Sleep Quality and Chronotype: Predictors of Exercise Engagement

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Abstract

Physical activity (PA) and exercise are a crucial component for improving and maintaining physical and psychological health outcomes. However, recent research has demonstrated a lack of exercise engagement and an increase in sedentary behaviour worldwide posing as a health risk. Hence, a greater understanding of factors that increase PA and exercise is paramount. It has been shown in prior research that sleep behaviours including chronotype may influence PA engagement (Kauderer & Randler, 2013; Kline, 2014; Tang & Sanborn, 2014). The current study examined whether sleep quality and morningness chronotype predicted individuals' PA and exercise engagement after controlling for confounding variables (age, gender, physical occupation and conscientiousness). 122 adults (males: 29.5%, females: 70.5%) with a mean age of 33.25 (*SD*= 13.13) were recruited on two social media websites (Facebook and Instagram). All participants completed the study questionnaire which included the International Physical Activity Questionnaire-short form, Pittsburgh Sleep Quality Index, Composite Scale of Morningness and the conscientiousness subscale of the Big Five Inventory, respectively. A hierarchical multiple regression analysis found sleep quality and morningness chronotype did not predict physical activity and exercise engagement. Physical occupation was the only significant predictor of PA (β = .40, p = < .001). The variance of the overall model was 18.9%. Based on the current cross-sectional study better sleep quality and morningness chronotype may not increase PA and exercise engagement.

Keywords: physical activity, exercise, sleep quality, morningness chronotype

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Sleep Quality and Chronotype: Predictors of Exercise Engagement

A vast amount of research evidence supports that engaging in physical activity (PA) and exercise regularly has a range of benefits on both physical and psychological health (Ahn, & Fedewa, 2011; Macera, Hootman, & Sniezek, 2003; Rebar et al., 2015). In accordance with the recognised benefits of exercise, both nationwide and majority of international guidelines recommend that a minimum of 150 minutes of moderate-to-vigorous PA per week is performed in adults. ("Get Ireland Active," 2018; Tremblay et al., 2011; World Health Organization [WHO], 2010). Overwhelming research on health benefits associated with PA has adopted exercise to be a non-pharmacological intervention for a large number of physiological and psychological outcomes (Ambrose & Golightly, 2015; Penedo & Dahn, 2005; Teixeira et al., 2010; Warburton, Nicol, & Bredin, 2006). Exercise interventions have been successful in the long-term benefits of reducing obesity which conversely, has reduced the risk of cardiovascular-related diseases and type two diabetes (Jakicic & Otto, 2006; Paffenbarger, Hyde, Wing, & Hsieh, 1986; Reiner, Niermann, Jekauc, & Woll, 2013). Other examples of exercise being an effective intervention for physical outcomes include the improvement of bone health including knee pain (Gay, Chabaud, Guilley, & Coudeyre, 2016; Gutin & Kasper, 1992; Yu et al., 2019). Furthermore, exercise interventions have been used to reduce psychological conditions, including anxiety and depressive disorders (Dinas, Koutedakis, & Flouris, 2011; Knapen, Vancampfort, Moriën, & Marchal, 2015; Rebar et al., 2015; Ströhle, 2009), sleep disturbances (Kline et al., 2012; Stewart, Rand, Hawkins, & Stines, 2011) and cognitive decline (Ma, 2008; Sofi et al., 2011). For example, a systematic review of six exercise-based randomised controlled trials (RTC) found beneficial effects on cognition in Alzheimer's Disease patients, promoting exercise to reduce the rate of cognitive decline caused by Alzheimer's Disease (Farina, Rusted,

& Tabet, 2014). Additional benefits of exercise include sleep quality improvement. Sleep is necessary for overall good wellbeing (Irwin, 2015). Some disturbances of sleep can be defined from total timing of sleep, sleep latency and the number of night-time awakenings (WHO, 2004). Exercise is associated with better sleep quality which improves psychological health (Stewart, Rand, Hawkins, & Stines, 2011). Even at low dose, exercise has incremental benefits in sleep value, reducing sleep disturbances (Kline et al., 2012). Kline et al. (2011) found that there was an improvement in participants' sleep quality, sleep duration and sleep latency, following the performance of exercise.

Exercise can be performed over a wide range of activities and can be categorized into two divisions, aerobic, low-intensity but high cardiovascular exercise, and anaerobic, high-intensity resistant strength training exercise (Howley, 2001; Skinner & Mclellan, 1980). As these two divisions of exercise differ in modality, each type has been demonstrated to have beneficial health outcomes. An extensive body of literature indicates that both types of exercise have psychological and physical advantages when employed including reducing depression, improving cognitive functioning and cardiovascular disease, and overall good well-being (Agarwal, 2012; Mandolesi et al., 2018). For example, both aerobic and anaerobic exercise independently and collectively had significant effects in reducing cardiovascular problems in type two diabetes patients. In another example covering aerobic exercise and psychological benefits, a review using longitudinal and RCT studies found moderate levels of aerobic exercise training was able to hinder and reverse cognitive deficits experienced at old age (Erickson & Kramer, 2009). Moreover, a systematic review on eight RCT demonstrated aerobic exercise to have a positive effect in psychological and cognitive functions of children aiding in academic and behavioural performance (Lees & Hopkins, 2013). Participants who undertook high intensity anaerobic exercise training displayed cognitive processing and alertness improvements when compared with a low anaerobic threshold (Córdova et al., 2009). Larvey et al. (2005) found non-strenuous exercise, in particular yoga, had a positive effect on enhancing mood in psychiatric patients where it was evident that yoga was a useful method of managing stress. Also, a recent study found that a single bout of exercise acted as a mood enhancer improving psychological health, further demonstrating the benefits of exercise even when performed at short low intensity amounts (Ensari, Sandroff, & Motl, 2016). As previous literature has indicated the many benefits of regular exercise and highlights why adherence is important, a large majority of the population do not meet the minimum recommended guidelines. Thus, physical inactivity has become a prominent public health concern worldwide (Kohl et al., 2012; Pratt, Norris, Lobelo, Roux, & Wang, 2014). Sedentary lifestyles among adults are widespread in most countries increasing the risk of developing adverse health issues and a lower quality of life (Blair, 2009). In Ireland only 33% of adults achieved at least thirty minutes of moderate to high intensity PA wherein 54.5% were somewhat active but did not meet the recommended physical requirements (WHO, 2018). This exposure to infrequent PA poses as a threat to adult health as the WHO (2009) ranked physical inactivity as the fourth leading risk of deaths worldwide. This crisis of physical inactivity in consequent to an increase in mortality rates also imposes as a global economic burden on healthcare costs with an estimated $67.5 billion in 2013 (Ding at al., 2016). Therefore, a greater understanding of the factors that influence regular PA and exercise behaviour is paramount. Theoretical models of behaviour change have been used to identify factors that influence PA and exercise and develop interventions targeted to increase exercise engagement. The transtheoretical model of behaviour change (TTM; Prochaska & DiClemente, 1983) is a stage theory approach that has been used to explain how individuals may change their exercise behaviour. In regards to the TTM, an individual's willingness to change their PA behaviour may be described through five sequential stages; precontemplation (no intent on behaviour change in PA engagement); contemplation (awareness on the knowledge of the costs and benefits of engagement in PA); preparation (plan development and beginning of PA engagement); action (an individual engages in PA and therefore becomes more active) and maintenance (an individual has the ability to remain active regularly) (Sutton, 1997). Interventions tailored to an individual's current stage of behaviour change is considered to be most effective. A review investigating TTM-based interventions promoting PA behaviour change, 34 articles were included where only six interventions had significant findings, one only having long-term results on intervention group success (Hutchison, Breckon, & Johnston, 2009). However, articles in this review did not include all dimensions of the TTM and limits the efficacy of TTM-based interventions in behaviour change on PA. Conversely, Spencer et al. (2006) reviewed a wealth of literature associated with applying the TTM to exercise behaviour. The authors found twenty-five of the 31 articles reviewed that the TTM was an effective intervention when applied to exercise behaviour and that stage-based interventions, when applied to the appropriate stage, enabled progress to the next stage and motivated an increase in exercise behaviour. However, it cannot be assumed that one design of intervention is desired over others, and that some interventions may need to target individual factors that promote exercise behaviour. The Theory of Planned Behaviour (TPB; Ajzen, 1985) has demonstrated that engagement of a health behaviour is based on our intentions. Similar to the preparation stage of the TTM, intention is the motivation, planning, and strong will to engage in a particular health behaviour and is a proximal predictor of engaging in that behaviour (Ajzen, 1991). However, a meta-analysis has found inconsistent findings regarding PA behavioural intentions predicting actual PA behaviour (weak effect size *d*

= 0.15) (Rhodes & Dickau, 2012). In their review, Rhodes and Dickau (2013) address this discord of findings by evaluating the moderators of behavioural intentions that lead to engaging in exercise. Results displayed a range of factors to have moderating effects on PA behaviour intention where intention stability was the main moderator of behavioural intention on PA. Some effects occurred from demographical factors but effects were minimal. Personal and environmental factors also displayed effects on moderating behavioural intentions on PA. Therefore, when developing and evaluating interventions that lead to behaviour change in PA and exercise, it may be necessary to identify the factors that determine individual's purpose for changing behaviour. There has been a range of factors that may impact on engagement in exercise and PA and have been identified as demographic, social, psychological and behavioural factors. A demographic factor previous research has established is age predicting exercise engagement (Brunet & Sabiston, 2011; Costa, Hausenblas, Oliva, Cuzzocrea, & Larcan, 2013; Garcia & Archer, 2014; Stepanczuk & Charvat, 2010) displaying a decline in exercise regularity with increased age. Gender, as another factor of exercise engagement, represents males to have overall higher PA (Lee, 2005). However, the magnitude of this gender difference is small, with differences occurring in female cultural roles (Belcher et al., 2010; Lee, 2005), exercise intensity dependent (Sherar, Esliger, Baxter-Jones, & Tremblay, 2007; Trost et al., 2002) and reason for exercise engagement (Craft, Carroll, & Lustyk, 2014). Occupation has also been found to be a predicting factor in exercise frequency. The nature of one's occupation can determine their engagement in exercise as evidence suggests that white-collar workers (e.g. administrative jobs) oppose to blue-collar workers (e.g. labour intense jobs) are less motivated to perform PA (Kirk & Rhodes, 2011; Wu & Porell, 2000). In relation to occupational nature, if a job is considered more physically demanding, research suggests this contributes to an individual's total exercise frequency (i.e. a job that is physically demanding indicates higher levels of exercise frequency) (Kirk & Rhodes, 2011; Kruger, Yore, Ainsworth, & Macera, 2006; Lallukka et al., 2004; Vandelanotte et al., 2015).

