AN INVESTIGATION OF DAY-TO-DAY CHANGES OF MOOD AND PHYSICAL ACTIVITY ON SLEEP QUALITY AMONG YOUNG ADULTS

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UNIVERSITI PENDIDIKAN SULTAN IDRIS

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AN INVESTIGATION OF DAY-TO-DAY CHANGES OF MOOD AND PHYSICAL ACTIVITY ON SLEEP QUALITY AMONG YOUNG ADULTS

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ABSTRACT

This study examined the temporal effects of mood and physical activity on subsequent night sleep quality and investigated the differences between objective and subjective sleep measures. Using a within-subject daily process method, 112 participants (81.3% female, mean age = 21.91 years) monitored their mood, physical activity, and sleep over seven days in natural environments. Mood was self-reported using mood diary, while physical activity was recorded via actigraphy (Philips AW2). Sleep quality – total sleep time (TST), sleep efficiency (SE), sleep onset latency (SOL), and sleep quality rating – was measured using actigraphy and sleep diary. Participants also completed questionnaires on demographics, Insomnia Severity Index, Pittsburgh Sleep Quality Index, and Global Physical Activity Questionnaire. Multilevel modeling of 784 observations revealed that physical activity, mood disturbance, and overall mood rating did not predict TST, SE, and SOL measured using actigraphy. However, sleep diary data indicated that mood disturbance significantly predicted TST ($p = .004$), SE ($p < .001$), and sleep quality rating ($p < .001$), while overall mood rating significantly predicted TST ($p = .022$) and sleep quality rating ($p < .001$). Physical activity also significantly predicted TST ($p = .041$), SE ($p = .001$), SOL ($p = .006$), and sleep quality rating ($p = .024$) assessed by sleep diary. A paired sample t-test revealed discrepancies between actigraphy and sleep diary measurements of TST ($t(111) = -4.96$, $p < .05$), SE ($t(111) = -4.47$, $p < .05$), and SOL ($t(111) = 2.59$, $p < .05$). In conclusion, lower mood disturbance and higher physical activity level significantly improve subsequent night sleep quality. Addressing mood and promoting regular physical activity are key strategies for improving sleep quality. Early screening for mood and sleep problems, combined with personalized interventions, could yield long-term benefits and improve overall well-being.

KAJIAN MENGENAI PERUBAHAN *MOOD* HARIAN DAN AKTIVITI FIZIKAL TERHADAP KUALITI TIDUR DALAM KALANGAN BELIA

ABSTRAK

Objektif kajian ini adalah untuk mengkaji kesan temporal perubahan *mood* dan aktiviti fizikal terhadap kualiti tidur malam serta perbezaan ukuran objektif dan subjektif tidur. Reka bentuk kajian *within-subject daily process method* digunakan melibatkan 112 peserta (81.3% perempuan, min umur = 21.91 tahun) memantau *mood*, aktiviti fizikal, dan tidur selama tujuh hari dalam persekitaran tempat tinggal mereka. *Mood* direkodkan menggunakan diari *mood,* manakala aktiviti fizikal direkodkan menggunakan *actigraphy* (Philips AW2). Kualiti tidur – tempoh masa tidur (TST), pengekalan tidur (SE), tempoh masa untuk tertidur (SOL), dan tahap kualiti tidur – direkodkan menggunakan diari tidur dan *actigraphy*. Peserta juga melengkapkan soal selidik demografi, Insomnia Severity Index, Pittsburgh Sleep Quality Index, dan Global Physical Activity Questionnaire. *Multilevel modelling* terhadap 784 pemerhatian menunjukkan aktiviti fizikal, gangguan *mood*, dan *mood* keseluruhan bukan peramal untuk TST, SE, dan SOL yang diukur menggunakan *actigraphy*. Namun, data diari tidur menunjukkan gangguan *mood* adalah peramal signifikan bagi TST (p = .004), SE (p < .001), dan tahap kualiti tidur (p < .001), manakala *mood* keseluruhan secara signifikan meramal TST (p = .022) dan tahap kualiti tidur (p < .001). Aktiviti fizikal juga secara signifikan meramal TST (p = .041), SE (p = .001), SOL (p = .006), dan tahap kualiti tidur (p = .024) yang diukur menggunakan diari tidur. Hasil *paired sample t-test* menunjukkan perbezaan antara *actigraphy* dan diari tidur dalam mengukur TST (t(111) = -4.96, p < .05), SE (t(111) = -4.47, p < .05), and SOL (t(111) = 2.59, p < .05). Kesimpulannya, gangguan *mood* yang lebih rendah dan aktiviti fizikal yang lebih tinggi memberi kesan signifikan terhadap kualiti tidur. Oleh itu, adalah penting untuk menangani gangguan *mood* dan menggalakkan aktiviti fizikal secara berkala bagi meningkatkan kualiti tidur. Selain itu, saringan awal masalah *mood* dan tidur, dan intervensi secara personal dapat memberikan manfaat jangka panjang dan meningkatkan kesejahteraan holistik.

