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EFFECTS OF DIFFERENT PHASES OF MENSTRUAL CYCLE ON DAYTIME DROWSINESS
AND MUSCULAR FATIGUE AMONG FEMALE RECREATIONAL BADMINTON PLAYER

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EFFECTS OF DIFFERENT PHASES OF MENSTRUAL CYCLE ON DAYTIME DROWSINESS AND MUSCULAR FATIGUE AMONG FEMALE RECREATIONAL BADMINTON PLAYER

By

LEE KAE SHYAN

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EFFECTS OF DIFFERENT PHASES OF MENSTRUAL CYCLE ON DAYTIME DROWSINESS AND MUSCULAR FATIGUE AMONG FEMALE RECREATIONAL BADMINTON PLAYER

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ABSTRACT

Background and Objective: The menstrual cycle (MC), a monthly event in females, involves hormonal fluctuations that may cause daytime drowsiness and muscular fatigue, impacting sports performance and injury risk. This study utilized the Epworth Sleepiness Scale and Sleep Diary to assess sleep efficacy, the Countermovement Jump (CMJ) to evaluate muscular fatigue, and the Wellness Questionnaire to measure perceived fatigue. The objective was to compare and explore the relationship between MC phases, daytime drowsiness, and muscular fatigue in female recreational badminton players.

Methods: This cross-sectional observational study recruited 31 eumenorrheic female recreational badminton players via convenience sampling. Participants self-reported their menstruation dates and completed 5 countermovement jump tests, along with questionnaires (Epworth Sleepiness Scale [ESS], Wellness Questionnaire, and Sleep Diary). Data were collected based on estimated menstrual cycle subphases using a calendar-based method: Early and late follicular, ovulation, mid and late luteal phases. Repeated ANOVA was used to analyze the comparison of collected data.

Results: Data from 31 participants showed that daytime drowsiness was highest during the EF phase, followed by LL, LF, ML, and OP phases. Muscular fatigue was unaffected by the menstrual cycle, and no association was found between daytime drowsiness and muscular fatigue. Perceived fatigue correlated with daytime drowsiness, particularly in the EF and LL phases, but was unrelated to muscular fatigue.

Conclusion: Eumenorrheic female recreational badminton players are more likely to experience daytime drowsiness during the EF and LL phases. Muscular fatigue is unaffected by MC hormonal events and shows no correlation with daytime drowsiness. Perceived fatigue aligns with daytime drowsiness during EF and LL phases but not muscular fatigue. Coaches and athletes are advised to create personalized training programs to minimize injury risks and optimize performance during advantageous phases.

Keywords: Early follicular phase, Late follicular phase, Ovulation, Mid luteal phase, Late luteal phase, Daytime drowsiness, Muscular fatigue, Countermovement jump, Female recreational badminton players

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has been a driving force and boost up my confidence, and I am truly blessed to have you by my side.

APPROVAL SHEET

This research project entitled **"EFFECTS OF DIFFERENT PHASES OF MENSTRUAL CYCLE ON DAYTIME DROWSINESS AND MUSCULAR FATIGUE AMONG FEMALE RECREATIONAL BADMINTON PLAYER"** was presented by LEE KAE SHYAN and submitted as partial fulfilment of the requirements for the degree of Bachelor of Physiotherapy (HONOURS) at Universiti Tunku Abdul Rahman.

Approved by:

Date: 20th Dec 2024

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PERMISSION SHEET

It is hereby certified that **LEE KAE SHYAN** (ID No: **21UMB03133**) has completed this Research project entitled "EFFECTS OF DIFFERENT PHASES OF MENSTRUAL CYCLE ON DAYTIME DROWSINESS AND MUSCULAR FATIGUE AMONG FEMALE RECREATIONAL BADMINTON PLAYER" under the supervision of DR. MUHAMAD NOH ZULFIKIR BIN MOHD JAMALI (Supervisor) and MR. TARUN AMALNERKAR (Co-Supervisor) from the Department of Physiotherapy, M. Kandiah Faculty of Medicine and Health sciences.

Yours truly,

(LEE KAE SHYAN)

DECLARATION

I hereby declare that the Research project is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UTAR or other institutions.

Name: LEE KAE SHYAN

Date: 20th Dec 2024

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LIST OF ABBREVIATIONS

MC	Menstrual Cycle
UTAR	Universiti Tunku Abdul Rahman
ESS	Epworth Sleepiness Scale
CMJ	Countermovement Jump
EF	Early Follicular Phase
LF	Late Follicular Phase
OP	Ovulation Phase
ML	Mid Luteal Phase
LL	Late Luteal Phase
SERC	Scientific and Ethical Review Committee
M	Mean
SD	Standard Deviation
PMS	Premenstrual Syndrome

CHAPTER 1

INTRODUCTION

1.1 Chapter Overview

This chapter is about the introduction of the research program with the tittle "EFFECTS OF DIFFERENT PHASES OF MENSTRUAL CYCLE ON DAYTIME DROWSINESS AND MUSCULAR FATIGUE AMONG FEMALE RECREATIONAL BADMINTON PLAYER". It will be covering the background of the badminton in Malaysia, menstrual cycle as a risk of injuries, prevalence and risk factors of badminton, problem statement, study objective, hypothesis, operational definition, rational and scope of the study.

1.2 Background

1.2.1 Background of Badminton in Malaysia

Badminton is a fast-paced and power-intensive court-based racquet sport played either as singles or doubles. The game requires a racket, a shuttlecock, and a rectangular court. In Malaysia, the Badminton Association of Malaysia (BAM) is registered under the Sports Development Act 1997 and is affiliated with the Badminton World Federation (BWF), Badminton Asia Confederation (BAC), and the Olympic Council of Malaysia. BAM's vision is to elevate badminton as a popular and dynamic sport that fosters social progress and contributes to nation-building. Their mission includes governing, supporting, and promoting badminton across the country. Recreational badminton players play a crucial role in supporting BAM's vision and goals (Adilah, 2015).

1.2.2 Menstrual Cycle as a Risk of Injuries

Menstrual cycle, the fluctuation of the hormones event might influence sleepiness and may lead to muscular fatigue and decreased performance. These are unwanted signs and symptoms but unavoidable to occur among some of the female players. The two primary female endogenous hormones which are estrogen and progesterone that mainly cause the incident (Carmichael et.al., 2021). Both are the main hormones that regulate anatomy structure, physiology function, mood and thermoregulation which are also closely related to sleepiness and muscular fatigue (Carmichael et al., 2021). Sleep quality is one of the crucial criteria to have an optimum sport performance as it is potentially leading to daytime drowsiness. With better management of daytime drowsiness, cognition and decision making can be enhanced in sports and reduce the risk of injuries that result from muscular fatigue (Morales et al, 2023).

1.2.3 Prevalence and Risk Factors of Badminton

Badminton is considered as the fastest racket game with multidirectional maneuver and jump-landing movements. All of the movements require a high level of muscle strength, musculoskeletal proprioception and neuromuscular control. The risk of injuries that are found in recreational badminton players are related to upper and lower limbs (Loiseau-Taupin et.al, 2021). Badminton is an overhead exercise such as smashing technique (Loiseau-Taupin et.al, 2021). It required large energy expenditure and shoulder biomechanical complex events and thus it tends to overuse injuries such as shoulder pain due to subacromial impingement, instability or dyskinesia of the scapulothoracic joint (Arora et.al, 2015). Moreover, most of the injuries are found in lower limbs in badminton games such as ACL injury, foot and ankle sprains (Alikhani et. al, 2019). Both poor knee proprioception and dynamic balance are the potential reasons to cause ACL injury in badminton (Alikhani et. al, 2019).

Other than biological anatomical structures, muscular fatigue also increases the risk of injury among badminton players (Loiseau-Taupin et.al, 2021). Muscular fatigue declines in physical performance accompanied by an increase in the perceived or actual difficulty of an activity by reducing the cognition between visual and motor control (Loiseau-Taupin et.al, 2021). During the early follicular phase and late luteal, the female players may face changes in training and competition performances due to fatigue (Loiseau-Taupin et.al, 2021). When the early follicular phase begins (menses), the muscle soreness onset will be further delayed and the performance will slightly reduce (Carmichael et al., 2021). This will further increase the risk of injury.

1.3 Problem Statement

The impact of the menstrual cycle on physical and cognitive performance is an area of growing interest, yet research remains limited on the specific interplay between daytime drowsiness and muscular fatigue across different phases of the menstrual cycle (MC). Despite evidence suggesting that daytime drowsiness may exacerbate muscular fatigue—leading to diminished muscle strength, reduced power, and an increased risk of injury—current findings are inconsistent and often contradictory, especially in the context of training programs for female athletes. This gap in understanding poses significant challenges for optimizing training strategies and maintaining the well-being of female players. Daytime drowsiness not only affects athletic performance but also influences overall quality of life, making it a critical concern for recreational badminton players aiming to compete. However, little is known about how variations in MC phases influence these parameters, nor how these influences translate into practical recommendations for training schedules. The absence of conclusive evidence limits the ability to design tailored training regimens that accommodate the physiological and psychological changes experienced by female athletes. This study aims to address this gap by investigating the relationship between daytime drowsiness and muscular fatigue on different phases of the MC among female recreational badminton players. Using validated tools such as the Epworth Sleepiness Scale, sleep diaries, wellness questionnaires, and objective measures of muscular fatigue (CMJ test), this research seeks to provide robust insights into these interactions. This knowledge will contribute to a more inclusive and scientifically grounded approach to athletic training for women, ensuring their physiological needs are adequately met.

1.4 Research Question

- What are the differences on daytime drowsiness on different phase MC (EF, LF, OP, ML and LL phases) among recreational female badminton players?
- What are the differences on muscular fatigue on different phases of MC (EF, LF, OP, ML and LL phases) among recreational female badminton players?

- What are the relationships on the incidents of daytime drowsiness and muscular fatigue across the 5 phases of the MC?

1.5 Study Objective

1. To compare the daytime drowsiness on different phases of MC (EF, LF, OP, ML and LL phases) among recreational female badminton players.

2. To compare the muscular fatigue on different phases of MC (EF, LF, OP, ML and LL phases) among recreational female badminton players.
3. To explore the relationship on daytime drowsiness and muscular fatigue across the 5 phases of MC among recreational female badminton players.

1.6 Hypothesis

First null hypothesis (H_0):

- There are no significant differences on daytime drowsiness on different phases of MC (EF, LF, OP, ML and LL phases) among recreational female badminton players.

First alternate hypothesis (HA):

- There are significant differences on differences on daytime drowsiness on different phases of MC (EF, LF, OP, ML and LL phases) among recreational female badminton players.

Second null hypothesis (H_0):

- There are no significant differences on muscular fatigue on different phases of MC (EF, LF, OP, ML and LL phases) among recreational female badminton players.

Second alternate hypothesis (HA):

- There are significant differences on muscular fatigue on different phases of MC (EF, LF, OP, ML and LL phases) among recreational female badminton players.

Third null hypothesis (H_0):

- There are no significant relationship on daytime drowsiness and muscular fatigue across the 5 phases of MC on among recreational female badminton players

Third alternate hypothesis (HA):

- There are significant relationship on daytime drowsiness and muscular fatigue across the 5 phases of MC on among recreational female badminton players

1.7 Operational Definition

(a) Menstrual cycle

Menstrual cycle is a physiological process that only occurs in adolescent females and before menopause which is regulated by hormones and prepares for possible pregnancy. It begins on the first day of menses until the next menses. The average length is 28 days and the regular cycle is between 23 to 35 days (Schmalenberger et al., 2021).

(b) Follicular phase

This phase begins on the first day of menses with raising the concentration of FSH in order to promote maturation of ovarian follicles which contain oocytes. The estrogen level rises gradually while progesterone level remains low. Early follicular phase takes the first 6 days of this phase while late follicular phase is around 7th to 13th days of this phase (Carmichael et al., 2021). This phase ends up with ovulation which takes around 12 to 14 days (Reed & Carr, 2018).

(c) Ovulation phase

Ovulation phase is the release of mature ovum from the secondary oocyte. It occurs between follicular and luteal phases. LH surge stimulates ovulation and synthesis of progesterone. The secondary oocyte without ovum will degenerate and progress to corpus luteum (Reed & Carr, 2018). This phase is probably dropped on the 12th to 16th day of the menstrual cycle (Carmichael et al., 2021).

(d) Luteal phase

Early luteal phase starts on the day after ovulation. The follicular cell without oocyte will degenerate and turn into corpus luteum. Corpus luteum produces estrogen and progesterone and it gradually releases more of them. During the late luteal phase, the corpus luteum involutes if the oocyte is not fertilized, which sets off the menstrual cycle by rapidly withdrawing estrogen and progesterone (Reed & Carr, 2018). Mid luteal phase is dropped around 20th to 23rd days of menstrual cycle while late luteal is about 24th to 28th days of menstrual cycle (Carmichael et al., 2021).

(e) Day drowsiness

Drowsiness refers to feeling abnormally sleepy or tired than normal during the day. People with drowsiness may fall undesired asleep (Elaine, 2019). It can be caused by environmental or physiological effects that lead to poor sleep quality (Elaine, 2019).

(f) Muscular fatigue

Muscular fatigue refers to decrease of muscle force and power in performing physical activities in response to muscle thin and think fibers contractility as known as stretch-shortening cycle (SSC) (Wan et al., 2017). It can be induced by repetitive, prolonged and intense exercise with or without intermittent rest for each set of exercise dosage (Twist & Eston, 2005).

(g) Recreational Players

Recreational players who engage in physical activity but do not train with the same intensity and concentration as a competitive player (Chona et al., 2020). Subjects who join a badminton game or training at least once in a week.

1.8 Rationale of Study

The purpose of this study is to improve the awareness of the effect of the menstrual cycle toward daytime drowsiness and muscular fatigue. The study is to improve the awareness & knowledge of acknowledgement among female players and society about the physiological change during menstrual cycle by hormones which is possible to impact sleepiness and further lead to muscular fatigue. It is also suggested and allows us to explore further on the assessing impact of sleep in planning the proper training days and maybe in the future come up with more specific strategies to improve quality of sleep. That eventually will reduce incidence and chances of daytime drowsiness and muscular fatigue and minimize the risk of injuries.

1.9 Scope of Study

The highlighted topic of this research is the effect of the menstrual cycle on daytime drowsiness and muscular fatigue. Some of the previous study proved the menstrual cycle is possible to affect the sleep quality and muscular fatigue among the female players but some not.

However, this shows the contradictory findings and limited detailed research on the relationship between menstrual cycle and sleep quality and muscular fatigue of female players.

SECTION 2

REVIEW OF LITERATURE

2.1 Chapter Overview

A literature review is an in-depth summary and appraisal of the theories, studies, and supporting data that have been developed on a specific subject or research question. It identifies trends, gaps, and important ideas in the field by synthesizing prior research and academic sources. Understanding the existing level of knowledge about a subject, developing a theoretical framework, and setting the stage for future research are the objectives.