As mentioned earlier, sleep quality has been shown to improve after engaging in exercise. The relationship among exercise and sleep quality however, may be seen as bidirectional as recent evidence shows that adherence to PA and exercise may also be influenced by sleep related factors. For example, current studies have shown that physical inactivity may occur due to poor sleep quality where insufficient sleep might contribute to low levels of PA (Kline, 2014; Mead, Baron, Sorby, & Irish, 2019). However, relatively few studies have investigated this relationship as the majority of literature has focused predominantly on PA and exercise improving sleep quality. In studies investigating the effects of sleep quality on exercise engagement, most have displayed a positive effect (Dzierzewski et al., 2014; Khan, Chu, Kirk, & Veugelers, 2015; Tang & Sanborn, 2014). However, there is some contrast of findings regarding the specific sleep parameters that are being investigated. For instance, a study using objective measures to investigate a reciprocal relationship between longer sleep duration and increased PA levels found a non-reciprocal relationship between the two variables, concluding that sleep duration may not predict PA levels (Mitchell et al., 2016). The authors of this study however, only investigated the total daily sleep time on PA and no other sleep factors. Conversely, sleep and PA levels were assessed in older women wearing an objective monitoring apparatus on their waist and wrist. Their PA (moderate-to vigorous-intensity) and sleep characteristics (sleep latency, total time, efficiency and disturbances) were monitored for seven consecutive days. Results revealed a positive effect of better sleep efficiency on exercise engagement the following day, demonstrating that improvement in some characteristics of sleep may foster a healthier active lifestyle (Lambiase, Gabriel, Kuller, & Matthews, 2013). Utilizing data from the National Sleep Foundation (2003), Chasens et al., (2007) evaluated older adults sleep behaviours and exercise frequency and found that adult's sleepiness during the day lead to a decrease in exercise. This finding may suggest that poorer sleep results in daytime sleepiness and leads to a reduction in exercise. Furthermore, due to the variability of sleep both between and within individuals, a study using objective and subjective methods assessed the different sleep parameters that may predict PA. Better sleep quality was found to be a significant factor of higher levels of PA the following day opposed to other sleep parameters (e.g. sleep efficiency) recognising sleep quality as a main factor of subsequent PA (Tang & Sanborn, 2014). Another study that attempted to find a bidirectional relationship between sleep factors and exercise found that poor sleep quality predicts a decrease in PA levels the following day (Baron, Reid, & Zee, 2013). The studies mentioned previously lead to the possibility that better sleep quality may increase PA and exercise engagement, facilitating a healthier active lifestyle. However, the evidence supporting this behavioural effect is scarce and therefore, further research needs to be conducted to support this. Other evidence also suggests that one's wake/sleep time preference may be an important predictor of PA and exercise engagement, independent of sleep duration or quality. An observational study conducted on Australian children found a relationship among obesity and physical inactivity in children whose bed and rise times were later than those of children who's were earlier, despite similar sleep durations (Olds, Maher, & Matricciani, 2011). This may attribute to sleep time preference relating to PA irrespective of sleep duration. Moreover, objective and subject measures of habitual wake/sleep time preferences over sleep duration may relate to PA levels (Evans et al., 2011; Shechter & St-Onge, 2014). This sleep time preference can be referred to as chronotype. Chronotype is an individual behavioural difference that describes one's cycle of sleep and day-time activities in a 24-hour period (Giannotti, Cortesi, Sebastiani, & Ottaviano, 2002). Chronotype is an expression of our endogenous circadian rhythms that act as a 'biological clock' to modulate sleep-wake cycles (Morse, Fritz, & Hastings, 1990). Individuals are typically classified as morningness or eveningness chronotypes depending on their preferred sleep-wake behaviours. An individual's chronotype can be influenced by environmental factors such as shift work, jet lag and daylight adjustment (Roenneberg, Wirz-Justice, & Merrow, 2003). To be more specific, chronotype refers to one's optimal peak in physical and psychological activity performance reflecting their diurnal preference (Facer-Childs, Boiling, & Balanos, 2018; Lara, Madrid, & Correa, 2014). As of such morning-types have an early-phase circadian rhythm that enables them to be early morning risers while being more productive at carrying out tasks earlier in the day (Adan et al., 2012). The opposite behaviour pattern applies to evening-types where activities and wake/sleep times are favoured later following a late-phase circadian rhythm (Adan et al., 2012). Chronotype may impact a person's response to exercise and performance including their outdoor activities (Koukkari & Sothern, 2007). A study found significant differences in athletes optimal exercise performance when performed at different times after awakening. This study found that morning-type athletes were at their peak-performance 5.5 hours after awakening and those who were evening-types were at peak-performance eleven hours after awakening (Facer-Childs & Brandstaetter, 2015). This study sheds light on how chronotype may be considered when determining one's optimal exercise performance. Moreover, a review revealed similar findings even though relatively few articles were identified (*N*= 10) due to a lack of scientific literature, the effects of chronotype on physical performance when engaging in sport activities were observed (Vitale & Weydahl, 2017). Results found that peak performance of PA and sport activities occurred when completed by morning chronotypes in the morning in comparison to evening-types. The review found morning chronotypes to generally display greater physical performances over evening chronotypes when performance took place at morning which may indicate chronotype to be an important factor to consider when determining individual's peak performance when engaging in exercise. Pervious research evidence has found morning chronotypes to exercise frequency to be higher compared to evening chronotypes and this finding is evident in a variety of sample populations (Kauderer & Randler, 2013; Suh et al., 2017; Urbán, Magyaródi, & Rigó, 2011). A potential reason for this found by Wennman et al. (2015) to be morning tiredness is more profound with evening-types than morning-types as a result of a later bedtime. The authors found five chronotype groups that categorised individuals into rested or tired chronotypes. Results displayed that those who belonged to the evening typology groups had lower to none PA levels, as compared to morning-types.

Chronotype may impact individuals' behavioural intentions to engage in exercise. Bailey and Jung (2014) used two studies to examine the congruency between behavioural intention and actually behaviour in PA. Study one assessed professional adults by examining their planned PA in either the morning or evening intentions. Study two had a similar purpose but utilised a prospective study design on a student sample population where after one week of reporting their exercise intentions participants had to report their actual exercise behaviour. Both studies reported similar findings that intentions made to exercise in the morning were followed through with than participants with evening intentions. The authors concluded this was because individuals were unable to regulate their exercise behaviour later in the day due to external demands suggesting those who have a morning chronotype could benefit more greatly when adhering to exercise. Furthermore, a study assessed psychological factors, including chronotype, on PA levels in an adolescent sample. The authors found morning-orientated participants significantly correlated with all PA variables indicating that morning-types may overall be more physically active than their evening-orientated counterparts (Schaal, Peter, & Randler, 2010). When considering the relationship between chronotype and exercise engagement some authors have suggested that personality factors may play a role when trying to understand this relationship. Particularly, the personality trait of conscientiousness has been recognised as a possible mediator between chronotype and exercise (Schaal et al., 2010). However, Hisler, Phillips and Krizan (2016) considered the mediating effects that personality factor conscientiousness may have in the relationship of chronotype and exercise outcomes and used a mediational analysis to see if such an effect occurred. The authors found that after controlling for conscientiousness, a relationship between chronotype and exercise outcomes occurred indicating that chronotype may independently predict exercise engagement. Conscientiousness is a personality characteristic that enables self-control. Sub-traits include organization, reliability, self-discipline and goal attainment (McCrae & Costa, 1987). As predicted, conscientious individuals commit to both intended and enaction of health-related behaviours such as exercise (Ajzen, Czasch, & Flood, 2009; Conner, Rodgers, & Murray, 2007; Rhodes, Courneya, & Jones, 2005). Evidence has found that morning chronotypes tend to be more conscientious and this also correlated with morning-types having a healthier sleep quality (Nguyen et al., 2018). These two features are recognised to have a reciprocal relationship wherein higher conscientiousness levels also significantly correlates with morningness chronotype (DeYoung, Hasher, Djikic, Criger, & Peterson, 2007; Duggan, Friedman, McDevitt, & Mednick, 2014; Tonetti, Fabbri, & Natale, 2009). As mentioned previously, morning-types may engage in higher levels of exercise and this reason may be because morning chronotypes have high levels of conscientiousness. Therefore, conscientiousness may act as a mediator between chronotype predicting exercise engagement, specifically morningness chronotype.

Adherence to frequent exercise is of utmost importance as the wide variety of benefits for physical and psychological health are well recognized. However, many individuals do not comply to the minimum recommended guidelines of PA and as a result are at risk of poor health and quality of life. Therefore, it is vital to recognize and understand the main determinants of exercise behaviour in order to tailor interventions that intend to increase PA in the general population. As mentioned, exercise is an effective non-pharmacological treatment that is employed in an array of forms to suit any individual’s ability or level (Ambrose & Golightly, 2015; Gates, Killackey, Phillips, & Álvarez-Jiménez, 2015; Teixeira et al., 2010). The literature has identified many demographical, social, psychological and behavioural factors as possible predictors of exercise frequency. However, the current study will focus on individual factors involving sleep-related variables and their influence on PA and exercise engagement.

Most research studies have predominately focused on exercise as a predictor of improving sleep quality instead of investigating whether sleep-related variables impact exercise behaviours (Holfeld & Ruthig, 2014; Youngstedt & Kline, 2006). Though some research evidence has shown consideration to the bidirectional relationship of these two variables, findings vary. Therefore, further research is necessary to understand what specific factors of sleep (i.e. quality and timing of sleep/wake behaviours) may contribute to an increase in PA and exercise engagement (Dzierzewski et al., 2014; Kline, 2014). In respect of this, the present study hopes to expand further novel findings in the literature on the effects that sleep quality and chronotype has on individuals’ exercise engagement. To the best of the researcher’s knowledge sleep quality and chronotype have not yet been investigated concurrently to determine individual's exercise engagement although, there was a study investigating both variables in relation to long-term weight loss in participants (Ross, Thomas, & Wing, 2016). Existing literature provides evidence that both sleep quality and chronotype may independently influence exercise behaviour. However, existing literature suggests that mediating effects of conscientiousness may occur between the relationship of morningness chronotype and exercise engagement. Thus, the current study aims to explore this more by controlling for conscientiousness characteristics. This study would like to address the following research questions: What impact does sleep quality have on individuals to engage in exercise? Does an individual's morningness chronotype determine whether they engage in exercise? After controlling for conscientiousness do morningness chronotypes engage in high levels of exercise?

After discussing the literature findings, this study aims to explore the relationship between sleep quality, morningness chronotype, and PA and exercise engagement. The study aims to examine if better sleep quality is related with increased levels of PA and exercise engagement. Moreover, morningness chronotype's PA and exercise engagement levels will be examined, while controlling for potential mediating effects of conscientiousness.