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LIST OF ABBREVIATIONS

5-HT	Serotonin
AA	Ambulatory Assessments
AIC	Akaike Information Criterion
ARAS	Ascending Reticular Activating System
ASAQ	Adolescent Sedentary Activity Questionnaire
BDI	Beck Depression Inventory
BMI	Body Mass Index
BRS	Brief Resilience Scale
BRUMS	Brunel Mood Scale
C	Constant
CESD	Center for Epidemiologic Studies Depression Scale
CERQ	Cognitive Emotion Regulation Questionnaire
CS	Conditioned Stimuli
CSD	Consensus Sleep Diary
DBAS	Dysfunctional Beliefs and Attitude about Sleep
ECG	Electrocardiogram
EEG	Electroencephalogram
EMA	Ecological Momentary Assessment
EMG	Electromyogram
EOG	Electrooculogram
ESM	Experience Sampling Methodology
ESS	Epworth Sleepiness Scale
GAD	Generalized Anxiety Disorder

GPAQ	Global Physical Activity Questionnaire
HADS	Hospital Anxiety and Depression Scale
IPAQ	International Physical Activity Questionnaire
IPAQ-SF	International Physical Activity Questionnaires–Short Form
ISI	Insomnia Severity Index
LRT	Likelihood Ratio Test
M	Mean
MaHTAS	Malaysia Health Technology Assessment Section
MDD	Major Depressive Disorder
MEQ	Morningness/ Eveningness Questionnaire
MET	Metabolic Equivalents
MVPA	Moderate-to-Vigorous Physical Activity
n.a.	Not available
NA	Number of Awakening
NCD	Non-Communicable Disease
NHMS	National Health Morbidity Survey
NREM	Non-Rapid Eye Movement
PARS	Physical Activity Rating Scale
PHQ	Patient Health Questionnaire
PMPUQ	Problematic Mobile Phone Use Questionnaire
POMS	Profile of Mood States
PSG	Polysomnography
PSQI	Pittsburgh Sleep Quality Index
PSS	Perceived Stress Scale
PTQ	Perseverative Thinking Questionnaire
QIDS-SR	Quick Inventory of Depressive Symptomatology-Self-Rated
REM	Rapid Eye Movement

SD	Standard Deviation
SE	Sleep Efficiency
SEES	Subjective Exercise Experience Scale
SMS	Short Message Service
SOL	Sleep Onset Latency
SOP	Standard Operating Procedure
SQQ	Sleep Quality Questionnaire
SWAN	Study of Women's Health Across the Nation
TIB	Time In Bed
TST	Total Sleep Time
UPSI	Universiti Pendidikan Sultan Idris
VLPO	Ventrolateral Preoptic Area of Hypothalamus
WASO	Wake After Sleep Onset
WHO	World Health Organization

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter presents a background on sleep quality and its related variables, specifically physical activity and mood. This chapter also discusses the concerning issues of high prevalence of physical inactivity, depression, and poor sleep quality which is common among young adults. The problem highlighted in this chapter is the limited studies which use actigraphy and diaries as measures to examine the day-to-day changes of physical activity, mood, and sleep quality among young adults. Based on the problem statement, the outlined research objectives and research questions centred on the main aim of the study which was to examine the daily changes of physical activity and mood affecting the subsequent night sleep quality among young adults, specifically undergraduate students in Malaysia. The conceptual framework of the

study was developed to clarify the relationships between the variables by grounding them in their definitions.

1.2 Background of Study

In accordance with a joint consensus statement reported by American Academy of Sleep Medicine and Sleep Research Society, the National Sleep Foundation recommended for adults aged 18 and above to sleep between seven to nine hours per day (Hirshkowitz et al., 2015; Suni & Singh, 2024; Watson et al., 2015). However, it is important to note that every individual's sleep duration may differ based on several factors such as the genetic, lifestyle, overall health, environment, and sleep patterns (Suni & Singh, 2024; Wang & Bíró, 2021; Watson et al., 2015). Sleep deprivation, when practiced on a regular basis, has been associated with many health problems including weight gain, obesity, hypertension, diabetes, heart-related diseases, depression, and anxiety (Institute for Public Health, 2024; Nurismadiana & Lee, 2018; Watson et al., 2015). Not only that, lacking sleep would also significantly impair executive functions, such as experiencing longer reaction time and making more errors, besides weaken the immune function and increase the risk of death (Skurvydas et al., 2020; Watson et al., 2015).

Past studies reported that young adults have high prevalence of sleep deprivation as they sleep less than the recommended hours (Albqoor & Shaheen, 2021; Al-Musharaf, 2022). Additionally, past studies also reported high prevalence of poor sleep quality among young adults (Farah et al., 2019; Nurismadiana & Lee, 2018; Sivertsen et al., 2019). Some contributing factors to longer sleep latency, sleep

deprivation, and poor sleep quality among young adults were physical inactivity, high sedentary time, smoking, using media devices before sleep, and stressing over academic achievements (Albqoor & Shaheen, 2021; Yuan et al., 2022). Poor sleep quality could then impact daily functioning and has been associated with the rising of many physical and psychological health concerns such as hypertension, obesity, heart-related diseases, depression, and anxiety (Al-Musharaf, 2020; Kim, 2023; Nurismadiana & Lee, 2018).

The key indicators of a good sleep quality, as recommended by National Sleep Foundation, are sleeping more time while in bed, able to fall asleep within 30 minutes or less, waking up no more than once in a night, and being awake for 20 minutes or less after initially falling asleep (Ohayon et al., 2017). There is no standard definition of sleep quality although it is a commonly used term (Krystal & Edinger, 2008; Ramlee et al., 2017). Therefore, sleep quality is defined in terms of sleep patterns or sleep parameters, rating the quality of sleep in a diary, and through objectives measures such as polysomnography and actigraphy (Krystal & Edinger, 2008).

Sleep pattern or sleep parameters includes total sleep time (TST), usually measured in hours or minutes, which is the amount of time a person is asleep. A low total sleep time may indicate that the individual had insufficient sleep which may be due to several reasons such as medical or sleep disorders, or due to the effect of taking medications. Meanwhile, long total sleep time may be due to sleep deprivation, medical conditions, or effects of consuming medications. Another sleep parameter is sleep efficiency (SE) or the percentage of total time in bed actually spent sleeping. It is calculated by summing up the time spent sleeping divided by the total time in bed and multiplied by 100. A low sleep efficiency percentage could be due to long sleep latency

and long sleep offset. Sleep onset latency (SOL) is another sleep parameter which is often measured in minutes. SOL is the time taken for the person to fall asleep for the first time since the start of the data recording or from the time the individual tries to sleep. Wake after sleep onset (WASO), one of the sleep parameters which is measured in minutes, is the period of wakefulness, starting from when they first fall asleep to when they become fully awake and do not attempt to go back to sleep. A good sleep quality is when the individual has greater total sleep time (TST), higher sleep efficiency (SE), shorter sleep onset latency (SOL), and shorter wake after sleep onset (WASO) (Carney et al., 2012; Krystal & Edinger, 2008; Shrivastava et al., 2014).