2.2 Menstrual cycle and hormones changes during different phases

2.2.1 Menstrual cycle

Menstrual cycle refers to the first day of menses to the next menses of the next menstrual cycle. Average duration of each cycle is 28 days while most cycle lengths occur between 25 to 30 days (McLaughlin, 2022 & Reed & Carr, 2018). Menstrual cycle can be divided into 3 main phases which are follicular, ovulation and luteal phases that are all regulated by hormones (Reed & Carr, 2018). To further narrowed the spectrum, the menstrual cycle phases are further divided into 5 phases which are EF, LF, OP, ML and LL phases (Reed & Carr, 2018) & (Bischof, 2024). Menstruation is the process of shedding of the endometrium wall which is included under the hormone mediation which takes place at the end of the luteal phase and onset of the follicular phase (McLaughlin, 2022). The chain of the events is regulated by the hypothalamic-pituitary-ovarian. The mean volume of menstruation is around 30 to 80 mL, it considers abnormal whichever out of this range (Reed & Carr, 2018). Other than the volume of menstruation, menstrual cycle days are also a parameter to determine the abnormal menstrual cycles. Polymenorrhagia means the menstrual cycle interval less than 21 days while oligomenorrhea means the menstrual cycle interval greater than 35 days (Schmalenberger et al., 2021)

2.2.2 Phase and Hormones Change of Menstruation Cycle

The first phase is the follicular phase, that takes place from the first day of menstruation until the next phase which is ovulation (McLaughlin, 2022). Follicular stimulating hormone (FSH) rises in the beginning of this phase and the levels of estrogen and progesterone are low at the early follicular phase in order to shed the thickened endometrium wall. In the late follicular phase, it stimulates the development of follicles in which the follicle is able to produce estrogen, thus estrogen level increases steadily (Reed & Carr, 2018). The increase of the estrogen level is due to the increase of the estradiol and inhibin A (Ali & Rehman, 2021). Luteinizing hormone (LH) level increased as an effect of both hormones as well (Ali & Rehman, 2021).

During the ovulation phase, the dramatic rise of the estradiol produced by the preovulatory follicle causes positive feedback on luteinizing hormone (Holesh et al., 2023). The surge of LH which stimulates the ovulation and synthesis of progesterone (Holesh et al., 2023). It usually happens 10 to 12 hours after the surge begins (McLaughlin, 2022). LH peak causes estradiol level drop dramatically due to direct inhibition of its synthesis by progesterone (Reed & Carr, 2018). Raising of FSH levels at the mid cycle leads to freeing the oocyte from follicular attachments and increase in LH receptor. However, the increase of progesterone leads to inhibition of LH release (Reed & Carr, 2018).

Moreover, the luteal phase is the phase that starts after ovulation and ends by follicular phase (McLaughlin, 2022). After ovulation there is a pigment called corpus luteum which mainly secretes progesterone and estrogen to prepare the endometrium for implantation of fertilized ovum (Reed & Carr, 2018). Before ovulation, LH level reaches peak before 34 to 36 hours of ovulation and drops after (Hedayat, 2020). After ovulation, the progesterone increases gradually and its level is higher than estrogen while estrogen plummets and rises right after ovulation (Reed & Carr, 2018). The progesterone level becomes plateauing with the low level of LH and FSH during ML phase (Bischof, 2024). ML phase is followed by LL phase which the progesterone level reduced to prepare the shedding of endometrium wall as known as EF phase (Bischof, 2024).

The intricate balance between both estrogen and progesterone hormones and their respective signaling processes are structured to continue a normal menstrual cycle and to maintain the pregnancy. (Haryanti & Legiran, 2023)

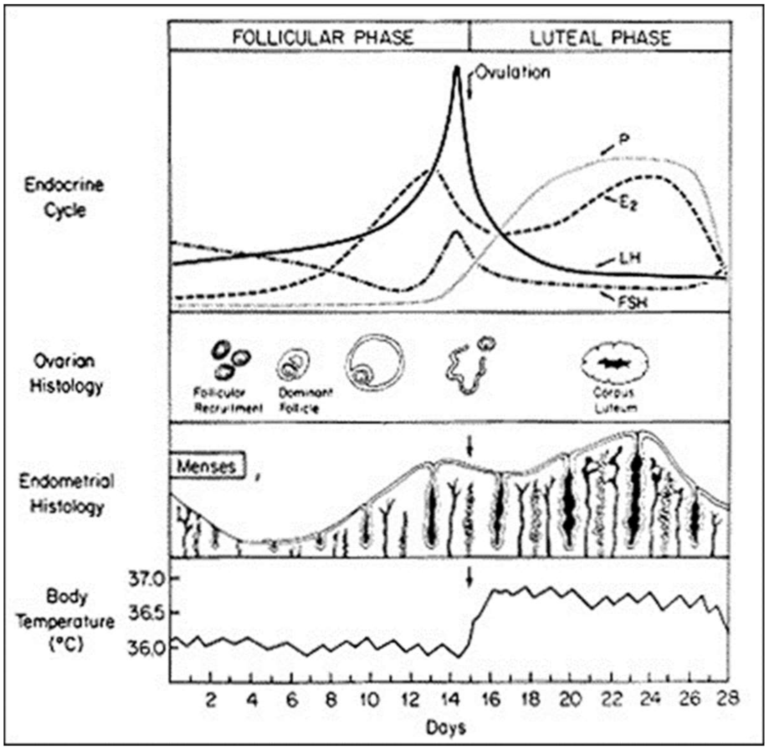

Figure 2.1: Profile of Menstrual Cycle with the Description of Hormone Concentration, Ovarian and Endometrial Histology and Body Temperature Changes

2.3 Relationship between Hormone and Substrate on Sleep Quality and Muscular fatigue

The relationship between estrogen with iron is indirectly proportional while serotonin is directly proportional (Yang et al., 2012 & Carmichael et.al., 2021). A blood test result shows that there is high in estrogen and low in iron (Yang et al., 2012). This is due to increased iron stores in bone marrow (Yang et al., 2012). The stored iron is functioning as the menstrual blood volume reducer to prevent period fatigue which is highly associated to daytime drowsiness due to heavy flow of menstruation which also reflects the excessive iron loss (Yang et al., 2012 & Panayi, 2019).

Besides, it is also vital in facilitating energy production by taking part in delivering oxygen around the organs in the body (Latorre, Pengelly & Minehan, 2023).

Moreover, serotonin will also affect the perception of tension-anxiety and fatigue of an players (Carmichael et.al., 2021). Serotonin hormone is accountable for raising the mood, as well as a host of other respective functions (Watson, 2023). Besides, it is also a source of mood elevation that makes a person feel good, grounded and relaxed. It is also highly associated with the production of sleep hormones such as dopamine and melatonin (Cleveland Clinic, 2022). With the moderate level of dopamine and melatonin, it could provide a better sleep quality in-term of sleep duration and number of times of waking in a sleep circadian (Cleveland Clinic, 2022). Serotonin level is relatively low in early follicular and late luteal phases (Cleveland Clinic, 2022).

In a study of assessing the effect of Vipassana meditation on serum melatonin and serotonin levels (Thambyrajah et al., 2023) observed raised serotonin and melatonin levels in the long-term meditators with possible positive impact in reducing stress and improving relaxation in individuals. A compensatory mechanism is found between estrogen, iron and serotonin levels to accommodate fatigue. During early follicular and late luteal phases, the estrogen level is relatively low, and it causes drop of serotonin level as well and thus lead to possible fatigue which is shown in poorer sleep efficiency and muscular fatigue. According to Sung et al. (2014), estrogen is the hormone that responsible to repair post-damage muscles after strength training through the activation and proliferation of the satellite cells. It refers that muscular fatigue and female athletes may have varies sports' performance across the whole menstrual cycle. However, the study done by Haufe & Leeners (2023) stated that there is no apparent correlation between estrogen and changes in sleep patterns related to the menstrual cycle.

2.4 Day Drowsiness during Different Phases of Menstrual Cycle

However, female players during menses (EF phases) increase their bed rest time and have more time in deep sleep compared to luteal phase (Carmichael et.al., 2021). Similarly, based on the research done by Driver & Baker (1998) also stated that 16 – 25% of females reported lethargy during late luteal phase while 25 – 32% of females during menses due to reduced sleep quality. Moreover, during the first EF phase they experience lesser total deep sleep time, sleep efficiency and prolonged sleep latency compared to late follicular phase (Carmichael et.al., 2021). One of the reasons is due to heavy menstrual bleeding which is highly likely to lead to day drowsiness.

Besides, Baker & Lee (2018) concluded the poorer sleep quality is only detected among the female population who has premenstrual syndrome (PMS) or intense lower abdominal pain (period pain) during menstruation. Sleepiness may be increased progressively from follicular phase to luteal phase as the increased of the progesterone level. Progesterone is the hormone that promote sleeping effects. Nevertheless, Ratini (2024) claim that the female with PMS is more prone to have sleep disturbance from less fresh after getting up from sleep to insomnia. Other than that, PMS will also cause unstable emotion which is known as mood swing. In contrast, Shechter & Boivin (2010), found out that the high concentration of estrogen could improve alertness while reduced daytime drowsiness.

During the ovulation phase, there is marked fluctuation of the hormones before (Estrogen, LH and FSH) and after (Progesterone) the phase (Reed & Carr, 2018). A phenomenon known as ovulation fatigue might be found among female (Gleanton, 2024). Estrogen and progesterone which are highly associated with sleep hormones and the spike of LH and FSH potentially lead to poor sleep quality and show drowsiness or even mental fog (Gleanton, 2024). However, a contradict study from Haslett (2024) stated there is no change of daytime alertness during OP phase due to short period of time (approximately 3 days).

Female players may suffer from a diminished sleep quality and increase in fatigue during the luteal phase especially late luteal phase (Carmichael et.al., 2021 & Driver & Baker, 1998). In this phase, the progesterone level is increased progressively, and it increases the body temperature which may cause reduction of sleep quality (Carmichael et.al., 2021 & Driver & Baker, 1998). Besides, Driver & Baker (1998) also found out that the young healthy women takes longer time in sleep latency during late luteal phase. Mental fatigue is one of the factors causing day drowsiness as well (Perry, 2021). Apart from that, progesterone also takes the role in inhibiting the cortical excitability and force production (Carmichael et.al., 2021).

With regard to "the absent of relationship between hormonal changes and daytime drowsiness" data are scarce. Database searches were carried out on PubMed, Ovid and CINAHL using combinations of the following keywords: "MC", "menstruation", "female", "female badminton player", "sleep", "daytime drowsiness", "daytime sleepiness", "sleepiness", the searches yielded no results. This implies that the is a gap of knowledge in this regard.

2.5 Muscular fatigue during Different Phases of Menstrual Cycle

The strength and power of the female players increased (lower muscular fatigue level) due to the high concentration of estrogen while poorer cognitive performance has been found out in this phase due to reduced sleep quality (Carmichael et.al., 2021) & (Vidafarl et al, 2018). With a more detailed study illustrated that female during LF phase will have the best strength performance among the entire menstrual cycle due to the peak of estrogen level (Sung et al., 2014). The muscular fatigue is also highly possible to be induced due to the ovulation (Gleanton, 2024). Thus, the female players will have lower strength and power in the luteal phase (higher muscular fatigue level). Other than that, the individual with eumenorrhea will experience mental fatigue but unchanged on physical fatigue during the mid-luteal phase (Carmichael et.al., 2021). The statement of higher possibility of muscular fatigue is also supported by the research done by Sung et al. (2014).

In addition, the body repairs and regrows tissues, muscle and bones during the deepest sleep stage (Villalobos, 2024). Therefore, muscular fatigue may be more vulnerable to be induced if body not fully recovered from energy exerted after a long day of training and activities with poor sleep quality (Villalobos, 2024).

There is limited data available on the lack of “no relationship between hormonal changes and muscular fatigue”. A database search was conducted on PubMed, Ovid, and CINAHL using keyword combinations such as “MC,” “menstruation,” “female,” “female badminton player,” “muscular fatigue,” “muscle strength,” “muscle power,” and “physical performance.” However, these searches returned no relevant results, highlighting a significant gap in knowledge on this topic.

2.6 Influence of Menstrual Cycle on Performance

The player’s performance is mainly regulated by both estrogen and progesterone (Carmichael et al., 2021). During the late follicular phase, the female players have shown up with better muscle strength and power (Carmichael et al., 2021) which is reflecting better performance. It is due to the increasing level of estrogen compared to early follicular phase and late luteal phase (Niering et al., 2024). This is because estrogen is also functioning as a neuroexcitatory and strength enhancing effect (Niering et al., 2024).

However, based on the narrative review from Carmichael et al. (2021) listed that multiple jump tasks such as countermovement jump (Smirniotou et al., 2004), vertical (Kishali et al., 2010) and squat jump test (Smirniotou et al., 2004) outcomes did not differ by menstrual cycle phases with the theory of no change of tissue stiffness over menstrual cycle phases. But according to the study of Tasmektepligil et al. (2010) stated a significant reduction in vertical jump height in the late luteal phase.

Repeated stretch-shortening cycle (SSC) and force production can be used to assess muscular fatigue, Shahraki et al. (2020), found out that ovulation phase has better performance in general as well as muscle strength. There is a contradictory finding by Romero-Moraleda et al. (2019) showing there is no significant change of muscle strength and power performance among all menstrual cycle phases. Nevertheless, muscular fatigue can also be detected by assessing muscle strength (Rodrigues et al., 2019). The study done by Rodrigues et al. (2019) got the result with better muscle strength in the follicular phase compared to other menstrual cycle phases. With a more detailed systematic review done by Carmichael et al. (2021) found an article stated muscle strength is lower in early follicular phase compared to mid and late luteal phases (Gordon et al., 2013); increased in late luteal phases (Andrade et al., 2017); remarkable (Shahraki et al., 2020) and non-remarkable increased in the ovulatory phases (Otaka et al., 2018).

Therefore, this research is to rule out whether different phases of the menstrual cycle will or will not affect recreational female badminton players' performance with the presence of muscular fatigue caused by MC hormonal events.

2.6.1 Influence of Menstrual Cycle on CMJ Height

Above literature review of the tittle of '2.5 Influence of Menstrual Cycle on Performance' illustrate that MC has the potential to affect female player performance (Carmichael et al., 2021), (Shahraki et al., 2020) & (Rodrigues et al., 2019). The performance can be affected by the fluctuations of the reproductive hormones particularly estrogen and progesterone which are strongly associated with the strength and power production (Carmichael et al., 2021). However, the findings from different studies remain contradictory. Some individuals' performance is not affected by MC (Carmichael et al., 2021), (Smirniotou et al., 2004), (Kishali et al., 2010) & (Smirniotou et al., 2004). This variation reflects that hormonal effects differ from person to person (Michelekaki et al., 2023).

The findings from Ogul et al. (2021), García-Pinillos et al. (2021), Morenas-Aguilar et al. (2023) & Pisapia et al. (2019) have proved that the CMJ height is not affected by hormonal effects. According to Ogul et al. (2021) the average vertical jump distance on FP is 29.5cm with the differ value of 0.8cm (SD) while average vertical jump distance on LP is 29.5cm with the differ value of 1.1cm (SD). Moreover, García-Pinillos et al. (2021) had done the research on menses phase, FP and LP. The researchers found out that the average CMJ height on each mentioned phase are 23.46cm with 5.1cm of SD; 24.50 cm with 5.6 cm of SD; 23.74cm with 5.57cm of SD. Besides, there are the records of the mean and SD of CMJ height on EF phase are 23.7 ± 5.4 and 24.0 ± 5.0; LF phase are 24.9 ± 5.9 and 23.6 ± 5.0 and Mid LP are 24.7 ± 5.4 and 23.4 ± 4.5 (Morenas-Aguilar et al., 2023). Nevertheless, the mean of the CMJ height from Pisapia et al. (2019) is 30cm on EF phase and 30.56cm during LP phase with the SD of 3.87cm and 2.96cm. Ogul et al. (2021) suggested that the prediction of the ML phase contributes to better vertical jump performance due to high concentration of estrogen level. However, their findings revealed a negative association.