Grounded on previous literature the following hypotheses have been formed for the current study.

1. There will be a significant relationship between sleep quality and levels of PA and exercise.
2. Morningness chronotype will predict individuals' level of exercise engagement after controlling for conscientiousness.

Methods

Participants

Participants were recruited through convenience sampling. The study consisted of 122 participants primarily female (*n* = 86) with a mean age of 33.25 years (*SD* = 13.1). Participants were recruited through an online link which was shared on two social media platforms, Facebook and Instagram. Inclusion criteria were that participants must be eighteen years of age or above due to ethical considerations. No exceeding age limit was specified as PA is a health behaviour that is continued throughout adult life. Using Tabachnick and Fidell's (2013) formula for a minimum sample size for multiple regression the minimum recommended for this study was 98. All participants took part voluntarily in the study with no incentive provided for participation.

Design

This study employed a quantitative cross-sectional design to obtain information on the study variables at one point in time and was correlational in nature. The present study investigated the relationship between sleep quality, chronotype and exercise engagement, respectively, using a multivariate analysis. The predictor variables of this study were age, gender, physical demands of occupation, sleep quality and chronotype. The criterion variable of the study was exercise engagement.

Measures

Demographics. Age and gender were self-reported along with occupational nature were respondents selected either yes, their occupation is physically demanding or no, their occupation is not physically demanding (Appendix A).

International Physical Activity Questionnaire-short form. The International Physical Activity Questionnaire-short form (IPAQ – SF) (Craig et al., 2003) was used to obtain information on physical activity levels (Appendix B). The IPAQ-SF is a 7-item scale which measures the time (in minutes) per week that participants engage in three categories of PA; vigorous, moderate and walking. The amount of time spent sitting on week days are also recorded. The scale asks about all types of physical accounts including work occupation, home-related work or gardening, transportation, and exercise or sport. Participants are asked to report the amount of days and minutes of those days that were spent engaging at each activity level. Each activity level is converted into Metabolic Equivalents (MET) – minutes per week. MET is the rate at which you burn calories while at rest wherein one MET equals to the expenditure of energy. MET-minutes is calculated by multiplying the number of minutes with 3.3 for walking, 4.0 for moderate activity and 8.0 for vigorous activity. MET-minutes of each activity level are summed to obtain a total MET-minute score of PA per week. Reliability of the IPAQ-SF reported being between 0.61 – 0.83 representing it to be a good reliable scale at measuring PA and exercise (Craig et al., 2003). The current study had a Cronbach's alpha of .72. The IPAQ-SF was found to have acceptable criterion validity when comparisons were made with objective PA measures (Papathanasiou et al., 2010; Ruiz-Casado et al., 2016). Guidelines for scoring protocol on IPAQ-SF for the current study were followed (Sjostrom et al., 2005).

Pittsburgh Sleep Quality Index. Participant's sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI) (Buysse, Reynolds III, Monk, Berman, & Kupfer, 1989) (Appendix C). The PSQI is a 19-item, 7 component scale that assesses subjective sleep duration, disturbances, latency, daytime dysfunction, sleep efficiency, sleep quality and sleep medication use over a one-month period. The first four items of the PSQI ask respondents to give an accurate estimate of their sleep duration, sleep latency, and sleep efficiency. Item 5 includes ten sub-items where item 5a assesses sleep latency and the remainder items assess sleep disturbances using a four-point Likert scale (0 – 3), greater scores representing frequent sleep disturbances. Using the same four-point Likert scale, the final four items of the PSQI examine respondent's daytime dysfunction, sleep medication use, and overall sleep quality. A score for each of the 7 components is calculated. A total score is computed from the sum of the 7 component scores and vary from 0-3. Global scores are between 0-21 wherein poor sleep is evident in a global score of 5 or more (Smyth, 1999). The PSQI is a well validated and reliable measure scale ($\alpha = 0.77$) (Moghaddam, Nakhaee, Sheibani, Garrusi, & Amirkafi, 2012). The current study had a Cronbach's alpha of .79.

Composite Scale of Morningness. Chronotype was measured using the Composite Scale of Morningness (CSM) (Smith, Reilly, & Midkiff, 1989) (Appendix D). This self-report scale includes 13-item multiple choice (Likert-type) questions such as "during the first half hour after having awakened in the morning, how tired do you feel?" or "when would you prefer to rise (provided you have a full day's work – 8 hours) if you were totally free to arrange your time?". Scores for each scale item vary from 1 to 4 or 1 to 5, where higher scores indicate higher levels of morningness. Total scores of the CSM was used in the current study. Possible total scores range from a score of 13, indicating an extreme E-type, or 55, an extreme M-type. The CSM improves on former questionnaires investigating chronotype, having a good internal reliability ($\alpha = .87$) (Smith et al., 1989) and is a valid measure (Jankowski, 2015). The current study had a Cronbach's alpha of .88.

Conscientiousness. Conscientiousness was measured using the 9-item conscientiousness sub-scale from John et al. (1991) 44-item Big Five Inventory relating to the conscientiousness traits (Appendix E). Items are scored on a five-point Likert scale varying from 1 for disagree strongly to 5 for agree strongly. Items 2, 4, 5 and 9 of the scale are reverse scored. A maximum score of 45 can be obtained and a minimum score of 9. Higher scores indicate higher levels of conscientiousness. The internal reliability of conscientiousness is acceptable ($\alpha = 0.9$) (Alansari, 2016). The current study had a Cronbach's alpha of .73.

Procedure

Participants for this study were recruited through two social media platforms. A link to the questionnaire was distributed on Facebook and Instagram. Therefore, any individual with either social media accounts could participate, although only individuals 18 years or above could take part as this age boundary was emphasized prior to study participation in the information sheet provided (Appendix F). The questionnaire link was released on November the 16th until the 20th of January to ensure a sufficient sample size was met. On reading the study information sheet, participants gave their informed consent by ticking the box provided before moving onto the next section. A copy of the consent form is appended (Appendix G). Participants reported demographics of age, gender and physical demands of occupation. On completing this section participants answered questions of each measure in order of IPAQ-SF, PSQI, CSM and the conscientiousness sub-scale of the BFI, respectively. Overall, the duration of the study took approximately fifteen to twenty-five minutes. The final section instructed participants to complete the questionnaire by submitting all answers following debriefing information and concluded with the researcher's gratitude for their participation. Ethical approval was given by National College of Ireland's Ethics Committee. Adherence to ethical considerations were followed when developing and conducting the study procedures. These included the informed consent from all study participants. Data protection methods (e.g. storage, management) of participants agreed with the National College of Irelands Data Protection Policy and Data Protection Act 2018.

Results

Statistical Analysis

Statistical analysis was conducted using IBM Statistical Package for the Social Science (SPSS) version 26 (IBM Corp, 2019). A hierarchical multiple regression analysis was preformed to investigate if sleep quality and chronotype predicted PA and exercise engagement. The study controlled for age, gender, physical occupation and conscientiousness as these variables have been shown to affect PA and exercise levels. All participants completed each measurement scale in the study survey ($N = 122$).

Descriptive Statistics

To describe the characteristics for gender and physical occupation type frequencies and percentages are presented in Table 1. The majority of study participants were female (70.5%) and just over half of participants' occupation was not physically demanding ($n = 63$). Descriptive characteristics of the samples continuous variables are presented in Table 2. Mean, standard deviation, range, and where applicable internal reliability (Cronbach's alpha) are presented for age, physical activity, sleep quality, chronotype, and conscientiousness. The mean age of participants was 33.25 ($SD = 13.1$). Participants age range was between 18 to 66 years.

Table 1

Frequencies for the current sample for categorical variables (*N* = 122)

Variable	Frequency	Valid Percentage
Gender		
Male	36	29.5
Female	86	70.5
Physical Occupational		
Yes	59	48.4
No	63	51.6

Table 2

Descriptive statistics and reliability of all continuous variables

	Mean	Median	SD	Range	Cronbach's Alpha
Age	33.25	26	13.13	48	-
Physical Activity	804.83	640.5	698.95	2754	.72
Sleep Quality	7.44	7	3.74	17	.79
Chronotype	33.69	34	7.81	36	.88
Conscientiousness	34.83	35	5.12	25	.73

Hierarchical Multiple Regression

A hierarchical multiple regression analysis was preformed to investigate whether sleep quality and morningness chronotype predict levels of physical activity and exercise after controlling for age, gender, physical demands of occupation and conscientiousness. Preliminary analyses were conducted to ensure there was no violation of the assumptions of normality, linearity, and homoscedasticity. Also, the correlations among the predictor variables were examined (as presented in Table 3). All correlations were weak to moderate ranging between r = .004 to .41 and tolerance and VIF (variance inflation factor) were acceptable. This indicates that multicollinearity was unlikely to be an issue (see Tabachnick & Fidell, 2013).

In the first step of hierarchical multiple regression, four predictors were entered: age, gender, physical occupation demands and conscientiousness. This model was statistically significant F (4, 117) = 6.28, $p < .001$ and explained 17.7% of variance in PA and exercise (see Table 4 for full details). After the entry of sleep quality and morningness chronotype at step 2 the total variance explained by the model was 18.9% F (6, 115) = 4.48, p = < .001). The introduction of sleep quality and chronotype explained an additional 1.3% of variance in PA scores. This change was not statistically significant (R^2 Change = .013; F (2,115) = .89 p = .413).

Table 3

Correlations matrix to show inter-correlations between variables

Variables	1	2	3	4	5	6	7
1. Physical Activity	1						
2. Age	.019	1					
3. Gender	-.15*	-.01	1				
4. Physical Occupation	.38***	-.17**	.05	1			
5. Conscientiousness	.02	.29**	.07	.03	1		
6. Chronotype	.12	.34***	.01	.01	.41***	1	
7. Sleep Quality	-.97	.01	.18*	.00	-.21**	-.24**	1

Note. Statistical significance: *$p < .05$; **$p < .01$; ***$p < .001$

In the final model, only physical occupation uniquely predicted PA and exercise engagement to a statistically significant degree. Physical occupation was a positive and also the strongest predictor of PA and exercise ($\beta = .40$, $p = < .001$) (see Table 4 for full results).

Table 4

Hierarchical regression model of physical activity and exercise

	R	R^2	R^2 *Change*	*B*	*SE*	*β*	*t*
Step 1	.24	.177***					
Age				4. 53	4.74	.09	.95
Gender				-258.01	128.52	-.17*	-2.0
Physical Occupation				555.66	119.2	.40***	4.67
Conscientiousness				-.03	12.01	.00	-.00
Step 2	.44	.189	.013				
Age				3.44	4.97	.07	.69
Gender				-238.73	131.5	-.16	-1.82
Physical Occupation				550.61	119.41	.40***	4.61
Conscientiousness				6.59	12.99	-.05	-.51
Chronotype				9.01	8.72	.10	1.03
Sleep Quality				-10.39	16.85	-.06	-.62

Note. R^2 = R-squared; B = unstandardized beta value; *β* = standardized beta value; SE = Standard errors of B; *t* = estimated coefficient; Statistical significance: *$p < .05$; **$p < .01$; ***$p < .001$

Having a physical occupation was correlated to have higher levels of PA. Relationships between both predictor variables and PA were not statistically significant.