There are two types of measures for sleep quality, the objective and subjective measures. Sleep diary is one of the subjective measures of sleep quality as it is a self-reported measure that is based on the perception of the individuals on their sleep. Data from sleep diary usually consists of sleep parameters of TST, SE, time in bed (TIB), SOL, WASO, and sleep quality rating (Carney et al., 2012). Polysomnography (PSG) is one of the most commonly used objective measures in sleep studies in clinical settings. PSG involved a procedure that utilizes the use of electroencephalogram, electrooculogram, electromyogram, electrocardiogram, and pulse oximetry which are connected to the individual every night before going to sleep (Rundo & Downey, 2019). Data collected from PSG includes measures of TST, SE, WASO, sleep architecture of sleep such as the percentage or temporal amounts of stage 1 sleep, stage 2 sleep, slow wave sleep or rapid eye movement (REM) sleep, and identification of pathological events (Blackwell et al., 2008; Rundo & Downey, 2019). However, PSG as sleep measure could be invasive, costly, and disruptive to sleep with the use machineries (Blackwell et al., 2008). Another option for objective measure is by using actigraphy

which will record the sleep pattern as it happens in natural setting. Actigraphy is a lightweight and unobtrusive accelerometer which is worn on the non-dominant wrist. This device utilizes the accelerometer to collect data on movement, which is used to infer sleep-wake pattern using validated algorithm. Compared to PSG, actigraphy is less intrusive, less expensive, and can be worn for an extended period. The data obtained from actigraphy is downloaded into its software and it includes sleep parameters of TST, SOL, WASO, SE, and number of awakening (NA) (Ancoli-Israel et al., 2003; Blackwell et al., 2008; Carney et al., 2012).

To improve sleep quality, physical activity and mood are a couple of variables that were found to have effects on sleep quality. Physical activity, or any bodily movement produced by skeletal muscles which requires energy expenditure, is very important and the recommendations of exerting oneself to physical activity differs with age and capabilities (World Health Organization, 2020). World Health Organization (WHO) (2020) has recommended for healthy adults aged 18 to 64 years old to do at least 150 to 300 minutes of moderate-intensity aerobic physical activity or 75 to 150 minutes of vigorous-intensity aerobic physical activity per week. Practicing regular physical activity could contribute to significant health benefits by preventing diseases and promoting a better sleep quality (Park & Suh, 2020; World Health Organization, 2020). Physical inactivity is a global and national concern, as it is one of the leading risk factors for mortality worldwide (Institute for Public Health, 2020, 2024; World Health Organization, 2020). It can adversely affect health systems, the environment, and economic development (World Health Organization, 2020). Low physical activity, specifically among students, could be attributed to several reasons such as high

sedentary behaviour, lack of time, lack of motivation, social factors, limited sport facilities, and stress (Balhareth et al., 2021; Tao et al., 2019).

Mood, or a tendency to respond emotionally in a particular way with diffusing intensity, differ from emotion in which mood is more stable, may last for hours, days, or even weeks, perhaps at a low level and without the person knowing what prompted the state (Beedie et al., 2005). McDouall (2021) explained how cognitive functions affects mood biologically. The regulation of certain neurotransmitters, specifically serotonin and norepinephrine, affects mood and other bodily functions such as appetite, sleep, and arousal. Imbalances of these neurotransmitters might lead to mood disorders such as depression. Depression is associated with abnormalities in several parts of the brain such as the amygdala and prefrontal cortex. Amygdala is responsible in assessing stimuli and its significance in order to express emotions. Heightened activity in amygdala is highly correlated with depression, especially when the stimuli evoke negative emotion. Even though the stimuli are removed, the negative emotion may persist for some time thus affecting the mood (McDouall, 2021; Šimić et al., 2021). The prefrontal cortex is responsible for emotion regulation and control. Less activity in this part of brain usually occurs among depressed individuals. The prefrontal cortex can affect the amygdala in which when negative stimuli is presented to depressed individuals and their prefrontal cortex could not function properly to regulate the emotion, the negative emotion evoked by the amygdala may lead to heightened negative mood states (McDouall, 2021).

Mood exists as a positive or as a negative affect state (Reeve, 2018). These two moods are independent and not opposite ways of feeling. They can co-exist at the same

time, for example, an individual can feel happy yet nervous when expecting good news. Positive affect is the low-level state of feeling good that individual experience every day. Individuals experiencing high positive affect typically feel enthusiastic, energized, alert, and optimistic, while those with low positive affect tend to feel lethargic, apathetic, and bored. On the other hand, negative affect represents a state of unpleasant engagement, where individuals with high negative affect often feel dissatisfied, nervous, and irritable, whereas those with low negative affect are generally calm and relaxed (Reeve, 2018). Mood directly impacts both mental and physical health, influencing conditions such as depression, anxiety, cardiovascular disease, addiction, psychological resilience, cognitive performance, aging and longevity (Bar, 2009; Shorofi et al., 2021; Triantafillou et al., 2019). It is recommended that individuals with depressed mood, lost interest and enjoyment, reduced concentration, reduced self-esteem, have ideas of self-harm or suicidal thought, and/or disturbed sleep and appetite to consult with medical officers for depression related concern (Institute for Public Health, 2020).