However, the studies done by Julian et al. (2017) and Davies et al. (1991) have found out the vertical jump height is influenced by menstrual cycle phases. Both of the studies proved that the EF phase has higher vertical jump height than LP. There is the mean height with 20.0cm ± 3.9 cm of SD while during ML phase the mean CMJ height is 29.6cm ± 3.0 cm of SD with the p-value 0.33 (Julian et al., 2017).

Thus, this study is to reveal does menstrual cycle lead to muscular fatigue and thus reduce the CMJ height among female recreational badminton player. The CMJ height will be further analyzed with the daytime drowsiness across different phases of MC with the purpose to study the relationship between both variables.

2.7 Common Sport and Risk of Injuries During Different Phases of Menstrual Cycle

Menstrual cycle may induce the change of anatomical structure and physiological system of a female player. An estimated ratio risk of anterior cruciate ligament (ACL) injury is 5 in female and 1 in male players (Martínez-Fortuny et.al, 2023).

Study from Ana et al. (2020) with a total of 322 injuries recorded from 150 recreational players claimed that the probability of knee injuries is 22.44%, leg is 18.3% while shoulder is 11.8% which is the most common injury site in upper limbs. Knee is the most common affected location in both male and female with 23.1% and 20.8%, respectively, but the shoulder was affected more frequently among females than male (17.8%). Besides, the incidence of musculoskeletal injuries in recreational badminton players was high in muscles (39.1%) followed by ligament injuries, sprains, and damage to the tendons (30.9%).

The epidemiological studies done by Yung et al. (2007) showed that most commonly affected by injury are the ankle (23.5%), knee (14.0%), foot (12.5%), arm (8.5%), and leg (5.4%). A statement "OP phases is the highest risk of getting injury compared to follicular and luteal phases" was proved by Martínez-Fortuny et.al, (2023), Khowailed et al. (2015), Shahraki et al. (2020) & Hohmann et al. (2015). Moreover, two of the studies claimed that there is higher risk of getting injury during follicular phase (Stijak et al., 2015) & (Lago-Fuentes et al., 2021). Lastly, there is only one study demonstrating higher risk in luteal phase due to the significant poor proprioception (Shahraki et al., 2020).

The peak of estradiol concentration level in blood leads to increased joint laxity and muscle strength while it decreases the muscle relaxation time and thus increases the muscle fatigability (Martínez-Fortuny et.al, 2023). The neuromuscular control is less well in follicular and ovulatory phases due to the estradiol. Besides, the hormone, relaxin that is detected in follicular and luteal phases also reduces the patellar tendon stiffness. The combination of increased quadricep strength and patellar tendon stiffness is resulting in ACL injury by slipping the patella from proper biomechanical location. Lastly, estrogen or progesterone may have an adverse effect on neuromuscular recruitment by influencing the central nervous system (Martínez-Fortuny et.al, 2023). Even thought, above literature reviews stated that female players had better performance during the late follicular phase but the findings from the studies were contradictory. Niering et al., (2024) attributed a finding that reduced musculotendinous stiffness or increased joint laxity is associated with elevated estrogen and dropped progesterone concentrations.

SECTION 3

METHODOLOGY

3.1 Chapter Overview

This chapter outlines the research design, research setting, sampling size, sample population, sampling method, instrumentation, procedure, statistical analysis and ethical approval. The participation selection will be based on the inclusion and exclusion criteria set to ensure the consistency and validity for the data collection and result. The selected questionnaires and instrument are used to test the research hypothesis to reach the research objectives and questions by bridging between data collection, subsequent analysis and interpretation of the results.

3.2 Research Design

- The type of research designs to be used are descriptive research design by cross-sectional and observational study.

In this study, the population is focusing on recreational female badminton player with eumenorrheic within the age range of 18 to 24 years old. By collecting their profiling of sleep quality data through sleep diary, it describes the effect of different phases of MC on day drowsiness with the aid of Epworth Sleepiness Scale (ESS). Moreover, the CMJ jump test was applied to assess muscular fatigue after completing the muscle induce fatigue protocol which is

40 squat jumps. Both of the data were used to further discuss their relationship and to modify a better training programme for recreational female badminton player.

3.3 Research Setting

- The research was conducted at KA 200A Physiotherapy Center 2 in Universities Tunku Abdul Rahman (UTAR Sungai Long Campus). Besides the temperature of the environment is fixed at 20°C.

  The purpose to fix the environment temperature is to avoid the influence of physical performance due to impaired thermoregulation (Siegel & Laursen, 2012).

3.4 Sampling Size

The sampling size was calculated by G-power version 3.1.9.4. The selected test family is “F tests” with the statistical test is “ANOVA: Repeated measures, within factors”. The type of power analysis is “A priori: Compute required sample size - given α, power and effect size”. The input parameters of effect size *f* are 0.25, α err prob is 0.05, power (1- β err prob) is 0.80, 1 number of groups, 5 number of measurements, corr among rep measures is 0.5, nonsphericity correlation ε is 1. When determining the effect size for the ANOVA test, Cohen defined "small," "medium," and "large" effect sizes as 0.1, 0.25, and 0.4, respectively. Additionally, G*Power offers standard effect size values, which can be viewed by hovering the cursor over the "effect size" option in the "input parameters" field. For this study, the sample size was calculated using a medium effect size of 0.25 Kang (2021). Moreover, the noncentrality parameter λ is 10.5, critical

F is 3.168, numerator df is 2.0, denominator df is 54.0, total sample size is 28 and actual power is 0.8124546. However, the total sample size will be added 5 more subjects into the final sample size which is 33 to take into consideration for participants who withdraw during the study. The guideline of sample size calculation is according to Kang (2021).

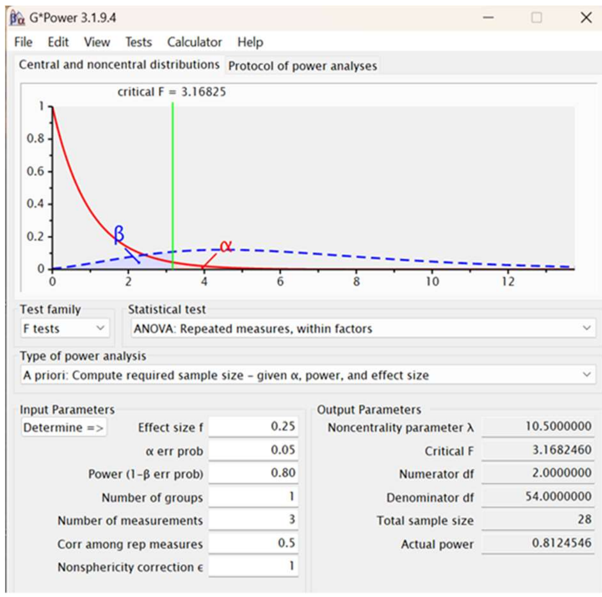

Figure 3.1: Sample Size Calculation using GPower 3.1.9.4 Software

3.5 Sample Population

- The sample population for this research is recreational female badminton players in UTAR with the age range of 18 to 24 years old.

3.6 Sampling Method

- The sampling method of this study is a convenience sampling method.

Convenience sampling in qualitative research enable a research paper to be straight forward approaching selected participants who meet the inclusion criteria. It is more time-efficient and cost-effectively because the sample population is accessible to the researcher. Apart from that, this method is able to maintain the consistency of subjects to be selected for getting more accurate result of research.

3.7 Inclusion Criteria

1. Recreational female badminton players with regular menstrual cycle in each of the past 3 months (eumenorrheic).
2. Female players between the age range of 18 to 24 years old.
3. Female players with at least once playing badminton in a week.

The inclusion criteria set are to serve to consistently, uniformly, reliably, and objectively identify the study population (Garg, 2016). The female players participating in the study must have at least 3 months of normal and regular menstrual cycle. Besides, monitoring the menstrual cycle over the past three months to determine whether any irregularities or the lack of menses for three consecutive months may be linked to menstrual abnormalities (Cleveland Clinic, 2023). Moreover, the female players should play badminton at least 1 time a week. This study is mainly focusing on university students thus the age range of the population is dropped within 18 to 24 years old.

3.8 Exclusion Criteria

1. Recreational female badminton players who take part in area, state, national or international level of competition.
2. Female players who uses contraceptive pills, injections, IUDs, or vaginal rings as an alternative form of birth control.
3. Pregnant woman
4. Presence of current musculoskeletal injuries

The traits or factors listed in the exclusion criteria render the recruited cohort ineligible for the study (Garg, 2016). The female badminton players who participates in the mentioned competition has a regular and intensive training programme, thus, the outcome measurement will have a gap between recreational players and professional athletes. Besides, participants must be free from contraceptive pills. Female sex hormones may strongly correlate with the techniques of birth control (Sitru-Ware & Nath, 2013). Therefore, it must be excluded to ensure the result is valid and reliable. Furthermore, the participants with the presence of current musculoskeletal injuries should be excluded to avoid causing further injuries.

3.9 Instrumentation

1. Menstrual Cycle calendar

Menstrual bleeding/cycle/phases will be recorded using a self-reporting calendar. This recorder is conducted by self-reporting menstrual bleeding days by the participant in. The female player will record down the days of menstrual bleeding in the calendar. The calendar will then be further divided into 5 subphases which are early and late follicular(1st to 3rd and 10^{th} - 12^{th} day of menstrual cycle), ovulation (14th day of menstrual cycle), mid and late-luteal phases (20th to 23rd and 24th to 28th of menstrual cycle) (Carmichael et.al., 2021). The average of the menstrual cycle is set as 28 days for the above calculation (HrozANOVA et.al, 2021). Each subphase will be calculated based on a person-to-person basis.

2. Epworth Sleepiness Scale (ESS)

Epworth sleepiness scale is a reliable subjective measurement of a person's sleepiness which was developed by Murray Johns in 1991 (Omobomi & Quan, 2018). In the test, it involves 8 situations with the rating of tendency to become sleepy on a scale of 0 (no chance of dozing), to 3 (high chance of dozing). The total score will be summed up and estimates whether the recreational female players are experiencing excessive sleepiness across a menstrual cycle that possibly lead to muscular fatigue and thus deteriorate in performance (John, 1991). The validity and reliability of the questionnaire has been proved by the research from Scharf (2022). The ICC value of the questionnaire is falls within 0.81 to 0.93 (Scharf, 2022).

3. Wellness questionnaire

The Wellness questionnaire is an assessment tool to monitor the sleep quality, perceived fatigue, muscle soreness and stress level of the recreational female badminton players. The screening purpose is to capture the effect of hormonal change by the menstrual cycle on perceived fatigue. The data can be used to develop a holistic training programme and thus reduce the risk of injuries which may be caused by daytime drowsiness and muscular fatigue. The questionnaire has to be completed after their training (Carmichael et.al., 2021). This questionnaire is adapted from McLean et al. (2010) and has been applied by Carmichael et.al. (2021).

4. Sleep diary

This is a tool used for sleep tracking by involving the questions such as sleep duration, nap time, how long to fall asleep, etc (Epstein, 2021). It may reveal sleep efficiency and perceived fatigue and thus be related to day drowsiness. Lastly, it must fill up in every attempt based on one day before the test. The sensitivity and specificity of it is 92.3% and 95.6% (Rogers et al. 1993). The high percentage shown its high reliability and validity to assess the sleep efficacy of a person.

5. Countermovement jump

Muscular fatigue will be assessed by Countermovement jump which is a measurement of lower limb extremity strength and power by taking the maximum height jumped by the participants which is also known as reach method after completed the muscular fatigue protocol of the continuous 40 times of the squat jumps (Leard et al., 2007). The ICC value of countermovement jump is 0.75 which reach the moderate strong reliability (Dasa et al., 2021).

The protocol is to induce muscular fatigue with stretching-shortening cycle theory about 4 sets of 10 continuous squat jumps with 90 degree of knee flexion (Knihs et al., 2022). The subject will be instructed to bend her knee approximately 90 degree of knee flexion during landing to produce muscle damage which will further lead to muscle fatigue (Twist & Eston, 2005). After a minute of rest, the subject was instructed to perform CMJ jump for data collection (Twist & Eston, 2005).

The participants have to jump as high as they can to hit the vanes with an overhead arm swing at the peak of the CMJ jump for 3 times. The average of the 3 times jump will be calculated and take as data collection (The formula is: Average jump height = [jump 1 + jump 2 + jump 3] / 3). The Vertec device consists of plastic swivel vanes arranged in 1 cm increments which are attached to a metal pole that can be adjusted to the players's reach height.

The muscular fatigue protocol is based on previous established article by Twist & Eston (2005) on effects of exercise-induced muscle damage and which has been applied by Knihs et al. (2022) in the study of effects of different levels of fatigue on vertical jump performance.

3.10 Procedures

This study is a cross-sectional and observational study. The study setting is set in UTAR. 33 recreational female badminton players will be recruited for this study. The subject should fill up the demographic data and screening form (**Refer to APPENDIX C)** is prepared for the participants who meet the inclusion criteria before conducting the data collection. The questionnaires were distributed to recreational female badminton players via Whatsapp, email, Microsoft Team or phone message in the form of "Google Form". A brief objective of the study of the description will be listed in the beginning of the form and the participant is allowed to raise out or discharge from the study if there is any discomfort throughout the study. They should also need to sign the consent form as well as the Personal Data Protection notice **(Refer to APPENDIX B)** after going through the study objectives and procedures.

Pre-jump height of the participants with hand raised was recorded during the first meet up. Each participant has to fill up the Epworth Sleepiness Scale **(Refer to APPENDIX D)**, Wellness questionnaire **(refer to APPENDIX F)**, Sleep Diary **(Refer to APPENDIX E)** and perform the countermovement jump for 5 times in a month duration based on their estimated subphases of menstrual cycle (Example: early and late follicular→ 1st to 3rd and 10^{th} - 12^{th} day of menstrual cycle, ovulation 14th day of menstrual cycle→ and mid and late luteal phases → 20th to 23rd and 24th to 28th of menstrual cycle) based on the calendar-based counting method. The subject was allowed to practice the jump as a familiarization session and then proceed to the fatigue protocol which is 4 sets with 10 repetitions of continuous squat jumps. After a minute of rest, 3 jumps were performed by the subject and the average score was recorded to assess the muscular fatigue of the specific phase of MC. Collected data were analyzed and further study were done after completing data collection.