Discussion

Factors that contribute to the increase of PA and exercise engagement vary. Motivated by research which found sleep quality and chronotype to be associated with subsequent physical performance (Dzierzewski et al., 2014; Vitale & Weydahl, 2017), the current study aimed to investigate if sleep-related factors (i.e. sleep quality and morningness chronotype) could predict individuals' level of exercise engagement after controlling for physical occupation, demographic and personality factors. The study hypothesized that there would be a significant relationship between an individual's sleep quality and levels of PA and exercise. The study also hypothesized that morningness chronotype would predict individuals' levels of PA and exercise engagement. The study analysis found both study hypotheses were not supported representing that sleep quality and chronotype may not be good predictors of exercise engagement. The regression analysis of the current study demonstrated that only physical occupation was the strongest significant predictor of PA and this relationship was positive. Before controlling for physical occupation, demographic and personality factors the regression model of PA and exercise was significant ($p = < .000$). However, on introducing sleep quality and morningness chronotype the regression model was nonsignificant explaining an additional 1.3% of variance ($R = .189\%$). Irrespective of the current study findings, previous research regarding sleep quality predicting subsequent PA has found a relationship to exists (Khan et al., 2015; Lambiase et al., 2013). However, as only a few studies have investigated the relationship between sleep quality and PA or the effects sleep has on subsequent PA performance, the support of whether a relationship exists remains unclear.

Prior research examining the relationship between sleep quality and PA is consistent with the current study's findings (Mitchell et al., 2016; Wu et al., 2019). Mitchell et al. (2016) did not find a relationship between sleep parameters and time spent engaging in PA the following day. This study used an observational design on a sample of adult women (*N* = 353). Participants wore accelerometers on their wrist and hip for seven consecutive days to record sleep and moderative-to-vigorous PA (MVPA) behaviour. In order to see if a reciprocal relationship among sleep parameters (i.e. total sleep time, sleep efficiency) and MVPA exists, analyses were conducted on a daily level. Associations of MVPA on one day was investigated with sleep on that night and the association between night-time sleep and PA the next day was investigated. In both analyses, there was no significant association found between sleep parameters predicting PA or vice versa. This study had a large sample size and also measured sleep and PA objectively over a one-week period. The study had a good methodology but failed to find a relationship among participant's sleep quality and subsequent PA. This finding corresponds with the current study and may imply that improving sleep quality may not immediately predict an increase in PA. The current study had notable differences in design compared with Mitchell et al. (2016) but found a similar result. This may indicate that using short-term methods to examine the relationship between sleep quality and PA may not be useful in finding such a relationship. Therefore, a longitudinal approach may be necessary to assess the correlation between sleep quality predicting PA and exercise.

For instance, longitudinal studies assessing the relationship between sleep quality and PA found that sleep quality was a strong predictor of later PA (Baron et al., 2013; Haario, Rahkonen, Laaksonen, Lahelma, & Lallukka, 2013). In a study using a two-year longitudinal design, the authors found that sleep quality one year later predicted PA levels in a sample of older adults (Holfeld & Ruthig, 2012). This study used self-reported measures to assess sleep quality and PA levels at baseline (2008; *N* = 489) and at two-year follow-up (2010; *N* = 426). As this study found sleep quality to predict higher levels of PA, it demonstrates that it might be necessary to use a long-term investigation to find whether a relationship exists between sleep quality predicting PA. Another study example is a longitudinal association between sleep quality mediating the relationship between post-traumatic stress disorder (PTSD) and PA (Talbot, Neylan, Metzler, & Cohen, 2014). A baseline measurement of sleep quality, PTSD and PA were recorded during 2008 to 2010, and then a follow-up measurement of PA one-year later. The authors investigated self-reported sleep over a one-month period using a modified item from the PSQI in a sample of military veterans (N = 736) as those who suffer from PTSD have a reduction in sleep quality. The authors found the relationship between baseline PTSD and PA at follow-up was no longer significant when sleep quality was added. Lower sleep quality at baseline significantly predicted lower PA at one-year follow-up and suggests that poor sleep quality may predict future physical inactivity.

As mentioned, assessing sleep quality in the short-term may not be useful to find an association with exercise the following day and may account for some of the mixed research findings hence, a longitudinal design may be needed. Nevertheless, some cross-sectional studies have found this association to exist between sleep quality and PA particularly those using objective measures to assess sleep and PA (Lambiase et al., 2013; Spina et al., 2017; Tang & Sanborn, 2014). An example of this was a recent study that investigated the relationship of sleep quality and PA engagement in patients with chronic obstructive pulmonary disease (COPD) who commonly suffer with sleep disturbances (Spina et al., 2017). The study wanted to investigate if disruptions in sleep interfered with daily PA engagement. The study used collective data from existing studies (N = 932) that used an arm actigraphy to monitor day and night-time sleep and activity levels. Data from those who wore the actigraphy almost all day for at least four consecutive days were included. After controlling for confounding variables (e.g. disease severity, gender etc.), patients whose sleep quality was least affected during the night, including longer sleep duration, engaged in longer PA engagement the subsequent day in comparison to those whose sleep quality was disrupted. This shows that diminished sleep quality may be associated with low PA performance. However, this study used a specific sample who would have regular sleep disruptions and although the authors found an association between sleep and PA these findings may not be generalizable to a non-clinical sample who are not diagnosed with breathing problems. When trying to establish a relationship between sleep quality predicting PA, research findings vary. As discussed, most research investigating this relationship uses short-term methods (e.g. a cross-sectional design). Some evidence suggests that longitudinal research might be necessary to determine if a relationship between better sleep quality and increased PA exists.

Chronotype was another sleep-related factor examined in this study, specifically morningness chronotype. Previous literature has found morning-orientated individuals had higher physical performance and frequency (Kauderer & Randler, 2013; Suh et al., 2017; Urbán et al., 2011). As noted, this current study did not find such a relationship. Using the total scores on the CSM to display higher morningness chronotype, participants' scores did not correlate with PA and therefore, did not predict their engagement in PA and exercise. A similar finding to the current study was found in a study consisting of medical students (N = 351) (Acet, Girit, Kaya, Süt, & Vardar, 2018). In this study participants answered two questionnaires regarding PA, the IPAQ-SF and IPAQ-Long Form. Chronotype was also obtained using a self-report measure. Acet et al. (2018) found a non-significant relationship representing that chronotype may not be an important predictor of PA. Both Acet et al.'s (2018) study and the current study used the same self-reported measure to obtain data on PA levels. Therefore, both study methods may need to be evaluated in order to achieve reliable results as recent research has found a relationship among the two factors to exist. For instances, Hisler et al. (2016) objectively measured participants' exercise frequency using a Fibit device over a four-week duration. The authors also used the moderate and vigorous items from the IPAQ to capture meaningful exercise activities when participants self-reported their exercise frequency. The study used the CSM to assess participants time-of-day preference and found that chronotype did predict exercise, specifically timing of exercise during the day. This relationship was found in other studies that used objective methods to assess PA & exercise (Facer-Childs & Brandstaetter, 2015; Rossi, Formenti, Vitale, Calogiuri, & Weydahl, 2015). It is possible to assume that the aforementioned studies found an association between morningness chronotype and PA levels as a result from objectively measuring exercise frequency as participants may over or underestimate this behaviour through self-report. Considering both the current study and Acet et al. (2018) used the same scale to assess exercise and was unable to find a relationship, the method used to measure exercise may have been unreliable. This might account for the non-significant results found in both studies. However, some studies using self-reported PA measurements have found a link between morningness chronotype and exercise engagement (Haraszti et al., 2014; Schall et al., 2010). Haraszti et al. (2014) examined the relationship between morningness chronotype and PA in a sample of professional women. Those who had a morning typology engaged in higher levels of PA. PA levels were assessed using an adapted version of the IPAQ-SF. There are some discrepancies in the above referenced studies and the current study to note. Haraszti et al. (2014) used a sample population of professional women ($N = 202$). In the literature it has been shown that females are higher in morningness than males (Cavallera & Giudici, 2008; Mateo, Díaz-Morales, Barreno, Prieto, & Randler, 2012). Therefore, the result found in Haraszti et al.'s (2014) study displaying morning-type's PA levels to be high could have been obtained due to the chosen sample. Schaal et al. (2010) had a large population of school students (*N* = 726) which may have contributed to the significant correlation between chronotype and PA as some of the effect sizes were small (e.g. $r = .20$, $p = .001$).

Strengths and Limitations

There are some strengths and limitations of the current study to consider. First, all assessments were self-reported measures making subjectivity a possible issue. Participants could have over or underestimated their quality of sleep, morningness level of chronotype and level of PA. Although the subjective measurement scales used in the study (i.e. IPAQ, PSQI and CSM) are well-established reliable scales with good scoring protocols, more objective measures of sleep quality and chronotype (e.g. actigraph) as well as PA (e.g. accelerometers) to assess these behaviours may support a relationship. It is noted in the literature that the correlation between objective and subjective measures of sleep are low (Aili, Åström-Paulsson, Stoetzer, Svartengren, & Hillert, 2017). Nonetheless, self-reported measures have been shown to be reliable and important method of measuring health outcomes such as sleep. Self-report of health behaviours may be just as important as objectively measuring them as how one perceives their health has an influence on their psychological well-being and may impact health outcomes (Lee & Oh, 2013; Menec, Chipperfield, & Perry, 1999). The PA measurement used in the current study assessed overall PA and movement. The IPAQ-SF measures general PA and not specified PA such as aerobic exercise. This measurement may not have fully captured participants' leisure PA and exercise engagement and may be accountable for the non-significant findings of the study. A domain of PA the IPAQ-SF examines is work-related PA. The current study found physical occupation to be the strongest and most significant predictor of PA. Previous studies have found if one's occupation is physically demanding these physical demands contribute to PA levels (Kirk & Rhodes, 2011; Kruger et al., 2006; Vandelanotte et al., 2015). This was found to be the case of the current study as participants whose occupation was physically demanding accounted for PA overall and may have contributed to why neither better sleep quality nor morningness chronotype influenced their PA engagement. An individual's sleep quality or sleep/wake time preference might not influence their ability to perform work demands hence, their engagement in physical work tasks would still occur to a reasonable standard. These work-related physical demands would contribute to higher levels of overall PA, as presented in the current study results.