The high prevalence of poor sleep quality among young adults is concerning as it could impact their daily lives in many ways. Therefore, the current study examined the temporal effect of physical activity and mood on sleep quality among young adults, specifically undergraduate students in Malaysia. The current study also utilised both subjective (i.e., sleep diary) and objective (i.e., actigraphy) measures of sleep quality.

1.3 Problem Statement

Young adults, specifically undergraduate students, should have a good night's sleep quality with sleep duration of about seven to nine hours daily in order to maintain good health and improve academic performance. Contradicting the ideal situation, several studies reported high prevalence of poor sleep quality and sleep deprivation among young adults in Malaysia (Farah et al., 2019; Institute for Public Health, 2024; Nurismadiana & Lee, 2018; Tien Ngu et al., 2017). This could be due to several reasons including physical inactivity and mood disturbance as past studies found that there are associations between physical activity and mood with sleep quality. Physical activity was found to be positively correlated with sleep quality in which when compared with sedentary group, the group with moderate physical activity had better sleep quality, earlier sleep onset, longer sleep duration, and higher sleep maintenance efficiency (Master et al., 2019; Park & Suh, 2020). Meanwhile, mood was reported to have complex bidirectional associations with sleep quality in which the mood could affect the subsequent night sleep quality which in turn affect the next day mood (Shorofi et al., 2021; Triantafillou et al., 2019).

Globally, WHO (2020) revealed that 28% of adults aged 18 and above were physically inactive in which they did not meet the recommended level of physical activity. It was reported that this issue of inactivity is due to lack of activity during leisure time and sedentary behaviour on the job and while at home, and the "passive" modes of transportation (World Health Organization, 2020). In the 2023 NHMS, it was reported that 1 in 3 adults (29.9%) were physically inactive (Institute for Public Health, 2024). This was an increase from 2019 NHMS which reported 1 in 4 adults (25.0%)

were physically inactive with 38% of them were young adults aged between 20 to 30 years old (Institute for Public Health, 2020). In the same report in 2023 survey, 1 in 2 adults in Malaysia led sedentary lifestyles by spending more than two hours either reclining, sitting, or lying down while awake (Institute for Public Health, 2024). Physical inactivity is the fourth leading risk factor for global mortality and has adverse effects on health systems, the environment, economic development, community well-being, and overall quality of life (World Health Organization, 2020). As physical activity was closely associated with sleep quality, this study examined the temporal effect of physical activity on sleep quality among young adults in Malaysia.

The 2019 NHMS revealed that the prevalence of depression among Malaysian adults aged 18 and above are 2.3% with 35% of them are young adults, age 20 to 30 years old, and 11% are students (Institute for Public Health, 2020). Even more concerning, the prevalence doubled in less than five years as the recent 2023 NHMS reported 4.6% people in Malaysia have depression (Institute for Public Health, 2024). Mood has effects on mental and physical health in which mood disturbance could lead to depression or anxiety, cardiovascular disease, addiction, psychological resistance, cognitive performance, aging and longevity (Bar, 2009; Shorofi et al., 2021; Triantafillou et al., 2019). With the high prevalence of depression among young adults as shown by the NHMS surveys, this study investigated the effects of mood disturbance, which is one of the causes of depression, on sleep quality among the current studied population of young adults.

The present study examined physical activity and mood as factors that influence sleep quality. The existing evidence from past studies, however, was largely based on

between-subjects design instead of within-subjects design. Besides, past research examining the temporal associations between the variables of physical activity and mood with sleep quality using multiple days of actigraphy data and diary among young adults were also limited (Master et al., 2019; Triantafillou et al., 2019). Therefore, the objectives of the present study were to examine the current sleep parameters, level of physical activity, and within-subject temporal association between physical activity and mood with sleep quality among young adults. The within-subject design was chosen to reduce variability and make it easier to detect the effects of independent variables of physical activity and mood on dependent variable of sleep quality. The data of participants' characteristics were collected using a set of questionnaires, while participants' physical activity, mood, and sleep quality for seven days were recorded using an actigraphy, mood diary, and sleep diary. Replicating and extending the study in Malaysian population could give an implication in understanding the prevalence of sleep quality in Malaysia and factors affecting it.

The study also examined the differences between two different measurements of sleep parameters (i.e., the actigraphy and the sleep diary). The use of both subjective measure (i.e., sleep diary) and objective measure (i.e., actigraphy) provided information about the variability of sleep patterns as well as the degree and pattern of discrepancy between these different types of assessment (Smith et al., 2018). Past studies comparing objective and subjective measures of sleep quality have highlighted significant differences in estimating sleep parameters like sleep duration, sleep efficiency, and sleep onset latency. Subjective measures of sleep such as self-reported questionnaire and sleep diaries were reported to be overestimating sleep duration (Matthews et al., 2018), sleep efficiency, and time spent in bed, and underestimating sleep latency and

wake after sleep onset when compared objective measures such as polysomnography and actigraphy (Lehrer et al., 2022). These differences indicated that different sleep measurements could significantly influence the results and interpretation in sleep studies. Therefore, the current study utilised the use of actigraphy as objective measure and sleep diary as subjective measure to compare the two different measures of sleep quality in measuring sleep parameters of TST, SE, and SOL.

1.4 Objective of Study

The present study aimed to examine the within-subject temporal effect of physical activity and mood affecting subsequent night sleep quality which was measured using actigraphy and sleep diary. The sleep quality was based on the sleep parameters of total sleep time (TST), sleep efficiency (SE), and sleep onset latency (SOL). The study also examined the differences between objective (i.e., actigraphy) and subjective (i.e., sleep diary) measures of sleep quality. The detailed objectives of the present study are as followed:

1. to examine the current sleep pattern among young adults.
2. to examine the current overall level of physical activity among young adults.
3. to examine the temporal effect of physical activity affecting total sleep time (TST-Actigraphy) on the subsequent night.
4. to examine the temporal effect of physical activity affecting sleep efficiency (SE-Actigraphy) on the subsequent night.
5. to examine the temporal effect of physical activity affecting sleep onset latency (SOL-Actigraphy) on the subsequent night.

