Independent and Joint Associations of Physical Activity and Sleep on Mental Health among 220,324 Adults in 214 Countries

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Abstract

With the emergent emphasis on the 24-hour movement paradigm, the importance of engaging in adequate amounts of sleep and physical activity (PA) is becoming increasingly apparent for several health outcomes. However, the joint effects of sleep and PA have received limited attention as it relates to mental health among adults. The present study used cross-sectional data from the Mental Health Million Project to examine the independent and joint effects of sleep and PA on mental health among adults, and whether these effects differ among individuals receiving mental health treatment. The sample included 220,324 participants (34.4% young adults, 45.2% middle-aged adults, 20.4% older adults; 57.8% females, 36.3% males, 1.0% other) from 214 countries that completed the 47-item Mental Health Quotient. Participants also reported weekly frequency of PA and adequate sleep, and whether they are currently receiving mental health treatment. A series of generalized linear mixed regression models were computed. The results demonstrated independent dose-response associations whereby greater amounts of PA engagement and adequate sleep each predicted better mental health. A synergistic interaction was observed in which mental health was positively associated with PA engagement and this relationship was strengthened with greater frequency of adequate sleep. These benefits were less pronounced among adults receiving mental health treatment. While findings suggest that healthier amounts of sleep can help to offset the negative influence of a physically inactive lifestyle (and vice versa), our results point to a “more is better” approach for both behaviors when it comes to promoting mental health.

Keywords: mental well-being, exercise, movement behaviors

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Mental health is an important aspect of overall health and well-being, however, evidence indicates mental health problems are a significant concern for many people in society today. For example, results from the 2019 Global Burden of Disease study estimated that the prevalence of mental health disorders is 11.7% in males and 12.8% in females, or roughly one in every eight people, with depression and anxiety disorders being the most common (GBD 2019 Mental Disorders Collaborators, 2022). Emerging evidence indicates that rates of mental health disorders have been exacerbated by the COVID-19 pandemic (Santomauro et al., 2021). The economic impact of mental health disorders is believed to be even greater than other non-communicable diseases such as cancer and diabetes (Bloom et al., 2012; Trautmann et al., 2016), many of which have received far greater research investment (Mahomed, 2020; National Institutes of Health, 2022). These observations have sparked a growing recognition of the importance of addressing mental health issues and taking preventative action to promote mental health and well-being (Firth et al., 2019; GBD 2019 Mental Disorders Collaborators, 2022; World Health Organization, 2013).

Over a decade ago, lifestyle was recognized to play a significant role in our mental health and well-being, including the prevention and management of mental health problems (Walsh, 2011). Modifiable health behaviors such as physical activity, diet, smoking and sleep are receiving increased attention for their potential (Firth et al., 2020). The recent release of the Canadian 24-Hour Movement Guidelines for Adults places an even greater emphasis on the importance of engaging in sufficient amounts of physical activity and sleep to achieve health benefits (Ross et al., 2020). For instance, evidence from several meta-analyses have shown that

regular physical activity engagement provides numerous mental health benefits including, but not limited to reduced risk of depression and anxiety as well as improved affect and mental well-being (Guo et al., 2022; Pearce et al., 2022; Rebar et al., 2015; Rosenbaum et al., 2014; White et al., 2017). A recent study by Santos et al. (2023) predicted that failure to improve physical activity levels worldwide between 2020 to 2030 would result in 215.7 million new cases of depression and anxiety, representing 43% of all new cases of preventable non-communicable diseases. Given the aforementioned economic costs of mental health disorders, it is worth noting that depression alone is expected to account for ~30% of direct health care costs attributed to physical inactivity (Santos et al., 2023). Evidently, physical activity has received considerable attention for its potential to prevent and reduce mental health problems. However, researchers to-date have largely taken a siloed approach that fails to consider the role of sleep and how these behaviors may interact to influence mental health.

Sleep has been overlooked compared to other health behaviors for its potential to improve mental health (Merlo & Vela, 2022). Syntheses of emerging evidence, however, have helped to establish sleep as a key pillar in the path forward for addressing societal mental health concerns. Specifically, reviews of the literature investigating relationships between various facets of sleep (e.g., duration, consistency, quality) with mental health and well-being have had consistent and favorable associations (Chaput et al., 2020; Faulkner & Bee, 2016; Firth et al., 2020; Grandner, 2018). Meta-analytic findings from 72 interventions indicate that improving sleep produces small to medium sized improvements across a range of mental health indicators (e.g., composite mental health, depression, anxiety, stress), including dose-response benefits for sleep quality (Scott et al., 2021). Moreover, changes in the physiological characteristics of particular sleep stages have been linked to mental health conditions, such as post-traumatic stress

disorder (e.g., Kobayashi et al., 2007). Akin to physical inactivity, insufficient sleep poses a significant burden on the economy. The economic cost of insufficient sleep is estimated to have a combined yearly impact of $680 billion in the United States, Canada, Germany, United Kingdom and Japan (Hafner et al., 2017), representing between 1.35% to 2.92% of the included countries' gross domestic product. Moving forward, adoption of an integrative approach that considers the interplay between sleep and physical activity stands to improve our current understanding by identifying combinations of optimal amounts in relation to mental health.

To date, few studies have examined interactive associations between physical activity and sleep on mental health. For the most part, studies have investigated children and youth (Gillis & El-Sheikh, 2019; Ogawa et al., 2019; Wang et al., 2021; Xiang et al., 2021; Zhang et al., 2022); only one study has examined adults, which focused on middle to older adulthood (Cheval et al., 2022). Findings from these studies have consistently shown that individuals who concurrently engage in low amounts of physical activity and sleep report the poorest mental health. Furthermore, these studies have shown higher levels of physical activity attenuate the association between poor sleep and mental health or vice versa. These studies provide initial insight into the collective influence of physical activity and sleep on mental health, yet shortcomings of this literature limit our current understanding. For example, these associations have yet to be examined among broader adult samples. Furthermore, physical activity and sleep are often examined as binary variables characterized as adequate/inadequate amounts or good/poor quality for sleep, which fails to consider a substantial portion of the variability in these behaviors and the potential for dose-response or threshold effects (e.g., some physical activity is better than none). Future research is therefore warranted to address these knowledge gaps as findings have the potential to inform behavioral interventions to improve mental health.

Another existing knowledge gap relates to whether the joint effects of physical activity and sleep may provide additional benefits for individuals receiving mental health treatment compared to those who are not. This relationship deserves attention given the high rates of physical inactivity (Schuch et al., 2017) and poor sleep (Faulkner & Bee, 2016) observed among individuals experiencing clinically relevant mental health problems. From this perspective, these individuals may have the potential to benefit more from engaging in a healthier lifestyle compared to their non-clinical peers. A recent study by Chekroud et al. (2018) supports this idea, having found a more pronounced beneficial effect of exercise on monthly mental health burden among adults who were previously diagnosed with depression than those who had not been diagnosed with depression. On the other hand, it is also reasonable to postulate that current treatment may buffer the beneficial effects typically observed with increasing amounts of physical activity and sleep, but these associations have yet to be explored. Such information has implications that span beyond the general population as we seek to identify alternative approaches to improve the mental health and well-being of individuals receiving treatment for psychological distress or other mental health disorders.

The primary purpose of the present study was to examine the independent and joint associations of physical activity and sleep in relation to mental health. Considering individuals receiving mental health treatment may have the poorest mental health, we also examined the potential interactive influence of mental health treatment status (MHTS). We hypothesized that greater frequencies of adequate sleep and physical activity engagement would be independently associated with more favorable scores for mental health and a synergistic interaction would be observed between sleep and physical activity in relation to mental health. Based on previous research that has shown exercise may be more beneficial for individuals with a previous

depression diagnosis than those without (Chekroud et al., 2018), we predicted that the independent and interactive benefits of increasing frequencies of adequate sleep and physical activity engagement would be more pronounced among individuals currently receiving mental health treatment than those who are not.

Methods

Study sample and data collection

This study used cross sectional data from the Mental Health Million (MHM) project. The MHM project is an on-going study seeking to assess the mental well-being of the global population. Initial recruitment targeted the English-speaking population living in the United States, United Kingdom, Canada, South Africa, Singapore, Australia, New Zealand and India, and later expanded to include Spanish and French speakers as well as other countries for the purpose of capturing a broader global sample. Participants were recruited through targeted advertising on Google and Facebook which sought to capture adults over the age of 18 within each age-gender demographic. Recruitment via Google Ads targeted individuals who searched for topics related to mental health assessments and tests, whereas Facebook recruitment targeted all adults on the platform with the tagline "What is your mental well-being score?" as well as individuals who searched for topics related to mental health and well-being more broadly. Data collection using the online Mental Health Quotient (MHQ) assessment took 15 minutes and participation was voluntary. The sample for the present study included a total of 220,324 participants from 214 countries who completed the MHM from April 9, 2020, to November 21, 2021.[1] More detail regarding recruitment strategies and the MHM project can be found

[1] For analytic purposes, we included responses up until the release of the Arabic version of the MHQ in November 2021 as not all Arabic responses were translated into English. Pilot data collected prior to April 9th, 2020 was collected using prior versions of the MHQ (versions 1.1, 1.2, 1.3) and therefore excluded. Additionally, a new

elsewhere (Newson et al., 2021). This study involved secondary analysis of existing de-identified data, thus Institutional Research Ethics Board approval was not sought.

Measures

Physical activity. Participants responded to a single item that asked: "How regularly do you engage in physical exercise (30 minutes or more)?" Response options included "Rarely/never"; "Less than once a week"; "Once a week"; "Few days a week"; and "Every day".

Sleep. Participants responded to a single item that asked: "In general, I get as much sleep as I need." Response options included "Hardly ever"; "Some of the time"; "Most of the time"; and "All of the time".

Mental health. Participants completed the MHQ, which is a 47-item web-based assessment tool that captures 47 elements of mental health, spanning both mental health problems and assets (Newson & Thiagarajan, 2020). Research has shown that the MHQ is a valid and reliable tool for assessing mental health and well-being (Newson et al., 2022). This tool was developed based on coding of symptoms from 126 commonly used mental health assessment tools for assessing 10 different disorders: depression, anxiety, bipolar disorder, attention-deficit/hyperactivity disorder, post-traumatic stress disorder, obsessive compulsive disorder, addiction, schizophrenia, eating disorder, and autism spectrum disorder (Newson et al., 2020). Given the homogeneity in symptoms assessed by tools within (29-58%) and across specific disorders (60% in at least half of all disorders) (Newson et al., 2020), the MHQ represents a standardized assessment tool that spans the full continuum of mental health symptoms akin to the mental health continuum put forth previously by Keyes (2002).

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version of the MHQ was launched in January 2022 and therefore only responses on versions 2.0 through 2.8 of the MHQ were included.

Participants responses for the 47 items were used to create an aggregate score on a spectrum ranging from -100 to +200[2], with negative scores representing clinical risk. Scores can be classified into six categories ranging from Clinical to Thriving: Clinical (≤-50), At Risk (-50 to <0), Enduring (0 to <50), Managing (50 to <100), Succeeding (100 to <150) and Thriving (150 to 200). Scores on the MHQ can be decomposed into six subdomains: core cognition, complex cognition, mind-body connection, mood and outlook, drive and motivation, and social self. The subdomains of the MHQ are scored on the same spectrum ranging from -100 to +200.

Covariates. These included age (within bounded ranges), gender, employment, education level, frequency of in-person social interactions with friends, medical condition diagnoses (yes/no), whether they are currently receiving mental health treatment (yes/no), whether they have experienced major trauma in their life (yes/no), and whether they have experienced any health or financial impacts from the COVID-19 pandemic (yes/no). These variables will be referred to as the full covariate set. All items in which participants responded "Prefer not to say" were recoded as missing for multiple imputation purposes.

Data inspection

Missingness ranged from 0% for physical activity and mental health to 9.3% for sleep (see Table 1). Missingness for sleep was predicted by other observed variables (e.g., more missingness among individuals who identify as non-binary or third gender, did not graduate high school, were unemployed), which led us to consider data missing at random and use multiple imputation to preserve our sample size.

Data Analysis

[2] A small proportion of MHQ scores fall below -100 due to the way that the MHQ score algorithm is calculated. This procedure ensures that the negative MHQ scores are more evenly distributed across the negative score window.

All analyses were performed in R (Version 4.1.1) and R Studio (Version 2022.02.3). First, we inspected the data for missingness using the *mice* package (van Buuren & Groothuis-Oudshoorn, 2011). Data were considered missing at random and multiple imputation by chained equations was conducted using the *mice* package to replace missing values. A total of 10 multiply imputed datasets were created as per recommendations to set $m > 100$ times the highest fraction of missing information (White et al., 2011).

For our primary purpose, a series of generalized linear mixed regression models were computed to examine the independent and joint effects of sleep and physical activity on mental health and each of the six subdomains of the MHQ. However, the MHM project measured sleep and physical activity using ordinal scales, and therefore, generalized linear mixed regression models present estimates for each individual combination of the main and interaction terms in comparison to a reference category. To address this issue, we computed an ANOVA of each regression model (e.g., physical activity, sleep, physical activity X sleep) to determine whether the main and interaction effects met the criteria for statistical significance, which was set at $\alpha < .05$. Given that MHTS may influence the independent and joint associations between sleep and physical activity in relation to mental health, we conducted a series of follow-up analyses in which MHTS was added as an interactive term in each of the aforementioned models and followed the same analytical procedures. All models were adjusted for the full covariate set. The *survey* package was used to handle the nested structure of the MHM dataset in all analyses (participants nested within countries) (Lumley, 2004).

Results

Descriptive statistics

Descriptive statistics for the sample demographic characteristics, physical activity, sleep and mental health are presented in Table 1.

Physical activity

Figure 1 shows the relationship between physical activity engagement and overall MHQ. An ANOVA of the generalized linear mixed model for the independent effect of physical activity on overall MHQ demonstrated a significant association ($F(4,22027)=1792.55$, $p<0.001$), in which increasing frequency of physical activity engagement was associated with more favorable scores.

Figure 2 shows the relationship between physical activity engagement and overall MHQ by MHTS. An ANOVA of the physical activity X MHTS generalized linear mixed model revealed significant main effects of physical activity ($F(4,220264)=1234.26$, $p<0.001$) and MHTS ($F(1,220287)=7636.17$, $p<0.001$) as well as a significant physical activity X MHTS interaction ($F(4,220242)=10.81$, $p<0.001$) in relation to overall MHQ. Greater frequency of physical activity engagement was associated with more favorable scores for overall MHQ across both groups, although scores for overall MHQ were considerably lower among those currently receiving mental health treatment. The beneficial association between physical activity and mental health appears to be stronger for individuals not currently receiving mental health treatments.

Sleep

Figure 3 shows the relationship between sleep and overall MHQ. An ANOVA of the generalized linear mixed model for the independent effect of sleep on overall MHQ demonstrated a significant association ($F(3,220272)=7193.64$, $p<0.001$), in which greater frequency of adequate sleep was associated with more favorable scores.

Figure 4 shows the relationship between sleep and mental health by MHTS. An ANOVA of the sleep X MHTS generalized linear mixed model revealed significant main effects of sleep ($F(3,220263)=5255.30$, $p<0.001$) and MHTS ($F(1,220289)=6353.62$, $p<0.001$) as well as a significant sleep X MHTS interaction ($F(3,220256)=37.28$, $p<0.001$) in relation to overall MHQ. Greater frequency of adequate sleep was associated with more favorable scores for overall MHQ across both groups, although scores were considerably lower among individuals currently receiving mental health treatment. The beneficial association between sleep and overall MHQ appears to be stronger for individuals not currently receiving mental health treatment.

Physical activity X sleep interaction

Figure 5 shows the relationship between physical activity and overall MHQ by sleep. Results from an ANOVA of the physical activity X sleep generalized linear mixed model revealed significant main effects of physical activity ($F(4,220258)=1144.07$, $p<0.001$) and sleep ($F(3,220252)=5471.85$, $p<0.001$) as well as a significant sleep X physical activity interaction ($F(12,220237)=12.73$, $p<0.001$) in relation to overall MHQ. Greater frequencies of adequate sleep and physical activity were associated with more favorable scores for overall MHQ and these associations appear to become more beneficial with healthier combinations of sleep and physical activity behavior.

Figure 6 shows the relationship between sleep and physical activity in relation to overall MHQ by MHTS. An ANOVA of the physical activity X sleep X MHTS generalized linear mixed model revealed significant main effects of physical activity ($F(4,220235)=778.37$, $p<0.001$), sleep ($F(3,220223)=3957.68$, $p<0.001$) and MHTS ($F(1,220251)=5141.19$, $p<0.001$) on overall MHQ. The results also demonstrated significant interactive effects of physical activity X sleep ($F(12,220217)=12.25$, $p<0.001$), sleep X MHTS ($F(3,220218)=18.22$, $p<0.001$) and physical

activity X sleep X MHTS ($F(12,22017)=2.96$, $p<0.001$) in relation to overall MHQ. A non-significant interaction was found for physical activity X MHTS ($F(4,220218)=1.68$, $p=0.15$). In brief, greater frequencies of adequate sleep and physical activity were associated with more favorable scores for overall MHQ, although the benefits of healthier combinations of sleep and physical activity appear to be stronger for individuals not receiving mental health treatment.

Subdomains of the MHQ

For all models, similar effects were observed for each of the subdomains of the MHQ; figures and ANOVA tables for each of the models are presented in Supplementary Materials Tables 1-6 and Figures 1-6.

Discussion

The present study was the first to examine the interactive effect of physical activity and sleep in relation to mental health among a global sample of adults. Findings revealed independent dose-response associations whereby greater amounts of physical activity and adequate sleep each predicted better mental health. Furthermore, a synergistic interaction was observed in which increasingly healthier combinations of physical activity and adequate sleep were associated with more favorable mental health scores, and these benefits appear to be more pronounced among adults not currently receiving mental health treatment. These findings were consistent across each subdomain of the MHQ. While results suggest that greater frequency of adequate sleep can help to offset the negative influence of a physically inactive lifestyle on mental health (and vice versa), evidence points to a “more is better” approach for both behaviors when it comes to promoting mental health. Collectively, these findings help to address a key knowledge gap and provide further support for the potential of behavioral medicine to buffer the toll on mental health experienced by many in our society.

Sleep and physical activity together have garnered more recent attention for their potential joint effects on mortality (Bellavia et al., 2014; Chen et al., 2022; Huang et al., 2021; Wennman et al., 2017), risk of chronic disease (Cassidy et al., 2016; Oftedal et al., 2022; Valenzuela et al., 2022) and other outcomes such as academic achievement (Brown et al., 2022). The present study contributes to the dearth of evidence investigating these associations with mental health and well-being using the largest sample to date. Using a global sample of over 220,000 adults from 214 countries, our results support the synergistic effect from physical activity and sleep on mental health, with consistent findings across six subdomains of mental health (i.e., core cognition, complex cognition, mind-body connection, mood and outlook, drive and motivation, and social self). Specifically, mental health scores were positively associated with greater weekly physical activity and that these relationships were strengthened with greater frequency of adequate sleep, which support previous findings (Cheval et al., 2022; Gillis & El-Sheikh, 2019; Ogawa et al., 2019; Wang et al., 2021; Xiang et al., 2021; Zhang et al., 2022). Also consistent with these studies is that the lowest scores for mental health were observed among adults who were physically inactive and hardly ever accrued adequate sleep (i.e., the least healthy combination). Accruing adequate sleep each night and exercising everyday (i.e., the healthiest combination), in contrast, was associated with an 86-point increase in mental health, which on the MHQ spectrum would be equivalent to improving by two categories (e.g., from At Risk to Managing). These findings speak to the potency of healthy active lifestyles and highlight the potential value of developing interventions that adopt integrative whole day approaches to improve mental health through physical activity and sleep concurrently.

Contrary to our hypothesis based on previous research (Chekroud et al., 2018), the interactive benefits of physical activity and sleep were more pronounced among adults not

currently receiving treatment for mental health problems than those receiving treatment. Closer inspection of the data revealed a plateau effect for the benefits of adequate sleep frequency at "most nights" among adults enrolled in mental health treatment, whereas a dose-response relationship was observed among those not receiving mental health treatment. Beyond the inclusion of sleep as an interaction term in the present study, one reason for the discrepancy in findings to those of Chekroud et al. is the characterization of the poor mental health groups. Chekroud et al. used previous diagnosis of depression to identify this group based on the assumption that it would be strongly associated with mental health burden. Comparatively, the MHQ survey did not include measures of previous mental health disorder diagnosis, and therefore based a mental health disorder from whether an individual reported they are currently receiving mental health treatment. However, it is estimated that only 40% of people diagnosed with a mental health disorder seek treatment in the 12 months around the time of the disorder or distress (Cairney et al., 2014; Urbanoski et al., 2008). Furthermore, it is plausible that accessing treatment might be a sign of symptom severity in that seeking help is increasingly likely among the most severe cases (Roberts et al., 2018). From this perspective, our sample of individuals receiving mental health treatment may not be representative of all those who have been diagnosed with a mental health disorder, and potentially skew to more severe cases. Considering physical activity is recognized by several national guidelines as an alternative treatment for less severe forms of depression (Malhi et al., 2015; National Institute for Health and Care Excellence, 2022; Ravindran et al., 2016; Stubbs et al., 2018), the effects among individuals receiving mental health treatment in the present study may have been buffered due to the potential severity of their mental health problems, or perhaps they are already experiencing benefits from their treatment and ceiling effects are occurring. Moving forward, researchers are strongly encouraged to

include items pertaining to the presence and severity of mental health disorders in future survey design. Such information will help to better understand whom stands to benefit the most from engaging in healthier patterns of lifestyle behaviors.