Another study limitation encountered was the cross-sectional nature of this study. Previous research has shown that a longitudinal approach might be necessary in order to find and observe an association between sleep quality and morningness chronotype to independently predict PA engagement (Haario et al., 2013; Holfeld & Ruthig, 2012; Talbot et al., 2014). However, due to a restricted time-frame given to conduct this undergraduate project a longitudinal design would not have been feasible. Moreover, data collection of the study sample may have presented a potential bias as participants were recruited from two social media websites, Facebook and Instagram. This may have affected the generalizability of the study findings as only those with either social media accounts could participate. Another feature of the current study to make note of was the overrepresentation of females in the study sample (70.5%). This unbalanced gender divide in the current study is not representative of males and may have also impacted the generalizability of the study findings.

To determine the minimum sample size for the study Tabachnick and Fidell's (2013) formula was calculated and an appropriate sample size to run a regression analysis was met.

However, had a larger sample size been obtained this would increase the statistical power of the study's analysis and therefore would have increased the reliability of the results. Finally, when investigating the relationship between sleep predicting exercise and PA engagement, most studies focus on other sleep parameters such as sleep duration and sleep efficiency (Lambiase et al., 2013; Mitchell et al., 2016). The current study examined overall sleep quality and found no effect on the relationship between sleep and PA. This may relate to what specific sleep parameters correlate to improve exercise frequency. Sleep quality has been cited in the literature to be a good predictor of subsequent PA (Baron et al., 2013; Tang & Sanborn, 2014) but the current study might not be comparable to these research findings due to methodological differences.

Future Research

The current study used a sample of adults recruited on two social media platforms. In order to replicate the study findings, a larger, more representative sample of adults is required. Other settings would be of interest to investigate sleep quality and morningness chronotype predicting exercise frequency. For example, investigating the relationship in a population of those with a sleep disorder or in those who have depression or anxiety disorders would be of interest as people with these diagnoses have poor sleep hygiene and health behaviours such as exercise. Reliable results from prior research has been provided from studies which have focused on patients diagnosed with sleep-related disorders on the relationship between sleep and exercise and their interrelated effects (Baron et al., 2013; Kline, 2014). It would be of interest to use an older adult population when investigating sleep-related factors predicting exercise as these health behaviours have been shown to decline with age (Espiritu, 2008; Madrid-Valero, Martínez-Selva, Couto, Sánchez-Romera, & Ordoñana, 2017; Sun, Norman, & While, 2013). Another recommendation future research could include is using a subjective measurement that exclusively captures aerobic and anaerobic exercise, not general PA. For instance, the Godin Leisure-Time Exercise Questionnaire (Godin, 2011) assesses strenuous, moderate, and light exercise per week and does not account for daily movement involved in gardening, housework or work-related PA. Also, it would be recommended to include both objective and subjective measures to examine the physical associations between sleep quality and chronotype on PA and exercise such as an exercise-related fitness test. As some studies have shown longitudinal methods have produced consistent findings when examining the relationship among sleep quality and PA future research could employ this study design, and not just examine next day effects using objective and subjective measures. Finally, it may be of interest to assess the impact sleep may have on the components of exercise as a lack of attention has been given. This would include whether one performs aerobic or anaerobic exercise and also, the amount of time spent performing either exercise type following the previous night's sleep.

Conclusion

The findings of the current study do have valuable implications for public health as a whole irrespective of sleep quality and morningness chronotype not predicting engagement in PA and exercise. Sleep and exercise are two fundamental health behaviours that should be considered when improving health-related quality of life of the public. Prior research has found exercise to be an effective intervention for improving and regulating sleep (Kline, 2011; 2012; Yang, Ho, Chen, & Chien, 2012) and despite the current study findings this relationship has been found to be bidirectional (Baron et al., 2013; Lambiase et al., 2013; Spina et al., 2017). Therefore, implementing interventions to enhance exercise frequency should consider examining sleep quality and sleep-related behaviours (sleep/wake time preferences) as these may be risk factors that contributes to individuals' physical inactivity and inadequate exercise. Improving overall sleep quality as well as applying an exercise regime that works alongside an individual's chronotype may be important aspects to consider when aiming to increase exercise frequency and engagement.

As research has demonstrated that sleep and morningness chronotype are both independently associated with PA and exercise levels (Bailey & Jung, 2014; Kline, 2014) the current study does not support this hypothesis. After controlling for confounding variables such as age, gender, physical occupation and levels of conscientiousness, overall sleep quality did not influence PA and exercise engagement. Similarly, morningness chronotype did not predict exercise and PA engagement levels. Grounded on the findings of the current study among a varied sample of adults, improving individual's sleep quality and an individual's chronotype may not predict their PA and exercise engagement. Nonetheless, the findings from the current study adds to the literature about the potential bidirectional relationship sleep-related factors may have on subsequent exercise. This research area is still growing and in order to obtain consistent validating findings further research is required, particularly research that allows for replication. The study limitations and strengths highlighted in the current study emphasizes the important points to consider for future research focused on this area.

References

Acet, O., Girit, Ç., Kaya, Ş., Süt, N., & Vardar, S. A. (2018). The relationship between chronotypes and physical activity in healthy young medical students. *Turkish Medical Student Journal*, *5*(2), 24-27.

Adan, A., Archer, S. N., Hidalgo, M. P., Di Milia, L., Natale, V., & Randler, C. (2012). Circadian typology: a comprehensive review. *Chronobiology International*, *29*(9), 1153-1175.

Agarwal, S. K. (2012). Cardiovascular benefits of exercise. *International Journal of General Medicine*, *5*, 541.

Aili, K., Åström-Paulsson, S., Stoetzer, U., Svartengren, M., & Hillert, L. (2017). Reliability of actigraphy and subjective sleep measurements in adults: the design of sleep assessments. *Journal of Clinical Sleep Medicine*, *13*(01), 39-47.

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In *Action control* (pp. 11-39). Springer, Berlin, Heidelberg.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179-211.

Ajzen, I., Czasch, C., & Flood, M. G. (2009). From Intentions to Behavior: Implementation Intention, Commitment, and Conscientiousness 1. *Journal of Applied Social Psychology*, *39*(6), 1356-1372.

Alansari, B. (2016). The Big Five Inventory (BFI): Reliability and validity of its Arabic translation in non clinical sample. *European Psychiatry*, *33*, S209-S210.

Ambrose, K. R., & Golightly, Y. M. (2015). Physical exercise as non-pharmacological treatment of chronic pain: why and when. *Best Practice & Research Clinical Rheumatology*, *29*(1), 120-130.

Bailey, K. J., & Jung, M. E. (2014). The early bird gets the worm! Congruency between intentions and behavior is highest when plans to exercise are made for the morning. *Journal of Applied Biobehavioral Research*, *19*(4), 233-247.

Baron, K. G., Reid, K. J., & Zee, P. C. (2013). Exercise to improve sleep in insomnia: exploration of the bidirectional effects. *Journal of Clinical Sleep Medicine*, *9*(08), 819-824.

Belcher, B. R., Berrigan, D., Dodd, K. W., Emken, B. A., Chou, C. P., & Spuijt-Metz, D. (2010). Physical activity in US youth: impact of race/ethnicity, age, gender, & weight status. *Medicine and Science in Sports and Exercise*, *42*(12), 2211.

Brunet, J., & Sabiston, C. M. (2011). Exploring motivation for physical activity across the adult lifespan. *Psychology of Sport and Exercise*, *12*(2), 99-105.

Buysse, D. J., Reynolds III, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Research*, *28*(2), 193-213.

Cavallera, G. M., & Giudici, S. (2008). Morningness and eveningness personality: A survey in literature from 1995 up till 2006. *Personality and Individual Differences*, *44*(1), 3-21.

Chasens, E. R., Sereika, S. M., Weaver, T. E., & Umlauf, M. G. (2007). Daytime sleepiness, exercise, and physical function in older adults. *Journal of Sleep Research*, *16*(1), 60-65.

Conner, M., Rodgers, W., & Murray, T. (2007). Conscientiousness and the intention–behavior relationship: Predicting exercise behavior. *Journal of Sport and Exercise Psychology*, *29*(4), 518-533.

Córdova, C., Silva, V. C., Moraes, C. F., Simões, H. G., & Nóbrega, O. D. T. (2009). Acute exercise performed close to the anaerobic threshold improves cognitive performance in elderly females. *Brazilian Journal of Medical and Biological Research*, *42*(5), 458-464.

Costa, S., Hausenblas, H. A., Oliva, P., Cuzzocrea, F., & Larcan, R. (2013). The role of age, gender, mood states and exercise frequency on exercise dependence. *Journal of Behavioral Addictions*, *2*(4), 216-223.

Craft, B. B., Carroll, H. A., & Lustyk, M. K. B. (2014). Gender differences in exercise Habits and quality of Life Reports: Assessing the Moderating effects of Reasons for exercise. *International Journal of Liberal Arts and Social Science*, *2*(5), 65.

Craig CL, Marshall AL, Sjostrom M, Bauman A, Booth ML, Ainsworth BE, … & Oja P. (2003) International Physical Activity Questionnaire: 12-country reliability and validity. *Medicine & Science in Sports & Exercise*, *35*(8), 1381-1395.

DeYoung, C. G., Hasher, L., Djikic, M., Criger, B., & Peterson, J. B. (2007). Morning people are stable people: Circadian rhythm and the higher-order factors of the Big Five. *Personality and Individual Differences*, *43*(2), 267-276.

Dinas, P. C., Koutedakis, Y., & Flouris, A. D. (2011). Effects of exercise and physical activity on depression. *Irish Journal of Medical Science*, *180*(2), 319-325.

Ding, D., Lawson, K. D., Kolbe-Alexander, T. L., Finkelstein, E. A., Katzmarzyk, P. T., Van Mechelen, W., ... & Lancet Physical Activity Series 2 Executive Committee. (2016). The economic burden of physical inactivity: a global analysis of major non-communicable diseases. *The Lancet*, *388*(10051), 1311-1324.

Duggan, K. A., Friedman, H. S., McDevitt, E. A., & Mednick, S. C. (2014). Personality and healthy sleep: the importance of conscientiousness and neuroticism. *PloS One*, *9*(3).

Dzierzewski, J. M., Buman, M. P., Giacobbi Jr, P. R., Roberts, B. L., Aiken-Morgan, A. T., Marsiske, M., & McCrae, C. S. (2014). Exercise and sleep in community-dwelling older adults: evidence for a reciprocal relationship. *Journal of Sleep Research*, *23*(1), 61-68.

Ensari, I., Sandroff, B. M., & Motl, R. W. (2016). Effects of single bouts of walking exercise and yoga on acute mood symptoms in people with multiple sclerosis. *International Journal of MS Care*, *18*(1), 1-8.