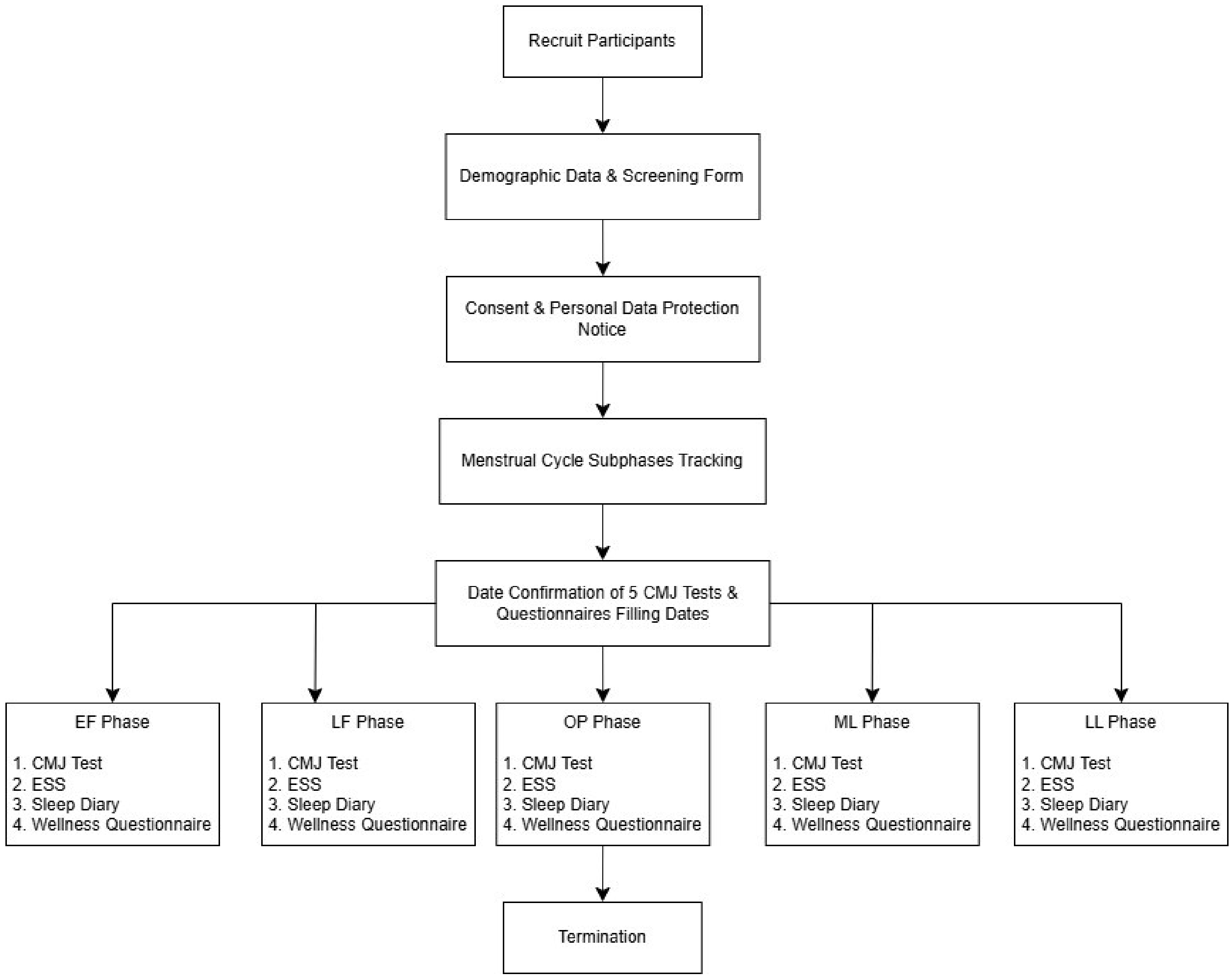

Figure 3.2: Flowchart of Procedure

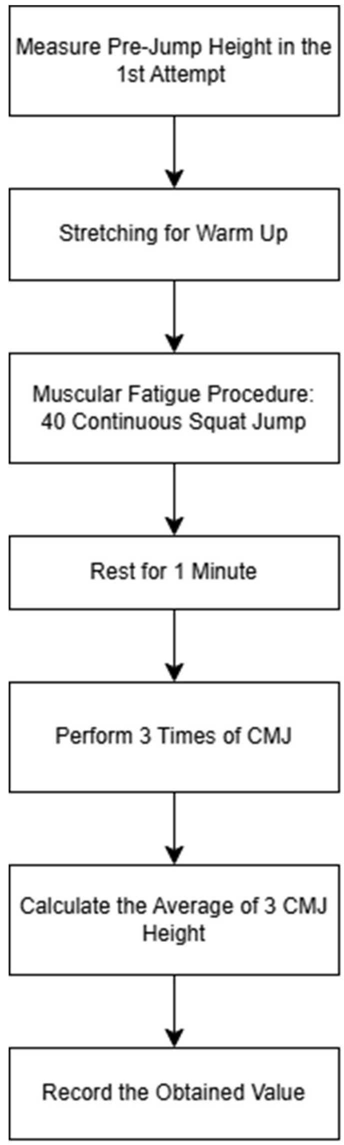

Figure 3.3: Flowchart of Performing CMJ Test

3.11 Statistic analysis

All of the data collection of this study is through distributing questionnaires to the participants and performed CMJ test. The type of analysis of the study was descriptive analysis by collecting the age, weight, height and dates of 3 months of menstrual cycles. of the participants. Sleep duration, hygiene and difficulty are the data to be collected from pre-test (1st – 3rd day of menstrual cycle), first post-test (10th – 12th), second (14th), third (20th – 23th) and fourth post-test (24th - 28th days with the average 28 days) followed by 3 to 5 assumptions of Repeated Measure ANOVA will be used to compare daytime drowsiness and muscular fatigue between different phases of the menstrual cycle. All of the collected data in this study were reported in the form of mean, standard deviation and significant value (p-value). The F value indicate the ratio of explained ratio to unexplained ratio while the p-value giving the observed data to either support null hypothesis or alternative hypothesis. Next, the Paired Sample T-test was used to analyze the comparison of different phases of MC on daytime drowsiness by using the data collected from ESS. Besides, Pearson Correlation Analysis is used to explore the linear correlation between ESS and CMJ height. Lastly, there is the additional analysis which use to support the collected data of daytime drowsiness is or not in line with perceived fatigue. Spearman Rank Correlation Analysis is used to study the relationship of (i) ESS and perceived fatigue and (ii) CMJ height and perceived fatigue on different phases of MC. The data analyzed by correlation analysis tests were reported in correlation coefficient (r-value) and significant value (p-value). The data will be further analyzed by the 29th version of the Statistical Analysis Software (SPSS). The significance level will be set at $p < 0.05$ with the confident interval of 95%.

3.12 Ethical Approval

This study was subjected to ethical approval by the Scientific and Ethical Review Committee (SERC) of University Tunku Abdul Rahman (UTAR) **(Refer to APPENDIX A)**. Informed consent will be obtained from all participants upon recruitment. Purpose of the study, length of participation, procedure, benefits and data confidentiality will be well-informed to the participants upon receiving the consent form.

Chapter 4

Results

4.1 Chapter overview

This chapter involves the result of collected data including demographic data (age, height, weight and BMI categories) which will be presenting in charts and descriptions. Data collected from ESS (refers to daytime drowsiness), CMJ height (refer to muscular fatigue), Sleep diary and Wellness questionnaire (refer to perceived fatigue) were analyzed by every each specific and suitable inferential tests to rules out the correlations and thus for hypothesis testing.

4.2 Demographic Characteristic of Participants

The researcher had successfully recruited 36 participants who voluntary agreed to participate in this research. However, only 31 participants fulfill the inclusion criteria as stated in Chapter 3. There were 5 participants in total who being excluded from this study. 2 participants who have been noted with irregular menstrual cycle in September; 1 participant who unable to manage time to take part in performing the test physically; the rest of the 2 participants to who got musculoskeletal injuries were not fully recovered with a proper clinical diagnosis. Thus, the data collected from the finalized 31 participants will be analyzed by using Microsoft Excel and IBM SPSS 26.0 version software. This section presents the demographic characteristic of the participant such as age, weight, height and BMI value which summarized by graphs, descriptions and table.

Characteristics	N (%)	Mean ± SD
Age (years)		21.19 ± 1.05
19	1 (3.2%)	
20	5 (16.1%)	
21	16 (51.6%)	
22	7 (22.6%)	
24	2 (6.5%)	
Weight (kg)	-	54.00 ± 6.34
Height (meter)	-	1.59 ± 0.05
BMI (kg/m^2)	-	21.23 ± 2.54
BMI Categories		-
Underweight	5 (16%)	
Normal	25 (81%)	
Overweight	1 (3%)	

*N = Frequency; SD = Standard Deviation; BMI = Body Mass Index

Table 4.1: Descriptive Statistics of Demographic Characteristics of Participants (N=31) at baseline

4.2.1 Age

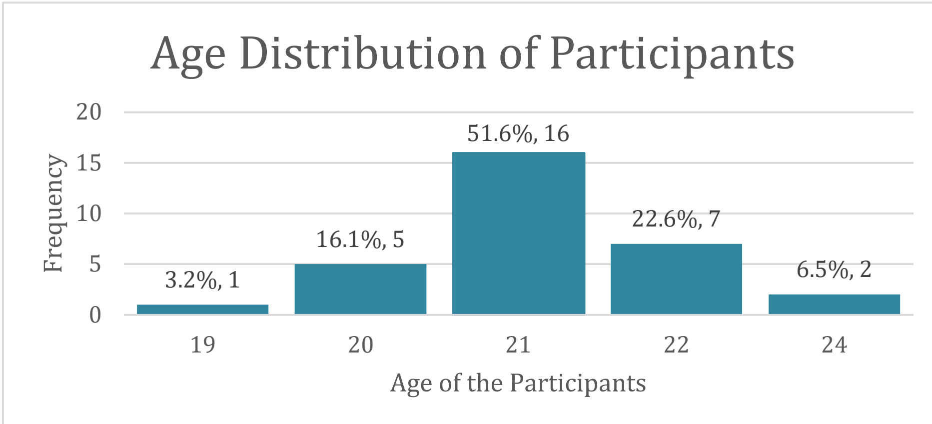

Figure 4.1: Bar Chart of Age Distribution of Participants

Figure 4.1 shows the bar chart distribution of the age range of the participants are within 19 to 24 except from aged 23. According to table 4.1 outlined that the mean age of participants is 21.19 with SD of 1.05. The majority of the participants are aged 21 covered with 51.6% in total recruited participants while there is only a participant who aged 19 which contribute to 3.2%. Moreover, there are 5 participants who are aged 20 (16.1%); 7 of the participants who are aged 22 (22.6%) and 2 of the participants who are aged 24 (6.5%).

4.2.2 Weight

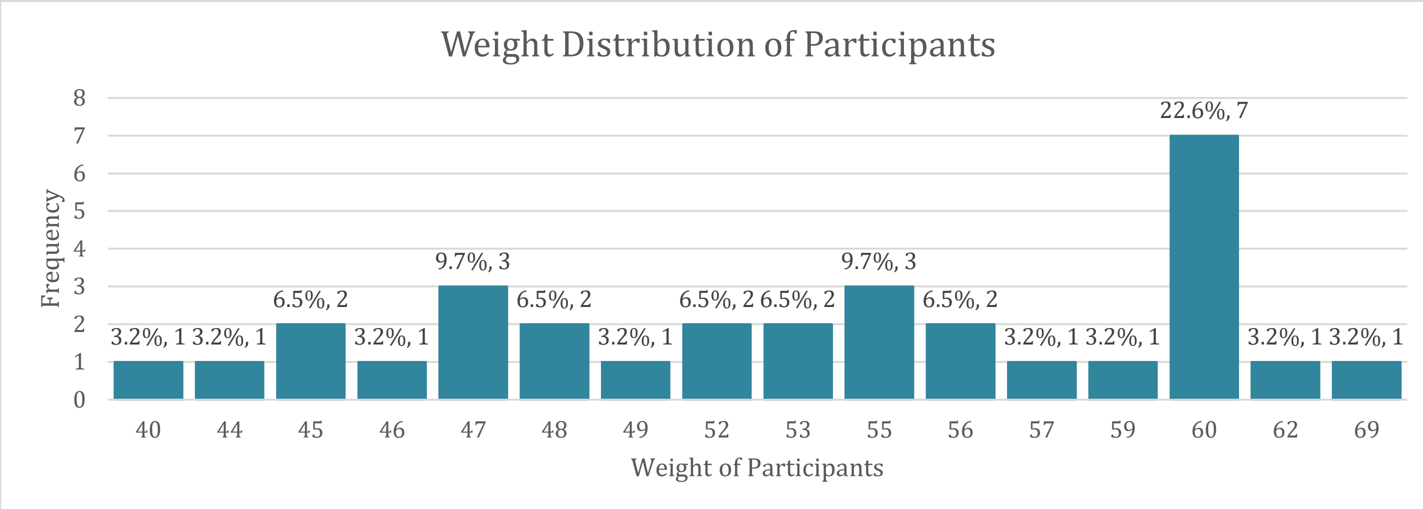

Figure 4.2: Bar Chart of Weight Distribution of Participants

Figure 4.2 outline the bar chart of the weight distribution of participants in kilograms. The average weight of the recruited participants is 54 kg with 6.34 SD within the spectrum from 40 kg to 69 kg. The most prevalent weights among the participants are 60kg which having 7 out of 31 that accounting for 22.6%. In contrast, the least prevalent weights among the participants are 40 kg, 44 kg, 46 kg, 49 kg, 57 kg, 59 kg, 62 kg and 69 kg, each represented by 3.2% or 1 of the participant. Besides, the weights categories lie on 45 kg, 48 kg, 52 kg, 53 kg and 56 kg, each accounting for 6.5% or 2 of the participants. Moreover, the weight categories fall at 47 kg and 55 kg each accounting for 9.5% or 3 of the participants. The bar chart has summarized that the mode of the weight distribution is 60 kg.

4.2.3 Height

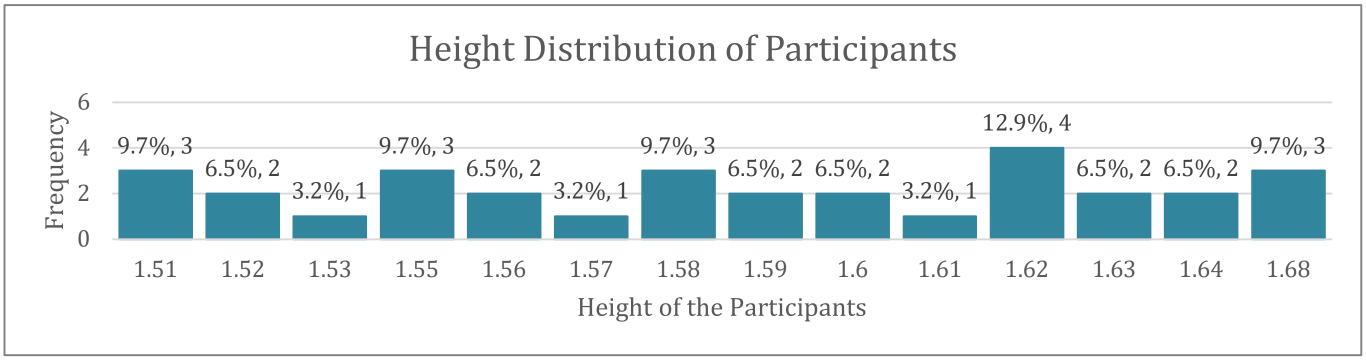

Figure 4.3: Bar Chart of Height Distribution of Participants

Figure 4.3 bar chart represents the height distribution of participants in meter (m). It illustrates the height range is within 1.51m to 1.68m with the mean of 1.59m (SD = 0.05). The most widespread height is 1.62m with 12.9% or 4 pf the participants while the least widespread heights was 1.53m, 1.57m and 1.61m with 3.2% or 1 of the participants. Apart from that, there are 4 categories of the height which fall on 1.51m, 1.55m, 1.58m and 1.68m each carries 9.7% or 3 of the participants. Furthermore, there were participants of different weights, each of whom made up 6.5% of the total or 2 of the participants, suggesting that the research sample size was further diverse in terms of weight. The various height comprised of 1.52m, 1.56m, 1.59m, 1.60m, 1.63m and 1.64m. This implied that there was no dominant height category in the sample and that there was an equal distribution over a range of heights.