6. to examine the temporal effect of physical activity affecting total sleep time (TST-Sleep Diary) on the subsequent night.
7. to examine the temporal effect of physical activity affecting sleep efficiency (SE- Sleep Diary) on the subsequent night.
8. to examine the temporal effect of physical activity affecting sleep onset latency (SOL- Sleep Diary) on the subsequent night.
9. to examine the temporal effect of physical activity affecting sleep quality rating measured from sleep diary on the subsequent night.
10. to examine the temporal effect of mood disturbance affecting total sleep time (TST-Actigraphy) on the subsequent night.
11. to examine the temporal effect of mood disturbance affecting sleep efficiency (SE-Actigraphy) on the subsequent night.
12. to examine the temporal effect of mood disturbance affecting sleep onset latency (SOL-Actigraphy) on the subsequent night.
13. to examine the temporal effect of mood disturbance affecting total sleep time (TST-Sleep Diary) on the subsequent night.
14. to examine the temporal effect of mood disturbance affecting sleep efficiency (SE- Sleep Diary) on the subsequent night.
15. to examine the temporal effect of mood disturbance affecting sleep onset latency (SOL- Sleep Diary) on the subsequent night.
16. to examine the temporal effect of mood disturbance affecting sleep quality rating measured from sleep diary on the subsequent night.
17. to examine the temporal effect of overall mood rating affecting total sleep time (TST-Actigraphy) on the subsequent night.

18. to examine the temporal effect of overall mood rating affecting sleep efficiency (SE-Actigraphy) on the subsequent night.
19. to examine the temporal effect of overall mood rating affecting sleep onset latency (SOL-Actigraphy) on the subsequent night.
20. to examine the temporal effect of overall mood rating affecting total sleep time (TST-Sleep Diary) on the subsequent night.
21. to examine the temporal effect of overall mood rating affecting sleep efficiency (SE- Sleep Diary) on the subsequent night.
22. to examine the temporal effect of overall mood rating affecting sleep onset latency (SOL- Sleep Diary) on the subsequent night.
23. to examine the temporal effect of overall mood rating affecting sleep quality rating measured from sleep diary on the subsequent night.
24. to examine the differences between actigraphy and sleep diary in measuring sleep parameters of TST, SE, and SOL.

1.5 Research Questions

From this study, the research questions raised are,

1. What are the current sleep patterns (total sleep time, sleep efficiency, sleep onset latency, and sleep quality rating) among young adults?
2. What is the current overall level of physical activity among young adults?
3. Is there a temporal effect of physical activity on total sleep time (TST-Actigraphy) on the subsequent night?

4. Is there a temporal effect of physical activity on sleep efficiency (SE-Actigraphy) on the subsequent night?
5. Is there a temporal effect of physical activity on sleep onset latency (SOL-Actigraphy) on the subsequent night?
6. Is there a temporal effect of physical activity on total sleep time (TST-Sleep Diary) on the subsequent night?
7. Is there a temporal effect of physical activity on sleep efficiency (SE- Sleep Diary) on the subsequent night?
8. Is there a temporal effect of physical activity on sleep onset latency (SOL- Sleep Diary) on the subsequent night?
9. Is there a temporal effect of physical activity on sleep quality rating measured by sleep diary on the subsequent night?
10. Is there a temporal effect of mood disturbance on total sleep time (TST-Actigraphy) on the subsequent night?
11. Is there a temporal effect of mood disturbance on sleep efficiency (SE-Actigraphy) on the subsequent night?
12. Is there a temporal effect of mood disturbance on sleep onset latency (SOL-Actigraphy) on the subsequent night?
13. Is there a temporal effect of mood disturbance on total sleep time (TST-Sleep Diary) on the subsequent night?
14. Is there a temporal effect of mood disturbance on sleep efficiency (SE- Sleep Diary) on the subsequent night?
15. Is there a temporal effect of mood disturbance on sleep onset latency (SOL-Sleep Diary) on the subsequent night?

16. Is there a temporal effect of mood disturbance on sleep quality rating measured by sleep diary on the subsequent night?
17. Is there a temporal effect of overall mood rating on total sleep time (TST-Actigraphy) on the subsequent night?
18. Is there a temporal effect of overall mood rating on sleep efficiency (SE-Actigraphy) on the subsequent night?
19. Is there a temporal effect of overall mood rating on sleep onset latency (SOL-Actigraphy) on the subsequent night?
20. Is there a temporal effect of overall mood rating on total sleep time (TST-Sleep Diary) on the subsequent night?
21. Is there a temporal effect of overall mood rating on sleep efficiency (SE- Sleep Diary) on the subsequent night?
22. Is there a temporal effect of overall mood rating on sleep onset latency (SOL-Sleep Diary) on the subsequent night?
23. Is there a temporal effect of overall mood rating on sleep quality rating measured by sleep diary on the subsequent night?
24. Are there differences between actigraphy and sleep diary in measuring sleep parameters of TST, SE, and SOL?

1.6 Hypotheses

From the variables involved in this study, the researcher comes out with several hypotheses to predict the outcome of the study. Below are the hypotheses developed by the researcher.