Erickson, K. I., & Kramer, A. F. (2009). Aerobic exercise effects on cognitive and neural plasticity in older adults. *British Journal of Sports Medicine*, *43*(1), 22-24.

Espiritu, J. R. D. (2008). Aging-related sleep changes. *Clinics in Geriatric Medicine*, *24*(1), 1-14.

Evans, D. S., Snitker, S., Wu, S. H., Mody, A., Njajou, O. T., Perlis, M. L., ... & Hsueh, W. C. (2011). Habitual sleep/wake patterns in the Old Order Amish: heritability and association with non-genetic factors. *Sleep*, *34*(5), 661-669.

Facer-Childs, E., & Brandstaetter, R. (2015). The impact of circadian phenotype and time since awakening on diurnal performance in athletes. *Current Biology*, *25*(4), 518-522.

Facer-Childs, E. R., Boiling, S., & Balanos, G. M. (2018). The effects of time of day and chronotype on cognitive and physical performance in healthy volunteers. *Sports Medicine-Open*, *4*(1), 47.

Farid, R., Azad, F. J., Atri, A. E., Rahimi, M. B., Khaledan, A., Talaei-Khoei, M., Ghafari, J. & Ghasemi, R. (2005). Effect of aerobic exercise training on pulmonary function and tolerance of activity in asthmatic patients. *Iranian Journal of Allergy, Asthma and Immunology*, 133-138.

Farina, N., Rusted, J., & Tabet, N. (2014). The effect of exercise interventions on cognitive outcome in Alzheimer's disease: a systematic review. *International Psychogeriatrics*, *26*(1), 9-18.

Feldt, R. C., Lee, J., & Dew, D. (2014). Criterion Validity of Facets versus Domains of the Big Five Inventory. *Individual Differences Research*, *12*(3).

Garcia, D., & Archer, T. (2014). Positive affect and age as predictors of exercise compliance. *PeerJ*, *2*, e694.

Gates, J., Killackey, E., Phillips, L., & Álvarez-Jiménez, M. (2015). Mental health starts with physical health: current status and future directions of non-pharmacological interventions to improve physical health in first-episode psychosis. *The Lancet Psychiatry*, *2*(8), 726-742.

Gay, C., Chabaud, A., Guilley, E., & Coudeyre, E. (2016). Educating patients about the benefits of physical activity and exercise for their hip and knee osteoarthritis. Systematic literature review. *Annals of Physical and Rehabilitation Medicine*, *59*(3), 174-183.

Giannotti, F., Cortesi, F., Sebastiani, T., & Ottaviano, S. (2002). Circadian preference, sleep and daytime behaviour in adolescence. *Journal of Sleep Research*, *11*(3), 191-199.

Godin, G. (2011). The Godin-Shephard leisure-time physical activity questionnaire. *The Health & Fitness Journal of Canada*, *4*(1), 18-22.

Haario, P., Rahkonen, O., Laaksonen, M., Lahelma, E., & Lallukka, T. (2013). Bidirectional associations between insomnia symptoms and unhealthy behaviours. *Journal of Sleep Research*, *22*(1), 89-95.

Haraszti, R. A., Purebl, G., Salavecz, G., Poole, L., Dockray, S., & Steptoe, A. (2014). Morningness–eveningness interferes with perceived health, physical activity, diet and stress levels in working women: A cross-sectional study. *Chronobiology International*, *31*(7), 829-837.

Hisler, G. C., Phillips, A. L., & Krizan, Z. (2016). Individual Differences in Diurnal Preference and Time-of-Exercise Interact to Predict Exercise Frequency. *Annals of Behavioral Medicine*, *51*(3), 391-401.

Holfeld, B., & Ruthig, J. C. (2014). A longitudinal examination of sleep quality and physical activity in older adults. *Journal of Applied Gerontology*, *33*(7), 791-807.

Horne, J. A., & Östberg, O. (1976). A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. *International Journal of Chronobiology*.

Howley, E. T. (2001). Type of activity: resistance, aerobic and leisure versus occupational physical activity. *Medicine & Science in Sports & Exercise*, *33*(6), S364-S369.

Hutchison, A. J., Breckon, J. D., & Johnston, L. H. (2009). Physical activity behavior change interventions based on the transtheoretical model: a systematic review. *Health Education & Behavior*, *36*(5), 829-845.

IBM Corp. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp; 2019.

World Health Organization (2018). Ireland - Physical activity factsheet 2018. Retrieved from http://www.euro.who.int/en/countries/ireland/data-and-statistics/ireland.

Jakicic, J. M., & Otto, A. D. (2006). Treatment and prevention of obesity: what is the role of exercise?. *Nutrition Reviews*, *64*(suppl_1), S57-S61.

Jankowski, K. S. (2015). Composite Scale of Morningness: psychometric properties, validity with Munich ChronoType Questionnaire and age/sex differences in Poland. *European Psychiatry*, *30*(1), 166-171.

John, O., Donahue, E., & Kentle, R. (1991). The big five inventory-Versions 4a and 54. Berkeley, CA: University of California. *Berkeley, Institute of Personality and Social Research.*

Kauderer, S., & Randler, C. (2013). Differences in time use among chronotypes in adolescents. *Biological Rhythm Research*, *44*(4), 601-608.

Kirk, M. A., & Rhodes, R. E. (2011). Occupation correlates of adults' participation in leisure-time physical activity: a systematic review. *American Journal of Preventive Medicine*, *40*(4), 476-485.

Khan, M. K., Chu, Y. L., Kirk, S. F., & Veugelers, P. J. (2015). Are sleep duration and sleep quality associated with diet quality, physical activity, and body weight status? A population-based study of Canadian children. *Canadian Journal of Public Health*, *106*(5), e277-e282.

Kline, C. E. (2014). The bidirectional relationship between exercise and sleep: implications for exercise adherence and sleep improvement. *American Journal of Lifestyle Medicine*, *8*(6), 375-379.

Kline, C. E., Crowley, E. P., Ewing, G. B., Burch, J. B., Blair, S. N., Durstine, J. L. & Youngstedt, S. D. (2011). The effect of exercise training on obstructive sleep apnea and sleep quality: a randomized controlled trial. *Sleep*, *34*(12), 1631-1640.

Kline, C. E., Sui, X., Hall, M. H., Youngstedt, S. D., Blair, S. N., Earnest, C. P., & Church, T. S. (2012). Dose–response effects of exercise training on the subjective sleep quality of postmenopausal women: exploratory analyses of a randomised controlled trial. *BMJ, 2*(4), e001044.

Knapen, J., Vancampfort, D., Moriën, Y., & Marchal, Y. (2015). Exercise therapy improves both mental and physical health in patients with major depression. *Disability and Rehabilitation*, *37*(16), 1490-1495.

Koukkari, W. L., & Sothern, R. B. (2007). *Introducing biological rhythms: A Primer on The Temporal Organization of Life, With Implications for Health, Society, Reproduction, and the Natural Environment*. Springer Science & Business Media.

Kruger, J., Yore, M. M., Ainsworth, B. E., & Macera, C. A. (2006). Is participation in occupational physical activity associated with lifestyle physical activity levels?. *Journal of Occupational and Environmental Medicine*, *48*(11), 1143-1148.

Lallukka, T., Sarlio-Lähteenkorva, S., Roos, E., Laaksonen, M., Rahkonen, O., & Lahelma, E. (2004). Working conditions and health behaviours among employed women and men: the Helsinki Health Study. *Preventive Medicine*, *38*(1), 48-56.

Lambiase, M. J., Gabriel, K. P., Kuller, L. H., & Matthews, K. A. (2013). Temporal relationships between physical activity and sleep in older women. *Medicine and Science in Sports and Exercise*, *45*(12).

Lara, T., Madrid, J. A., & Correa, Á. (2014). The vigilance decrement in executive function is attenuated when individual chronotypes perform at their optimal time of day. *PloS One*, *9*(2), e88820.

Lees, C., & Hopkins, J. (2013). Peer reviewed: effect of aerobic exercise on cognition, academic achievement, and psychosocial function in children: a systematic review of randomized control trials. *Preventing Chronic Disease*, *10*. doi: 10.5888/pcd10.130010

Lee, B. A., & Oh, D. J. (2013). The effects of health perception on living health belief, living satisfaction and wellbeing-oriented activities according to swimming participation with middle-aged women. *Journal of Exercise Rehabilitation*, *9*(3), 381.

Ma, Q. (2008). Beneficial effects of moderate voluntary physical exercise and its biological mechanisms on brain health. *Neuroscience Bulletin*, *24*(4), 265-270.

Madrid-Valero, J. J., Martínez-Selva, J. M., Couto, B. R. D., Sánchez-Romera, J. F., & Ordoñana, J. R. (2017). Age and gender effects on the prevalence of poor sleep quality in the adult population. *Gaceta Sanitaria*, *31*, 18-22.

Mandolesi, L., Polverino, A., Montuori, S., Foti, F., Ferraioli, G., Sorrentino, P., & Sorrentino, G. (2018). Effects of physical exercise on cognitive functioning and wellbeing: biological and psychological benefits. *Frontiers in Psychology*, *9*, 509.

Mateo, M. J. C., Díaz-Morales, J. F., Barreno, C. E., Prieto, P. D., & Randler, C. (2012). Morningness-eveningness and sleep habits among adolescents: age and gender differences. *Psicothema*, *24*(3), 410-415.

McCrae, R. R., & Costa, P. T. (1987). Validation of the five-factor model of personality across instruments and observers. *Journal of Personality and Social Psychology*, *52*(1), 81.

Menec, V. H., Chipperfield, J. G., & Perry, R. P. (1999). Self-perceptions of health: A prospective analysis of mortality, control, and health. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences*, *54*(2), P85-P93.

Mitchell, J. A., Godbole, S., Moran, K., Murray, K., James, P., Laden, F., ... & Glanz, K. (2016). No evidence of reciprocal associations between daily sleep and physical activity. *Medicine and Science in Sports and Exercise*, *48*(10), 1950.

Moghaddam, J. F., Nakhaee, N., Sheibani, V., Garrusi, B., & Amirkafi, A. (2012). Reliability and validity of the Persian version of the Pittsburgh Sleep Quality Index (PSQI-P). *Sleep and Breathing*, *16*(1), 79-82.

Morse, D. S., Fritz, L., & Hastings, J. W. (1990). What is the clock? Translational regulation of circadian bioluminescence. *Trends in Biochemical Sciences*, *15*(7), 262-265.

Mummery, W., Kolt, G., Schofield, G., & McLean, G. (2007). Associations between physical activity and other lifestyle behaviors in older New Zealanders. *Journal of Physical Activity and Health*, *4*(4), 412-423.

