JONA KONG ZONG NA

FOAM ROLLING FOR RECOVERY:
EXAMINING DOMS REDUCTION IN
RECREATIONAL VERSUS COMPETITVE
ATHLETIC POPULATIONS

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BACHELOR OF PHYSIOTHERAPY (Honours)

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FOAM ROLLING FOR RECOVERY: EXAMINING DOMS REDUCTION IN RECREATIONAL VERSUS COMPETITVE ATHLETIC POPULATIONS

By

JONA KONG ZONG NA

A Research project submitted to the Department of Physiotherapy,
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FOAM ROLLING FOR RECOVERY: EXAMINING DOMS REDUCTION IN RECREATIONAL VERSUS COMPETITIVE ATHLETIC POPULATIONS

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ABSTRACT

Background and Objective: Foam rolling, a type of massage therapy, has shown potential to alleviate delayed-onset muscle soreness (DOMS) induced by intense exercise. However, its effects on recreational versus competitive athletes remain underexplored. This study aims to investigate the effects of foam rolling on DOMS-related pain in recreational and competitive athletes.

Methods: A total of 22 participants from UTAR Sg Long campus were recruited. Each participant underwent two conditions—control and foam rolling—separated by four weeks. Both conditions involved a DOMS-inducing protocol of 10 sets of 10 repetitions of back squats at 60% of their one-repetition maximum. Foam rolling was performed immediately, 24-, 48-, and 72-hours post-exercise for a total of 20 minutes, following Hendricks et al. (2019)'s protocol of 30-60 seconds per muscle group per limb for three sets, with 10-30 seconds rest between sets.

Results: Independent t-tests were used to compare pain levels between pre-DOMS (0h) and post-exercise (24h, 48h, and 72h). ANOVA determined significant differences in foam rolling effects between recreational and competitive athletes. Foam rolling significantly reduced pain perception in both groups ($p < 0.05$), with greater benefits observed in competitive athletes, especially within the first 48 hours post-exercise.

Conclusion: Foam rolling effectively alleviates DOMS-related pain, with competitive athletes experiencing more pronounced benefits. While foam rolling showed small improvements in jump performance for competitive athletes, no consistent effects were observed on sprint speed or jump performance in recreational athletes. These findings highlight the potential of foam rolling as a recovery tool, particularly for competitive athletes.

Keywords: Foam rolling, Delayed Onset Muscle Soreness (DOMS), recreational, competitive, athletic performance, magnitude-based inference, massage, pain.

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APPROVAL SHEET

This Research project entitled **<u>"FOAM ROLLING FOR RECOVERY: EXAMINING DOMS REDUCTION IN RECREATIONAL VERSUS COMPETITIVE ATHLETIC POPULATIONS"</u>** was prepared by JONA KONG ZONG NA and submitted as partial fulfilment of the requirements for the degree of Bachelor of Physiotherapy (Honours) at Universiti Tunku Abdul Rahman.

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PERMISSION SHEET

M. KANDIAH FACULTY OF

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Date: 20/12/ 2024

PERMISSION SHEET

It is hereby certified that **JONA KONG ZONG NA** (ID No: **21UMB01842**) has completed this Research project entitled “FOAM ROLLING FOR RECOVERY: EXAMINING DOMS REDUCTION IN RECREATION VERSUS COMPETITIVE ATHLETIC POPULATIONS” under the supervision of MS KAMALA A/P KRISHNAN (Supervisor) from the Department of Physiotherapy, M. Kandiah Faculty of Medicine and Health sciences.