Independent associations observed between physical activity and sleep with mental health also support what has been found in their respective bodies of literature in that dose-response relationships were found (Guo et al., 2022; Scott et al., 2021). It is important to note that the most significant improvements for mental health were observed when increasing from never/hardly ever engaging in physical activity or getting adequate rest to the next amount (e.g., some of the time for sleep, less than once a week for physical activity). Further benefits were observed with increasing amounts of sleep and physical activity, but the magnitude of the improvements began to dissipate. These findings align with previous work investigating associations between physical activity and morbidity and mortality (Warburton & Bredin, 2017); supporting the notion that "every move counts" not only for physical activity, but also when it comes to getting enough sleep. Moreover, it is well established that certain crucial sleep stages, such as slow-wave sleep ("deep sleep"), get priority over other important stages (e.g., Rapid Eye-Movement (REM) sleep) when the total amount of sleep an individual gets is less than the recommended daily amount (e.g., Brunner et al., 1990). In that respect, it is possible that participants reporting the least amount of adequate sleeping time have been especially lacking sufficient REM sleep – which, in turn, has long been associated with various mental disorders (Kobayashi et al., 2007; Pace-Schott et al., 2015a, 2015b). In light of these findings, public health messaging campaigns should also consider developing content specific to the importance of even slight increases in the frequency of nights that adults accrue adequate sleep.

Despite the many strengths of the current study, it is not without limitations. First, a cross-sectional design was employed, which limits our understanding of the causal nature of the relationships between physical activity and sleep with mental health. While the present study focused on physical activity and sleep as predictors of mental health, it would be remiss to not acknowledge an alternative interpretation of the data – people with mental health issues tend to avoid physical activity (Schuch et al., 2017) and report poorer sleep (Faulkner & Bee, 2016). Longitudinal studies have provided insight into the temporal nature of the relationship between physical activity and sleep (Atoui et al., 2021), but this work needs to be extended to include indicators of mental health to further unpack these potential bi-directional associations. Second, sleep and physical activity were self-reported, which may introduce recall errors or social desirability bias (Sallis & Saelens, 2000). Future large-scale studies could consider capitalizing on technology as consumer wearables that provide estimates of physical activity and sleep become increasingly ubiquitous in society. Finally, although the sample included a diverse participant pool from 214 countries, it should be acknowledged that convenience sampling through Google and Facebook was employed, which may limit the generalizability of the findings to the global population. Moreover, all data for the study was collected during the peak of the COVID pandemic, which potentially could further limit its generalizability.

In sum, the present study represents the first to explore joint associations between physical activity and sleep in relation to mental health among a broad sample of adults from 214 countries. Results demonstrated that inadequate amounts of physical activity and sleep are each inversely associated with mental health. Engaging in increasing amounts of physical activity is associated with favorable benefits for mental health and this relationship can be further strengthened with greater frequency of adequate sleep; however, these effects are less

pronounced for adults receiving mental health treatment. Collectively, these findings highlight the potential potency for public health interventions to adopt approaches rooted in behavioral medicine to improve the overall mental health of the population.

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Table 1. *Descriptive statistics.*

	N (%)	Missing
Gender		10775 (4.9%)
Female	127367 (57.8%)	
Male	79928 (36.3%)	
Other	2254 (1.0%)	
Age (years)		0 (0%)
18-24	49759 (22.6%)	
25-34	25905 (11.8%)	
35-44	23519 (10.7%)	
45-54	32711 (14.8%)	
55-64	43348 (19.7%)	
65-74	32917 (14.9%)	
75-84	10818 (4.9%)	
85+	1347 (0.6%)	
Education		8742 (4.0%)
Less than high school	16226 (7.4%)	
High school	66491 (30.2%)	
Undergraduate degree	61184 (27.8%)	
Vocational training	14752 (6.7%)	
Graduate degree	37371 (17.0%)	
Other	15558 (7.1%)	
Employment		0 (0%)
Studying	38392 (17.4%)	
Employed	95723 (43.4%)	
Homemaker	13381 (6.1%)	
Retired	47215 (21.4%)	
Unable to work	7033 (3.2%)	
Unemployed	18580 (8.4%)	
MHQ*	66.1 (74.3)	0 (0%)
Core Cognition*	82.5 (66.5)	0 (0%)
Complex Cognition*	87.2 (68.0)	0 (0%)
Drive & Motivation*	82.4 (66.9)	0 (0%)
Mood & Outlook*	64.6 (72.8)	0 (0%)
Social Self*	66.0 (77.8)	0 (0%)
Mind & Body Connection *	71.0 (65.0)	0 (0%)
Currently Receiving Mental Health Treatment (Yes)	48588 (22.1%)	5604 (2.5%)
Weekly Adequate Sleep Frequency		20541 (9.3%)
Hardly ever	29188 (13.2%)	
Some of the time	68230 (31.0%)	
Most of the time	79529 (36.1%)	
All of the time	22836 (10.4%)	
Weekly Exercise Frequency		0 (0%)
Rarely/Never	66569 (30.2%)	

Less than once a week	30460 (13.8%)	
Few days a week	64332 (29.2%)	
Every day	37613 (17.1%)	
Few days a week	64332 (29.2%)	
Frequency of Socializing		0 (0%)
Rarely/never	52937 (24.0%)	
1-3 times/month	47199 (21.4%)	
Once a week	53207 (24.1%)	
Several days a week	66981 (30.4%)	
Medical Condition Diagnosis (Yes)	55107 (25.0%)	10182 (4.6%)
Experienced Previous Trauma (Yes)	166746 (75.7%)	15807 (7.2%)
Finances affected by COVID-19 Pandemic (Yes)	76215 (34.6%)	8853 (4.0%)
Health affected by COVID-19 Pandemic (Yes)	79455 (36.1%)	8853 (4.0%)

Note: *Mean and SD presented.

Figures

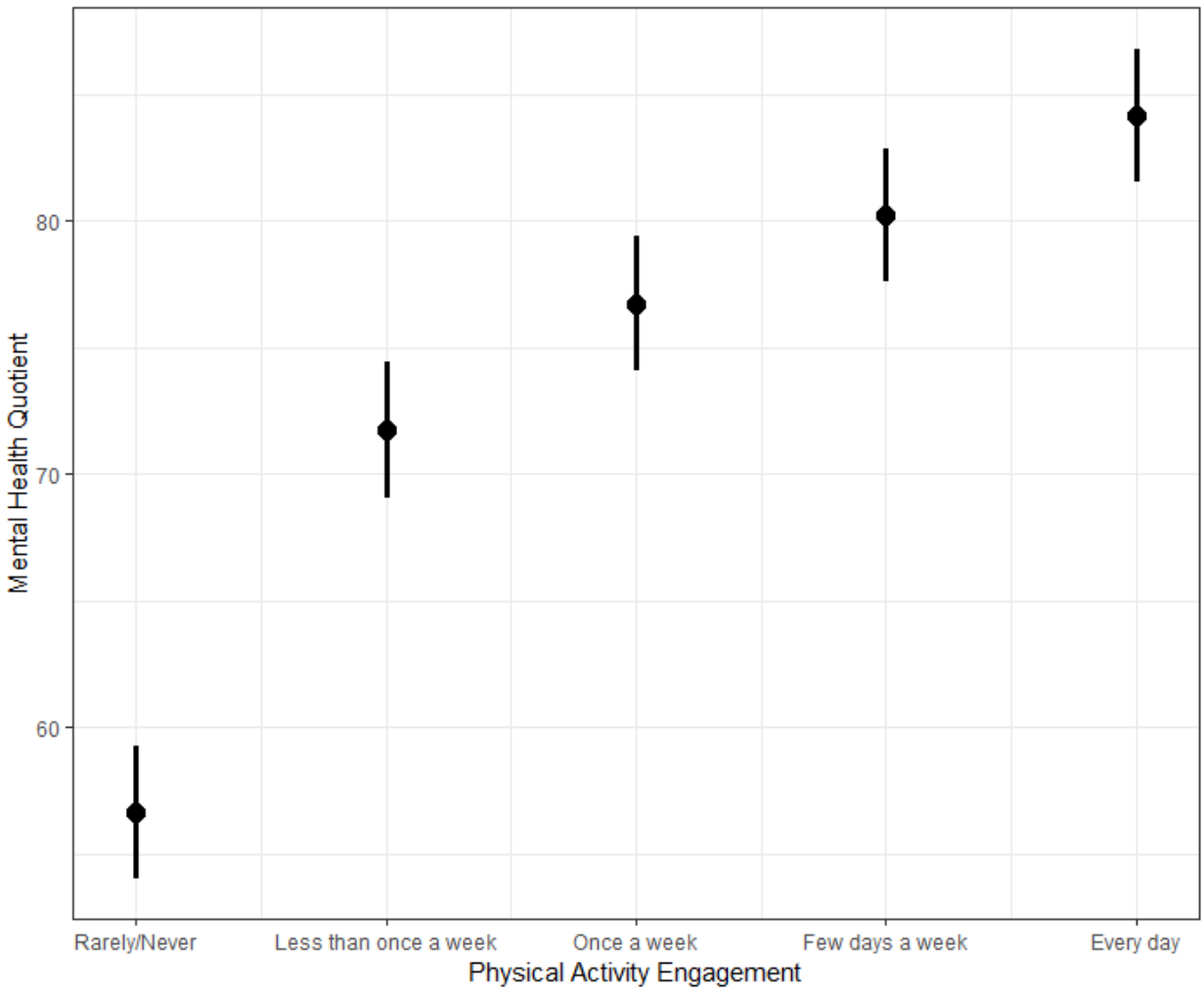


Figure 1. Relationship between physical activity and mental health quotient. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), mental health treatment (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

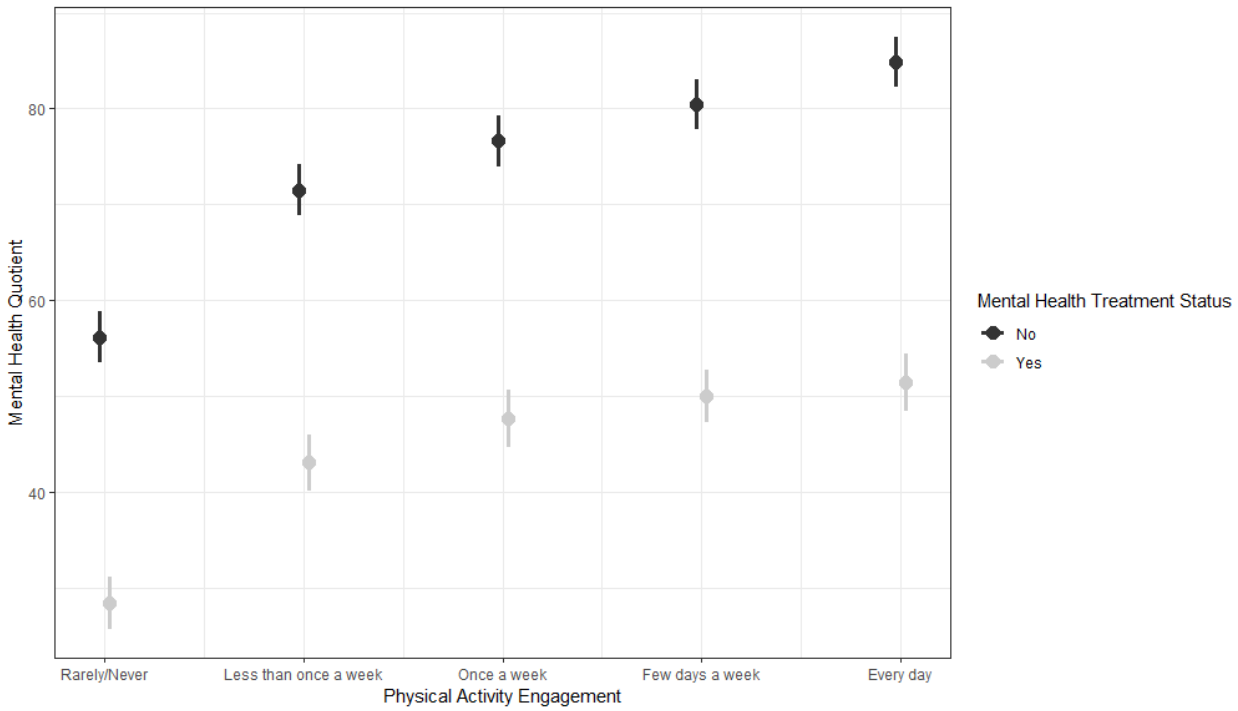


Figure 2. Relationship between physical activity and mental health quotient by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

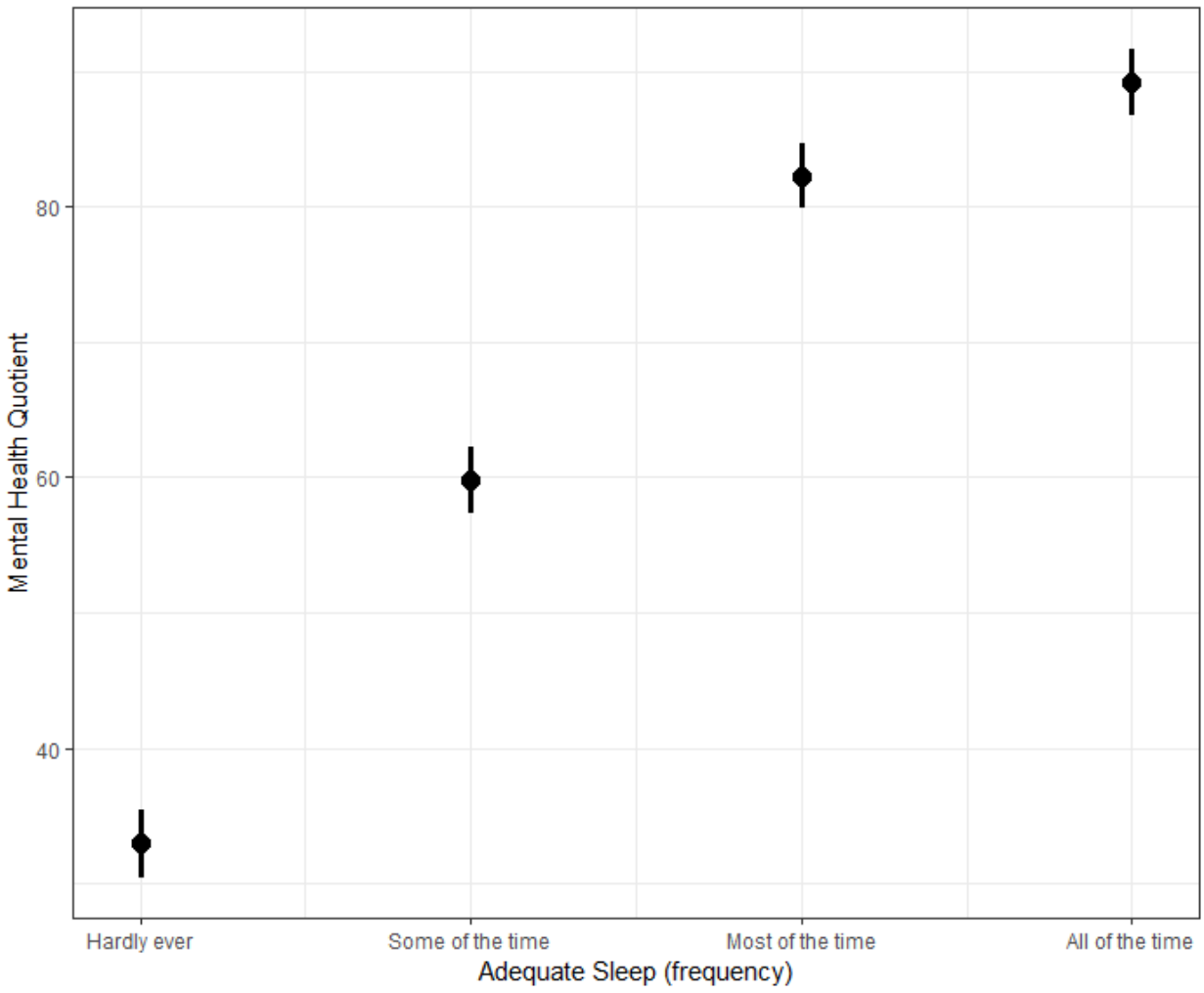


Figure 3. Relationship between sleep and mental health quotient. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), mental health treatment (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

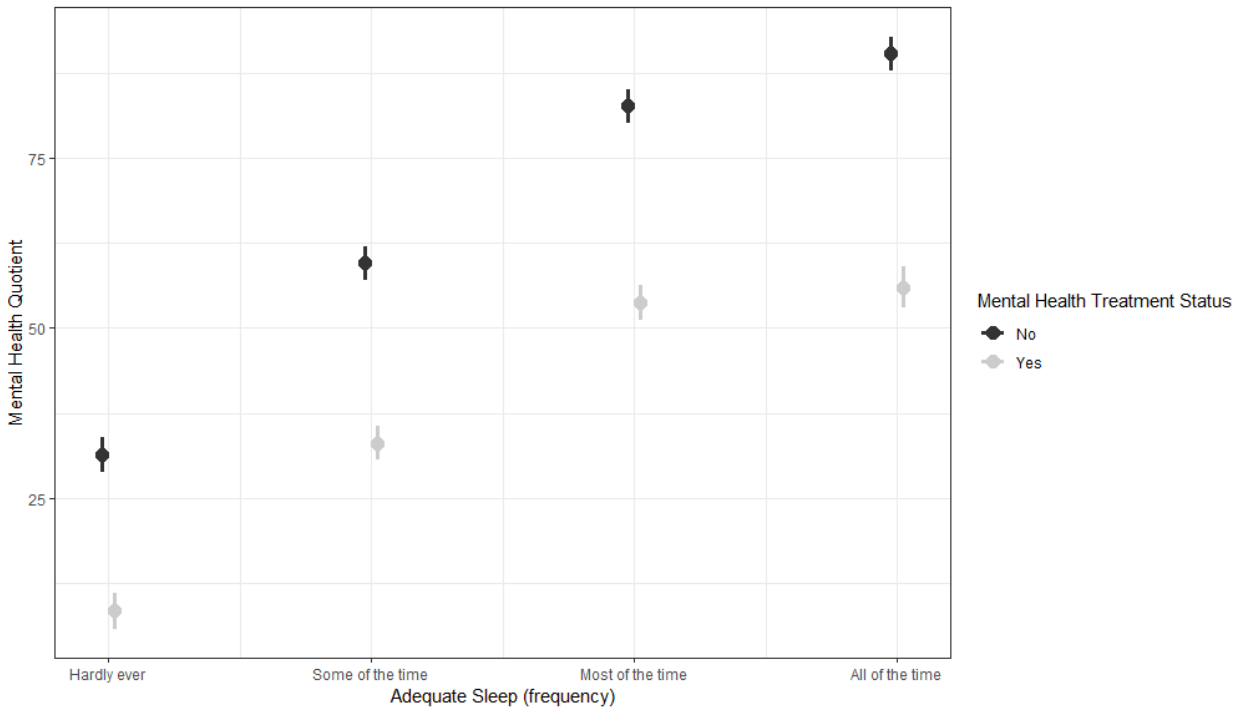


Figure 4. Relationship between sleep and mental health quotient by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