4.2.3 BMI Categories of Participants

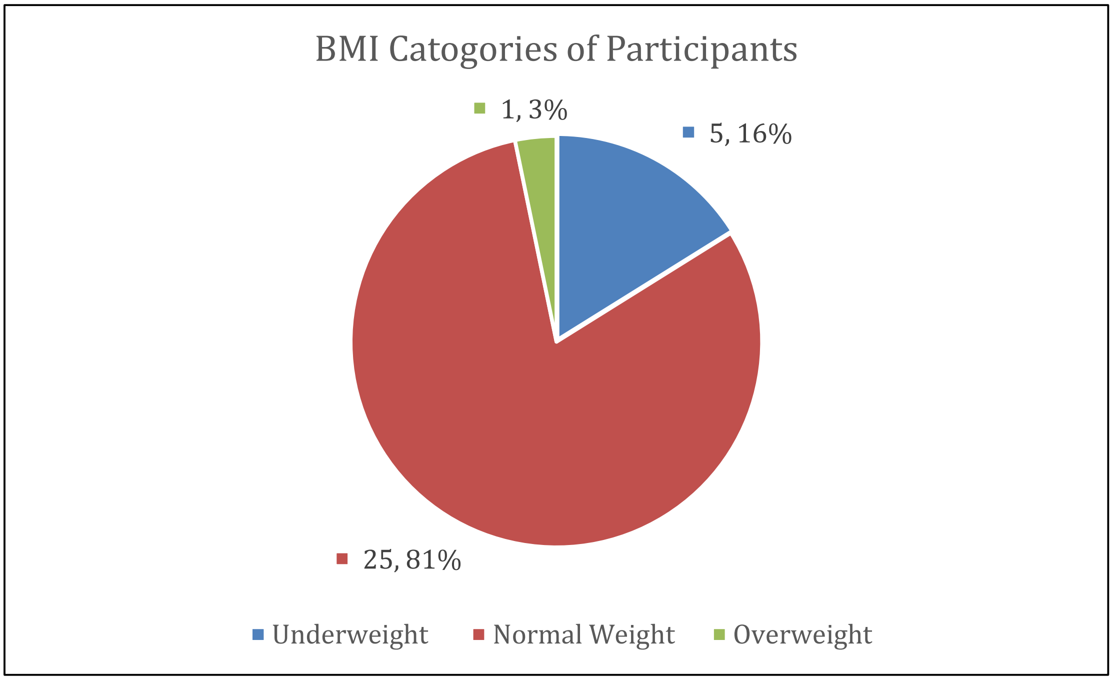

Figure 4.4: Pie Chart Distribution for BMI Categories of the Participants

The pie chart above shows that the BMI categories of the study participants. The distribution of the BMI provided the mean with 21.23 kg/m^2 and SD with 2.54. The majority of the participants made up by 25 over 31 of the total participants which hold for 81% are categorized by “Normal weight”. Moreover, there is only 1 of the participants who represented 3% from the sample size with “Underweight”. Lastly, the third segment which constitute 5 or 16% of the participants have been classified as “Overweight”.

4.3 Interferential Analysis Test

The interferential analysis test involved Repeated ANOVA Analysis, Paired Sample T-test, Pearson Correlation Analysis and Spearman Rank Correlation Analysis. Repeated ANOVA Analysis was used to analyze the (i) ESS of each phases of MC and (ii) CMJ height of each phases of MC. Next, Paired Sample T-test is applied to analyze the comparison of different phases of MC on daytime drowsiness by using the data collected from ESS. Moreover, the Pearson Correlation Analysis is used to explore the linear correlation between ESS and CMJ height. Lastly, the Spearman Rank Correlation Analysis is used to study the relationship of different phases of MC on (i) ESS and perceived fatigue and (ii) CMJ height and perceived fatigue.

4.3.1 Repeated ANOVA Analysis for ESS

MC Phases	ESS (Mean ± SD)	Sig. (*p*-value)
EF Phase	9.06 ± 4.37	0.04 (<0.05)
LF Phase	7.29 ± 4.73	
OP Phase	6.94 ± 4.11	
ML Phase	7.23 ± 4.43	
LL Phase	8.42 ± 3.72	

Table 4.2: Comparison of Daytime Drowsiness on different phases MC

4.3.2 Paired Sample T-test for ESS on Different Phases of MC

	Mean	SD	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed) (*p*-value)
				Lower	Upper			
EF vs LF	1.774	4.287	.770	.202	3.347	2.304	30	0.028
EF vs OF	2.129	3.547	.637	.828	3.430	3.342	30	0.002
EF vs ML	1.839	3.900	.700	.408	3.269	2.625	30	0.013
EF vs LL	.645	2.470	.444	-.261	1.551	1.454	30	0.156
LF vs OF	.355	2.927	.526	-.719	1.429	.675	30	0.505
LF vs ML	.065	4.449	.799	-1.567	1.697	.081	30	0.936
LF vs LL	-1.129	4.105	.737	-2.635	.377	-1.531	30	0.136
OF vs ML	-.290	3.917	.704	-1.727	1.147	-.413	30	0.683
OF vs LL	-1.484	3.275	.588	-2.685	-.283	-2.523	30	0.017
ML vs LL	-1.194	3.859	.693	-2.609	.222	-1.722	30	0.095

Table 4.3: Pairwise comparison of Daytime Drowsiness between MC phases

The mean and SD values of ESS (refer to daytime drowsiness) on different phases of MC are stated in table 4.2. There is a difference in daytime drowsiness between different phases of menstrual cycle [$F(1,30) = 2.92$, $p = 0.04$]. The higher the ESS scoring, indicates the higher level of daytime drowsiness. In the table 4.2 presents that there is the mark increased of level of daytime drowsiness during EF followed by LL compare to the rest of the 3 MC phases. Additionally, the daytime drowsiness level was similar within LF, OP and ML phases. This indicates that level of daytime drowsiness was affected by different phases of MC.

When analyzed between MC phases (table 4.3), EF phase was significantly different from LF, OP, and ML phases ($p < 0.05$), while LL phase was only significantly different from OP phase ($p < 0.05$). However, EF and LL phases were comparable ($p > 0.05$). There was no significant different between other phases. These findings indicated that EF and LL have the highest daytime drowsiness.

In the nutshell, first null hypothesis of this study is rejected. Therefore, there are significant differences on daytime drowsiness on different phases of MC (EF, LF, OP, ML and LL phases) and the most affected MC phases is EF followed by LL phase among recreational female badminton players.

4.3.3 Repeated ANOVA Analysis for CMJ Height

MC Phases	CMJ Height (cm) (Mean ± SD)	Sig. (*p*-value)
EF Phase	27.03 ± 5.80	0.08 (>0.05)
LF Phase	27.29 ± 5.82	
OP Phase	27.13 ± 5.74	
ML Phase	28.16 ± 5.44	
LL Phase	27.16 ± 5.65	

Table 4.4: Comparison of Muscular Fatigue on different phases MC

The CMJ height refers to the induced muscular fatigue of the participants. The mean and SD values of CMJ height on different phases of MC were stated in table 4.4. There is no effects observed significant different of the jumping height in different phases of MC [F(1,30) = 2.34, p = 0.08]. This implies that MC does not influence muscular fatigue. The mean and SD scores of each MC phases were EF = 27.03 ± 5.80, LF = 27.29 ± 5.82, OP = 27.13 ± 5.74, ML = 28.16 ± 5.44 and LL = 27.16 ± 5.65.

In the nutshell, second null hypothesis of this study is failed to be rejected. There are no significant differences on muscular fatigue on different phases of MC (EF, LF, OP, ML and LL phases) among recreational female badminton players.

4.4.4 Pearson Correlation Analysis for ESS and CMJ Height

Relationship of Different MC Phases on ESS and CMJ Height	Correlation Coefficient (*r*)	Sig. (*p*-value)
EF Phase	0.081	0.665
LF Phase	0.086	0.644
OP Phase	0.245	0.185
ML Phase	0.044	0.814
LL Phase	0.122	0.514

Table 4.5: Relationship of Daytime Drowsiness and Muscular Fatigue on Different Phases MC

The table 4.5 shows the relationship on daytime drowsiness and muscular fatigue on different phases MC. Both of the variables are not statistically significant ($p > 0.05$) (EP Phase = 0.665, LF Phase = 0.644, OP Phase = 0.185, ML Phase = 0.814 & LL Phase = 0.514) Besides, the correlation of both variables are existing positively but poor ($r < 0.3$) (EP Phase = 0.081, LF Phase = 0.086, OP Phase = 0.245, ML Phase = 0.044 & LL Phase = 0.122). This reveals that different phases of MC on daytime drowsiness and muscular fatigue were not statistically significant.

In the nutshell, third null hypothesis of this study is failed to be rejected. There are no significant relationship on daytime drowsiness and muscular fatigue across the 5 phases of MC on among recreational female badminton players

4.4.5 Spearman's Rank Correlation Coefficient for ESS and Perceived Fatigue

Relationship of Different MC Phases on ESS and Perceived Fatigue	**Correlation Coefficient (*r*)**	**Sig. (*p*-value)**
EF Phase	-0.454	0.010
LF Phase	-0.246	0.183
OP Phase	-0.155	0.407
ML Phase	-0.121	0.517
LL Phase	-0.451	0.011

Table 4.6. Relationship on Daytime Drowsiness and Perceived Fatigue on Different Phases MC

The table 4.6 presents the existence relationship of daytime drowsiness and perceived fatigue on different phases of MC. During EF and LL phases, the *p*-values were 0.010 and 0.011 ($p < 0.05$). Thus, the results of these 2 phases are statistically significant. Besides, the *r*-value of

EF phase was -0.454 and LL phase was -0.451. These indicate fair and negatively relationship between daytime drowsiness and perceived fatigue of the mentioned phases. However, there is not statistically significant of both variables on LF, OP and ML phases. Each phase yielded *p*-value of 0.183, 0.407 and 0.517 and *r*-value of -0.246, -0.155 and -0.121 respectively ($p > 0.05$). The strength of association of the LF, OP and ML phases are negative and poor. To sum up, there is association between daytime drowsiness and perceived fatigue during EF and LL phases.

4.4.6 Spearman's Rank Correlation Coefficient for Relationship of CMJ Height on Perceived Fatigue

Relationship of Different MC Phases on CMJ Height and Perceived Fatigue	Correlation Coefficient (*r*)	Sig. (*p*-value)
EF Phase	0.084	0.653
LF Phase	-0.073	0.697
OP Phase	0.036	0.849
ML Phase	0.089	0.734
LL Phase	-0.138	0.549

Table 4.7: Relationship on Muscular Fatigue and Perceived Fatigue on Different Phases MC

The table 4.7 presents the relationship of CMJ Height (refers to muscular fatigue) and perceived fatigue on different phases MC. The *p*-value of each MC phases were scored higher than 0.05 which also refers to there is not statistically significant between different phases MC on muscular fatigue and perceived fatigue. The *p*-value of EF phases was 0.653; LF phase was 0.697; OP phase was 0.849; ML phase was 0.734 and LL phase was 0.549. Moreover, each MC phases' *r*-values of EF = 0.084, LF = -0.073, OP = 0.036, ML = 0.089 and LL = -0.138 respectively. The correlation coefficient shows positive poor association on EF, OP and LL phases on muscular fatigue and perceived fatigue during different phases of MC while the result of LF and LL phases were negatively poor associated. To sum up, there is no association between muscular fatigue and perceived fatigue on different phases of MC.

4.4 Hypothesis Testing

First null hypothesis (H_0):

- There are no significant differences on daytime drowsiness on different phases of MC (EF, LF, OP, ML and LL phases) among recreational female badminton players.

First alternate hypothesis (HA):

- There are significant differences on daytime drowsiness on different phases of MC (EF, LF, OP, ML and LL phases) among recreational female badminton players.

Second null hypothesis (H_0):

- There are no significant differences on muscular fatigue on different phases of MC (EF, LF, OP, ML and LL phases) among recreational female badminton players.

Second alternate hypothesis (HA):

- There are significant differences on muscular fatigue on different phases of MC (EF, LF, OP, ML and LL phases) among recreational female badminton players.

Third null hypothesis (H_0):

- There are no significant relationship on daytime drowsiness and muscular fatigue across the 5 phases of MC on among recreational female badminton players

Third alternate hypothesis (HA):

- There are significant relationship on daytime drowsiness and muscular fatigue across the 5 phases of MC on among recreational female badminton players

Chapter 5

Discussion

5.1 Chapter Overview

This chapter will discuss the key findings of the results in the previous chapter with the current evident based support with reasoning. Additionally, this chapter also illustrates the limitation of the study, recommendation for future research and conclude the study findings.

5.2 Discussion

This study aims to explore the effects and relationship of the 5 phases of the menstrual cycle (EF, LF, OP, ML and LL phases) on daytime drowsiness and muscular fatigue among recreational female badminton players.

With the collected data in this study found that that EF followed by LL have the highest daytime drowsiness. Next, the hormonal events of MC do not influence the muscular fatigue. Moreover, there is not statistically significant association on daytime drowsiness and muscular fatigue between different phases of MC. Additionally, the perceived fatigue is correlated to daytime drowsiness but not been found in muscular fatigue. According to the analyzed data, the researched observed that the daytime drowsiness during EF and LL phases are statistically significant with perceived fatigue while not in the rest of the MC phases.

The finding from the researcher noted that the EF and LL have the highest daytime drowsiness.

There were multiple researches have done the study of the effect of MC on daytime drowsiness. Their studies have found out some factors that lead to higher daytime drowsiness during specific phases of MC. Female players tend to feel more daytime drowsiness during EF phase are due to the hormonal effect and reduced sleep quality compared to LL phase (Carmichael et al., 2021) & (Driver & Baker, 1998). The result was supported by Driver & Baker (1998) who stated that 16 – 25% of females reported lethargy during late luteal phase while 25 – 32% of females during mesense due to reduced sleep quality. Additionally, EF phase refers to bleeding phase, thus the alertness which caused by drowsiness of the subjects could affect by heavy bleeding the first few days of EF phase. During this phase, female more prone to reduce in total deep sleep time, sleep efficiency and prolonged sleep latency compared to late follicular phase (Carmichael et.al., 2021).

Reduced sleep quality during EF and or LL phase are more prone to happen among female who having menstrual symptoms which known as PMS (Ames, 2020). The menstruation symptoms which occurred during EF and LL phases included physical, emotional and behavioral sign and symptoms (Ames, 2020). The physical sign and symptoms are intense lower abdominal pain (period pain), low back pain, headache, joint or muscle pain and etc. Moreover, the emotional and behavioral sign and symptoms are poor concentration, mood swings and bad sleep quality. These are the fluctuation hormonal effects that occur around and or during menstruation (Ames, 2020). A study found out that the female with PMS is 2 time greater to have poor sleep quality then those who did not have PMS. 69 females with PMS and 52 females without PMS have been assessed with ESS (Conzatti, 2021). The statistically significant value has scored by females with

PMS during follicular phase are 0.006 with odd ratio of 3.057 and the 95% of confident interval from 1.44-6.45 (Conzatti, 2021). During luteal phase, females with no PMS scored $p = 0.014$ while females with PMS score $p = 0.22$ (Conzatti, 2021). Both of the results reviewed that females with PMS facing more daytime drowsiness during EF & LL phases.