Yours truly,

Jonakong

(JONA KONG ZONG NA)

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: JONA KONG ZONG NA

Date: 20/12/2024

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LIST OF ABBREVIATIONS

FR	Foam Rolling
DOMS	Delayed Onset Muscle Soreness
CMJ	Counter Movement Jump
SMFR	Self- induced Myofascial Release
RM	Repetition Maximum
NRS	Numerical Rating Scale
SBJ	Standin Broad Jump
ACL	Anterior Cruciate Ligament
VAS	Visual Analogue Scale
VFR	Vibration Foam Roller

CHAPTER 1: INTRODUCTION

1.1 Background

Myofascial release (MFR) has gained popularity as a manual therapeutic technique for addressing fibrous adhesions (Macdonald et al., 2013). It has been widely embraced in the fields of physical therapy, sports medicine, and holistic health practices. The approach focuses on releasing the built-up tension formed in the fascia, a connective tissue surrounding muscles, bones, and organs, with the aim of alleviating pain and improving range of motion. One of the common ways of manipulating soft tissue is self- induced myofascial release (SMR). SMR and MFR have the same basic manipulations except that MFR is the therapy done by an external source that is the therapist whereas SMR, by its name, is done by the individual themselves with the use of equipment such as massage balls, roller massagers and foam rollers (Macdonald et al., 2013).

SMR has a direct impact on delayed onset muscle soreness (DOMS) which is a topic that has been explored by researchers (Maclennan et al., 2013; Macdonald et al., 2014; Macgregor et al., 2018; Kriventosova et al., 2019). According to Pearcey et al. (2015), exercise is the main cause of DOMS due to its ability to induce body fatigue depending on the type, the intensity, duration, and frequency of the exercise.

During athletic performance and training, DOMS could have negative effects on them (Pearcey et al., 2015). DOMS leads to the reduction of extensibility in soft tissues that leads to abnormal muscle mechanics, shortening the muscle length, decreases the joint ROM and causes musculoskeletal pain. Athletes are usually exposed to intense physical activities that requires a high demand on muscular involvement during their training sessions and activities (Maclennan et al., 2023) .When DOMS are induced during training, it reduces the athletic performance that includes reduced strength and power, over-estimation of force production and changes in recruitment patterns (Pearcey et al., 2015). Hence, this naturally leads to an increased risk of injury due to the need for high-speed activities and increased participation in sports (Maclennan et al., 2013).

Various types of treatment are used to manage DOMS that includes massage therapy, compression, hot and cold therapy, other forms of physical therapy interventions, and nutritional intervention (Heiss et al., 2019). Among the multiple types of massage therapy, one of it is foam rolling. A type of massage therapy that could alleviate DOMS is foam rolling (Pearcey et al., 2015). Foam rolling (FR) is a well-known treatment for managing DOMS due to its convenience, accessibility, and affordable benefits. There is numerous FR research that centres around sport recovery and performance which involves DOMS recovery (Macgregor et al., 2018). Evidence suggests that FR improves joint range of motion (ROM), promotes tissue extensibility, decreases DOMS, and has an effect towards sports performances and exercise (Cheatham et al., 2015). FR necessitates the individual to place their body weight on the neoprene-covered cylinder through consistent rolling movements to apply pressure on the muscle. Hendericks et al. (2019) conducted a systematic review to guide practitioners on the use of foam rollers that will be optimal for performance and recovery. They recommended a FR for a period of 30s to 60s in a constant pace for 3 to 5 set. Rest periods will be 1030s between each set (Hendricks et al., 2019).

Up to date, there are several studies done on the effects of FR on DOMS. For the past decade, Macdonald et al. (2013) and Jay et al. (2014) studies proved that FR could significantly reduce muscle soreness. Kriventsova et al. (2019) study on fencers has shown the reduction in the level of DOMS using SMR techniques that involve FR and could also reduce the pain impact on daily life.

Based on the information available to me, Cheatham & Stull (2018) and Nahon et al. (2021) reported lack of research on SMR using FR. Hence, this study aims to find out the effects of FR on DOMS in terms of pain in recreational athletes in comparison to competitive athletes.