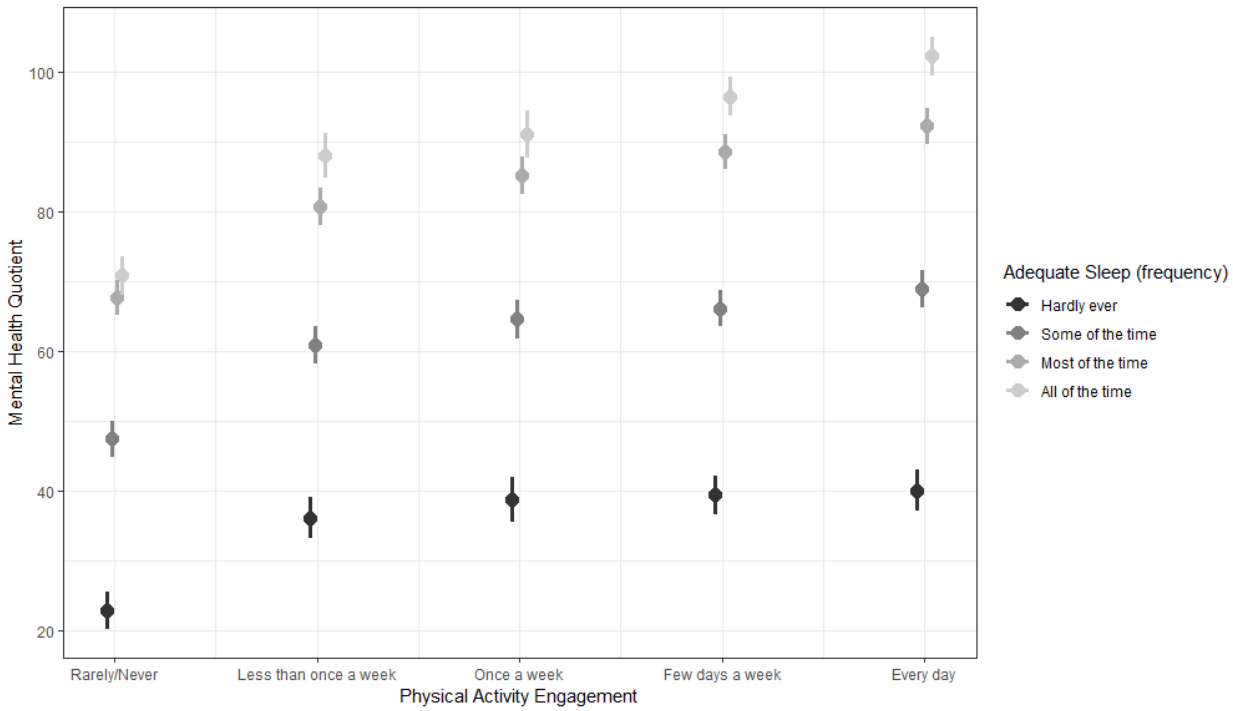


Figure 5. Interactive association between physical activity and sleep in relation to mental health quotient. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), mental health treatment (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

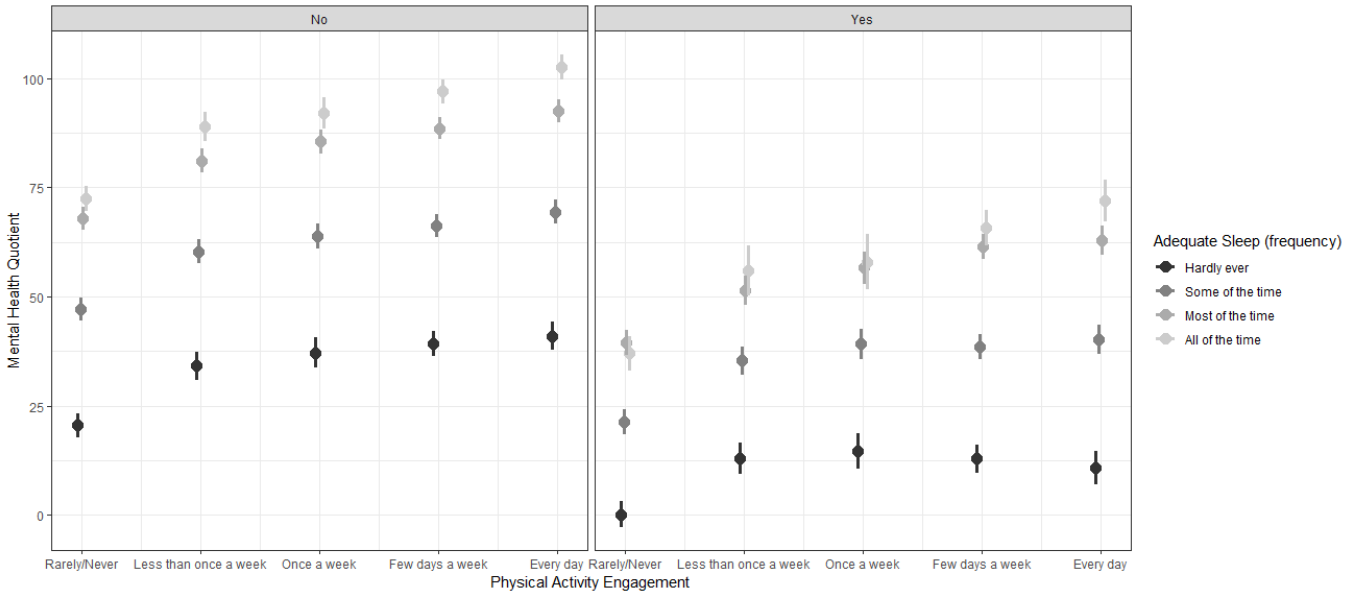


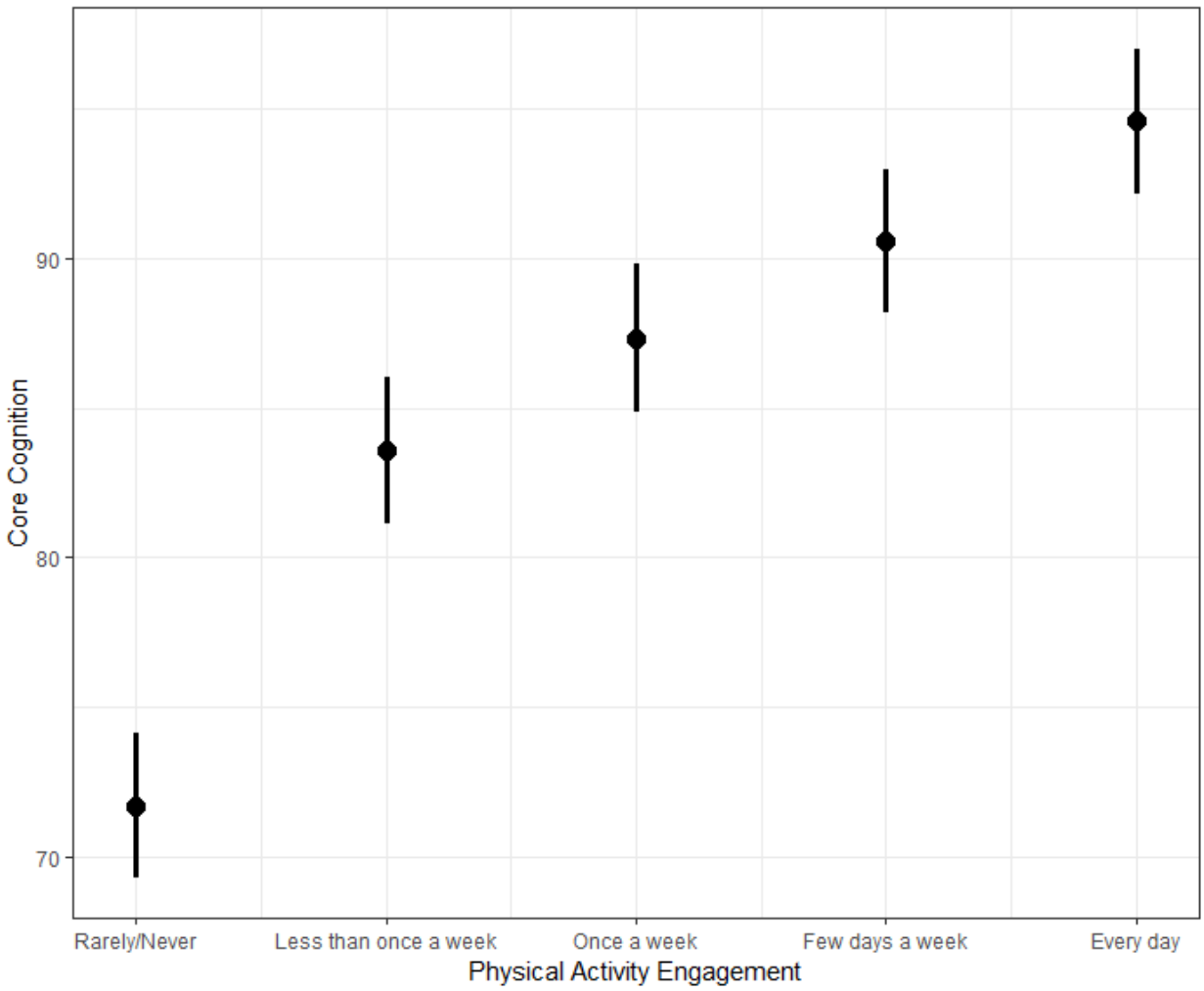
Figure 6. Interactive association between physical activity and sleep in relation to mental health quotient by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

Supplementary Materials.

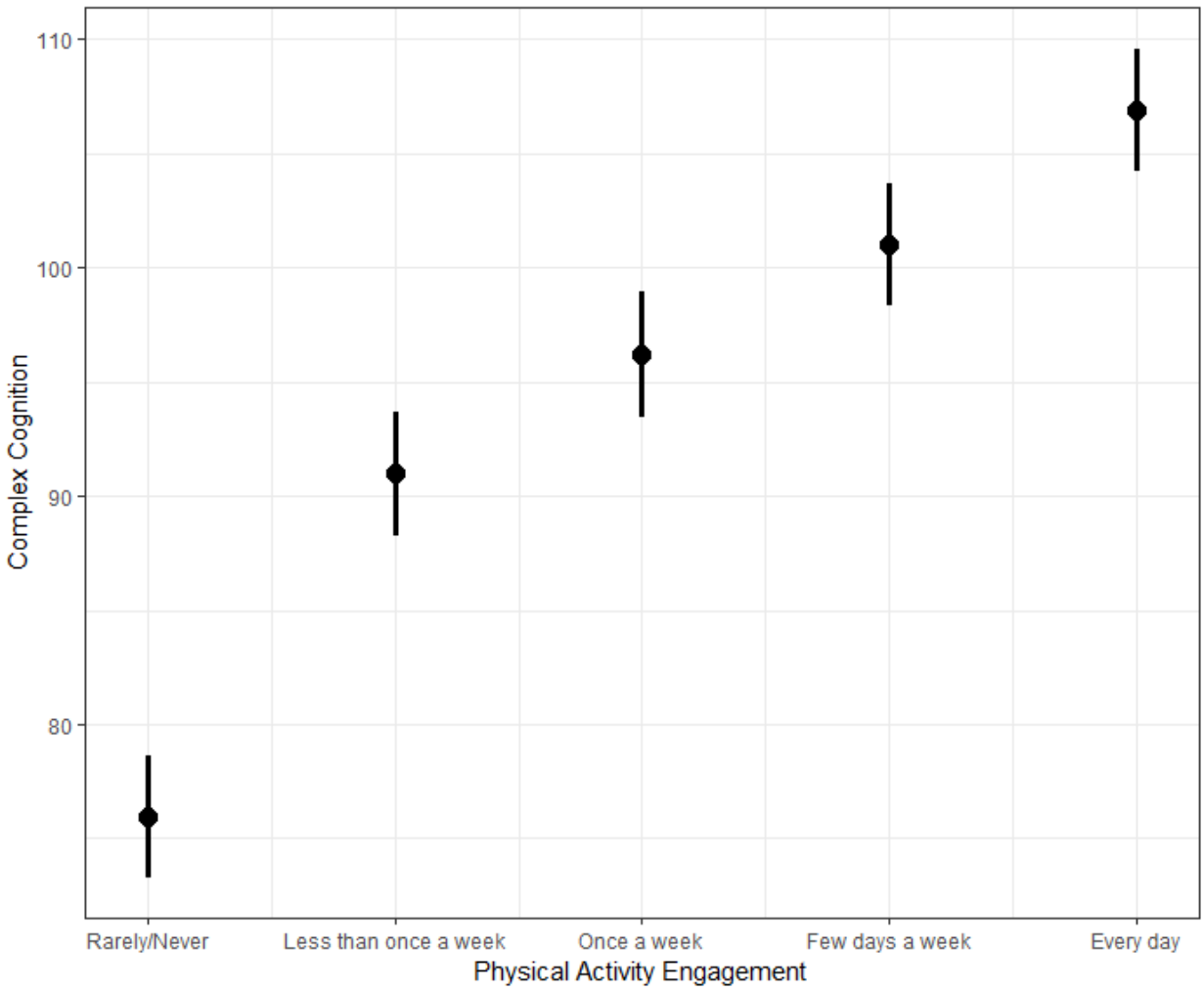
Supplementary Table 1. *Analysis of variance table for the generalized linear mixed models examining independent associations between physical activity and subdomains of the Mental Health Quotient.*

Effect	df	*F*	*p*
Physical Activity			
Core cognition	4, 220275	1354.99	< .001
Complex cognition	4, 220271	2327.70	< .001
Drive and motivation	4, 220272	1739.24	< .001
Mood and outlook	4, 220276	1446.83	< .001
Social self	4, 220276	1009.82	< .001
Mind and body connection	4, 220277	2647.52	< .001

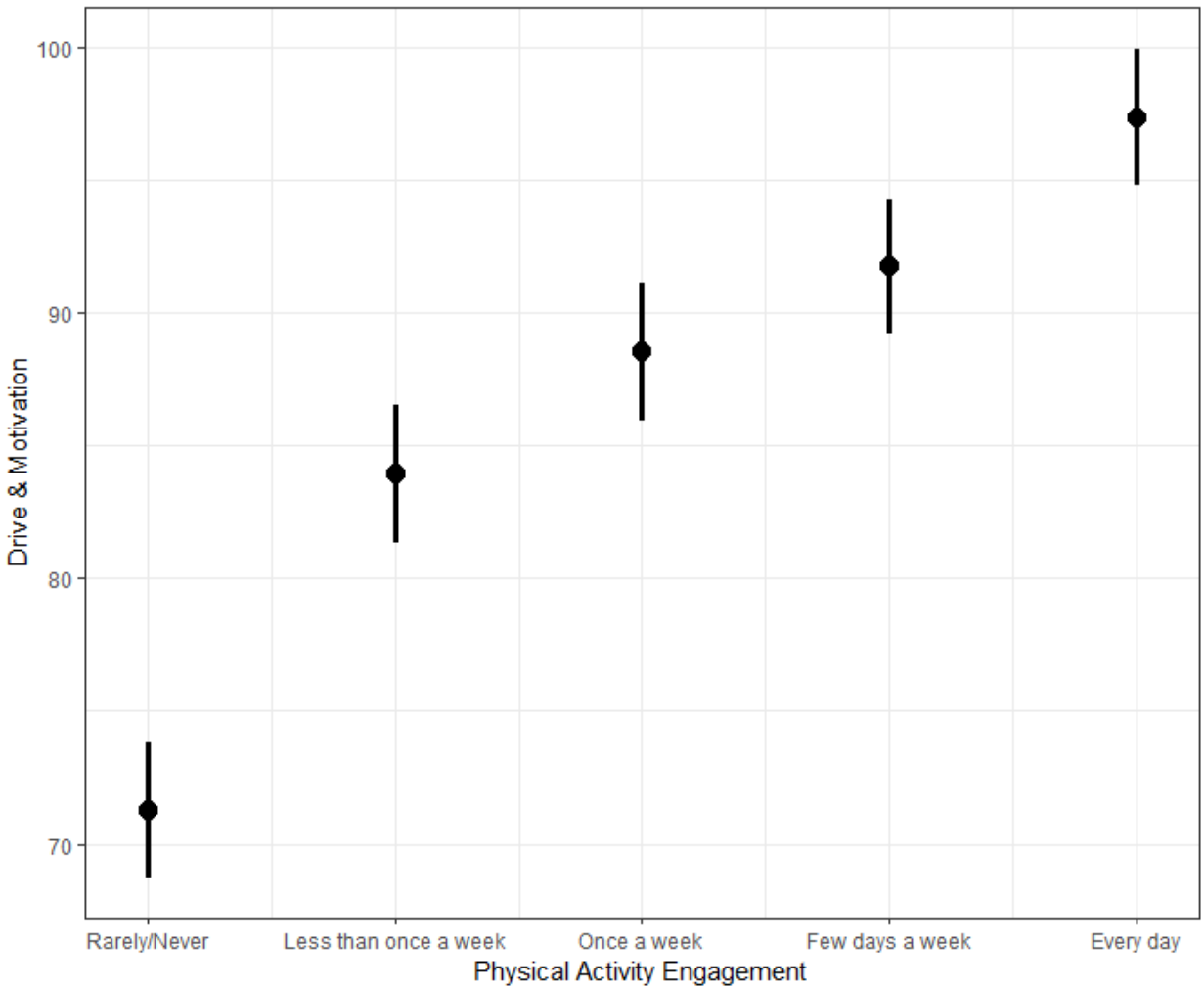
Note: Degrees of freedom were approximated by Satterthwaite's method.



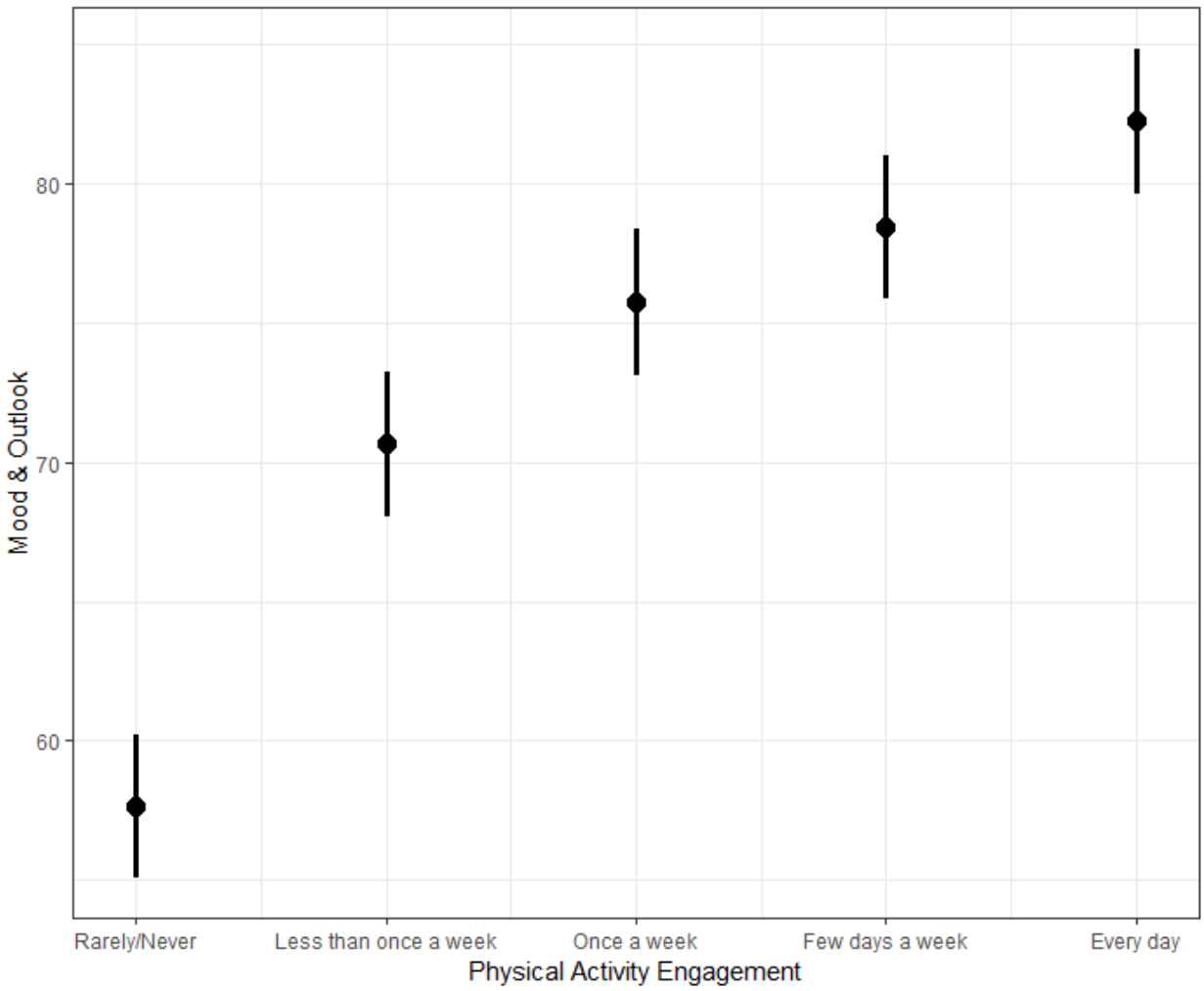
Supplementary Figure 1a. Relationship between physical activity and core cognition. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), mental health treatment (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).