National Sleep Foundation. *Sleep in America Poll*. National Sleep Foundation, Washington, DC, 2003.

Nguyen, H., Ruiz, C., Wilson, V., Strong, D., & Djamasbi, S. (2018, January). Using personality traits and chronotype to support personalization and feedback in a sleep health behavior change support system. In *Proceedings of the 51st Hawaii International Conference on System Sciences*.

Olds, T. S., Maher, C. A., & Matricciani, L. (2011). Sleep duration or bedtime? Exploring the relationship between sleep habits and weight status and activity patterns. *Sleep*, *34*(10), 1299-1307.

Paffenbarger Jr, R. S., Hyde, R., Wing, A. L., & Hsieh, C. C. (1986). Physical activity, all cause mortality, and longevity of college alumni. *New England Journal of Medicine*, *314*(10), 605-613.

Papathanasiou, G., Georgoudis, G., Georgakopoulos, D., Katsouras, C., Kalfakakou, V., & Evangelou, A. (2010). Criterion-related validity of the short International Physical Activity Questionnaire against exercise capacity in young adults. *European Journal of Cardiovascular Prevention & Rehabilitation*, *17*(4), 380-386.

Penedo, F. J., & Dahn, J. R. (2005). Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Current Opinion in Psychiatry*, *18*(2), 189-193.

Pratt, M., Norris, J., Lobelo, F., Roux, L., & Wang, G. (2014). The cost of physical inactivity: moving into the 21st century. *British Journal of Sports Medicine*, *48*(3), 171-173.

Prochaska, J. O., & DiClemente, C. C. (1983). Stages and processes of self-change of smoking: toward an integrative model of change. *Journal of Consulting and Clinical Psychology*, *51*(3), 390.

Rebar, A. L., Stanton, R., Geard, D., Short, C., Duncan, M. J., & Vandelanotte, C. (2015). A meta-meta-analysis of the effect of physical activity on depression and anxiety in non-clinical adult populations. *Health Psychology Review*, *9*(3), 366-378.

Reiner, M., Niermann, C., Jekauc, D., & Woll, A. (2013). Long-term health benefits of physical activity–a systematic review of longitudinal studies. *BMC Public Health*, *13*(1), 813.

Rhodes, R. E., Courneya, K. S., & Jones, L. W. (2005). The theory of planned behavior and lower-order personality traits: Interaction effects in the exercise domain. *Personality and Individual Differences*, *38*(2), 251-265.

Rhodes, R. E., & Dickau, L. (2012). Experimental evidence for the intention–behavior relationship in the physical activity domain: A meta-analysis. *Health Psychology*, *31*(6), 724.

Rhodes, R. E., & Dickau, L. (2013). Moderators of the intention-behaviour relationship in the physical activity domain: a systematic review. *British Journal of Sports Medicine*, *47*(4), 215-225.

Roenneberg, T., Wirz-Justice, A., & Merrow, M. (2003). Life between clocks: daily temporal patterns of human chronotypes. *Journal of Biological Rhythms*, *18*(1), 80-90.

Ross, K. M., Thomas, J. G., & Wing, R. R. (2016). Successful weight loss maintenance associated with morning chronotype and better sleep quality. *Journal of Behavioral Medicine*, *39*(3), 465-471.

Rossi, A., Formenti, D., Vitale, J. A., Calogiuri, G., & Weydahl, A. (2015). The effect of chronotype on psychophysiological responses during aerobic self-paced exercises. *Perceptual and Motor Skills*, *121*(3), 840-855.

Ruiz-Casado, A., Alejo, L. B., Santos-Lozano, A., Soria, A., Ortega, M. J., Pagola, I., ... & Lucia, A. (2016). Validity of the physical activity questionnaires IPAQ-SF and GPAQ for Cancer survivors: insights from a Spanish cohort. *International Journal of Sports Medicine*, *37*(12), 979-985.

Schaal, S., Peter, M., & Randler, C. (2010). Morningness-eveningness and physical activity in adolescents. *International Journal of Sport and Exercise Psychology*, *8*(2), 147-159.

Shechter, A., & St-Onge, M. P. (2014). Delayed sleep timing is associated with low levels of free-living physical activity in normal sleeping adults. *Sleep Medicine*, *15*(12), 1586-1589.

Sherar, L. B., Esliger, D. W., Baxter-Jones, A. D., & Tremblay, M. S. (2007). Age and gender differences in youth physical activity: does physical maturity matter?. *Medicine & Science in Sports & Exercise*, *39*(5), 830-835.

Sjostrom, M., Ainsworth, B., Bauman, A., Bull, F., Hamilton-Craig, C., & Sallis, J. (2005). Guidelines for data processing analysis of the International Physical Activity Questionnaire (IPAQ)-Short and long forms.

Smith CS, Reilly C, Midkiff K. (1989). Evaluation of three circadian rhythm questionnaires with suggestions for an improved measure of morningness. *Journal of Applied Psychology, 74*(5): 728-738.

Smyth, C. (1999). The Pittsburgh sleep quality index (PSQI). *Journal of Gerontological Nursing*, *25*(12), 10-10.

Sofi, F., Valecchi, D., Bacci, D., Abbate, R., Gensini, G. F., Casini, A., & Macchi, C. (2011). Physical activity and risk of cognitive decline: a meta‐analysis of prospective studies. *Journal of Internal Medicine*, *269*(1), 107-117.

Spencer, L., Adams, T. B., Malone, S., Roy, L., & Yost, E. (2006). Applying the transtheoretical model to exercise: a systematic and comprehensive review of the literature. *Health Promotion Practice*, *7*(4), 428-443.

Spina, G., Spruit, M. A., Alison, J., Benzo, R. P., Calverley, P. M., Clarenbach, C. F., ... & van Gestel, A. J. (2017). Analysis of nocturnal actigraphic sleep measures in patients with COPD and their association with daytime physical activity. *Thorax*, *72*(8), 694-701.

Stepanczuk, B., & Charvat, J. M. (2010). Women's and Men's Exercise Adherence After a Cardiac Event: Does Age Make a Difference?. *Research in Gerontological Nursing*, *3*(1), 30.

Stewart, J. C., Rand, K. L., Hawkins, M. A. W., & Stines, J. A. (2011). Associations of the shared and unique aspects of positive and negative emotional factors with sleep quality. *Personality and Individual Differences, 50*, 609 – 614

Suh, S., Yang, H. C., Kim, N., Yu, J. H., Choi, S., Yun, C. H., & Shin, C. (2017). Chronotype differences in health behaviors and health-related quality of life: a population-based study among aged and older adults. *Behavioral Sleep Medicine*, *15*(5), 361-376.

Sun, F., Norman, I. J., & While, A. E. (2013). Physical activity in older people: a systematic review. *BMC Public Health*, *13*(1), 449.

Sutton, S. R. (1997). Transtheoretical model of behaviour change. *Cambridge Handbook of Psychology, Health and Medicine*, 180-183.

Tabachnick, B. G., & Fidell, L. S. (2013). Multiple Regression. Using Multivariate Statistics. 6. Baskı.

Talbot, L. S., Neylan, T. C., Metzler, T. J., & Cohen, B. E. (2014). The mediating effect of sleep quality on the relationship between PTSD and physical activity. *Journal of Clinical Sleep Medicine, 10*(07), 795-801.

Tang, N. K., & Sanborn, A. N. (2014). Better quality sleep promotes daytime physical activity in patients with chronic pain? A multilevel analysis of the within-person relationship. *PLoS One*, *9*(3), e92158.

Teixeira, C. V. L., Gobbi, L. T. B., Corazza, D. I., Stella, F., Costa, J. L. R., & Gobbi, S. (2012). Non-pharmacological interventions on cognitive functions in older people with mild cognitive impairment (MCI). *Archives of Gerontology and Geriatrics*, *54*(1), 175-180.

Tonetti, L., Fabbri, M., & Natale, V. (2009). Relationship between circadian typology and big five personality domains. *Chronobiology International*, *26*(2), 337-347.

Torsvall, L., & Åkerstedt, T. (1980). A diurnal type scale: construction, consistency and validation in shift work. *Scandinavian Journal of Work, Environment & Health*, 283-290.

Trost, S. G., Pate, R. R., Sallis, J. F., Freedson, P. S., Taylor, W. C., Dowda, M., & Sirard, J. (2002). Age and gender differences in objectively measured physical activity in youth. *Medicine and Science in Sports and Exercise*, *34*(2), 350-355.

Urbán, R., Magyaródi, T., & Rigó, A. (2011). Morningness-eveningness, chronotypes and health-impairing behaviors in adolescents. *Chronobiology International*, *28*(3), 238-247.

Vandelanotte, C., Short, C., Rockloff, M., Di Millia, L., Ronan, K., Happell, B., & Duncan, M. J. (2015). How do different occupational factors influence total, occupational, and leisure-time physical activity?. *Journal of Physical Activity and Health*, *12*(2), 200-207.

Vitale, J. A., & Weydahl, A. (2017). Chronotype, physical activity, and sport performance: a systematic review. *Sports Medicine*, *47*(9), 1859-1868.

Warburton, D. E., Nicol, C. W., & Bredin, S. S. (2006). Health benefits of physical activity: the evidence. *CMAJ: Canadian Medical Association Journal*, *174*(6), 801-809.

World Health Organization. (2004). WHO technical meeting on sleep and health.

World Health Organization. (2009). *Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks*. Geneva: World Health Organization.

Wu, B., & Porell, F. (2000). Job characteristics and leisure physical activity. *Journal of Aging and Health*, *12*(4), 538-559.

Wu, J., Einerson, B., Shaw, J. M., Nygaard, I. E., Sheng, X., Wolpern, A., & Egger, M. J. (2019). Association between sleep quality and physical activity in postpartum women. *Sleep Health*, *5*(6), 598-605.

Youngstedt, S. D., & Kline, C. E. (2006). Epidemiology of exercise and sleep. *Sleep and Biological Rhythms*, *4*(3), 215-221.

Yang, P. Y., Ho, K. H., Chen, H. C., & Chien, M. Y. (2012). Exercise training improves sleep quality in middle-aged and older adults with sleep problems: a systematic review. *Journal of physiotherapy*, *58*(3), 157-163.

Yu, P. A., Hsu, W. H., Hsu, W. B., Kuo, L. T., Lin, Z. R., Shen, W. J., & Hsu, R. W. W.

(2019). The effects of high impact exercise intervention on bone mineral density, physical fitness, and quality of life in postmenopausal women with osteopenia: A retrospective cohort study. *Medicine*, *98*(11), e14898.

Appendices

Appendix A

Demographics

1. Select your gender by choosing ONE of the options.

□ Male

□ Female

2. Please provide your age in number form.

____

3. You are required to select your occupational nature. This is in regards to your occupation's physical demands. Please select ONE of the following.