1. $H_1$1: Individuals who have higher physical activity will be more likely to have greater total sleep time (TST-Actigraphy) on the subsequent night.
2. $H_1$2: Individuals who have higher physical activity will be more likely to have higher sleep efficiency (SE-Actigraphy) on the subsequent night.
3. $H_1$3: Individuals who have higher physical activity will be more likely to have shorter sleep onset latency (SOL-Actigraphy) on the subsequent night.
4. $H_1$4: Individuals who have higher physical activity will be more likely to have greater total sleep time (TST-Sleep Diary) on the subsequent night.
5. $H_1$5: Individuals who have higher physical activity will be more likely to have higher sleep efficiency (SE-Sleep Diary) on the subsequent night.
6. $H_1$6: Individuals who have higher physical activity will be more likely to have shorter sleep onset latency (SOL-Sleep Diary) on the subsequent night.
7. $H_1$7: Individuals who have higher physical activity will be more likely to have higher sleep quality rating measured by sleep diary on the subsequent night.
8. $H_1$8: Individuals who have lower mood disturbance will be more likely to have greater total sleep time (TST-Actigraphy) on the subsequent night.
9. $H_1$9: Individuals who have lower mood disturbance will be more likely to have higher sleep efficiency (SE-Actigraphy) on the subsequent night.
10. $H_1$10: Individuals who have lower mood disturbance will be more likely to have shorter sleep onset latency (SOL-Actigraphy) on the subsequent night.
11. $H_1$11: Individuals who have lower mood disturbance will be more likely to have greater total sleep time (TST-Sleep Diary) on the subsequent night.
12. $H_1$12: Individuals who have lower mood disturbance will be more likely to have higher sleep efficiency (SE-Sleep Diary) on the subsequent night.

13. $H_1$13: Individuals who have lower mood disturbance will be more likely to have shorter sleep onset latency (SOL-Sleep Diary) on the subsequent night.
14. $H_1$14: Individuals who have lower mood disturbance will be more likely to have higher sleep quality rating measured by sleep diary on the subsequent night.
15. $H_1$15: Individuals who have higher overall mood rating will be more likely to have greater total sleep time (TST-Actigraphy) on the subsequent night.
16. $H_1$16: Individuals who have higher overall mood rating will be more likely to have higher sleep efficiency (SE-Actigraphy) on the subsequent night.
17. $H_1$17: Individuals who have higher overall mood rating will be more likely to have shorter sleep onset latency (SOL-Actigraphy) on the subsequent night.
18. $H_1$18: Individuals who have higher overall mood rating will be more likely to have greater total sleep time (TST-Sleep Diary) on the subsequent night.
19. $H_1$19: Individuals who have higher overall mood rating will be more likely to have higher sleep efficiency (SE-Sleep Diary) on the subsequent night.
20. $H_1$20: Individuals who have higher overall mood rating will be more likely to have shorter sleep onset latency (SOL-Sleep Diary) on the subsequent night.
21. $H_1$21: Individuals who have higher overall mood rating will be more likely to have higher sleep quality rating measured by sleep diary on the subsequent night.
22. $H_1$22: There are differences between actigraphy and sleep diary in measuring sleep parameters of TST, SE, and SOL.

1.7 Conceptual Framework

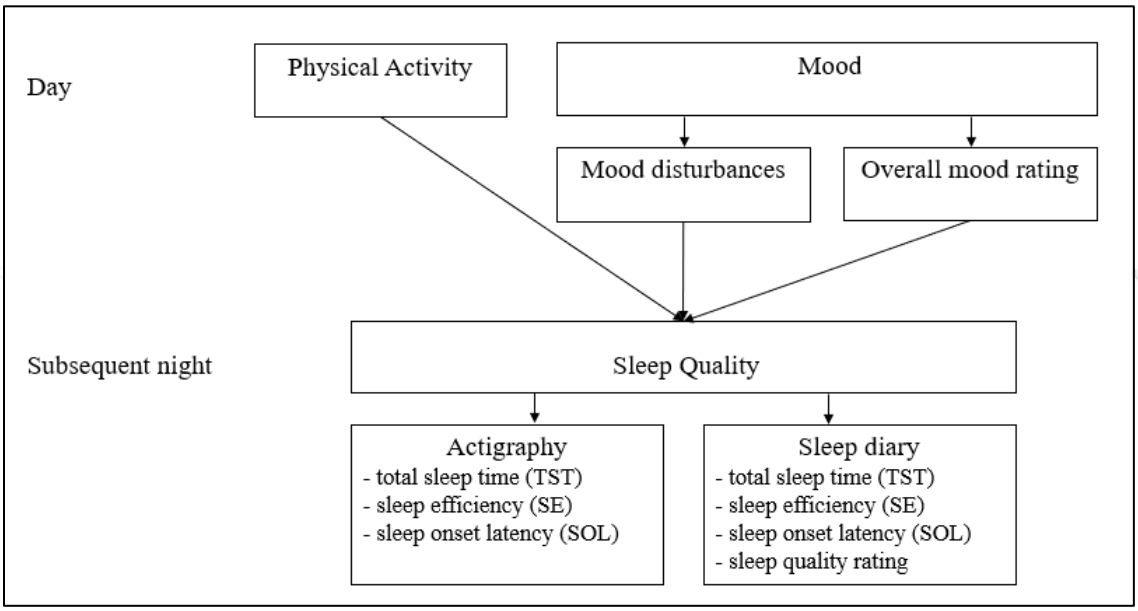
The conceptual framework, as shown by Figure 1.1, is a general figure of the correlation between the variables of physical activity, mood, and sleep quality that were observed and assessed in this study. The conceptual framework for this study is the result of synthesizing insights from Harvey's Cognitive Model of Insomnia, Morin's Model, Spielman's Model of Insomnia, and Neurocognitive Theory of Insomnia, which are extensively discussed in Chapter 2. Together, these models provide a comprehensive understanding of how cognitive, biological, psychological, social, and behavioural factors contribute to the development and maintenance of insomnia. Harvey's and Morin's models emphasize the role of cognitive and emotional factors, such as mood disturbances and maladaptive thought patterns, in perpetuating poor sleep quality. Spielman's model highlights predisposing, precipitating, and perpetuating factors, including behavioural and environmental influences. The Neurocognitive Theory further underscores the biological and neurophysiological mechanisms underlying insomnia. By integrating these perspectives, the framework offers a multidimensional view of how physical activity and mood interact to influence sleep quality, recognizing their connections to broader cognitive and behavioural processes.