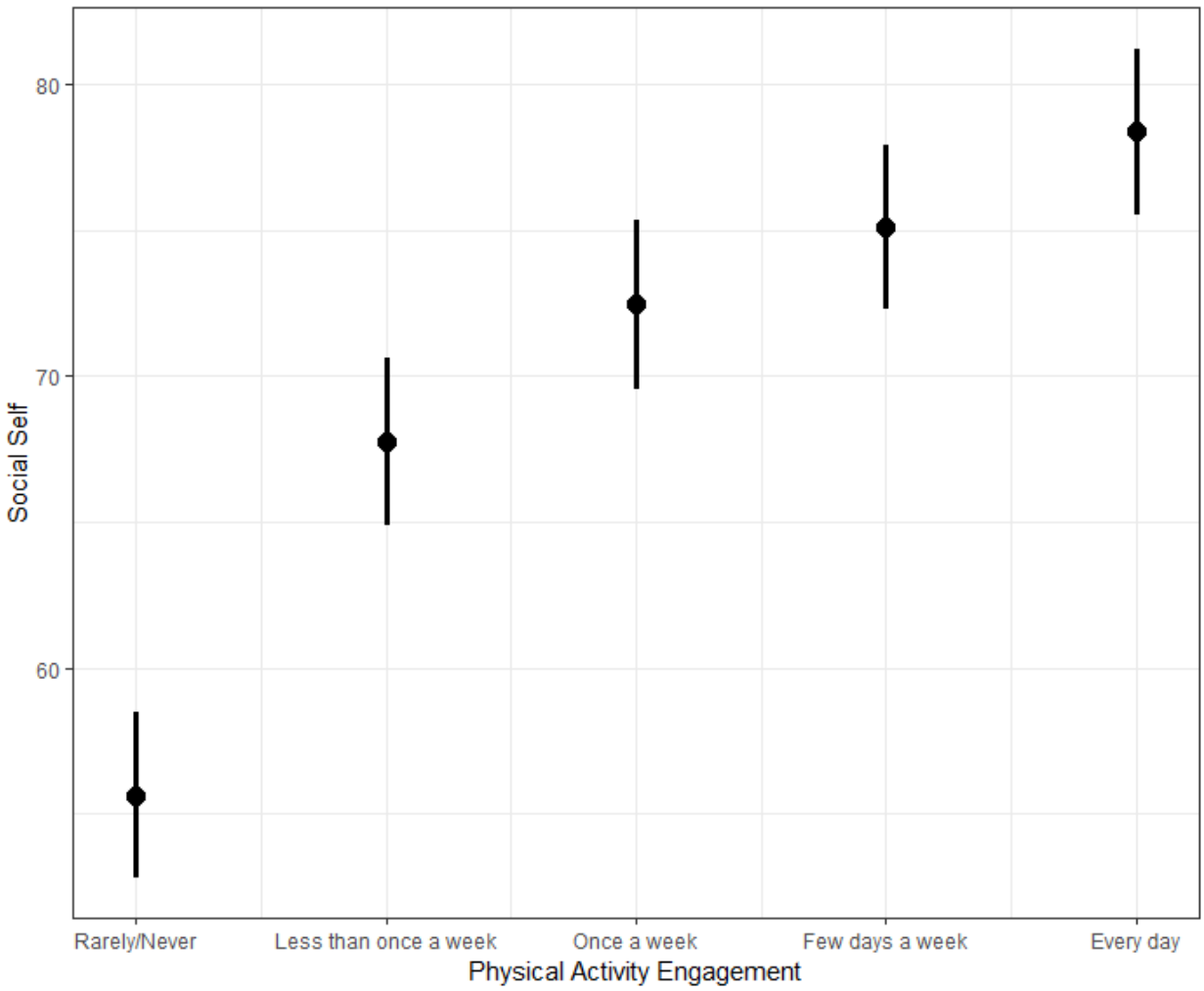
Supplementary Figure 1b. Relationship between physical activity and complex cognition. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), mental health treatment (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).



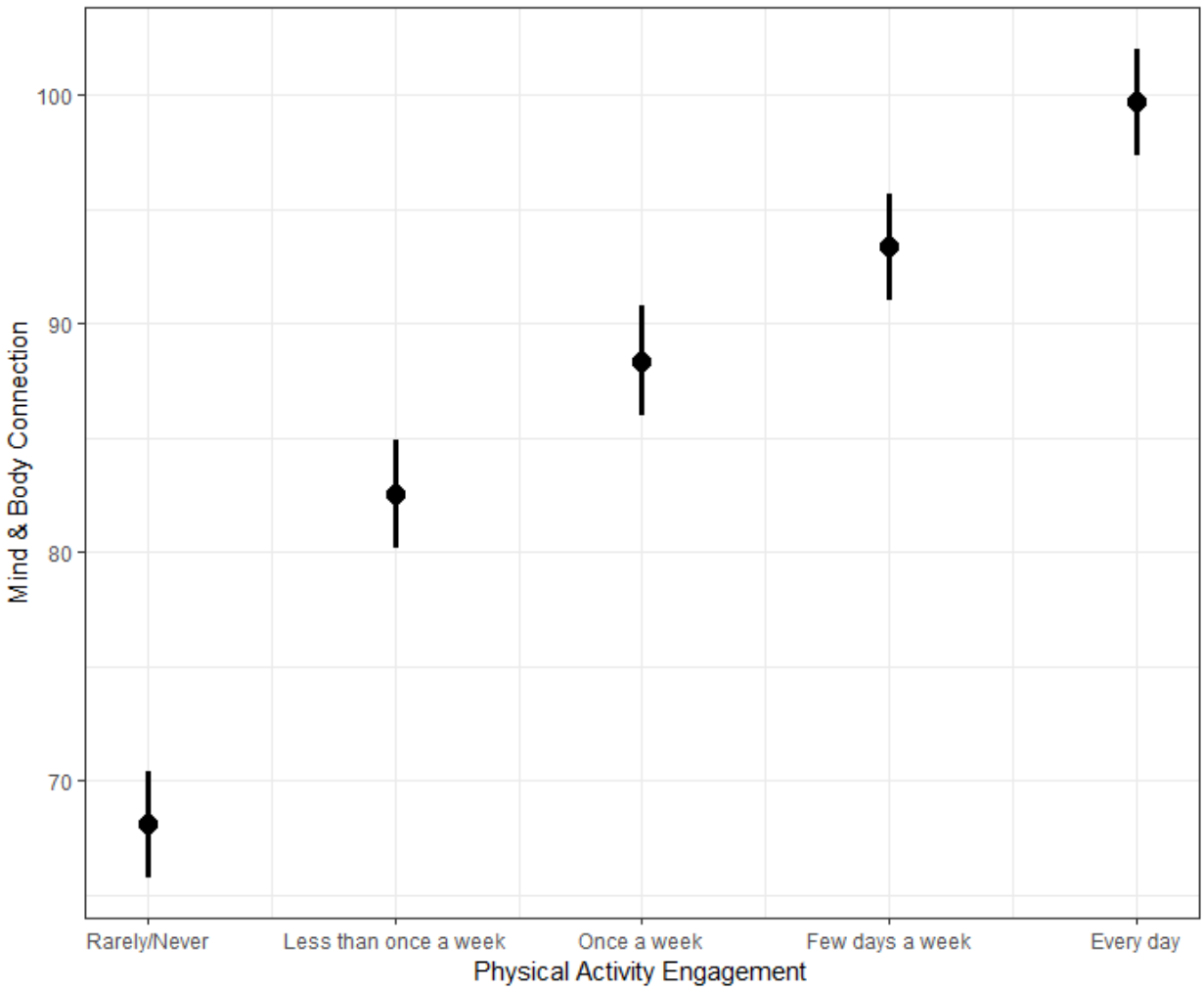
Supplementary Figure 1c. Relationship between physical activity and drive and motivation. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), mental health treatment (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).



Supplementary Figure 1d. Relationship between physical activity and mood and outlook. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), mental health treatment (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).



Supplementary Figure 1e. Relationship between physical activity and social self. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), mental health treatment (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).



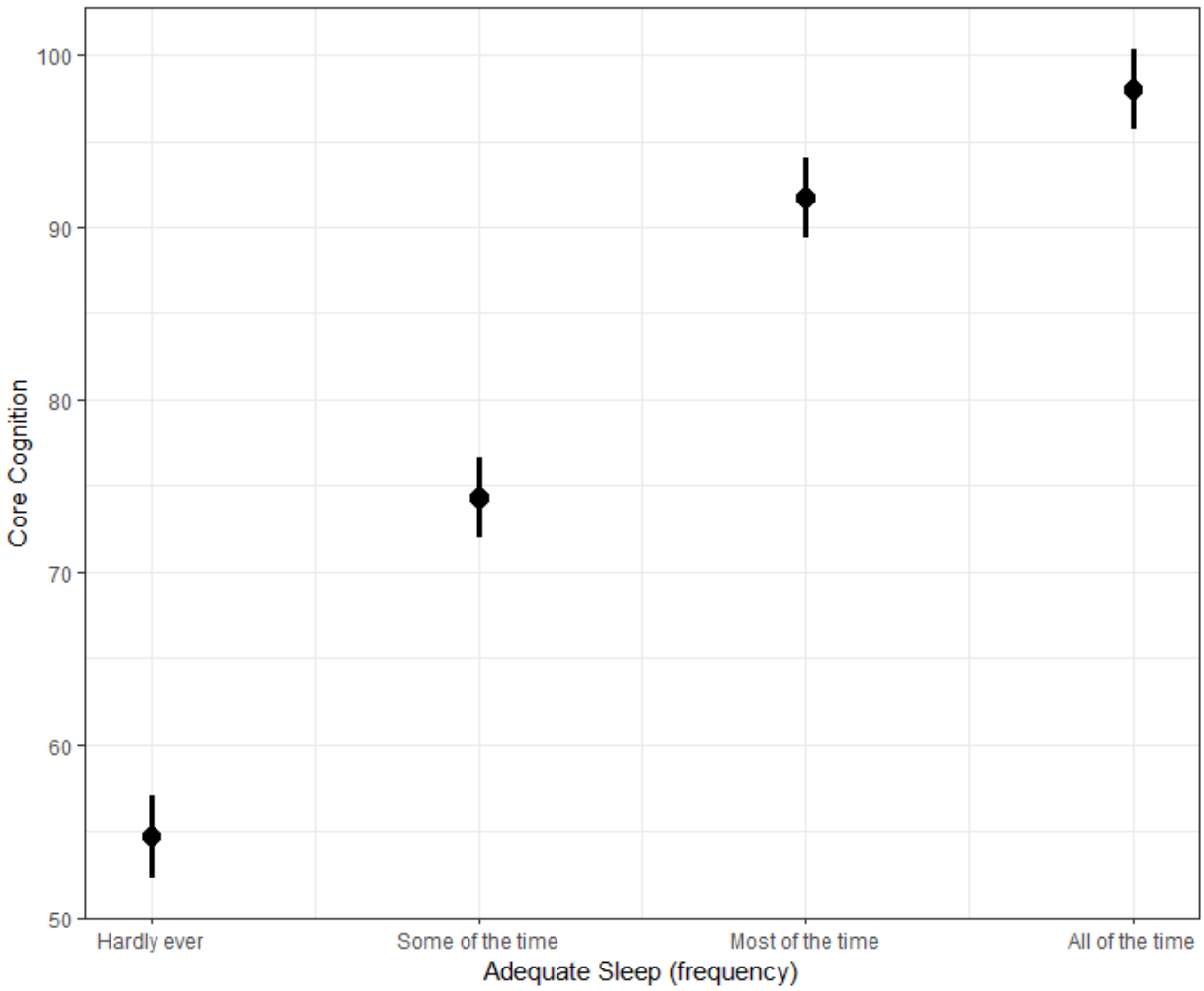
Supplementary Figure 1f. Relationship between physical activity and mind and body connection. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), mental health treatment (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

Supplementary Table 2. *Analysis of variance table for the generalized linear mixed models examining independent associations between sleep and subdomains of the Mental Health Quotient.*

Effect	df	*F*	*p*
Sleep			
Core cognition	3, 220270	4667.99	< .001
Complex cognition	3, 220271	4502.73	< .001

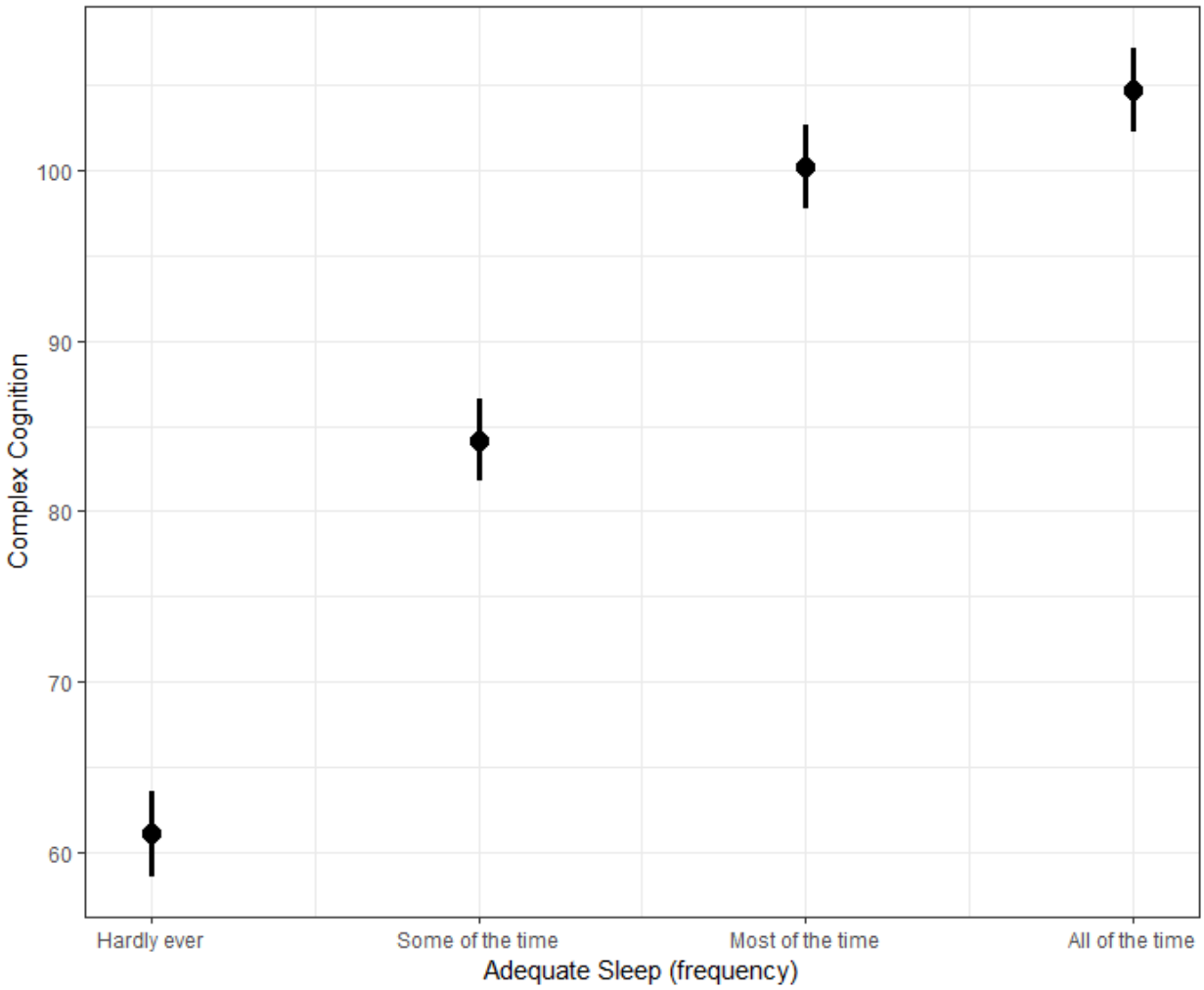
Drive and motivation	3, 220268	4384.06	< .001
Mood and outlook	3, 220274	7036.47	< .001
Social self	3, 220275	4205.00	< .001
Mind and body connection	3, 220279	12446.41	< .001

Note: Degrees of freedom were approximated by Satterthwaite's method.

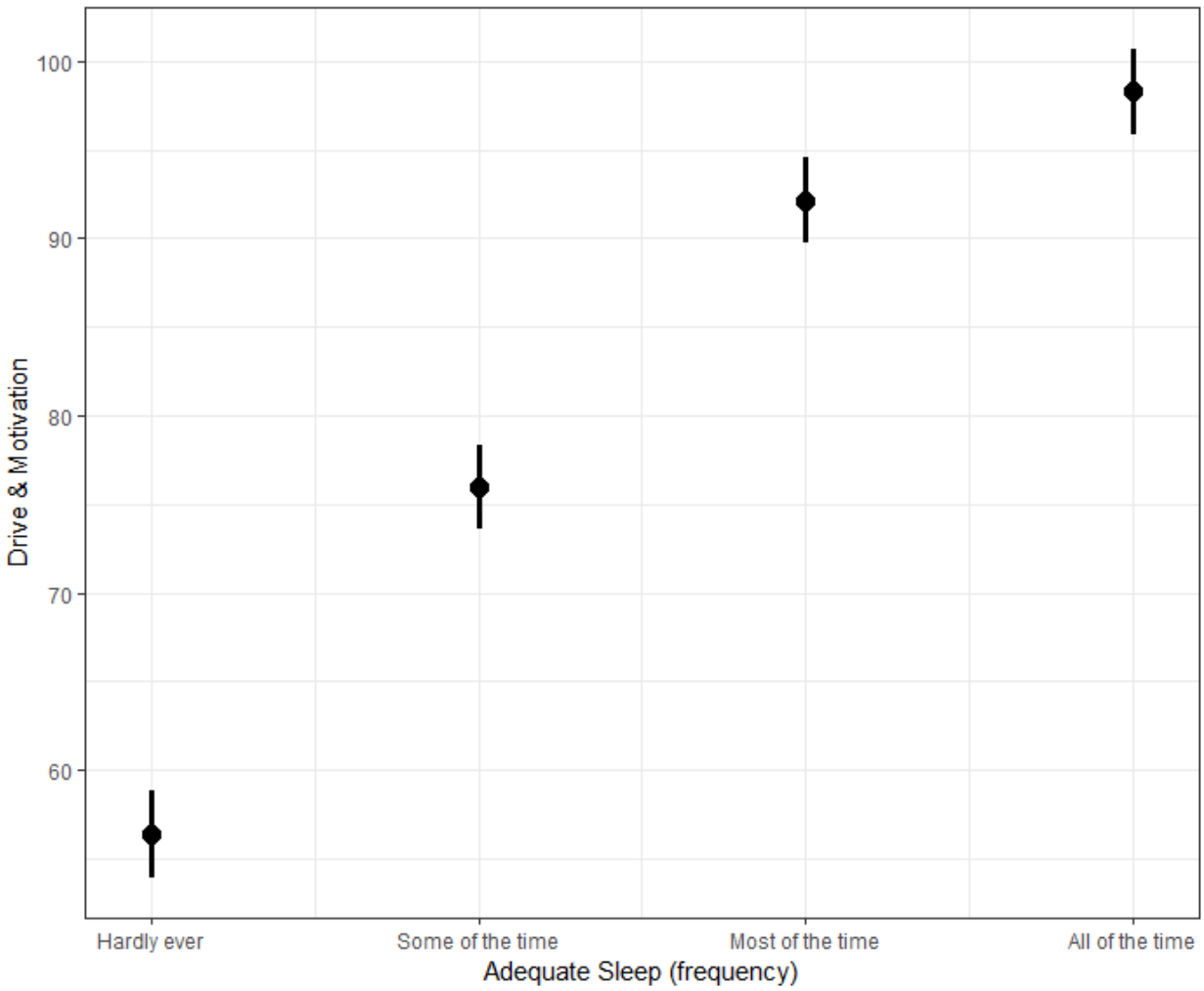


Supplementary Figure 2a. Relationship between sleep and core cognition. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), mental health treatment (no),

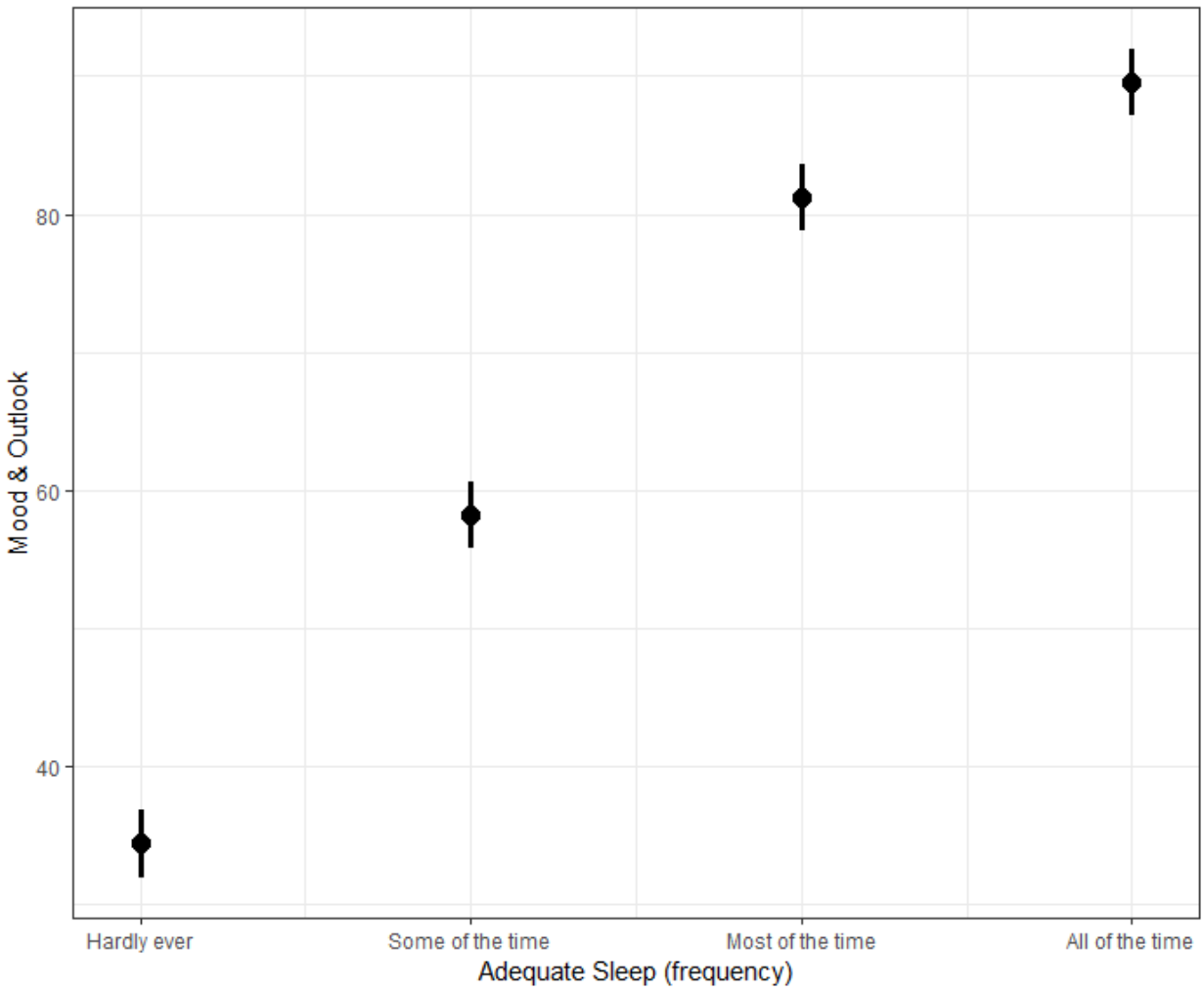
major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).