1.2 Definition

Terms	Definition
Delayed Onset Muscle Soreness (DOMS)	DOMS is categorized as a temporary muscle damage after high intensity exercises, that is mainly from the eccentric portion of the exercise movement and being new or unaccustomed to the specific exercise (Nahon et al., 2021)
Myofascial Release (MFR)	Manual therapeutic technique (MFR) is a manual therapeutic technique used for addressing fibrous adhesions done by an external source that is usually the therapist (Macdonald et al., 2013)
Self- Myofascial Release (SMR)	Same basic manipulation of the soft tissue but is done by the individual themselves using devices such as massage balls, roller massagers and foam rollers (Macdonald et al., 2013)
Recreational athletes	Recreational athletes engage in exercise about four hours a week and participates in unregulated competitions (Campa & Coratella, 2021)
Competitive athletes	Competitive athletes train at least for 6 hours a week and emphasizes on improving performance. (Campa & Coratella, 2021)

1.3 Rationale

To my best knowledge, there is a noticeable lack of studies on the utilization FR on DOMS among badminton players. Furthermore, investigations into the impact of FR on DOMS have not yet explored population comparisons. Consequently, this research will focus on badminton players as the target population to address the existing gap identified in prior studies, and it will also compare the varying effects of FR on recreational athletes versus competitive athletes. The study's outcomes will provide valuable insights for athletes, coaches, and sports professionals looking to incorporate FR as a method for addressing DOMS and enhancing recovery.

1.4 Scope of Study

The scope of this study is to find out the effects of foam rolling on DOMS in recreational athletes in comparison to competitive athletes, focusing specifically on badminton players.

1.5 Problem Statement

Delayed-onset muscle soreness (DOMS) is a common issue experienced by athletes after high-intensity or unaccustomed exercise, negatively affecting their performance, recovery, and injury risk. Foam rolling, a self-myofascial release technique, has been widely recognized for its potential to alleviate DOMS, enhance recovery, and improve muscle performance. However, there is a notable lack of research of the effects of FR in badminton players —a population that frequently experiences DOMS due to the sport's high reliance on lower-limb movements like lunges and jumps. To our best knowledge, there has not been any studies comparing between the effects of FR on competitive and recreational athletes particularly in DOMS, recovery and muscle performance. Most existing studies on foam rolling have focused on single populations, such as recreational athletes or specific sports, without comparing its effects across different levels of athletic expertise. Hence, this study aims to address this gap by examining the effects of foam rolling on DOMS in terms of pain among badminton players, comparing its impact on recreational and competitive athletes.

1.6 Research Question

- Research Question 1: What are the effects of foam rolling on DOMS in recreational athletes?
- Research Question 2: What are the effects of foam rolling on DOMS in competitive athletes?
- Research Question 3: Are there any significant differences between the effects of foam rolling on DOMS in terms of pain in recreational athletes and competitive athletes?

1.7 Specifics

- Objective 1: To find out the effects of foam rolling on DOMS in recreational athletes.

- Objective 2: To find out the effects of foam rolling on DOMS in competitive athletes.
- Objective3: To investigate the significant difference between the effects of foam rolling on DOMS in terms of pain in recreational athletes and competitive athletes.

1.8 Hypothesis

- Objective 1: No hypothesis
- Objective 2: No hypothesis
- Objective 3:
    - H_0: There is no significant difference between the effects of foam rolling on DOMS in terms of pain in recreational athletes and competitive athletes.
    - H_A: There is significant difference between the effects of foam rolling on DOMS in terms of pain in recreational athletes and competitive athletes.

CHAPTER 2: LITERATURE REVIEW

2.1 Athletes

Athletes are individuals who engage in sports and demonstrate a high level of physical skill, dedication, and training. Athletes can compete at various levels, from amateur and collegiate to professional and Olympic. They undergo rigorous training to improve their physical abilities, refine their techniques, and optimize their performance in their chosen sports (Lorenz et al., 2013 ;Campa & Coratella, 2021). According to Campa and Coratella (2021), competitive athletes refer to individuals who performs exercise more than 6 hours a week emphasizing performance improvement. Conversely, recreational athletes engage in exercise for approximately four hours a week and typically participate in unregulated competitions. (Campa & Coratella, 2021). Recreation activities undertaken for enjoyment, relaxation, and leisure, typically during one's free time which are not driven by a necessity or obligation but are rather pursued voluntarily for the purpose of personal satisfaction and well-being such as sports (Arun Deshmukh & Shriram Saoji, 2019).