Furthermore, in the EPISONO study cohort, 96 females had taken one-night polysomnography. The results gave female having better sleep efficiency during mid or late follicular phase with the mean and SD scores or 89.9% ± 9.6 compared to menses phase 83.0% ± 10.8 and luteal 83.7% ± 12.7 (Ishikura et al., 2024). Besides, during the mid or late follicular females' average time taken for sleep latency is shorter (7.1 ± 7.1 min) compared to the menstrual (22.3 ± 32.4 min) and luteal groups (15.9 ± 14.7 min) (Ishikura et al., 2024). This implies that mid or late follicular phases has better sleep quality and thus result in less daytime drowsiness. Nevertheless, the researcher of this study had found that there no or less daytime drowsiness during ML phases compared with other phases of MC. The finding has been supported by Kar & Agrawala (2018) which conveys the female undergoes deeper sleep stage (stage 2) and reduced in rapid eye movement (REM) during ML phases compared to mid follicular phase (Kar & Agrawala, 2018).

The main endogenous hormones progesterone takes role of promoting sleepiness while estrogen improves alertness (Shechter & Boivin, 2010). Higher chance of drowsiness during EF phase due to both of the hormones are low similar to LL phase which experiencing the dropping of both hormones from ML phase (Carmichael et.al., 2021). Moreover, the progesterone is also functionally positive associated with body temperature and promoting sleeping effect (Charkoudian & Stachenfeld, 2016) & (Driver & Baker, 1998). Females will experience lower body temperature during the early follicular stage while higher core body temperature in the late luteal phase (increased 0.5°C to 1°C, the body temperature reach 36.5°C to 37°C) (Charkoudian & Stachenfeld, 2016) & (Driver & Baker, 1998). With the higher of the thermoregulation of the dissipation of body temperature and higher sleeping effect were result in reduced sleep quality and thus lead to daytime drowsiness during luteal phase especially beginning of the LL phases (Charkoudian & Stachenfeld, 2016).

Referring to the ovulation fatigue, the finding of this study has demolished the theory from Gleanton (2024) who claimed that the spike of the estrogen and progesterone could lead to poor sleep quality and increase the daytime drowsiness or mental fog. The theory from Haslett (2024) mentioned that the period of hormones fluctuation is short (OP phase takes approximately 3 days) while according to McLaughlin (2022) stated that ovulation usually take 16 to 32 hours thus, the subject will not feel sleepiness with the short period of hormonal changes. According to the proved of endogenous hormonal event during different phases of MC from McNulty et al. (2020) and Farage et al. (2012) show that the estrogen decreased steadily while progesterone increases smoothly during OP phase. Thus, the sleep quality is not affected by hormones during OP phase. In short, daytime drowsiness is influenced by MC phases due to the endogenous hormonal events.

In this study, there is no detected muscular fatigue influenced by the different phases of MC.

The CMJ height is used to measure the muscular fatigue among female recreational badminton player by applying fatigue protocol (40 squat jumps). The finding of this study has aligned with the researches done by Ogul et al. (2021), García-Pinillos et al. (2021), Morenas-Aguilar et al. (2023) & Pisapia et al. (2019) which proved that the CMJ height is not affected by different phases of MC which also implies that the muscular fatigue is not affected by hormonal events. A narrative review from Carmichael et al. (2021) listed that multiple jump tasks such as countermovement jump (Smirniotou et al., 2004), vertical (Kishali et al., 2010) and squat jump test (Smirniotou et al., 2004) outcomes did not differ by menstrual cycle phases with the theory of no change of tissue stiffness over menstrual cycle phases. Conversely, vertical jump height is influenced by menstrual cycle phases have been proved by Julian et al. (2017) and Davies et al. (1991).

Besides, in this study there is no report previous experience in strength training from the subjects of this study which become a confounding factor on determining the type of efforts (García-Pinillos et al., 2021). Jumping is a movement that highly recruiting stretch-shortening cycle (SSC), muscle strength to generate adequate force and power. Referring to Niering et al. (2024), female player will have better performance during LF phase due to the higher level of estrogen compared to other phases of MC. It is because estrogen responsible to neuroexcitatory and strength enhancing effect (Niering et al., 2024). The main endogenous hormones estrogen and progesterone take role in force production. The estrogen functions as a component for force production and to repair post-damage muscles after strength training through the activation and proliferation of the satellite cells (Sung et al., 2014). Moreover, the peak estrogen level creates better strength performance due to better neuroexcitatory effect during LF phase (Sung et al., 2014), (Carmichael et.al., 2021) (Vidafarl et al, 2018) & (Niering et al., 2024). Despite this, people have different responses to hormonal events, resulting in contradictory findings regarding the effect of different MC phases on vertical jump height (Michelekaki et al., 2023).

Additionally, the player's performance is possible to be influenced by body composition (García-Pinillos et al., 2021). Typically, the anabolic effect of estrogen improves the muscle mass and strength and fat oxidation of a body and found in different ability across different phases of MC (García-Pinillos et al., 2021). However, the trained females have shown that they have different body composition throughout the MC phases and result in no changes on jumping ability (Rael et al., 2021). In this study, relationship of estrogen level and vertical jump performance is negatively associated.

Nevertheless, the sample populations of the recent studies were varying with this current study. The selected participants in the study of Ogul et al. (2021) are eumenorrheic physical active female population with 1162.2 ± 189.1 MET-min/week (Ogul et al., 2021). Besides, the sample population of García-Pinillos et al. (2021) was elite futsal female players. Moreover, Morenas-Aguilar et al. (2023) had selected handball female players for their research. Lastly, Pisapia et al. (2019) was targeted on female athletes. Endocrine function especially reproductive sex hormone is sensitive to lifestyle factors such as physical activity level and type including intensity, volume, rest intervals, repetition speed, frequency, as well as the selection and order of exercise involved (Copeland et al., 2004) & (Mennitti et al., 2024). Anabolic hormones are associated with muscle mass through their influence on protein carriers and receptors, resulting in varying hormonal responses that impact physical performance (Copeland et al., 2004). There is the increase level of estrogen and cortical hormones found among those females who performed acute exercise (Mennitti et al., 2024). Besides, another literature also found out that an acute bout of exercise is potential to increase the estradiol concentration level (Jennifer et al., 2002).

Moreover, the motivation for sports participation varies significantly between recreational players and competitive athletes. Recreational players are primarily driven by enjoyment, health benefits, social interaction, and stress relief (Kilpatrick et al., 2005). Their focus is on personal well-being and leisure rather than competition, with goals that are typically self-directed and aimed at improving fitness or acquiring new skills in a less structured environment (Ryan & Deci, 2000). In contrast, athletes are motivated by a desire to achieve excellence, gain recognition, and outperform their competitors (Deci & Ryan, 1985). Their focus is highly goal-oriented, involving disciplined and rigorous training to reach peak performance. Unlike recreational players, athletes' performance goals are often tied to external rewards or intrinsic desires for mastery (Vallerand, 2004). These differences underscore the varied approaches and purposes that individuals bring to sports participation. Lastly, it might be the factor that shown in unchanged of CMJ height on different phases of MC.

Last but not least, the type of diet intake could affect the reproductive sex hormone production. Estradiol is a steroid hormone derived primarily from dietary fats, is the primary form of estrogen (Bennett & Ingram, 1990). It enhances muscle strength performance by increasing the intrinsic contraction rate of muscle fibers (Lowe et al., 2010). Female who changed to vegetarian diet from usual meat-eating diet or at least 3 times fish consumed per week have shown significantly reduce in estradiol hormonal level (Bennett & Ingram, 1990). In premenopausal women, a low-fat diet providing 20% of total energy intake reduced non-protein-bound estradiol levels from 1.48% to 1.27% (Ingram et al., 1987). The meta-analysis revealed that postmenopausal women receiving hormone therapy which estrogen was included in the therapy exhibited approximately 5% greater strength than those without HT (effect size = 0.23) (Greising et al., 2009). In studies measuring specific force, hormone therapy showed a trend for approximately 10%

strength increase (Greising et al., 2009). These findings reveal that estrogen only affects muscle strength differently in premenopausal and postmenopausal females.

Moreover, the result of this study shown that no correlation on daytime drowsiness and muscular fatigue across different phases of MC.

ESS is used to access the daytime drowsiness while CMJ is used to detect muscular fatigue by recording jump's height across different phases of MC. The findings illustrated that both of the variables are negatively associated with the p-values > 0.05.

This is due to the different mechanisms behind the mentioned variables. Daytime drowsiness among female population may be due to endogenous hormonal effect and poor sleep quality, emotion, sleep apnea, narcolepsy and restless legs syndrome in general gender or maybe due to some severe medical condition (Stuart, 2023). Daytime drowsiness could reduce cognitive alertness but not physical ability (Stuart, 2023). Apart from that, muscular fatigue is due to the physiological change of the muscle properties due to high loading of physical activity, insufficient recovery period and lack of neuromuscular control (Enoka & Duchateau, 2008).

ESS is a subjective retrospective tool to tract the daytime sleepiness while CMJ is a physical examination to detect the present of muscular fatigue (Omobomi & Quan, 2018) & (Alba-Jiménez et al., 2022). The ESS scoring is affected by the daily activities, nap length, food consumption, emotional and behavioral of a person (Omobomi & Quan, 2018). In some case, the subject is being noted sleepiness by people who surrounding them instead of him or herself (Omobomi & Quan, 2018). Therefore, there could be a bias in the result. Muscular fatigue in this study is induced by repeated jumping movement which was a set of continuous 40 squat jumps (Leard et al., 2007). The purpose of setting no rest interval during the intervention was to create muscle damage and thus result in muscular fatigue in order to theoretically reduced jumping ability (Twist & Eston, 2005).

In a study, the subjects who took 30 minutes nap were reduced in daytime drowsiness but jumping ability were remained the same (Daaloul et al., 2019). The finding is in line with the research conducted if the sleep inertia is present (Suppiah et al., 2019). In a study conducted by Morita et al. (2016) among sixteen female college students eight (experimental group) took a 2-hour nap after putting into practice the juggling, while remaining eight didn’t take the nap (control group). Juggling performance was testes in the morning and in then was re-tested in the evening. Juggling performance improved after the period of 2-hour nap, on the other hand the subjects among the control group did not displayed improvement (Morita et al., 2016). To sum up, both variables have no direct correlation thus, there is no existing association.

Additionally, the daytime drowsiness which correlate to perceived fatigue has stronger feeling of fatigue during EF and LL phases.

In the table 4.6 pointes that there is statistically significant on daytime drowsiness and perceived fatigue during the EF and LL phases. The phenomena can be explained by the production and level of serotonin hormone (Carmichael et al., 2021). Nevertheless, the perceived fatigue is also increasing the drowsiness and deteriorating the concentration in performing a task (Takeda et al., 2015). As mentioned above, the main endogenous hormone of female is estrogen and progesterone which are highly associated with sleep hormones (Gleanton, 2024).

Estrogen is the hormone that functionally regulate the serotonin and iron level (Yang et al., 2012 & Carmichael et.al., 2021). The correlation of estrogen concentration with serotonin concentration is positive while its correlation with iron concentration is negative. Apart from that, serotonin causes perceived fatigue by producing sleep hormones such as dopamine and melatonin (Cleveland Clinic, 2022). Both of the hormones promote better sleep quality in-term of deep sleep time and reduced number of times of awake from sleep (Cleveland Clinic, 2022). 13 eumenorrhea females reported they experience stronger perceived fatigue and tension-anxiety during EF and LL phases with the low level of estrogen level as well as serotonin level (Kikuchi et al., 2010).

Iron is responsible for energy production by delivering the oxygen to cell for metabolic and energy production purposes (Latorre, Pengelly & Minehan, 2023). Besides, the iron is also takes role as a menstrual blood volume reducer but due to the excessive flow of bleeding, thus the perceived fatigue is high in EF phase (Yang et al., 2012 & Panayi, 2019). During LL phase, the low estrogen level is low, and it also result in high perceived fatigue as well (Cleveland Clinic, 2022).

Apart from that, the progesterone level gives positive response on the perceived fatigue. During luteal phase, there is high progesterone level with more stronger feeling of subjective fatigue (Freeman et al., 2008). In a study highlighted that the subjects took longer response time in mental rotation task during luteal phase which is the timepoint that progesterone level is high (Noreika et al, 2014). Besides, task performance effectiveness is also delayed during EF (low estrogen) and ML (high progesterone) phases. In contrast, perceived fatigue is not been found with high level of progesterone (Courvoisier et al., 2013) & (Kass et al., 1998). More studies should be conducted to study the progesterone effect of perceived fatigue which the topic remain elusive compared to the study of estrogen effect on perceived fatigue (Noreika et al, 2014). In the nutshell, low level of estrogen and high level of progesterone could lead to high perceived fatigue.

Lastly, the researcher also found that the muscular fatigue is not statistically significant with perceived fatigue on different phases of MC.

Countermovement jump is an objective measurement tool to assess the physical performance (Alba-Jiménez et al., 2022). It can be used to evaluate numerous types of fatigues which in this study is mainly focus on the muscular fatigue. Muscular fatigue can be induced by high load of repetition training and reduced muscle fiber contraction ability thus reduced in generation of strength and power within muscle fiber. However, the finding of this study, the countermovement jump performance is not induced by fatigue protocol and it is no affected by different MC phases. This study's finding is also supported by Ogul et al. (2021), García-Pinillos et al. (2021), Morenas-Aguilar et al. (2023) & Pisapia et al. (2019). However, Julian et al. (2017) and Davies et al. (1991) stated that the CMJ height is affected by hormonal events due to the estrogen and progesterone which will affect the physical performance in-term of muscle strength and power production. The research's finding is sameness with the finding from Martínez-Martí at al. (2021). Besides, the muscular fatigue is related to metabolic factors and fatigue substance during the process of contraction (Wan et al., 2017). The fatigue substance involved hydrogen (H^+) ions, lactate, inorganic phosphate (P_i), reactive oxygen species (ROS), heat shock protein (HSP) and orosomucoid (ORM) (Wan et al., 2017). The muscular fatigue was induced by high-volume of fatigue protocol with the dosage of 14 sets of 10 continuous jumps with 1 minute of the resting interval between sets but not low-volume protocol (7 sets of 10 continuous jumps with 1 minute of the resting interval between sets) (Knihs et al., 2022).

Perceived fatigue is a subjective sense of lethargy which employed by multifactorial approach such as physical, mental and physiological (Gorman, 2015). The symptom assessment tool to measure perceived fatigue is subjective. In this research, the component of fatigue in wellness questionnaire were used to explore the perceived fatigue during different phases of menstrual cycle. The finding of this study proved that the perceived fatigue of the subjects was affected by menstrual cycle hormonal events (Michelekaki et al., 2023) & (Carmichael et al. 2021). According to Michelekaki et al. (2023) & Carmichael et al. (2021), the researches stated that the perceived fatigue is affected by endogenous hormone. PMS during EF and LL phases and poor sleep quality may lead to perceived fatigue (Michelekaki et al., 2023). This is due to the low estrogen level during EF and LL phases which declined the fatigue tolerance and high level of progesterone during LL phase which reduced the sleep quality (Michelekaki et al., 2023). However, 44.6% of college athletes have the thought that perceived fatigue impaired the sport's performance due to the low estrogen hormones (Takeda et al., 2015). Similarly, one of the studies stated that perceived fatigue will only be found within female with severe PMS (Baker & Colrain, 2009). This is due to the personal hormonal sensitivity is difference from person-to-person (Michelekaki et al., 2023). A narrative review study declared that at least one physical performance measure was affected by MC hormonal events in a total of 15 studies; however, no evidence of impaired physical performance due to MC phases was found in 20 other studies (Carmichael et al., 2021). In the nutshell, the CMJ height and perceived fatigue have no correlation to each other due to different of physiology & type of assessment (objective and subjective).

