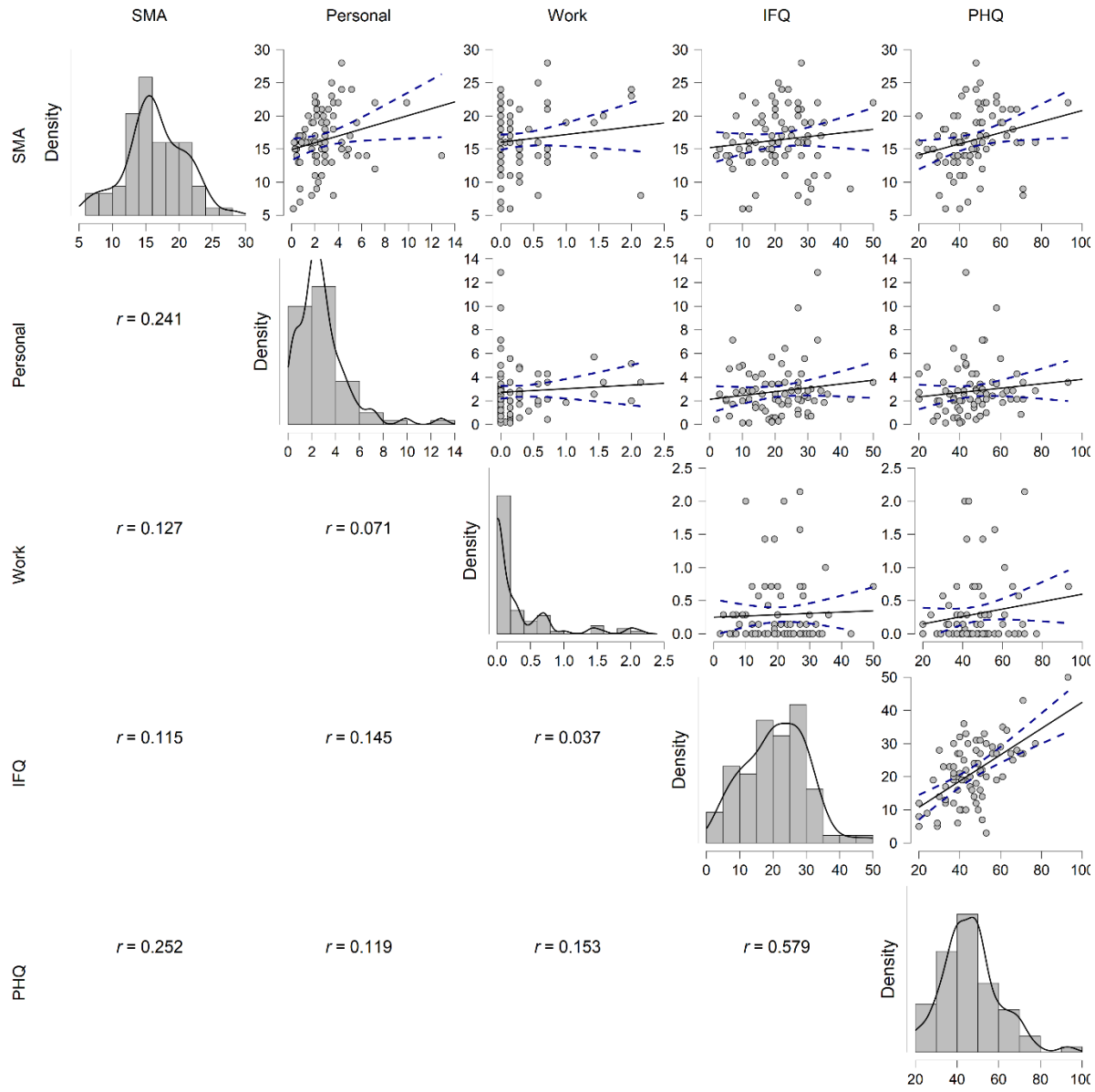

Figure 2: Pearson correlations between sleep quality, activity, junk food consumption, health eating habits, anxiety, and depression, along with scatterplots showing 95% confidence intervals, and distributions for each variable.