2.2 Badminton and its prevalence of injury

Badminton is a high-intensity racket sport that can be played recreationally or competitively, and it's popular worldwide (Fu et al., 2017; Molaeikhaletabadi et al., 2022). Many people enjoy playing badminton recreationally for fun and fitness, while others participate in organized tournaments at various levels of competition (Fu et al., 2017). Achieving high-level performance in badminton demands qualities such as speed, power, agility, flexibility, endurance, and strength (Deshmukh & Saoji, 2019; Molaeikhaletabadi et al., 2022). During the intense short- and long-term physical exertion, both aerobic and anaerobic energy systems are utilized. Moreover, studies have shown that single match in badminton are known to be more demanding than doubles match (Molaeikhaletabadi et al., 2022). Badminton itself is recognized as a safe and non-contact sport characterized by swift changes in direction, jumps, movement towards the net (lunges), and quick movements of the arms aimed to strike the shuttlecock from different positions (Molaeikhaletabadi et al., 2022).

Badminton requires more use of the lower extremity, especially the lunging movement as proven by previous studies that the lunge was present in over 15% of the movements in one badminton match. In addition, the main injury site occurs most on the dominant lower limb (Fu et al., 2017; Mohd Jamali et al., 2022) proving a more frequent use of the lower extremity during a badminton game. This frequent use of the muscle could induce DOMS which can often affect an athlete's performance and recovery. Hence, the focus of this study will be towards the lower extremity of the body.

2.3 Delayed Onset Muscle Soreness (DOMS)

DOMS is categorized as a temporary muscle damage after high intensity exercises, that is mainly from the eccentric portion of the exercise movement and being new or unaccustomed to the specific exercise (Nahon et al., 2021). To put it simply, DOMS is also a heightened level of soreness (Markus et al. 2021). According to Nahon et al. (2021), the main mechanism driving the pathophysiology of DOMS is hypothesized to be the microdamage inflicted on the muscle, which is followed by inflammation and causes discomfort, oedema, flushing, heat, and relative functional impairment. Moreover, the fatigue induced during the exercise is an essential element in an effective strength training program and is an intentional progressive overload for improving performance and allowing muscle adaptation to occur (Nahon et al., 2021).

According to Pearcey et al. (2015), the intensity of DOMS usually increases in the first 24 hours after exercise, peaks in the next 24 to 72 hours, and then decreases and finally resolves after five to seven days. DOMS symptoms vary from having mild stiffness in the muscles that goes away with normal daily activities to excruciating agony that prevents any movement at all (Pearcey et al., 2015). In addition to pain, a DOMS clinically replicates symptoms such as decreased peak torque, muscle weakness, restricted range of motion, and muscle stiffness. According to Pearcey et al. (2015) hypothesized that a reduction in DOMS will cause changes to neural segment of the brain that will improve movement and fibre recruitment patterns. Dated till today, the actual mechanism remains unknown (Pearcey et al., 2015). As hypothesized by Nahon et al. (2015), there is a reduced muscle activation and leads to compensatory stress and recruitment of the muscles, tendons, and ligaments. Therefore, there is an increased risk for injury if an athlete returns to sports practice earlier without the complete recovery from DOMS.

2.4 Assessment on DOMS recovery

2.4.1 Muscle Soreness

BS-11 Numerical Rating Scale (NRS) has been used in numerous studies and has been proven to be reliable and valid measures of pain intensity (Thong et al., 2018). As per a previous FR study by Macdonald et al. (2013), he has used NRS to measure the degree of muscle soreness. This tool has provided a means for the participant to perceive the level of muscle soreness using a numerical scale value ranging from ''0'' as ''absolutely no muscle soreness'' to ''10'' as ''the worst muscle soreness you have ever felt''

(Macdonald et al. 2013). This method of assessment has been used in Macdonald et al. (2013)'s study that studied the effectiveness of FR as a recovery tool after exercise-induced muscle damage. The NRS could use show the effectiveness of FR in reducing muscle soreness by determining the recovery rate in muscle soreness between the control condition and the FR condition (MacDonald et al. 2013). In this study, the muscle soreness assessment will be conducted before each testing session. During the sessions, participants executed a squat using only their body weight (no external resistance), descending until their thighs were parallel with the floor. After assuming the squat position with parallel thighs, participants were then prompted to assess and rate their perceived pain based on muscle soreness. Hence, showing that NRS will be an outcome measure tool for this study.