The researcher had concluded that the daytime drowsiness is influenced by MC while no effect on muscular fatigue. Furthermore, the daytime drowsiness and muscular fatigue have no relationship between each other variables. The additional collected data to support the research findings had proved that the daytime drowsiness is correlated to perceived fatigue but no correlation on muscular fatigue and perceived fatigue.

5.3 Limitation of study

The researcher had noticed there are some limitations of this study which could bring bias to the study's findings. Firstly, the method to determine the menstrual cycle phases was self-reported by the participants instead of utilizing the endogenous hormone measurement tool due to financial constraint and ethical concerns. Serum biomarkers which included estradiol, luteinizing hormone and progesterone are the parameter to acknowledge the menstrual cycle phases (Anckaert et al., 2021). However, the menstrual cycle length is vary from person-to-person thus miss tracking of the MC phases might be happed (McLaughlin, 2022).

The instrument to measure the CMJ height in this study is vertec jump device. This decide gives ICC value of 0.75 which consider moderate reliable (Dasa et al., 2021) & (Koo & Li, 2016). However, there is a better instrument to assess CMJ height by recording the action-time audio and visual biofeedback which known as KForce Plates system (Plakoutsis et al., 2023). Its ICC value reach up to 1 which indicate excellent reliability (Koo & Li, 2016). Both instruments are reliable and valid but due to the cost consideration, the researcher decided to use the vertect jump device which is cost efficient and more portable.

Besides, the fatigue protocol dosage should be reviewed. Due to the concerning of physical performance ability of the recreational badminton player, the researcher decided to reduce the fatigue protocol dosage from 7 sets of 10 continuous jumps to 4 sets of continuous squat jumps (Knihs et al., 2022). This could be a confounding reason that the muscular fatigue is not being induced and further not detected in the CMJ height.

The ESS is only collecting the data of the level of daytime drowsiness based on the specified situation (Omobomi & Quan, 2018). However, daytime drowsiness may be caused by numerous reasons. One of the possible reasons is postprandial somnolence as known as reduce energy level due to calorie or carb-rich meals (Fisher, 2024). Therefore, the time to fill up the daytime drowsiness and sleep related questionnaires should be fixed.

The subject of this research is only limited to recreational female badminton player, thus the finding is not relevant to those out from this sample groups. A player or an athlete's performance could be determined by a person training load. Over training might cause amenorrhea that could lead to reduce in sport's performance due to increased musculoskeletal injury and poor health condition. Apart from that, the eumenorrhea player or athlete is able to support sport's performance and development (Ihalainen et al., 2024). Besides, the target sample population is only limited on UTAR female recreational badminton player with the sample size of 31 in this study. The sample size considered medium compared to the population of Selangor area. Thus, the finding emphasized to this sample size which could has bias from the finding in larger sample size.

5.4 Recommendation for future research

In order to enhance the research finding, the researcher suggests that apply self-reported MC and serum hormone measurement tool to tract the MC phases by the specific value of hormones concentration level. This practice is able to provide more accurate finding of effect of daytime drowsiness and muscular fatigue on different phases of MC.

Next. future studies should consider using advanced tools like the KForce Plates system to measure CMJ height, offering superior reliability (ICC = 1) and detailed biofeedback (Plakoutsis et al., 2023). While the Vertec jump device used in this study was cost-efficient and portable, its moderate reliability (ICC = 0.75) (Dasa et al., 2021) may limit precision. Utilizing the KForce system could enhance data accuracy and provide deeper insights into CMJ performance.

Besides, the dosage of fatigue protocol should be increased to study the muscular fatigue. Knihs et al. (2022) had successfully produce muscle fatigue by instructing the subjects to perform 10 sets of maximal vertical jumps with 1-minute resting interval between each set (Twist & Eston, 2005). Apart from that, low volume protocol with 7 sets of maximal vertical jumps with 1-minute resting interval has failed to induced muscular fatigue (Knihs et al., 2022). This implies that, the higher dosage of fatigue protocol may contribute better muscular fatigue foundation and provide more comprehensive understanding on the influence of MC phases on muscular fatigue.

Moreover, the time to conducting the CMJ test and answering the questionnaire is suggested to done before getting a meal. This is because the heavy, high carbohydrates or oily meal may cause postprandial somnolence. The participants were not able to clarify whether the cause of daytime drowsiness was postprandial somnolence, or a hormonal event related to the MC. This could reduce the sensitivity of the self-reported daytime drowsiness data.

Lastly, the sample size of the study should be increased to reduce the study bias. A larger sample size could provide a stronger statistical power in-term of validity, reliability, sensitivity and generalizability of the research findings. This provides more comprehensive insights into the scope of study.

5.5 Conclusion

In conclusion, this research was established to explore the effects and relationship of the 5 phases of the menstrual cycle (EF, LF, OP, ML and LL phases) on daytime drowsiness and muscular fatigue among recreational female badminton players. The researcher observed a significant increase in daytime drowsiness during the EF and LL phase as compared to LF, OP, ML phases. Besides, the analyzed data claimed that the muscular fatigue is not influenced by MC phases. Additionally, the perceived fatigue correlated to daytime drowsiness during EF and LL phases but not LF, OP, ML phases while it is not correlated to muscular fatigue. The findings of this research also contribute more detailed insights to the existing knowledge in sport injuries prevention but also provide comprehensive knowledge for the training plan to optimize the performance of female badminton players and athletes. Recognizing the influence of hormonal fluctuations during the MC on daytime drowsiness and muscular fatigue can help coaches, female athletes, and players optimize their training plans. This approach may reduce injury risks and improve performance during favorable phases of the cycle. For example, adjustments such as lowering training intensity, shortening session durations, or increasing rest intervals during specific MC phases have been recommended. While these findings offer a valuable starting point, further research is necessary to uncover the mechanisms and clarify the connections between the menstrual cycle, daytime drowsiness, muscular fatigue, and injury risk.

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APPENDIX A - ETHICAL APPROVAL LETTER

UNIVERSITI TUNKU ABDUL RAHMAN

Wholly Owned by UTAR Education Foundation (Company No. 578227-M)

Re: U/SERC/78-363/2024

23 September 2024

Mr Muhammad Noh Zulfikri bin Mohd Jamali
Head, Department of Physiotherapy
M. Kandiah Faculty of Medicine and Health Sciences
Universiti Tunku Abdul Rahman
Jalan Sungai Long
Bandar Sungai Long
43000 Kajang, Selangor

Dear Mr Muhammad Noh,

Ethical Approval For Research Project/Protocol

We refer to your application for ethical approval for your students' research project from Bachelor of Physiotherapy (Honours) programme enrolled in course UMFD3026. We are pleased to inform you that the application has been approved under Expedited Review.

The details of the research projects are as follows:

No	Research Title	Student's Name	Supervisor's Name	Approval Validity
1.	The Effect of Diaphragm Muscle Exercise on Dynamic Balance among Post-COVID-19 Older Adults in Klang Valley, Malaysi	Goh Le Yi	Ms Premala a/p Krishnan	23 September 2024 – 22 September 2025
2.	Relationship Between Cognitive Domains, Dynamic Postural Stability and Fall Risk in Elderly Individuals with Mild Cognitive Impairment: A Pilot Study	Chaw Jade Wern		
3.	Smartphone Addiction and Its Relationship with Forward Head Posture and Grip Strength Among University Students in Klang Valley	Chuar Yu Cheng	Mr Chew Wai Hoong	
4.	Dynamic Balance and Life-Space Mobility Among Community Dwelling Older Adults: A Correlation Study	Grace Wong Mui Kar		
5.	Relationship Between Neck Disability, Sleep Quality, and Perceived Stress Among University Students in Klang Valley	Low Jun Kai		
6.	Association Between Medial Longitudinal Arch and Body Mass Index Among Young Adults in Klang Valley and Selangor, Malaysia	Mahaasiri a/p Kamalavallo	Ms Ambusam a/p Subramaniam	
7.	Effectiveness of Mulligan's Traction Straight Leg Raise Technique on Young University Students with Symptoms of Restless Leg Syndrome	Lim Chun Qi	Mr Tarun Amalnerkar Ms Swapneela Jacob	
8.	Effect of 4-week Inspiratory Muscle Training (IMT) Program on Young Adult with Mild Obstructive Sleep Apnea (OSA)	Sia Cai Ni	Mr Tarun Amalnerkar Ms Swapneela Jacob Mr Sathish Kumar Sadagobane	

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No	Research Title	Student's Name	Supervisor's Name	Approval Validity
9.	Assessment Of Diagnostic Clinical Reasoning Skills Among Undergraduate Physiotherapy Students	Jason Ho Yi Zeng	Mr Avanianban Chakkarapani	23 September 2024 – 22 September 2025
10.	Awareness, Knowledge, Attitude and Perception of Active Isolated Stretching Among Physiotherapy Academics and Students in a Private University: A Cross Sectional Study	Law Jing Tien		
11.	Knowledge Of Quadriceps Angle (Q-Angle) Among Physiotherapy Students	Tay Yu Xin		
12.	Cortical Excitability and Body Awareness in Individuals with Adolescent Idiopathic Scoliosis: An Exploratory Study	Mark Isaac Fernandez	Dr Deepak Thazhakkattu Vasu	
13.	Exercise Interventions in Primiparous Women for the Prevention and Management of Pelvic Floor Dysfunction: A Systematic Review	Jenny Peng Mei Shi		
14.	Exploring the Novel Sensor System for Detecting Postural Reactions Among Healthy Younger Adults: A Pilot Study	Ooi Xin Rou		
15.	Prevalence of Chronic Fatigue Syndrome (CFS) and Its Association on Quality of Life and Sleep Quality Among Young Adults: A Cross-sectional Study	Delphine Yeo Sze Qi	Mr Sathish Kumar Sadagobane Co-Supervisor: Mr Tarun Amalnerkar	
16.	Association Between Level of Ergonomic Knowledge and Prevalence of Neck Pain Among Part-time Postgraduate Students in Klang Valley	Ng Jia Xuan	Mr Sathish Kumar Sadagobane Co-Supervisor: Mr Edwin Gaspar	
17.	Effectiveness of Kinesiotaping with Static Stretching and Proprioceptive Neuromuscular Facilitation Stretching for Gastrocnemius Tightness Management Among Adults	Tan Jia Yin	Ms Heaw Yu Chi	
18.	Awareness, Knowledge and Perceptions of Chronic Fatigue Syndrome/ Myalgic Encephalomyelitis Between Student and Working Physiotherapists: A Comparative Study	Tee Yee Pei		
19.	Effect of Pulmonary Rehabilitation on Dyspnea and Quality of Life Among Chronic Obstructive Pulmonary Disease Patients: A Systematic Review	Chin Jay Ven	Mr Imtiyaz Ali Mir	
20.	Efficacy of Music Therapy and Mindfulness Meditation on Blood Pressure and Mental Health Among University Students	Tan Pei Chen		
21.	Effects of Music Therapy on Haemodynamic Variables and Mental Health in Patients with Coronary Artery Disease: A Systematic Review	Foong Ei Yan		
22.	Effects of Different Phases of the Menstrual Cycle on Daytime Drowsiness and Muscular Fatigue Among Recreational Female Badminton Players	Lee Kae Shyan	Mr Muhammad Noh Zulfikri Bin Mohd Jamali Co-supervisor: Mr Tarun Amalnerkar	
23.	Association between Gastrocnemius Tightness, Hallux Valgus and Physical Activity Among University Students	Chong Yi Xian	Ms Siti Hazirah Binti Samsuri	
24.	The Prevalence of Lower Urinary Tract Symptoms (LUTS) and Its Associated Risk Factors Among Male University Students	Gan Xinyi		
25.	Examining Doms Reduction in Recreational Versus Competitive Athletic Populations	Jona Kong Zong Na	Ms Kamala a/p Krishnan	
26.	Effectiveness of Virtual Reality Games on Hand Movement and Strength rehabilitation in Stroke Patients: A Systematic Review	Rachel Hew Zi Qi		

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No	Research Title	Student's Name	Supervisor's Name	Approval Validity
27.	Prevalence of Menstrual Migraine Among University Students and Its Impact on Quality of Life: A Cross Sectional Study	Jing Ni Wong	Ms Swapneela Jacob Co- supervisor Mr Tarun Amalnerkar	23 September 2024 – 22 September 2025
28.	Prevalence of Functional Constipation and Its Impact on Quality of Life Among Young Adults: A Cross Sectional Study	Ow Yong Jie Min		
29.	A Study to Anlayse the Correlation Between Migraine Symptoms, Motion Sensitivity and Balance Impairment: A Cross-sectional Study Among University Students	Stella Chen Sing Yi	Ms Kiruthika Selvakumar	
30.	A Study to Analyse the Impact of Headache on Level of Physical Activity and Dynamic Balance Among University Students	Lee Wan Fei		
31.	Comparison of the Attitudes and Awareness of Elderly Falls and Fall Prevention Across Diverse Age Groups: A Cross-sectional Study	Ng Sin Ru	Ms Mahadevi A/P Muthurethina Barathi	
32.	A Cross-sectional Study on the Knowledge of Knee Osteoarthritis and Attitude Towards Prevention of Knee Osteoarthritis in Young Adults	Lim Shi Qi		
33.	Challenges and Possible Risk Factors Associated with Using Wearable Devices for Assessing the Motor Symptoms of People with Parkinson's Disease: A Scoping Review	Lee Wen Ke	Pn Nur Aqliliriana Binti Zainuddin Co-supervisor: Mr Tarun Amalnekar	
34.	The Utilization and Barriers of Adoption of Wearable Devices for Rehabilitation Among Physiotherapists: A Cross-Sectional Study	Yap Wei Qi	Pn Nur Aqliliriana Binti Zainuddin	
35.	Knowledge and Awareness of Parkinson's Disease and Its Associated Factors Among General Population in Malaysia: A Cross-sectional Survey	Jolyn Cheah En		
36.	Association Between Breast Size and Upper Crossed Syndrome Among Perimenopausal Aged Women	Connie Chuo Yi Ching	Ms Meneka Naidu a/p Mohnaraju	
37.	Awareness of Cervical Cancer Among Premenopausal Women in Klang Valley, Malaysia: A Cross-sectional Study	Havilah Wong Sie Chii		
38.	Prevalence and Risk Factors of Postpartum Depression and Anxiety After COVID-19 Pandemic: A Systematic Review	Lee Shi En	Pn Nadia Safirah Binti Rusli	
39.	Post-natal Functional Abilities and Its Association with Depression Following Cesarean Section: A Cross-sectional Study	Seah Yi Shean		
40.	Prevalence and Associated Risk Factors of Musculoskeletal Disorders Among Food Delivery Riders in Klang Valley: A Cross-Sectional Study	Odelia Chew Yong Xin		
41.	Impact of Academic Stress on Executive Functions and Sleep Quality Among University Students: An Observational Study	Lai Yu Wei	Mr Nizar Abdul Majeed Kutty	
42.	Knowledge and Awareness of Re-Warm Up Programs on Physical Performance Among University Athletes. A Cross Sectional Study	Emmanuel James Loh Kuan Hung		

The conduct of this research is subject to the following:

(1) The participants' informed consent be obtained prior to the commencement of the research;

(2) Confidentiality of participants' personal data must be maintained; and

(3) Compliance with procedures set out in related policies of UTAR such as the UTAR Research Ethics and Code of Conduct, Code of Practice for Research Involving Humans and other related policies/guidelines.