Examples of physically demanding occupations include construction workers, retail or service jobs, farming, emergency services personnel etc.

Examples of low physical or sedentary occupations include administration, technology, transportation jobs etc.

□ Yes, my occupation is physically demanding.

□ No, my occupation does not require a high level of physical activity.

Appendix B

International Physical Activity Short Form Questionnaire (IPAQ-sf)

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ days per week

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ hours per day

   _____ minutes per day

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ days per week

   ☐ No moderate physical activities → ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

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

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Appendix C

The Pittsburgh Sleep Quality Index (PSQI)

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

1. When have you usually gone to bed? _______________

2. How long (in minutes) has it taken you to fall asleep each night? _______________

3. When have you usually gotten up in the morning? _______________

4. How many hours of actual sleep do you get at night? (This may be different than the number of hours you spend in bed) _______________

5. During the past month, how often have you	Not during the past month (0)	Less than once a week (1)	Once or twice a week (2)	Three or more times week (3)
a. Cannot get to sleep within 30 minutes				
b. Wake up in the middle of the night or early morning				
c. Have to get up to use the bathroom				
d. Cannot breathe comfortably				
e. Cough or snore loudly				
f. Feel too cold				
g. Feel too hot				
h. Have bad dreams				
i. Have pain				
j. Other reason(s), please describe, including how often you have had trouble sleeping because of this reason(s):				
6. During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				
8. During the past month, how much of a problem has it been for you to keep up enthusiasm to get things done?				

	Very good (0)	Fairly good (1)	Fairly bad (2)	Very bad (3)
9. During the past month, how would you rate your sleep quality overall?				

Questionnaire Cont'd

Component 1 #9 Score...C1________

Component 2 #2 Score (≤15min=0; 16-30 min=1; 31-60 min=2, >60 min=3) + #5a Score (if sum is equal 0=0; 1-2=1; 3-4=2; 5-6=3) ……………...........C2________

Component 3 #4 Score (>7=0; 6-7=1; 5-6=2; <5=3) ....C3________

Component 4 (total # of hours asleep)/ (total # of hours in bed) x 100 >85%=0, 75%-84%=1, 65%-74%=2, <65%=3………………….................................C4________

Component 5 Sum of Scores #5b to #5j (0=0; 1-9=1; 10-18=2; 19-27=3) ....C5________

Component 6 #6 Score...C6________

Component 7 #7 Score + #8 Score (0=0; 1-2=1; 3-4=2; 5-6=3) ....C7________

Add the seven component scores together _________ **Global PSQI Score** _________

Appendix D

Composition Scale of Morningness

Directions: Please *check* the response for *each* item that best describes *you.*

1. Considering only your own "feeling best" rhythm, at what time would you get up if you were entirely free to plan your day?

5:00-6:30 a.m.	☐	(5)
6:30-7:45 a.m.	☐	(4)
7:45-9:45 a.m.	☐	(3)
9:45-11:00 a.m.	☐	(2)
11:00 a.m.-12:00 (noon)	☐	(1)

2. Considering your only "feeling best" rhythm, at what time would you go to bed if you were entirely free to plan your evening?

8:00-9:00 p.m.	☐	(5)
9:00-10:15 p.m.	☐	(4)
10:15 p.m.-12:30 a.m.	☐	(3)
12:30-1:45 a.m.	☐	(2)
1:45-3:00a.m.	☐	(1)

3. Assuming normal circumstance, how easy do you find getting up in the morning? (Select one)

Not at all easy	☐	(1)
Slightly easy	☐	(2)
Fairly easy	☐	(3)
Very easy	☐	(4)

4. How alert do you feel during the first half hour after having awakened in the morning? (Select one.)

Not at all alert	☐	(1)
Slightly alert	☐	(2)
Fairly alert	☐	(3)
Very alert	☐	(4)

5. During the first half hour after having awakened in the morning, how tired do you feel? (Select one.)

Very tired	☐	(1)
Fairly tired	☐	(2)
Fairly refreshed	☐	(3)
Very refreshed	☐	(4)

6. You have decided to engage in some physical exercise. A friend suggests that you do this one hour twice a week and the best time for him is 7:00-8:00 a.m. Bearing in mind nothing else but your own "feeling best" rhythm, how do you think you would perform?

Would be in good form	☐	(4)
Would be in reasonable form	☐	(3)
Would find it difficult	☐	(2)
Would find it very difficult	☐	(1)

7. At what time in the evening do you feel tired and, as a result, in need of sleep?

8:00-9:00 p.m.	☐	(5)
9:00-10:15 p.m.	☐	(4)
10:15 p.m.-12:30 a.m.	☐	(3)
12:30-1:45 a.m.	☐	(2)
1:45-3:00 a.m.	☐	(1)

8. You wish to be at your peak performance for a test which you know is going to be mentally exhausting and lasting for two hours. You are entirely free to plan your day, and considering only your own "feeling best" rhythm, which ONE of the four testing times would you choose?

8:00-10:00 a.m.	☐	(4)
11:00 a.m.-1:00 p.m.	☐	(3)
3:00-5:00 p.m.	☐	(2)
7:00-9:00 p.m.	☐	(1)

9. One hears about "morning" and "evening" types of people. Which ONE of these types do you consider yourself to be?

Definitely a morning type	☐	(4)
More a morning than an evening type	☐	(3)
More an evening than a morning type	☐	(2)
Definitely an evening type	☐	(1)

10. When would you prefer to rise (provided you have a full day's work—8 hours) if you were totally free to arrange your time?

Before 6:30 a.m.	☐	(4)
6:30-7:30 a.m.	☐	(3)
7:30-8:30 a.m.	☐	(2)
8:30 a.m. or later	☐	(1)

11. If you always had to rise at 6:00 a.m., what do you think it would be like?

Very difficult and unpleasant	☐	(1)
Rather difficult and unpleasant	☐	(2)
A little unpleasant but no great problem	☐	(3)
Easy and not unpleasant	☐	(4)

12. How long a time does it usually take before you "recover your senses" in the morning after rising from a night's sleep?

0-10 minutes	☐	(4)
11-20 minutes	☐	(3)
21 -40 minutes	☐	(2)
More than 40 minutes	☐	(1)

13. Please indicate to what extent you are a morning or evening active individual.

Pronounced morning active (morning alert and evening tired)	☐	(4)
To some extent, morning active	☐	(3)
To some extent, evening active	☐	(2)
Pronounced evening active (morning tired and evening alert)	☐	(1)

Appendix E

Conscientiousness: The Big Five Inventory (BFI)

Here are a number of characteristics that may or may not apply to you. Please write a number next to each statement to indicate the extent to which you agree or disagree with that statement.

Disagree strongly	Disagree a little	Neither agree nor disagree	Agree a little	Agree strongly
1	2	3	4	5

<u>I see Myself as Someone Who...</u>

____1. Does a through

____2. Can be somewhat careless

____3. Is a reliable worker

____4. Tends to be disorganized

____5. Tends to be lazy

____6. Perseveres until the task is finished

____7. Does things efficiently

____8. Makes plans and follows through with them

____9. Is easily distracted

Scoring:

Conscientiousness scoring ("R" denotes reverse-scored items):

1, 2R, 3, 4R, 5R, 6, 7, 8, 9R

Appendix F

Participation Information Sheet: Part A

You are being invited to take part in a research study. Before deciding whether to take part, please take the time to read this information, which explains why the research is being done and what it would involve for you.

Study Title: Sleep Quality and chronotype: determines of exercise engagement

What is this study about?
The aim of this study is to investigate whether sleep quality and chronotype (whether you are more of a morning/evening type person) is associated with an individual's level of exercise engagement. This study is a final year undergraduate project conducted by Lyndsay Murphy, a psychology student at the School of Business, National College of Ireland (NCI). The project is supervised by Dr Caoimhe Hannigan, Lecturer in Psychology at NCI.

What does taking part involve?
If you decide to take part in this research, you will be asked to complete an online questionnaire which contains items related to your sleep, your preferred time of day for engaging in activities, and your physical activity. The questionnaire should take approximately 15-25 minutes to complete.

Do you have to take part?
Participation in this study is entirely voluntary. If you decide not to take part, there will be no consequences for you. You can withdraw from the study at any time during your participation. To withdraw, simply exit the questionnaire by pressing the exit button located at the top of the right-hand corner of the browser window. Once you have submitted your questionnaire, it will not be possible to withdraw your data from the study, because all questionnaires are submitted anonymously and individual responses cannot be identified.

What are the possible risks or benefits of taking part?
There are no direct benefits to taking part in this research. However, you will have an opportunity to contribute to research that helps us to understand what factors influence engagement in exercise. There is a very small risk that some of the questions may cause minor distress or negative self-evaluation for some participants. If you experience this, you may choose to discontinue participation and exit the questionnaire. Contact information for the researcher and for relevant support services are also provided at the end of the questionnaire.

Will taking part be confidential?
The questionnaire responses will be anonymous. It is not possible to identify any participant based on their responses to the questionnaire. All data collected for this study will be strictly confidential. Responses obtained from the questionnaire will be stored securely in a password protected electronic file on the researcher's computer. No one except the researcher and their supervisor will have access to the data. Data will be retained for 5 years in accordance with the NCI data retention policy.

What will happen to the results of the research?
The results of this study will be submitted to National College of Ireland as part of my final year undergraduate project. Results from this final year project may be disseminated through publication and/or poster presentation at an undergraduate congress.

Contact for further information.
If you have any further questions concerning the study or study procedures and would like additional information before considering to participate in the study, please do not hesitate to get in contact. Below provided is the researcher's and supervisor's email details.

Lyndsay Murphy: x17775109@student.ncirl.ie
Supervisor: Dr Caoimhe Hannigan, Email: caoimhe.hannigan@ncirl.ie

Informed Consent Form: Part B

By giving your informed consent you are agreeing to the following:

Please tick the box below to confirm that:

- You are 18 years of age or over
- You have read the information above agree to take part in this research

Consent

☐ I agree

Appendix G

Debriefing Information

You have reached the end of the questionnaire. Please click the ‘submit’ button below to submit your responses and complete your participation in the study.

Thank you for taking the time to participate in this study. The data collected will be used to investigate whether sleep quality and chronotype (morning/evening preference) influence individuals’ likelihood to engage in exercise.

If you have any questions or concerns about the nature of the study or have been affected in any way from any of the questions asked, you can contact the researcher, or the research supervisor, using the contact details below. Additionally, below are freephone helplines if you wish to seek further guidance.

Lyndsay Murphy Email: x17775109@student.ncirl.ie
Supervisor: Dr Caoimhe Hannigan Email: caoimhe.hannigan@ncirl.ie

Helplines: Samaritans: 116 123,
Niteline: 1800 793 793