Physical activity and mood were two independent variables in this study, while sleep quality was the dependent variable. Mood was further distinguished into two, namely mood disturbance and overall mood rating. Sleep quality was measured using two different measures in which the actigraphy provided data of sleep parameters of TST, SE, and SOL while sleep diary provided data of all three parameters with an additional data of sleep quality rating. The study examined the temporal effect of

physical activity affecting sleep quality on the subsequent night, the temporal effect of mood disturbance affecting sleep quality on the subsequent night, and the temporal effect of overall mood rating affecting sleep quality on the subsequent night. The study also examined the differences between two measurements of sleep quality, namely the actigraphy and sleep diary, in measuring sleep parameters of TST, SE, and SOL.

Figure 1.1

Conceptual framework



1.8 Definition of Variables

The variables involved in this study were physical activity, mood, and sleep quality. Each variable was defined conceptually and operationally. Conceptual definition explained the variables in term of "what" exactly the variables that were measured and

observed in this study. Meanwhile, operational definition provided information on "how" the variables were identified, measured, and assessed.

1.8.1 Conceptual definition of physical activity

Physical activity is defined as any movement of the body generated by the contraction of skeletal muscles that requires energy expenditure exceeding resting metabolic rate (Caspersen et al., 1985). It is characterized by its modality, intensity, frequency, duration, and context of practice (World Health Organization, 2020). All movement during leisure time, transporting to-and-fro places, or as part of work processes are referred as physical activity (World Health Organization, 2022). Piggin (2020) provided a broader definition of physical activity as involving movement, action, and behaviours of individuals within culturally specific environments and contexts, shaped by particular interests, emotions, ideas, instructions, and social relationships. The later definition was explained as being more inclusive of biomechanical, physiological, cognitive, affective, situated, social, cultural, and political aspects of physical activity. The focus was more on people moving instead of the action and reaction of muscles (Piggin, 2020).

1.8.2 Operational definition of physical activity

Physical activity was operationally defined as the scores obtained from Global Physical Activity Questionnaire (GPAQ; Armstrong & Bull, 2006) and actigraphy (Model/

brand: Actigraphy Actiwatch 2 by Philips). GPAQ classified level of physical activity of low, moderate, and high based on the total Metabolic Equivalents (MET) value (in minutes) in a week. MET value represents the ratio of a person's working metabolic rate compared to their resting metabolic rate, with one MET equivalent to burning 1 kcal/kg/hour. It is estimated that compared to sitting quietly, a person burns calories at a rate four times higher when engaged in moderate activity and eight times higher during vigorous activity. Therefore, moderate activity is assigned a value of 4 METs, while vigorous activity is assigned 8 METs (Ainsworth et al., 2011; Armstrong & Bull, 2006). Based on the total MET minutes a week, the scores will classify the participants into three categories of low (< 600 MET), moderate (≥ 600 or < 3000 MET), and high (≥ 3000 MET) physical activity level (*Global Physical Activity Questionnaire (GPAQ) Analysis Guide*, n.d.). Actigraphy is a device that has built-in well-engineered sensors such as accelerometer and light receptor that collect data on physical activity through physical motion detected (Fekedulegn et al., 2020). The actigraphy was worn on non-dominant hand for seven days continuously and automatically recorded daily physical activity at 30-seconds epoch or every 30 seconds. The data collected, of activity count per minute, were analysed to obtain participants' overall level of physical activity.

1.8.3 Conceptual definition of mood

Mood is defined as a group of persisting feelings linked with evaluative and cognitive states, which influence future emotions, judgments, and behaviours (Amado-Boccara et al., 1993). Mood can also be defined as a tendency to respond emotionally in a particular way with diffusing intensity and is different from emotion in which mood is

more stable, may last for hours, days, or even weeks, perhaps at a low level, and arises from different antecedent causes usually without the person knowing what prompted the state (Beedie et al., 2005; Reeve, 2018). Lischetzke and Könen (2021) defined mood as affective states that are diffuse, not concentrated, not directed toward a specific object, and are continually present in the background of experiences but fluctuate over time. Mood has different action-specificity as compared to emotions in which emotions mostly influence behaviour, directed towards specific courses of action, and occur in phases rather than continuously, while mood influence cognition and direct thoughts and are almost always present in the background of consciousness (Lischetzke & Könen, 2021; Reeve, 2018).

1.8.4 Operational definition of mood

Mood was distinguished into two, mood disturbance and overall mood rating. Mood disturbance was operationally defined by the scores of Profile of Mood States (POMS; McNair et al., 1971) which was adapted into mood diary. The mood diary was filled at night before going to sleep based on the mood during the whole day. POMS assesses six mood subscales of tension-anxiety, depression, anger-hostility, vigour, fatigue, and confusion. The total mood disturbance score was computed by adding the five negative subscale scores of tension-anxiety, depression, anger-hostility, fatigue, and confusion, and subtracting the vigour score. Higher scores for the total mood disturbance score indicate a greater degree of mood disturbance. One item added into the mood diary asked about overall mood rating, “How would you rate your mood?” in which it was

rated from 0 to 10. 0 indicated a very poor overall mood during the day and 10 indicated a very good mood during the day, thus higher scores indicated a better mood.