(4) Written consent be obtained from the institution(s)/company(ies) in which the physical or/and online survey will be carried out, prior to the commencement of the research.

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Should the students collect personal data of participants in their studies, please have the participants sign the attached Personal Data Protection Statement for records.

Thank you.

Yours sincerely,

Professor Ts Dr Faidz bin Abd Rahman
Chairman
UTAR Scientific and Ethical Review Committee

c.c Dean, M. Kandiah Faculty of Medicine and Health Sciences
Director, Institute of Postgraduate Studies and Research

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APPENDIX B - PERSONAL DATA PROTECTION STATEMENT

FYP_Effects of Different Phases of the Menstrual Cycle on Daytime Drowsiness and Muscular Fatigue among Recreational Female Badminton Players

PERSONAL DATA PROTECTION NOTICE

Please be informed that in accordance with Personal Data Protection Act 2010 ("PDPA") which came into force on 15 November 2013, Universiti Tunku Abdul Rahman ("UTAR") is hereby bound to make notice and require consent in relation to collection, recording, storage, usage and retention of personal information.

1. Personal data refers to any information which may directly or indirectly identify a person which could include sensitive personal data and expression of opinion. Among others it includes:
a) Name
b) Identity card
c) Place of Birth
d) Address
e) Education History
f) Employment History
g) Medical History
h) Blood type
i) Race
j) Religion
k) Photo
l) Personal Information and Associated Research Data

2. The purposes for which your personal data may be used are inclusive but not limited to:
a) For assessment of any application to UTAR
b) For processing any benefits and services
c) For communication purposes
d) For advertorial and news
e) For general administration and record purposes
f) For enhancing the value of education
g) For educational and related purposes consequential to UTAR
h) For replying any responds to complaints and enquiries
i) For the purpose of our corporate governance
j) For the purposes of conducting research/ collaboration

3. Your personal data may be transferred and/or disclosed to third party and/or UTAR collaborative partners including but not limited to the respective and appointed outsourcing agents for purpose of fulfilling our obligations to you in respect of the purposes and all such other purposes that are related to the purposes and also in providing integrated services, maintaining and storing records. Your data may be shared when required by laws and when disclosure is necessary to comply with applicable laws.

4. Any personal information retained by UTAR shall be destroyed and/or deleted in accordance with our retention policy applicable for us in the event such information is no longer required.

5. UTAR is committed in ensuring the confidentiality, protection, security and accuracy of your personal information made available to us and it has been our ongoing strict policy to ensure that your personal information is accurate, complete, not misleading and updated. UTAR would also ensure that your personal data shall not be used for political and commercial purposes.

Consent:
6. By submitting or providing your personal data to UTAR, you had consented and agreed for your personal data to be used in accordance to the terms and conditions in the Notice and our relevant policy.

7. If you do not consent or subsequently withdraw your consent to the processing and disclosure of your personal data, UTAR will not be able to fulfill our obligations or to contact you or to assist you in respect of the purposes and/or for any other purposes related to the purpose.

lkshyan2003@1utar.my Switch account

* Indicates required question

Email *

Your email

Acknowledgment of Notice *

◯ I have been notified and that I hereby understood, consented and agreed per UTAR above notice.

◯ I disagree, my personal data will not be processed.

Electronic Signature *
e.g Electronically s/d initials

Your answer

FYP_Effects of Different Phases of the Menstrual Cycle on Daytime Drowsiness and Muscular Fatigue among Recreational Female Badminton Players

Dear participants,

I am **Lee Kae Shyan**, an undergraduate Bachelor of Physiotherapy (Hons) student from University Tunku Abdul Rahman (UTAR) and currently conducting a research study with the tittle "**Effects of Different Phases of the Menstrual Cycle on Daytime Drowsiness and Muscular Fatigue among Recreational Female Badminton Players**"

Please read this information sheet and contact me to ask any questions that you may have before agreeing to take part in this study.

Purpose of the Research Study
To explore the relationship between different phases of the menstrual cycle on daytime drowsiness and muscular fatigue among recreational female badminton players.

Procedures
This study consists of 5 sessions (early and late follicular→ 1st to 3rd and 10th - 12th day of menstrual cycle, ovulation 14th day of menstrual cycle→ and mid and late luteal phases → 20th to 23rd and 24th to 28th of menstrual cycle_average 28 days of menstrual cycle). Each sessions roughly take about 5 - 10 minutes to complete. You will be asked to self-report on the 1st day of menstruation. During each sessions, daytime drowsiness will be assed by Epworth Sleepiness Scale and Sleep Diary Questionnaires while muscular fatigue will be assed by Countermovement Jump (CMJ). Lastly, Wellness Questionnaire is used to tract current status after training.

Risk and Benefits
There are no risks from participating in this study. The benefits of participating in this study include increase awareness of the hormonal changes on the daytime drowsiness and muscular fatigue and making adjustments on the training plan to prevent injuries during training or competition.

Confidentiality
All of the information obtained regarding this study will be kept **STRICTLY CONFIDENTIAL.** Your response will be solely used for academic purposes and not be identified in any data or report.

Voluntary Nature of Study
Participation in this study is voluntary. If you withdraw or decline participations, you will not be panelized or lose benefits or services unrelated to the study. If you decide to participate, you may decline to answer any question and may choose to withdraw at anytime.

Contacts and Questions
If you have any question, clarifications, concerns or complaints, about the research, the researcher conducting this study can be contacted at 012-3190103 or by email at lkshyan2003@1utar.my

APPENDIX C – DEMOGRAPHIC QUESTIONNAIRE AND SCREENING SHEETS

Demographic Data

Q1. Name (Eg: Lee Xiao) *

Your answer

Contact number (Eg: 0123456789) *

Your answer

Q2. Age *

Your answer

Q3. Date of birth (mm/dd/yy) *

Date

mm/dd/yyyy

Q4. Weight (in kg) *

Your answer

Q5. Height (in cm) *

Your answer

Details of Badminton Games

Q6. Do you play badminton? *

- ◯ Yes
- ◯ No

Q7. How frequently do you play badminton **in a week**? *

Your answer

Q8. What is the duration of each training session? (in minutes, Eg: 30 min) *

Your answer

Menstrual Cycle

Q9. When is your first menstruation? (the year of first menstruation and better with month, Eg: June 2010) *

Your answer

Q10. Is your menstrual cycle regular in the last 3 months? (**July, August & September 2024**) *

- ◯ Yes
- ◯ No

Q11a. When is the date of menstruation in **July 2024**? *

Your answer

Q11b. When is the date of menstruation in **August 2024**? *

Your answer

Q11c. When is the date of menstruation in **September 2024**? *

Your answer

Q11d. When is the date of menstruation in **October 2024**?
** Skip to the next question if your period hasn't come yet this month

Your answer

Q12. Do you have any symptoms during menstruation in particular months of **July, August & September 2024**? *

- ◯ Yes
- ◯ No

Q12a. Do you have any symptoms during menstruation in particular months of **October 2024**?
** Skip to the next question if your period hasn't come yet this month

- ◯ Yes
- ◯ No

Q13a. According to Q12, if yes, please thick the symptoms that you experience in **July 2024**. *

- ☐ Lower abdominal pain (menstrual pain)
- ☐ Reduced sleep quality
- ☐ Nausea
- ☐ Vomiting
- ☐ Diarrhea
- ☐ Mood Swing
- ☐ Other: ____________________

Q13b. According to Q12, if yes, please thick the symptoms that you experience in **August 2024**. *

- [ ] Lower abdominal pain (menstrual pain)
- [ ] Reduced sleep quality
- [ ] Nausea
- [ ] Vomiting
- [ ] Diarrhea
- [ ] Mood Swing
- [ ] Other: ____________

Q13c. According to Q12, if yes, please thick the symptoms that you experience in **September 2024**. *

- [ ] Lower abdominal pain (menstrual pain)
- [ ] Reduced sleep quality
- [ ] Nausea
- [ ] Vomiting
- [ ] Diarrhea
- [ ] Mood Swing
- [ ] Other: ____________

Q13c. According to Q12, if yes, please thick the symptoms that you experience in **October 2024**.
** Skip to the next question if your period hasn't come yet this month

- [ ] Lower abdominal pain (menstrual pain)
- [ ] Reduced sleep quality
- [ ] Nausea
- [ ] Vomiting
- [ ] Diarrhea
- [ ] Mood Swing
- [ ] Other: ____________

Q14a. How was your menstrual volume in **July 2024**? *

- ◯ Very light
- ◯ Light
- ◯ Moderate
- ◯ Heavy
- ◯ Very Heavy

Q14b. How was your menstrual volume in **August 2024**? *

- ◯ Very light
- ◯ Light
- ◯ Moderate
- ◯ Heavy
- ◯ Very Heavy

Q14c. How was your menstrual volume in **September 2024**? *

- ◯ Very light
- ◯ Light
- ◯ Moderate
- ◯ Heavy
- ◯ Very Heavy

Q15. Are you pregnant currently? *

◯ Yes

◯ No

Q16. Do you take any oral contraceptive pills or birth control? *

◯ Yes

◯ No

Q17. Do you take any medicine? *

◯ Yes

◯ No

Q18. According to Q17, if Yes, please state which medicine that you are using. (Example: pain killer, insomnia medication, etc.)

Your answer

APPENDIX D – EPWORTH SLEEPINESS SCALE (ESS)

Section 2 of 6

Epworth Sleepiness Scale (ESS)

Description (optional)

Sitting and reading *

	0	1	2	3	
No chance of dozing	○	○	○	○	High chance of dozing

Watching TV *

	0	1	2	3	
No chance of dozing	○	○	○	○	High chance of dozing

Sitting inactive in a public place (e.g., a theater or a meeting) *

	0	1	2	3	
No chance of dozing	○	○	○	○	High chance of dozing

As a passenger in a car for an hour without a break *

	0	1	2	3	
No chance of dozing	○	○	○	○	High chance of dozing

Lying down to rest in the afternoon when circumstances permit *

	0	1	2	3	
No chance of dozing	○	○	○	○	High chance of dozing

Sitting and talking to someone *

	0	1	2	3	
No chance of dozing	○	○	○	○	High chance of dozing

Sitting quietly after a lunch without alcohol *

	0	1	2	3	
No chance of dozing	○	○	○	○	High chance of dozing

In a car, while stopped for a few minutes in traffic *

	0	1	2	3	
No chance of dozing	○	○	○	○	High chance of dozing

APPENDIX E – SLEEP DIARY

Section 3 of 6

Sleep Diary

Description (optional)

Q1. Did you take a nap yesterday? *

- ◯ Yes
- ◯ No

Q2. According to Q1, if Yes, please state the time and lengths (3pm & 1h).

Short answer text

Q3. Do u feel sleepy during the day of yesterday? *

- ◯ Very sleepy & hard to keep attention
- ◯ Somewhat tired
- ◯ Fairly alert
- ◯ Alert

Q4. Do u take caffeinated, alcoholic drinks and medicine yesterday? *

- ◯ Caffeine
- ◯ Alcohol
- ◯ Medicine
- ◯ None

Q5. Do you exercise yesterday *

- ◯ Yes
- ◯ No

Q6. According to Q5, if Yes, please state the time and lengths (Eg: 2pm & 2h)

Short answer text

Q7. What time did you go to bed last night? (Eg: 11pm) *

Short answer text

Q8. How long did it take you to fall asleep? (Eg: 10min) *

Short answer text

Q9. What time did you wake up this morning? (Eg: 7:30am) *

Short answer text

Q10. What were your total hours of sleep last night? (Eg: 8.5h) *

Short answer text

Q11. Number of awakenings and total time awake last night. (Eg: 1 & 30min /or/ 0 & -) *

Short answer text

Q12. What was your feeling when you got up this morning? *

- ○ Fresh
- ○ Alert but a little tired
- ○ Sleepy

APPENDIX F – WELLNESS QUESTIONNAIRE

Section 4 of 6

Wellness Questionnaire

Description (optional)

Sleep Quality *

	1 -Extremely g...	2 - Good sleep	3 - Normal nigh...	4 - Poor sleep	5 - Very bad (c...
Sleep Quality	○	○	○	○	○

Fatigue *

	1 -Extremely E...	2 - Energetic	3 - Normal ene...	4 - A little flat &...	5 - Very flat & ti...
Fatigue	○	○	○	○	○

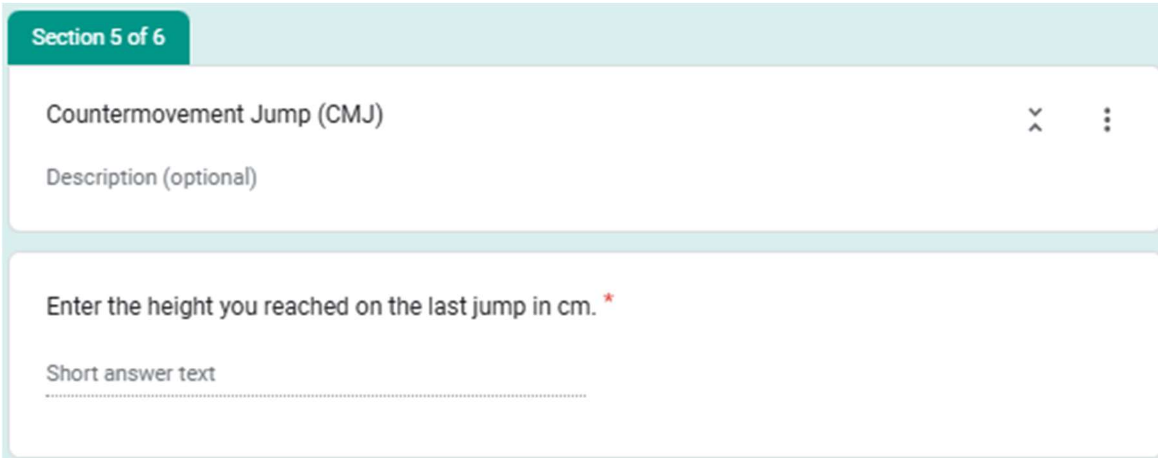
Stress *

	1 - Life is great	2 - Life is good	3 - Normal stre...	4 - Slightly stre...	5 - Very stressed
Stress	○	○	○	○	○

Soreness *

	1 - Feeling grea...	2 - Feeling good	3 - Average sor...	4 - Abit soreness	5 - Very sorene...
Soreness	○	○	○	○	○

APPENDIX G – COUNTERMOVEMENT JUMP



Section 5 of 6

Countermovement Jump (CMJ)

Description (optional)

Enter the height you reached on the last jump in cm. *

Short answer text

APPENDIX H – INSTRUMENT

Vertec jump measuring device, Vertec Vertical Jump Trainer

APPENDIX I – MC CALANDER

Average	28
EF	12 - 13 Nov
LF	23 - 25 Nov
OP	28 Oct
ML	5 - 7 Nov
LL	11 Nov

APPENDIX J – TURNITIN REPORT

Lee Kae Shyan_21UMB03133

ORIGINALITY REPORT

12%	3%	1%	11%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

MATCH ALL SOURCES (ONLY SELECTED SOURCE PRINTED)

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