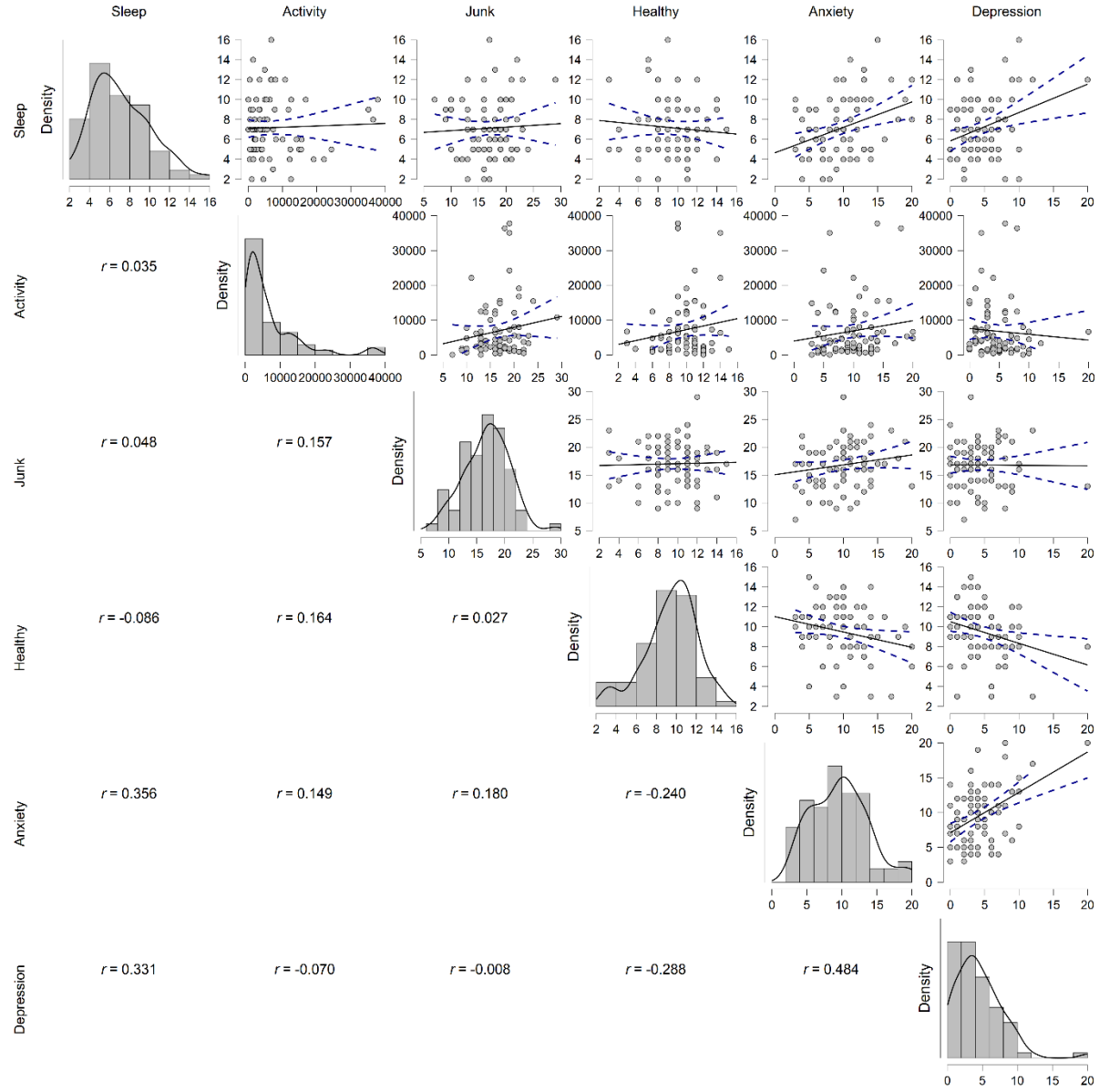

Figure 3: Results of a mediation analysis between the social media addiction (SMA), meditators (sleep quality, anxiety, and depression), and immune function (Top panel) and physical health (bottom panel). Solid lines are significant relationships (the thickness of the line reflects the degree of significance), and dotted lines represent nonsignificant relationships.