1.8.5 Conceptual definition of sleep quality

Sleep quality is a commonly use term, however, there is no standard definition of sleep quality in sleep studies (Krystal & Edinger, 2008; Ramlee et al., 2017). Sleep quality is defined as feeling rested on waking, feeling restored on waking, and feeling alert throughout the day (Harvey et al., 2008). Similarly, Kline (2013) define sleep quality as an individual's overall satisfaction with their sleep experience, encompassing factors such as sleep initiation, sleep maintenance, sleep quantity, and refreshment upon awakening. In sleep studies, sleep quality is defined in terms of rating the quality of sleep in a diary, a collection of patterns of sleep measures or parameters, and through objectives measures such as polysomnography and actigraphy (Krystal & Edinger, 2008). Based on a concept analysis by Nelson et al. (2022), they defined sleep quality as satisfaction with aspects of sleep experience which include sleep efficiency, sleep onset latency, wake after sleep onset, and sleep architecture that can be measured. The National Sleep Foundation also defined sleep quality as good sleep continuity with the elements of sleep latency (amount of time to fall asleep), wake time after sleep onset (amount of time awake at night), and sleep efficiency (proportion of the time in bed spent sleeping). Thus, the indicators of good sleep quality for all age groups are having shorter sleep latencies, fewer awakenings, reduced wake after sleep onset, and higher sleep efficiency (Ohayon et al., 2017).

1.8.6 Operational definition of sleep quality

Sleep quality was operationally defined by the data obtained from sleep diary and actigraphy which were sleep parameters of total sleep time (TST), sleep efficiency (SE), sleep onset latency (SOL), and sleep quality rating. TST is the amount of time a person is asleep, SE is the percentage of total time in bed actually spent sleeping, SOL is the time taken the person to fall asleep for the first time since the start of the data recording, and sleep quality rating is the rate, from 0 (very poor) to 10 (very good), given based on sleep experience. In sleep studies, there are two types of measures for sleep quality, the objective and subjective measures. The current study used actigraphy as the objective measure of sleep quality. Actigraphy automatically recorded the sleep-wake pattern as it happens and was worn continuously for seven days during the study period. The actigraphic data provided included sleep parameters of TST, SE, and SOL. Additionally, the current study also used sleep diary as subjective measures of sleep quality which adapted contents of the Consensus Sleep Diary (CSD; Carney et al., 2012). The sleep diary was a self-reported measure based on what the individual perceives of their sleep. Data from the sleep diary included sleep parameters of TST, SE, SOL, and sleep quality rating. The sleep diary was filled upon waking up in the morning based on the experience of sleep of the previous night.

1.9 Significance of Study

The findings in this study might be fundamental for future studies involving the variables of physical activity, mood, and sleep quality. Methodologically, the different

study design of longitudinal research design using a within-subject daily process research method adapted in this study provided different but significant findings compared to other studies with cross-sectional study design especially with the use of actigraphy to measure physical activity, mood diary to record mood, and actigraphy and sleep diary as instruments to measure sleep quality. The advantages of daily process study are the ability to have data as closely as possible to its occurrences or changes, could reduce biases such as recall bias, and identify the temporal association between variables across days within an individual instead of across groups of people in naturalistic settings which strengthen the causal inference when analysed (Affleck et al., 1999; Tang et al., 2012). As the current study was conducted for seven days, this method was the best suited to observe, measure, and record the changes of all three variables of physical activity, mood, and sleep quality as its occurrence.

The findings could also be beneficial to researchers in sleep studies. The current study utilises two different measures of sleep quality that are commonly used in this field, namely actigraphy and sleep diary. Combining these instruments could provide a comprehensive understanding of sleep quality. Actigraphy provides objective, unbiased data by monitoring sleep-wake patterns through movement while sleep diary is based on subjective perceptions of sleep experiences. Moreover, the current study examines whether there are discrepancies between these two measures of sleep quality. Identifying these differences might help to uncover factors that affect sleep quality such as mood disturbance and perception biases. The findings of this study also shed light on the current sleep patterns among young adults, highlighting potential impacts on daily lives, especially when sleep duration and quality fall short of recommended standard.

As the study involved young adults, the findings contributed to the widespread importance of practicing regular physical activity and mood regulation in order to have good quality of sleep among the population. From the findings, awareness could be raised on practicing physical activity as recommended by WHO and influence young adults to live a healthier lifestyle. This study's objectives were also in line with the guidance released by the Institute for Public Health (2020) which recommended the promotion and enhance awareness on the issue of depression, improve the public understanding on mental health programs, and increase intervention programs focusing on mental health. Economically, when the public is more aware of the importance of the issue of poor sleep quality, more people will seek professionals in order to help them cope if they have serious problem such as having insomnia and thus, they will seek medical attention. This is especially important since many sleep problems among young adults are not diagnosed at the early stage. Studies have shown that any undiagnosed and untreated sleep disturbance at the early stage could be harmful for young adults' mental and physical health and performance (Chervin et al., 2001; Kumar, 2008; Lewandowski et al., 2011; Palatty et al., 2011). In addition, people will invest more to have an active lifestyle such as buying equipment to exercise, spending on gym membership, or as simple as buying suitable attire to do physical activity. These would help to improve the economic-wise in the field of medical, psychological treatment, and sports-related field.

Therefore, the study will not only benefit other researchers but also the public based on the findings of the effect of physical activity on sleep quality, and the effect of mood on sleep quality. Significant results from this study could benefit young adults in the long run by promoting healthy lifestyles and encouraging them to engage in

regular physical activity and work on mood regulation, thus improving sleep quality. Additionally, the researchers in sleep studies could benefit from the findings of comparing objective and subjective measures of sleep quality when deciding on the instruments that will be used in future studies.

1.10 Conclusion

This chapter starts with a brief introduction on sleep quality and how it is measured, specifically on the use of objective and subjective measures of sleep quality. This chapter also presents the intertwining associations between physical activity and mood with sleep quality. Next, the research objectives and research questions were refined to fill in the gaps from the stated problem statement. Based on the research objectives and the definition of each variable, the conceptual framework was outlined to illustrate the expected relationship between the variables. In the next chapter, the theories behind the relationship between the studied variables are presented. Additionally, the next chapter also presents the reviewed past studies that were conducted to investigate the relationship between physical activity and mood with sleep quality using different approaches and on a variety of populations.