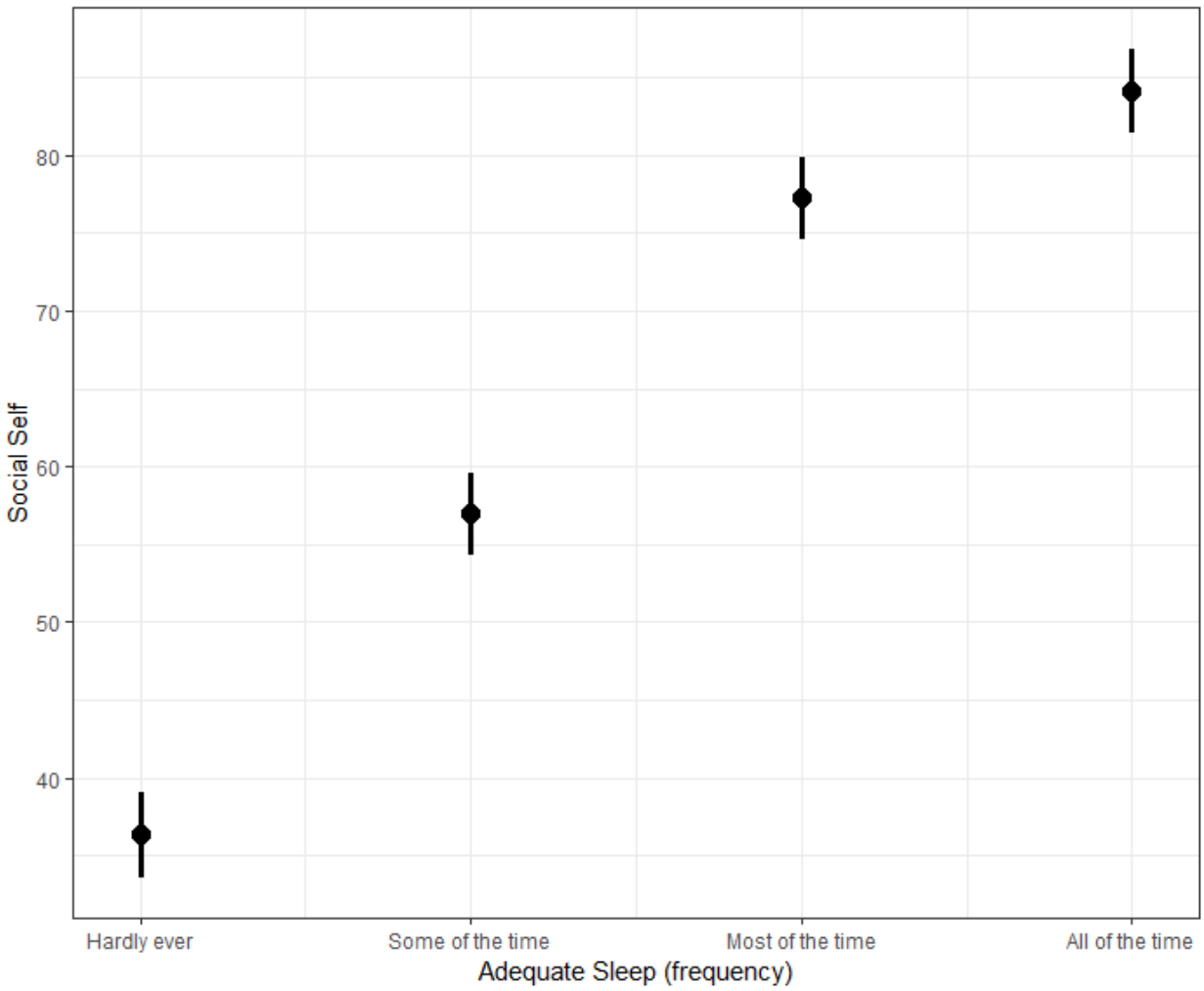
Supplementary Figure 2b. Relationship between sleep and core cognition. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), mental health treatment (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).



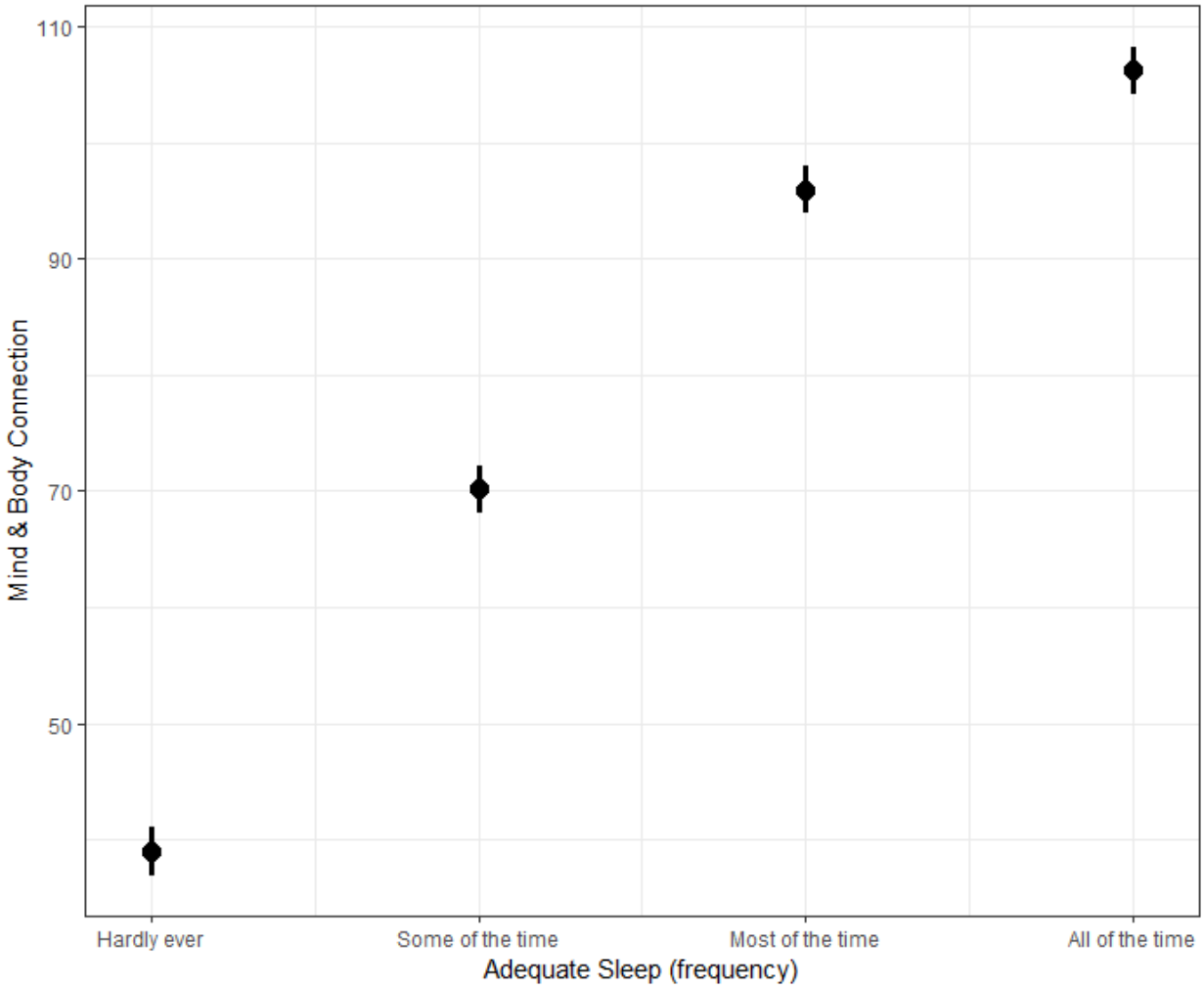
Supplementary Figure 2c. Relationship between sleep and drive and motivation. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), mental health treatment (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).



Supplementary Figure 2d. Relationship between sleep and mood and outlook. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), mental health treatment (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).



Supplementary Figure 2e. Relationship between sleep and social self. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), mental health treatment (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).



Supplementary Figure 2f. Relationship between sleep and mind and body connection. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), mental health treatment (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

Supplementary Table 3. *Analysis of variance table for the generalized linear mixed models examining joint associations between physical activity and mental health treatment related to the subdomains of the Mental Health Quotient.*

Effect	df	F	*p*
Core cognition			
Physical activity	4, 220265	918.07	< .001

Mental health treatment	1, 220289	6737.87	< .001
Physical activity*Mental health treatment	4, 220241	9.39	< .001
Complex cognition			
Physical activity	4, 220259	1665.39	< .001
Mental health treatment	1, 220281	5848.21	< .001
Physical activity*Mental health treatment	4, 220237	3.24	.01
Drive and motivation			
Physical activity	4, 220260	1226.98	< .001
Mental health treatment	1, 220281	7570.90	< .001
Physical activity*Mental health treatment	4, 220238	3.35	.009
Mood and outlook			
Physical activity	4, 220266	924.86	< .001
Mental health treatment	1, 220288	8228.17	< .001
Physical activity*Mental health treatment	4, 220244	25.09	< .001
Social self			
Physical activity	4, 220266	644.94	< .001
Mental health treatment	1, 220289	5241.67	< .001
Physical activity*Mental health treatment	4, 220244	17.80	< .001
Mind and body connection			
Physical activity	4, 220268	1838.92	< .001
Mental health treatment	1, 220289	5172.47	< .001
Physical activity*Mental health treatment	4, 220247	7.03	< .001

Note: Degrees of freedom were approximated by Satterthwaite's method.

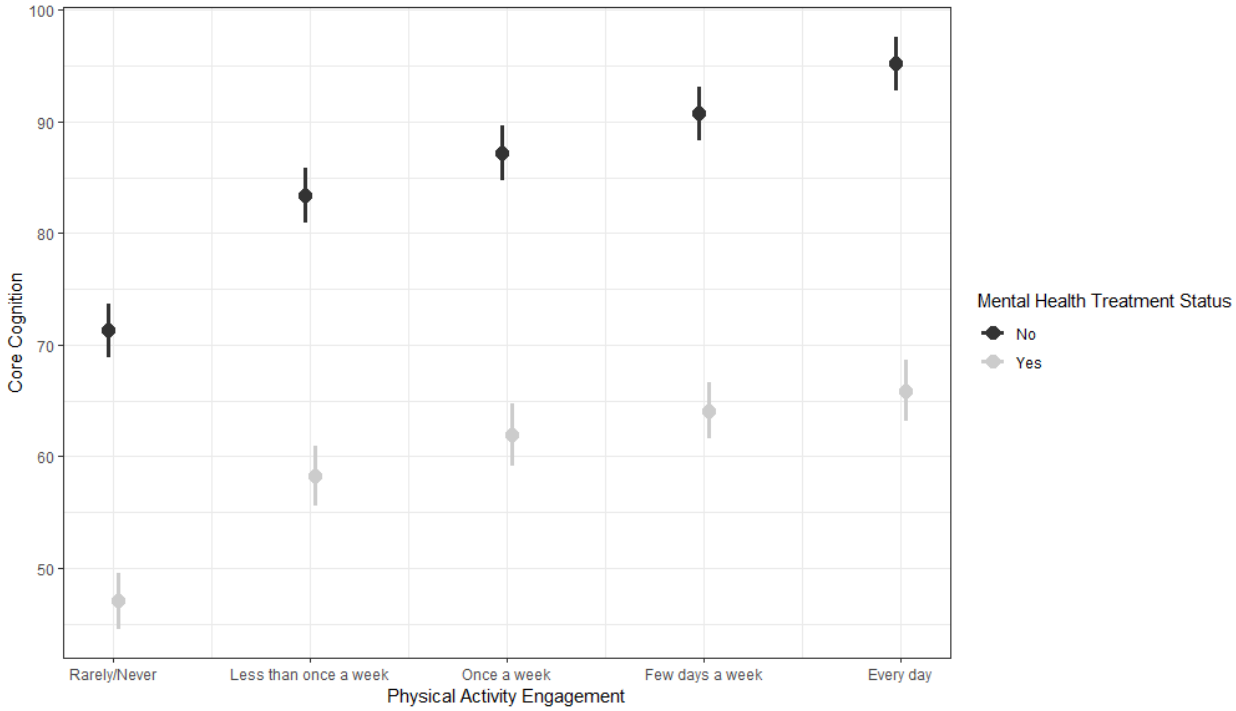


Figure 3a. Relationship between physical activity and core cognition by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

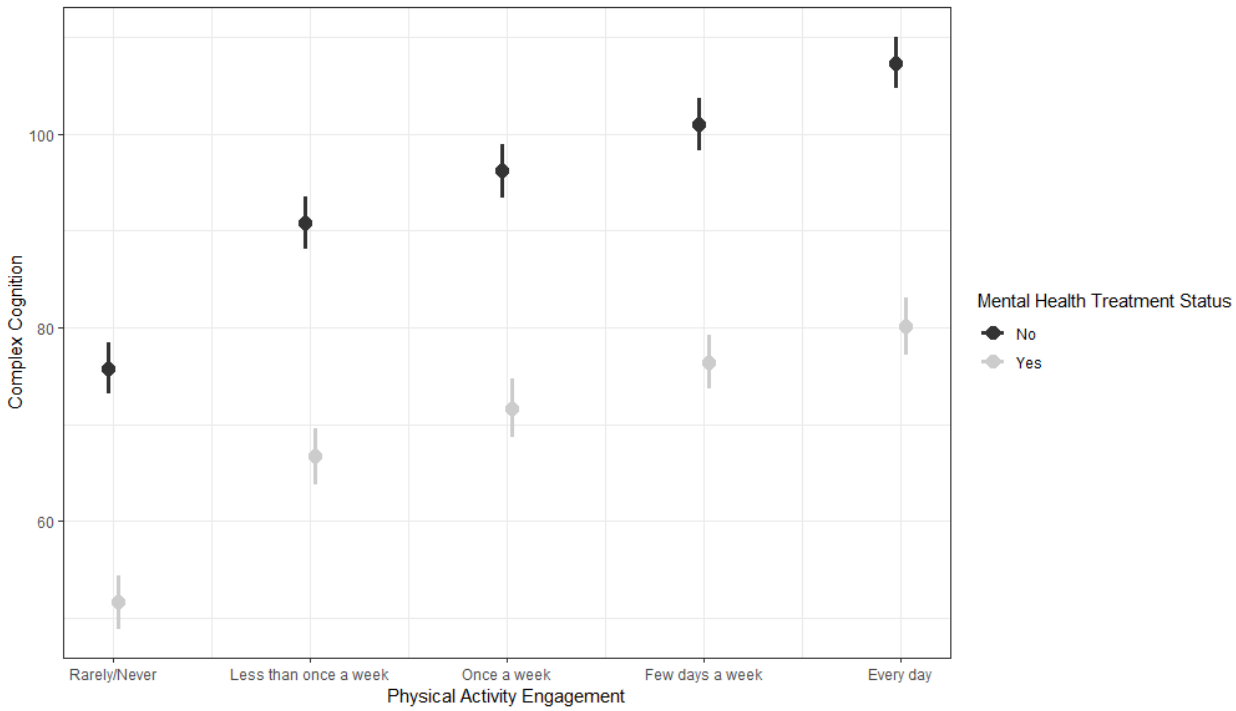


Figure 3b. Relationship between physical activity and complex cognition by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

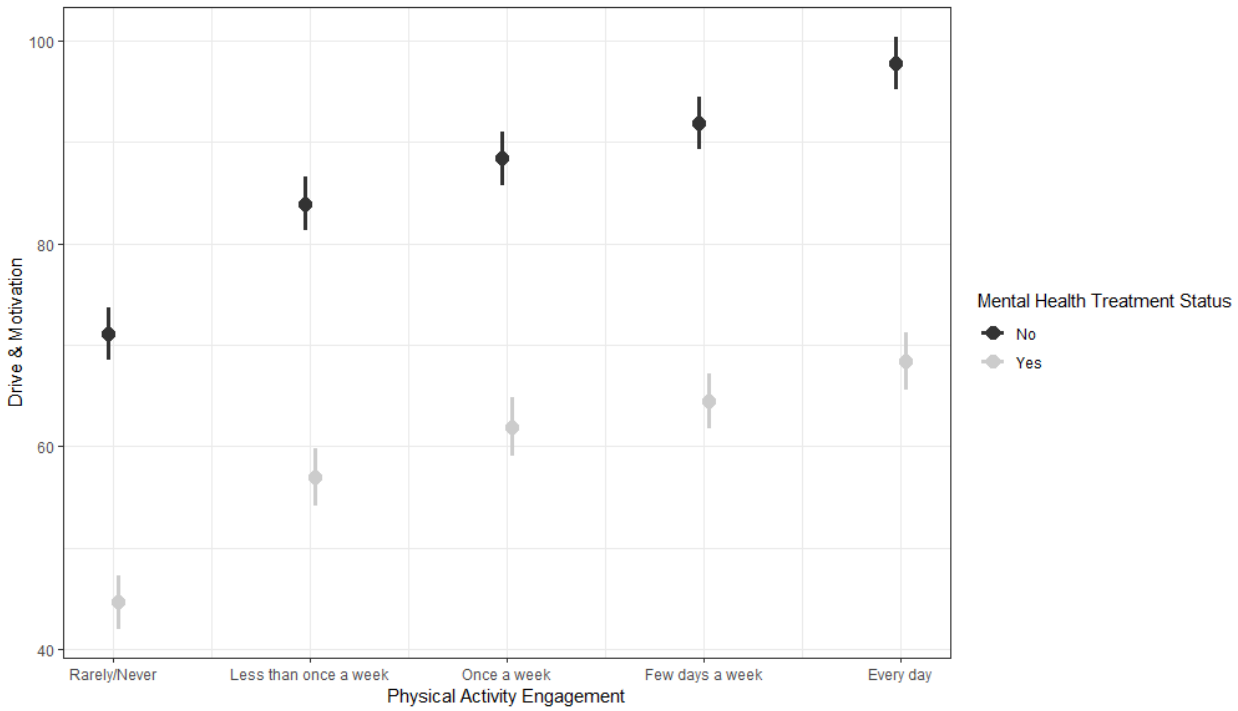


Figure 3c. Relationship between physical activity and drive and motivation by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

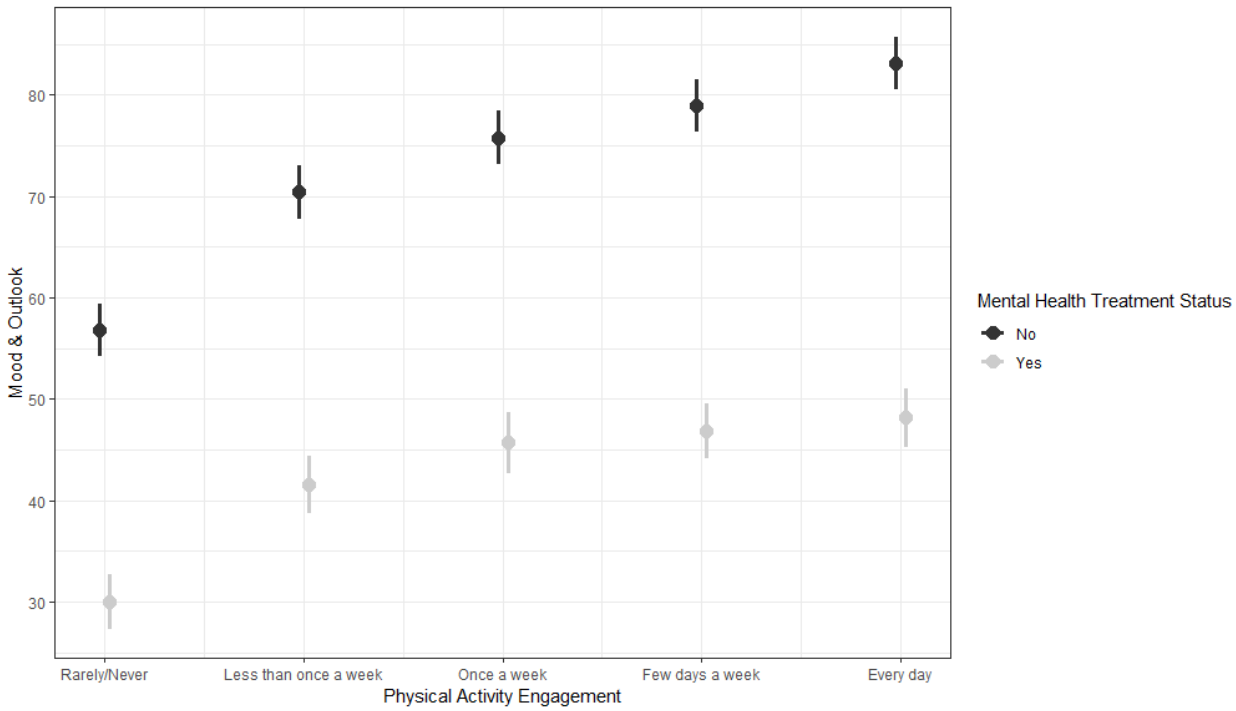


Figure 3d. Relationship between physical activity and mood and outlook by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

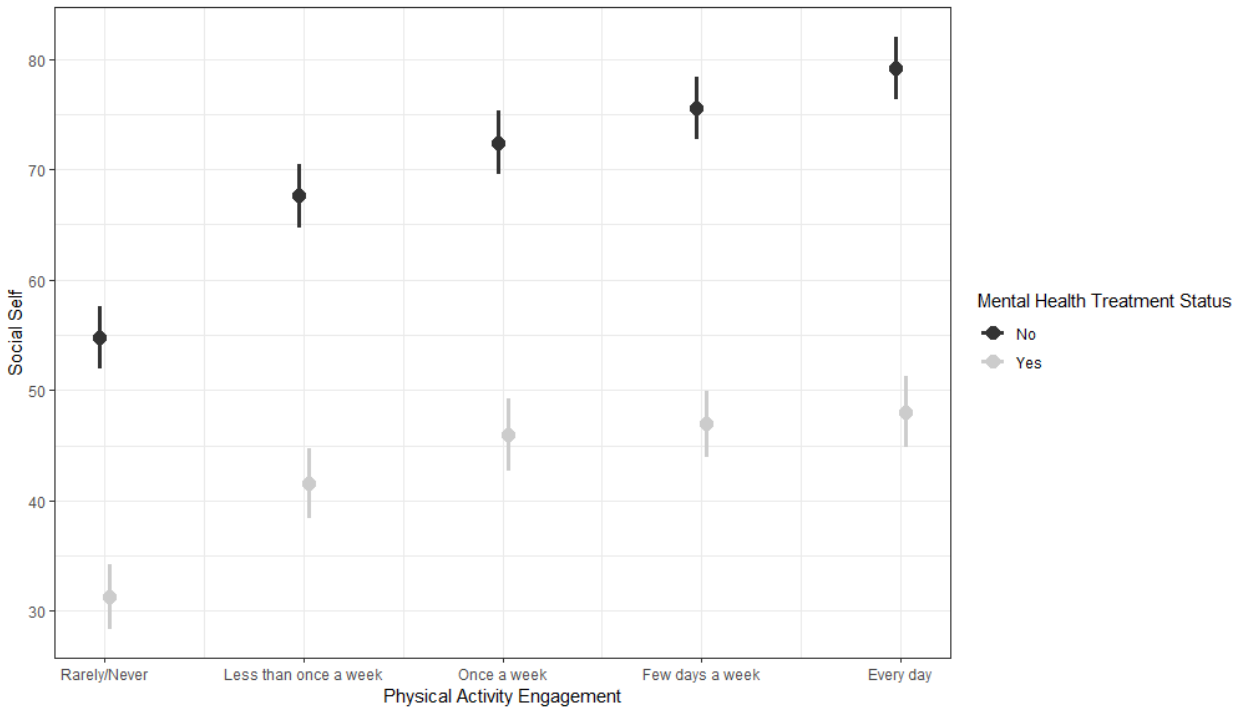


Figure 3e. Relationship between physical activity and social self by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

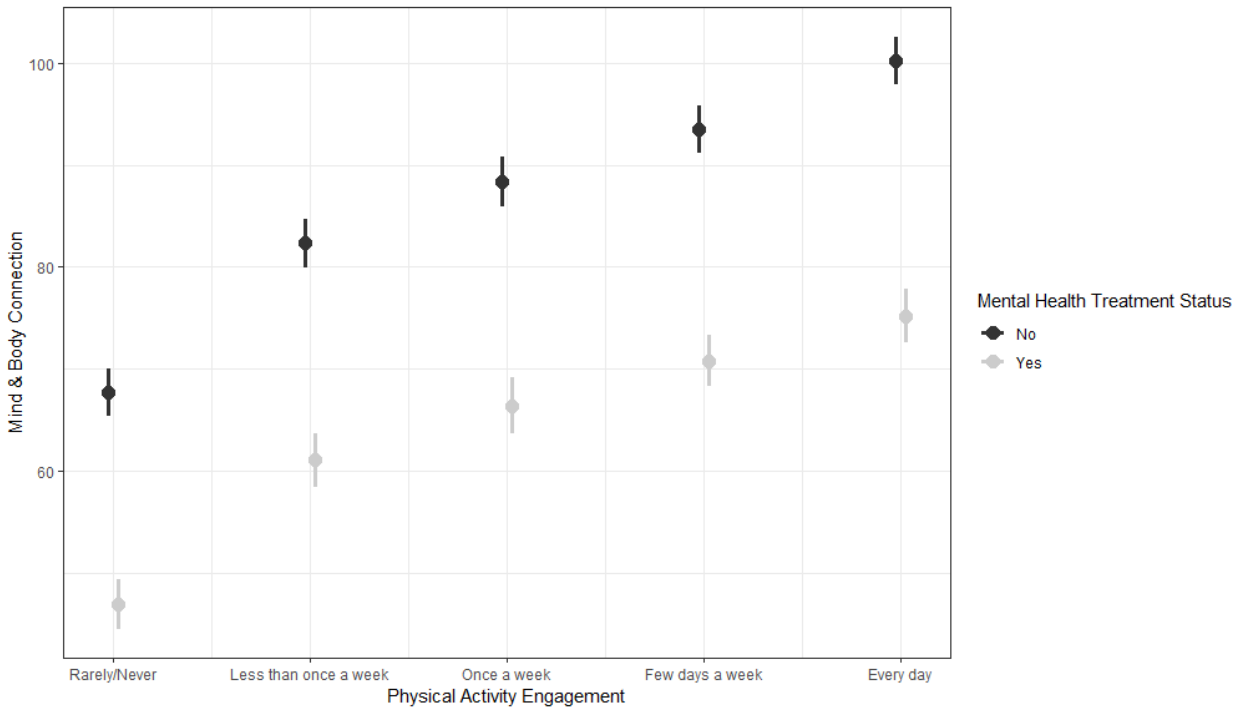


Figure 3f. Relationship between physical activity and mind and body connection by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

Supplementary Table 4. *Analysis of variance table for the generalized linear mixed models examining joint associations between sleep and mental health treatment related to the subdomains of the Mental Health Quotient.*

Effect	df	F	*p*
Core cognition			
Sleep	3, 220261	3417.94	< .001
Mental health treatment	1, 220289	5569.81	< .001
Sleep*Mental health treatment	3, 220255	18.04	< .001
Complex cognition			
Sleep	3, 220262	3381.92	< .001
Mental health treatment	1, 220287	4873.72	< .001

Sleep*Mental health treatment	3, 220257	21.45	< .001
Drive and motivation			
Sleep	3, 220260	3215.18	< .001
Mental health treatment	1, 220286	6313.26	< .001
Sleep*Mental health treatment	3, 220256	17.76	< .001
Mood and outlook			
Sleep	3, 220264	4831.54	< .001
Mental health treatment	1, 220290	6850.79	< .001
Sleep*Mental health treatment	3, 220259	89.93	< .001
Social self			
Sleep	3, 220265	2885.70	< .001
Mental health treatment	1, 220291	4228.65	< .001
Sleep*Mental health treatment	3, 220259	51.89	< .001
Mind and body connection			
Sleep	3, 220269	9092.14	< .001
Mental health treatment	1, 220292	4219.92	< .001
Sleep*Mental health treatment	3, 220261	59.25	< .001

Note: Degrees of freedom were approximated by Satterthwaite's method.

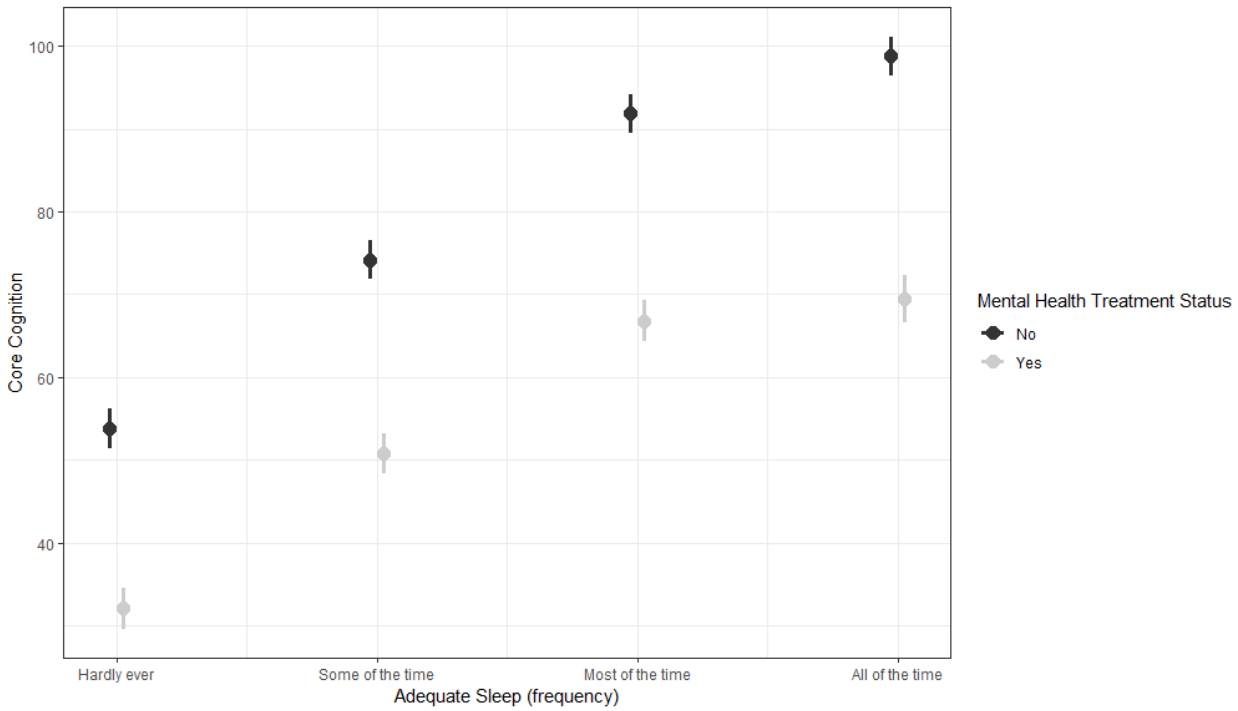


Figure 4a. Relationship between sleep and core cognition by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

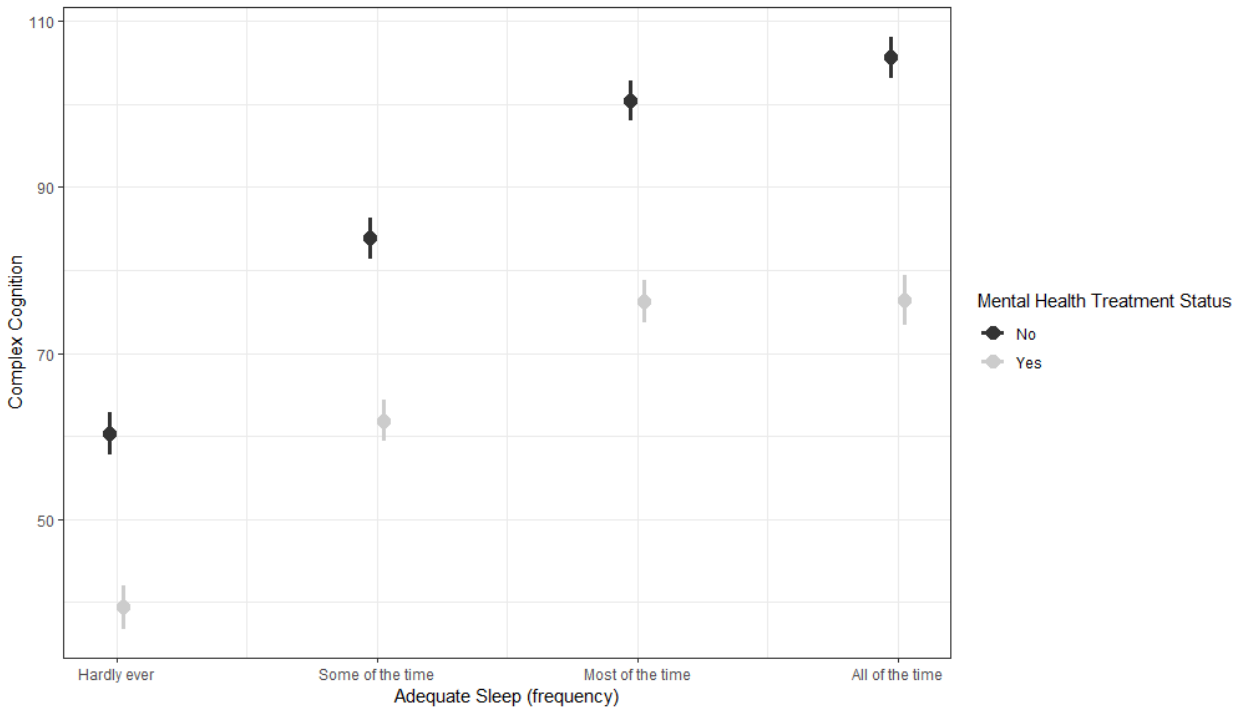


Figure 4b. Relationship between sleep and complex cognition by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

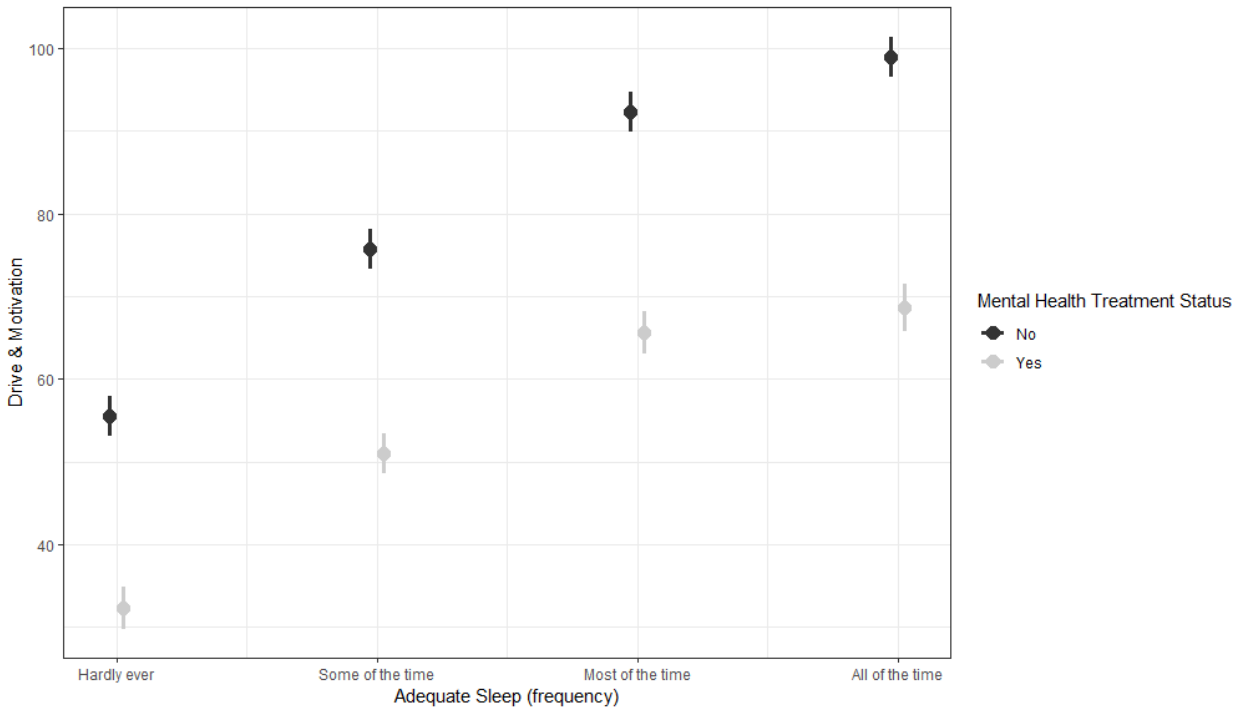


Figure 4c. Relationship between sleep and drive and motivation by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

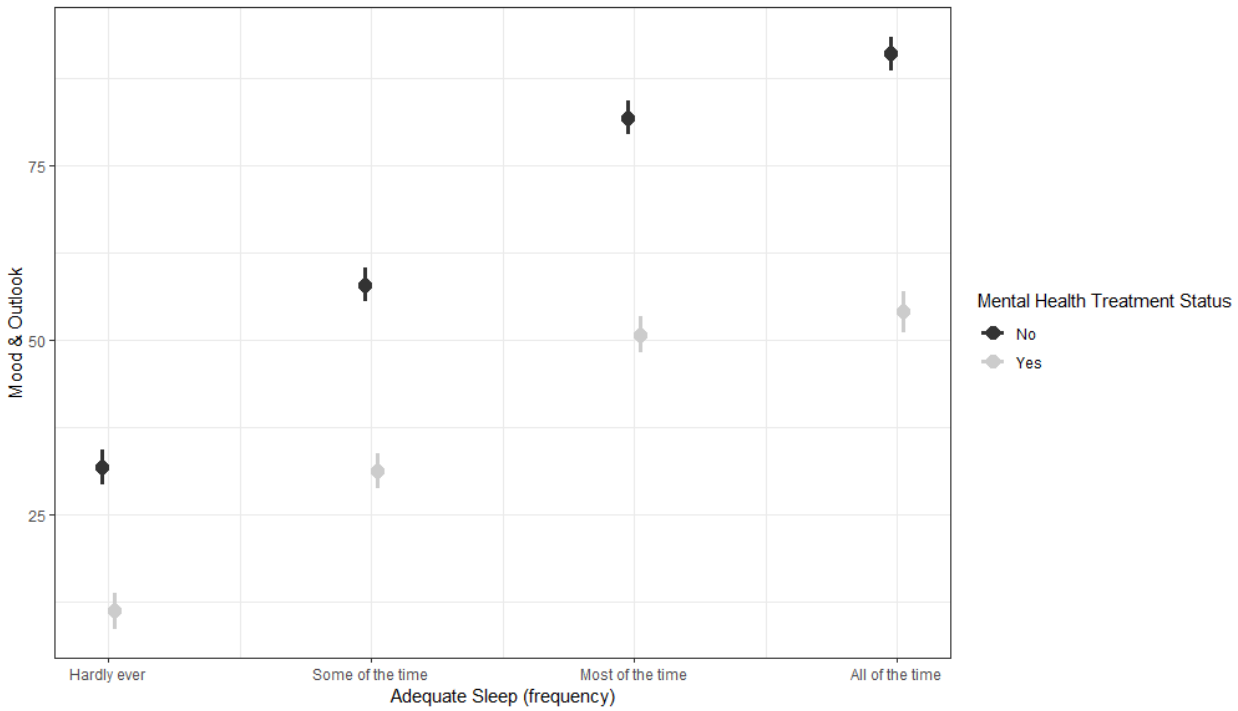


Figure 4d. Relationship between sleep and mood and outlook by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

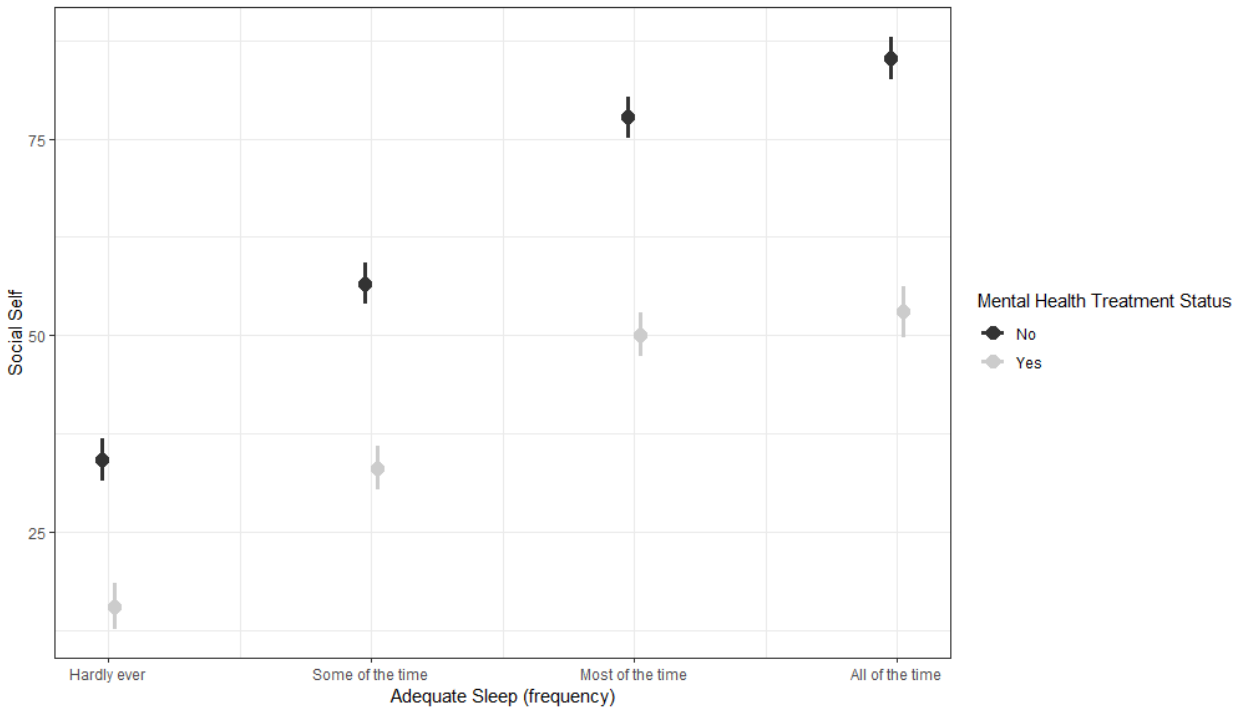


Figure 4e. Relationship between sleep and social self by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

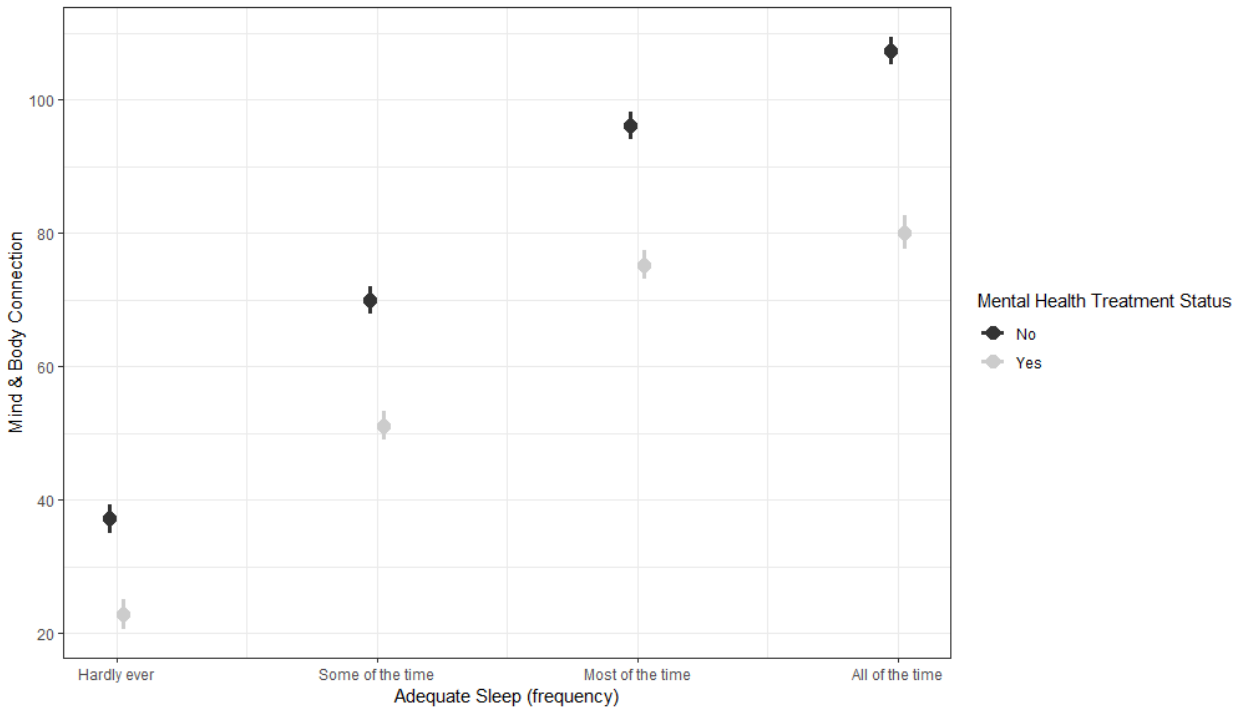


Figure 4f. Relationship between sleep and mind and body connection by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

Supplementary Table 5. *Analysis of variance table for the generalized linear mixed models examining joint associations between sleep and mental health treatment related to the subdomains of the Mental Health Quotient*

Effect	df	F	*p*
Core cognition			
Physical activity	4, 220258	868.67	< .001
Sleep	3, 220252	3499.24	< .001
Physical activity*Sleep	12, 220236	8.62	< .001
Complex cognition			
Physical activity	4, 220254	1595.37	< .001
Sleep	3, 220248	3300.87	< .001

Physical activity*Sleep	12, 220234	7.59	< .001
Drive and motivation			
Physical activity	4, 220254	1152.63	< .001
Sleep	3, 220247	3250.92	< .001
Physical activity*Sleep	12, 220234	9.45	< .001
Mood and outlook			
Physical activity	4, 220259	882.49	< .001
Sleep	3, 220253	5483.81	< .001
Physical activity*Sleep	12, 220239	21.81	< .001
Social self			
Physical activity	4, 220260	613.03	< .001
Sleep	3, 220254	3214.92	< .001
Physical activity*Sleep	12, 220238	16.03	< .001
Mind and body connection			
Physical activity	4, 220261	1736.30	< .001
Sleep	3, 220256	9734.10	< .001
Physical activity*Sleep	12, 220241	18.19	< .001

Note: Degrees of freedom were approximated by Satterthwaite's method.

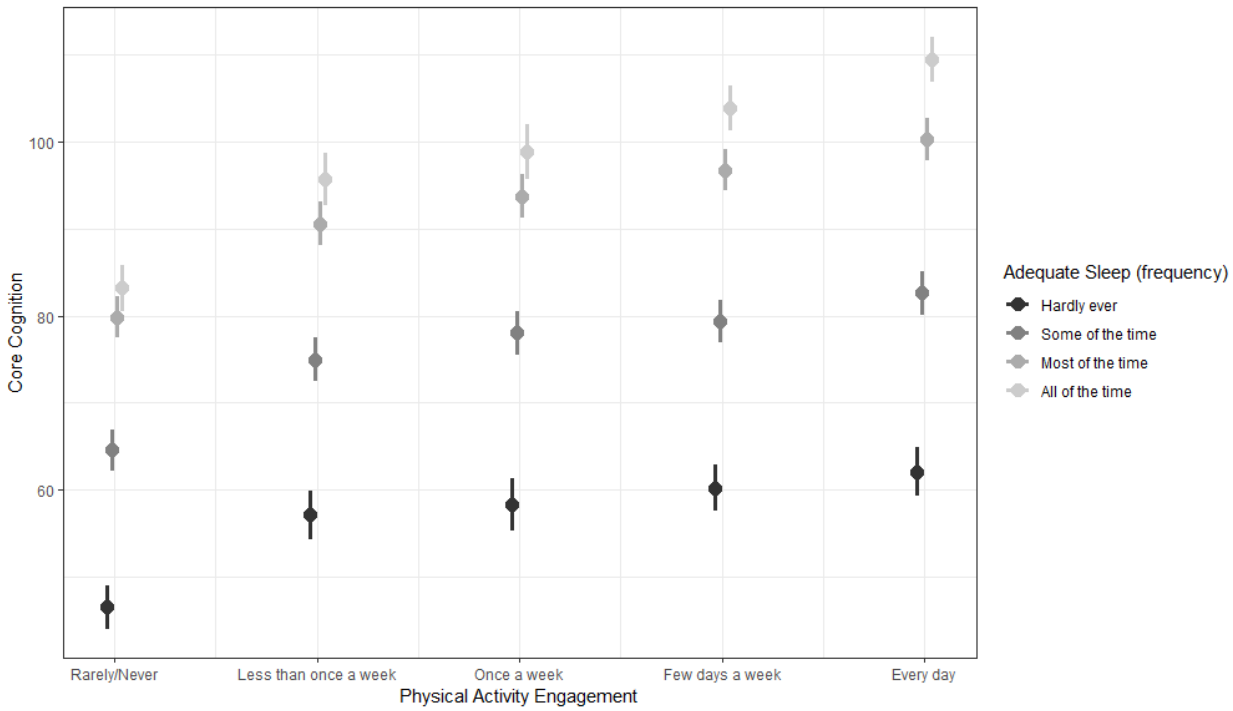


Figure 5a. Interactive association between physical activity and sleep in relation to core cognition. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), mental health treatment (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

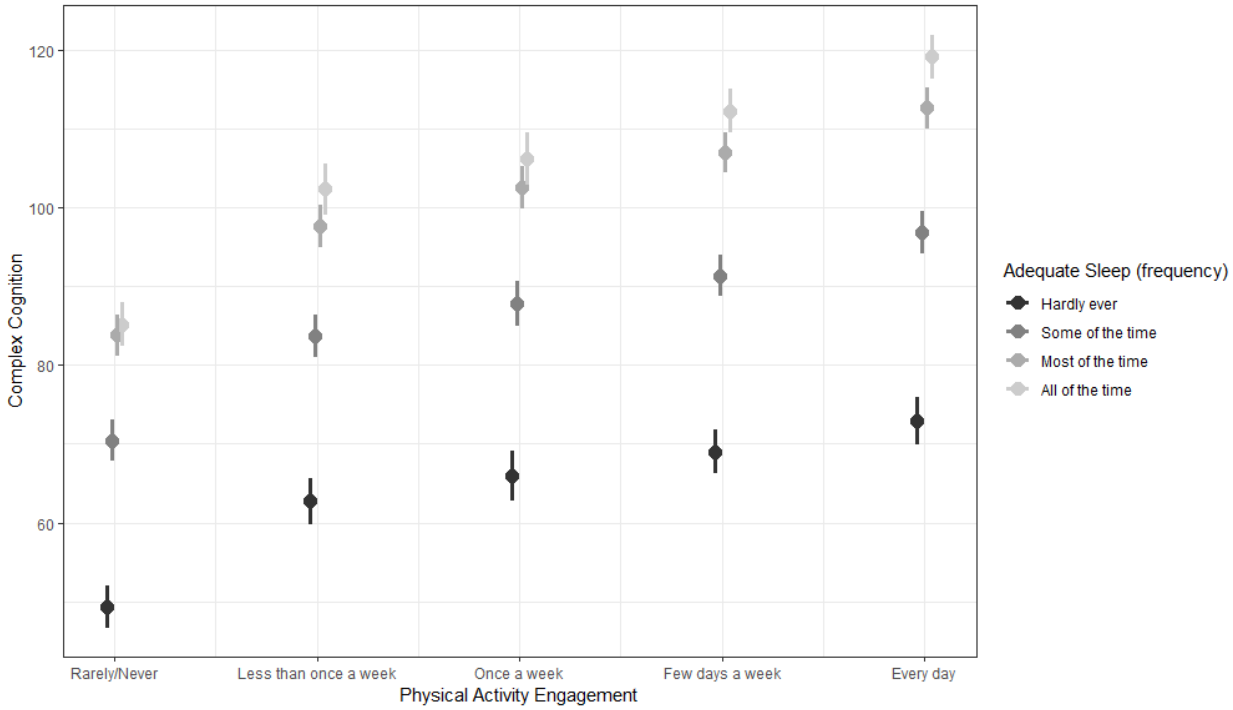


Figure 5b. Interactive association between physical activity and sleep in relation to complex cognition. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), mental health treatment (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

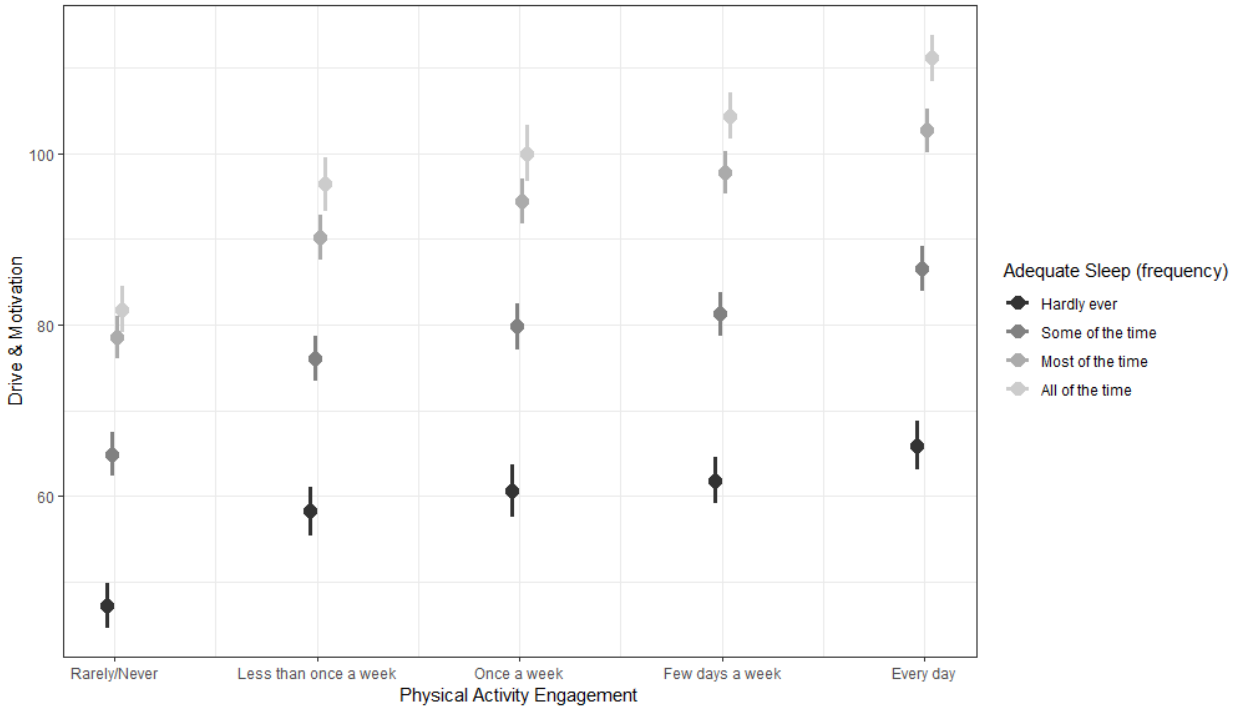


Figure 5c. Interactive association between physical activity and sleep in relation to drive and motivation. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), mental health treatment (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

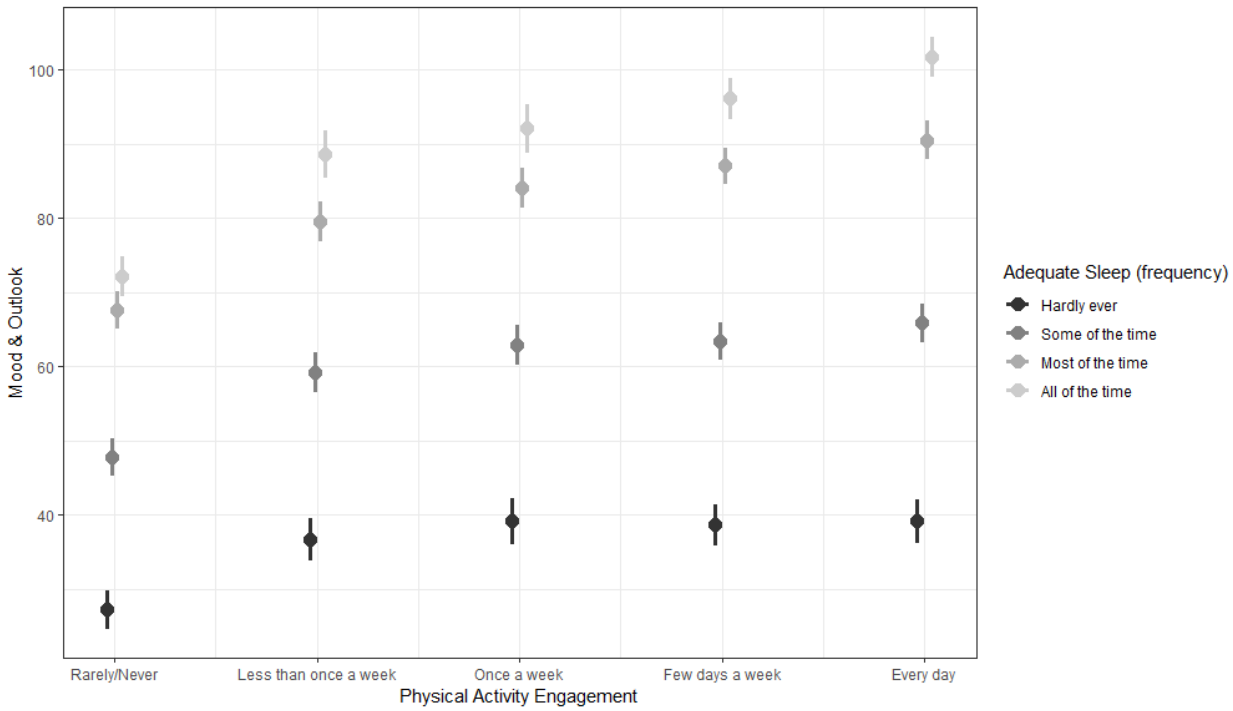


Figure 5d. Interactive association between physical activity and sleep in relation to mood and outlook. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), mental health treatment (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

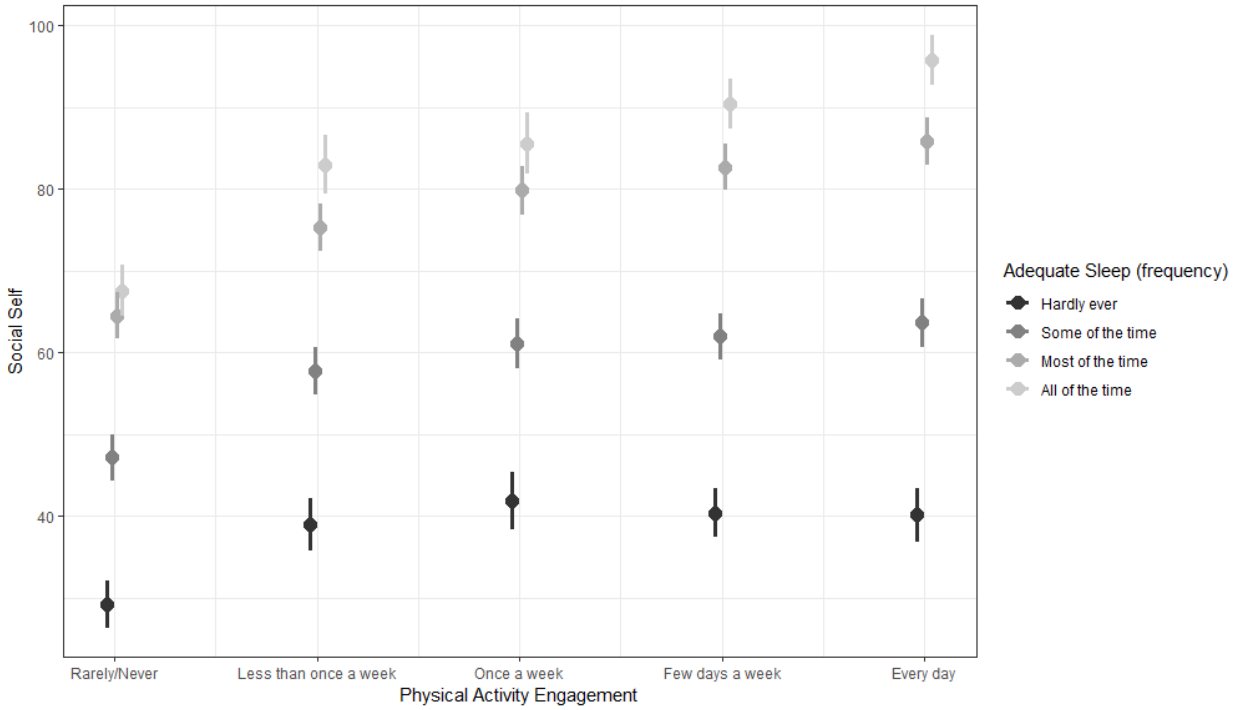


Figure 5e. Interactive association between physical activity and sleep in relation to social self. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), mental health treatment (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

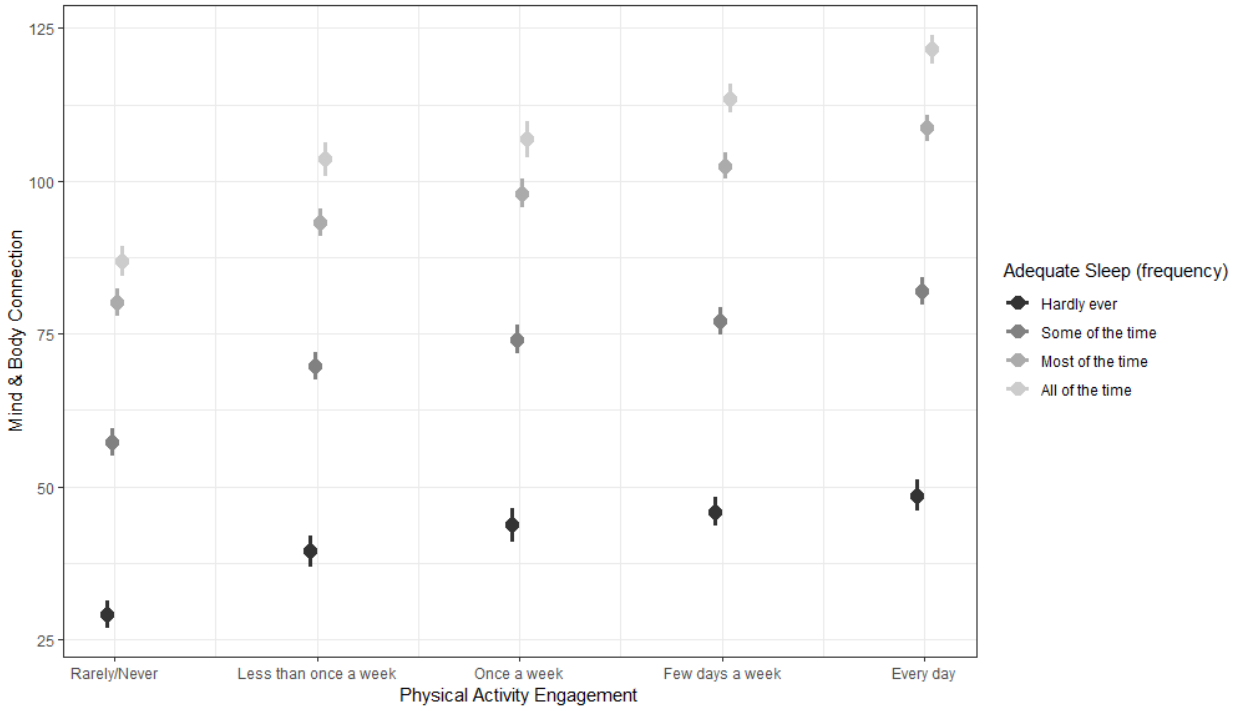


Figure 5f. Interactive association between physical activity and sleep in relation to mind and body connection. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), mental health treatment (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

Supplementary Table 6. *Analysis of variance table for the generalized linear mixed models examining joint associations between physical activity and sleep by mental health treatment related to the subdomains of the Mental Health Quotient*

Effect	df	F	*p*
Core cognition			
Physical activity	4, 220235	778.37	< .001
Sleep	3, 220223	3957.68	< .001
Mental health treatment	1, 220251	5141.19	< .001
Physical activity*Sleep	12, 220217	12.25	< .001

Physical activity*mental health treatment	4, 220218	1.68	.15
Sleep*mental health treatment	3, 220218	18.22	< .001
Physical activity*sleep*mental health treatment	12, 220217	2.96	< .001
Complex cognition			
Physical activity	4, 220235	578.63	< .001
Sleep	3, 220223	2539.99	< .001
Mental health treatment	1, 220252	4493.29	< .001
Physical activity*Sleep	12, 220216	8.10	< .001
Physical activity*mental health treatment	4, 220217	2.31	.06
Sleep*mental health treatment	3, 220217	8.07	< .001
Physical activity*sleep*mental health treatment	12, 220216	2.34	.005
Drive and motivation			
Physical activity	4, 220231	1112.31	< .001
Sleep	3, 220220	2481.11	< .001
Mental health treatment	1, 220245	3957.13	< .001
Physical activity*Sleep	12, 220214	8.24	< .001
Physical activity*mental health treatment	4, 220216	1.20	.31
Sleep*mental health treatment	3, 220215	9.02	< .001
Physical activity*sleep*mental health treatment	12, 220215	3.03	< .001
Mood and outlook			
Physical activity	4, 220231	801.50	< .001
Sleep	3, 220219	2364.36	< .001
Mental health treatment	1, 220245	5072.32	< .001

Physical activity*Sleep	12, 220214	10.40	< .001
Physical activity*mental health treatment	4, 220216	1.56	.18
Sleep*mental health treatment	3, 220215	8.73	< .001
Physical activity*sleep*mental health treatment	12, 220215	3.23	< .001
Social self			
Physical activity	4, 220236	567.95	< .001
Sleep	3, 220225	3724.92	< .001
Mental health treatment	1, 220251	5571.65	< .001
Physical activity*Sleep	12, 220218	17.75	< .001
Physical activity*mental health treatment	4, 220220	4.52	.001
Sleep*mental health treatment	3, 220219	52.54	< .001
Physical activity*sleep*mental health treatment	12, 220219	2.09	.01
Mind and body connection			
Physical activity	4, 220237	390.31	< .001
Sleep	3, 220225	2168.33	< .001
Mental health treatment	1, 220253	3438.39	< .001
Physical activity*Sleep	12, 220218	12.76	< .001
Physical activity*mental health treatment	4, 220220	3.64	.006
Sleep*mental health treatment	3, 220219	31.87	< .001
Physical activity*sleep*mental health treatment	12, 220219	2.00	.02

Note: Degrees of freedom were approximated by Satterthwaite's method.

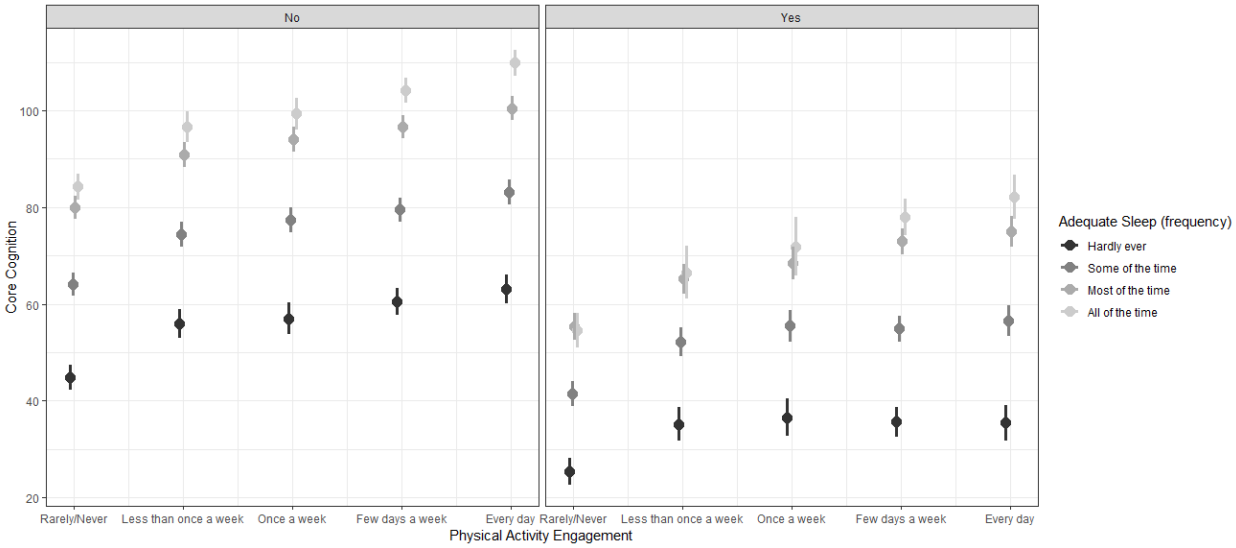


Figure 6a. Interactive association between physical activity and sleep in relation to core cognition by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

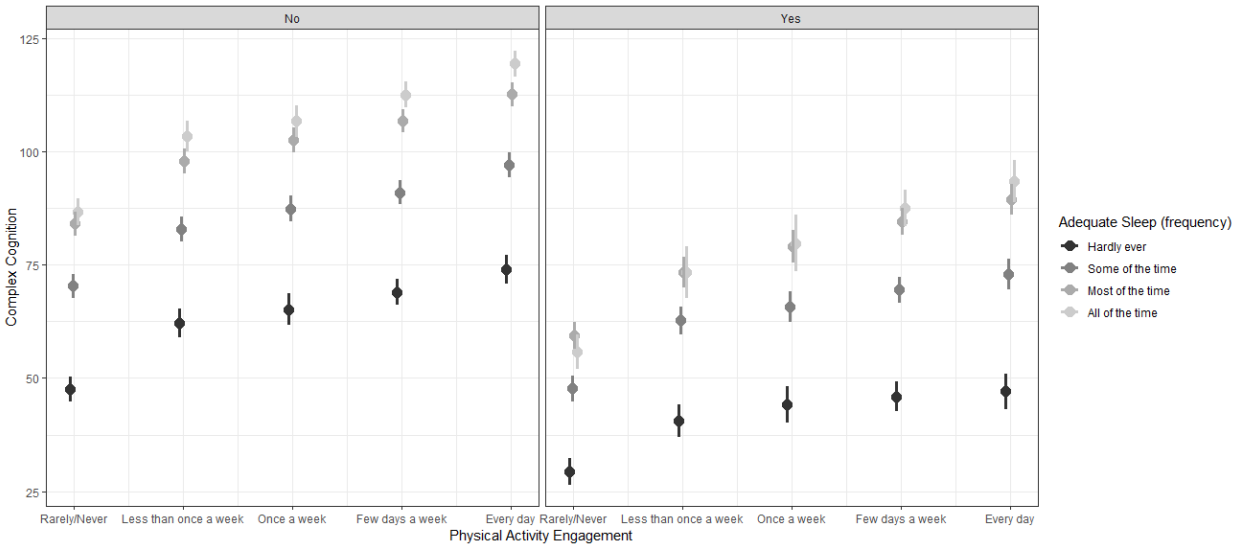


Figure 6b. Interactive association between physical activity and sleep in relation to complex cognition by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

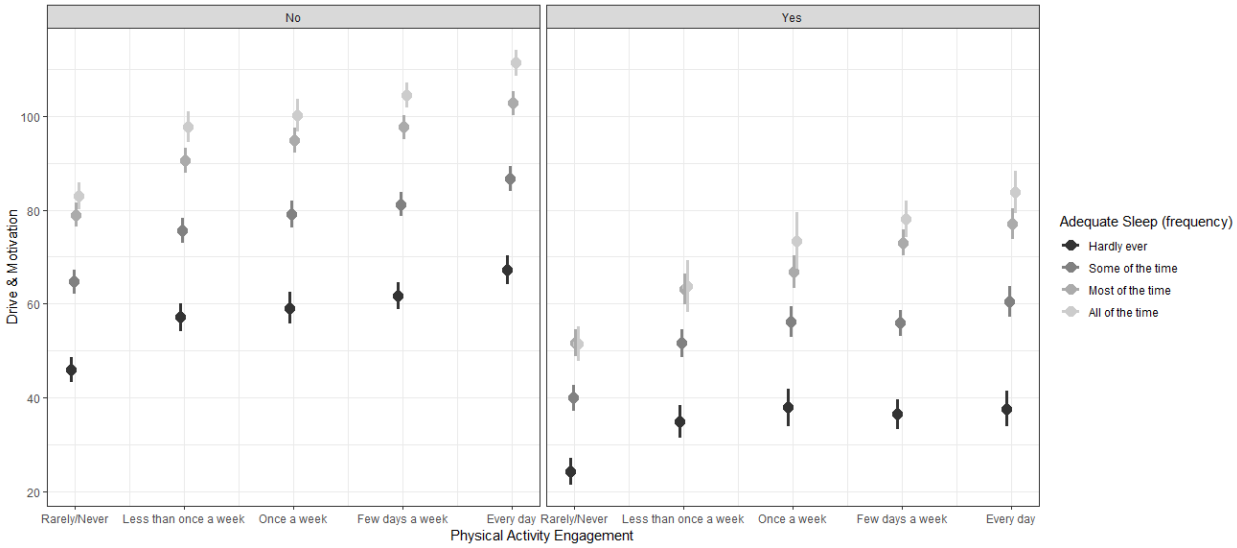


Figure 6c. Interactive association between physical activity and sleep in relation to drive and motivation by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

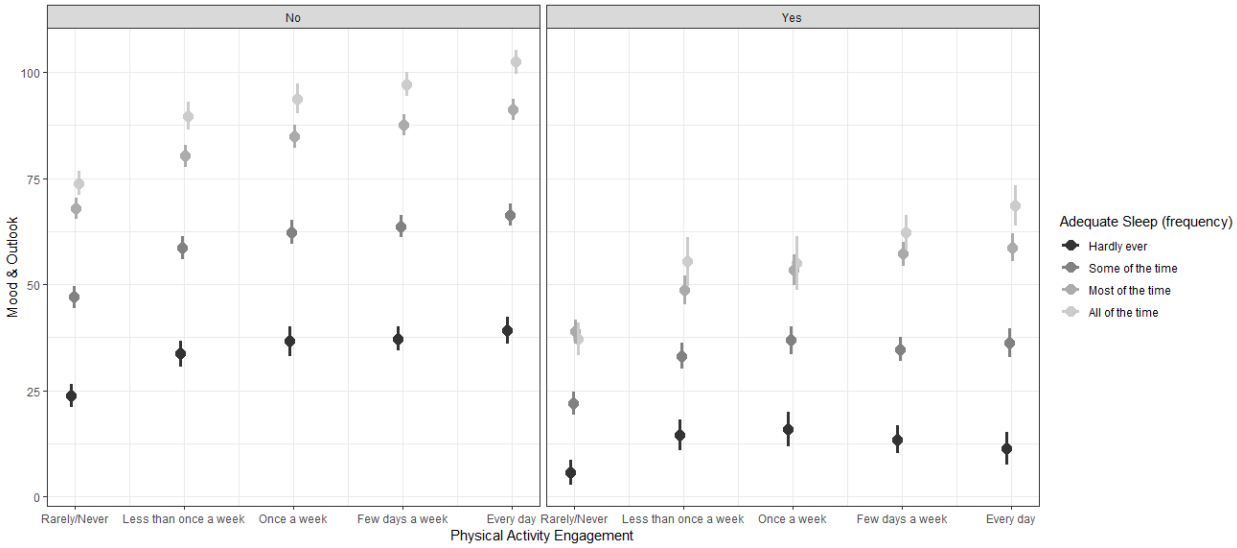


Figure 6d. Interactive association between physical activity and sleep in relation to mood and outlook by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

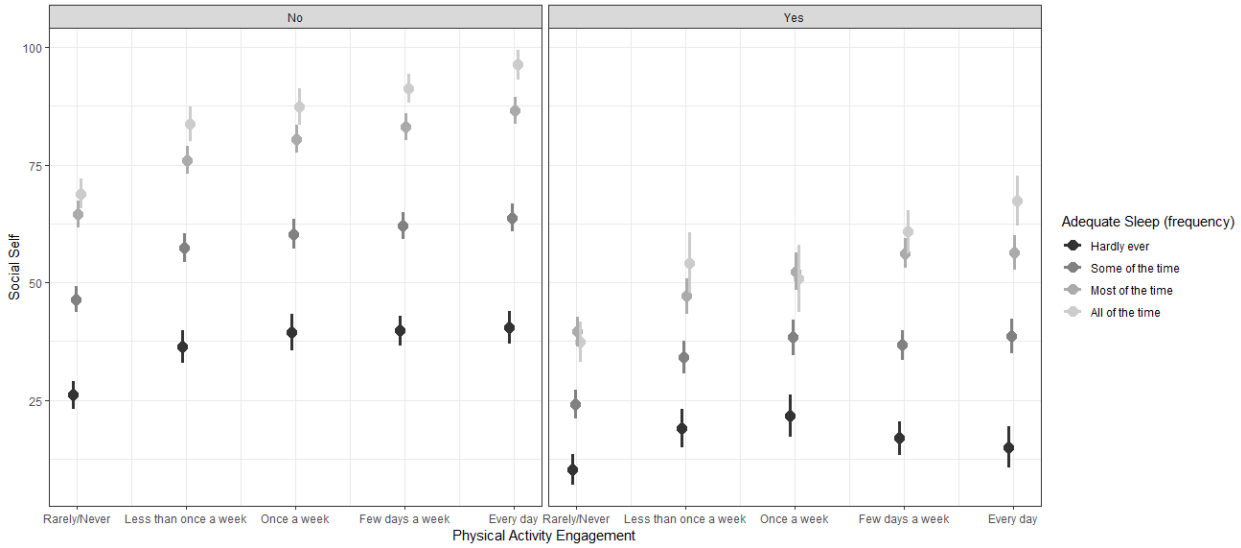


Figure 6e. Interactive association between physical activity and sleep in relation to social self by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).

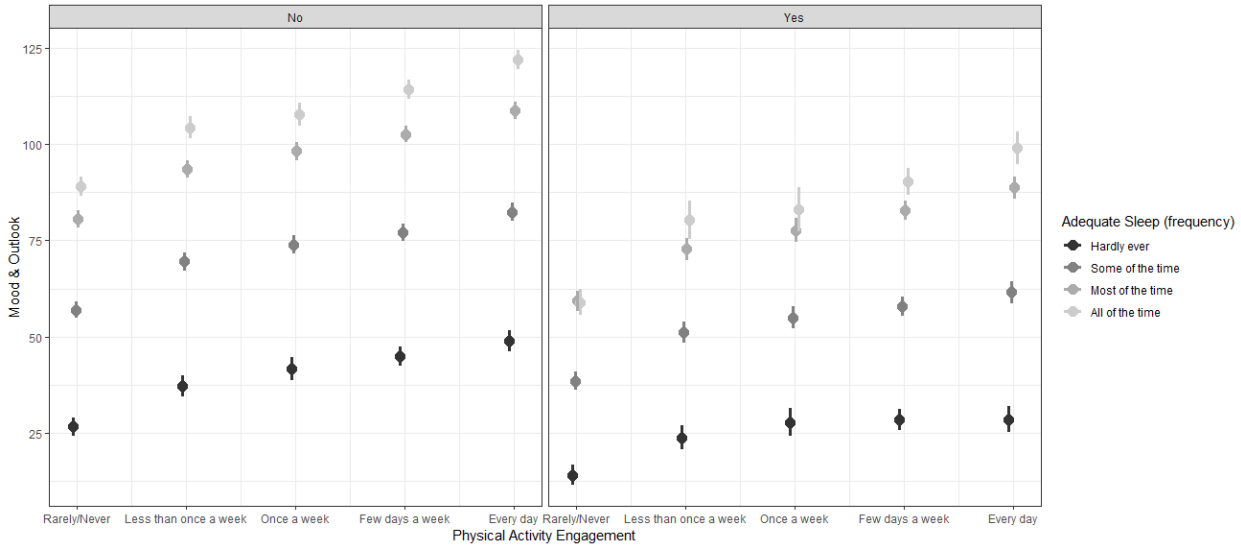


Figure 6f. Interactive association between physical activity and sleep in relation to mind and body connection by mental health treatment status. Model adjusted for age (18-24), gender (female), education (undergraduate degree), employment (employed), frequency of socialization (once a week), medical condition (no), major life trauma (no), health impacted by Covid-19 (no) and financially impacted by Covid-19 (no).