2.4.2 Power

The second assessment of performance is power by doing a standing broad jump (SBJ). SBJ has been proven to be reliable and valid to assess leg power (Rahman et al., 2021). According to Pearcey et al. (2015), this assessment was used to see if FR decreased pain from DOMS and increased performance measures throughout 72 hours for all dependent variables which involves the dynamic power. FR positively affected power performance during Pearcey et al. (2015) which is because of the single body direction movement. The standing broad jump will require the participants to jump as far as they can with feet shoulder width apart while taking the measurements from the starting line to the point where their heels land. Two trials will be done by the participant separated by a 2-minute rest and the farthest jump distance will be used for analysis (Pearcey et al. 2014).

2.4.3 Sprint Testing

The third assessment of performance will be a 10m sprint test. According to Altmann et al. (2019)'s research, it was found that linear sprint testing showed acceptable validity and high levels of reliability in speed testing. Moreover, there was a positive result showed on FR effects on sprint speed in Pearcey et al. (2014)'s study. Participants will be performing a 10m sprint test with the starting point marked with tape and cones. In the sprint testing procedure, the participant will sprint as fast as they could for 2 trials with a 2-minute break between the trials. A stopwatch will be used to record the time of the sprint. Participants will be in a 3-point stance with the dominant foot slightly behind the non-dominant foot. Then, participants will be instructed to start and encouraged to give their maximum efforts in their sprint where the results with the fastest sprint will be taken (Pearcey et al., 2014). Sprint testing will be done during pre-tests in the first testing session and post-tests in the second to fourth testing session to determine whether FR improved performance metrics and reduced DOMS pain over the course of a 72-hour period (Pearcey et al., 2014). If the participant can attain similar speed for the pretests and post-tests, it shows recovery from the DOMS (Markus et al., 2021).

2.4.4 Summary of findings

From a performance standpoint, recovery is defined as returning to baseline performance measures (Markus et al. 2021). Basically, if an athlete has not returned to baseline performance levels, they are considered as unrecovered. Several studies have evaluated performance through the participants completing a specific exercise intensity relative to their maximum strength (Markus et al. 2021). After several days of recovery, the exercise protocol is repeated. The number of repetition that the participants could perform is the measure of the extent of recovery. Moreover, different studies employed the use of quantifiable physical activities to gauge recovery such as jump power and cycling performance (Markus et al. 2021). Hence, this study will test the participants' muscle soreness (BS-11 NRS), power test and sprint test to evaluate the return to baseline performance showing full recovery from DOMS.

2.5 Management of DOMS using Foam Roller

There are numerous ways of managing DOMS that include massage therapy, compression, ultrasound, exercises, FR, cryotherapy, other physical therapy interventions, acupuncture, stretching, phototherapy, and nutritional intervention (Heiss et al., 2019; Nahon et al., 2021). According to studies, the application of the mentioned modalities could reduce DOMS symptoms, alleviate muscle damage and restore body functions without prolonging it (Nahon et al., 2021).

An equipment commonly used to manage DOMS is the use of FR which is a SMR where an individual uses their body weight as pressure onto a cylindrical shaped tool to exert force onto the muscle (Haeley et al., 2014; Cheatham et al., 2015; Hendricks et al., 2019). A systematic review also suggested that FR could have various benefits that include increased ROM, enhanced muscle recovery and increased muscle performance (Cheatham et al., 2015). According to Beardsley et al. (2015) also performed a systematic review on the effects of SMR found the positive beneficial acute effects of FR on DOMS in both trained and untrained populations using different outcome measure that includes pressure pain threshold (PPT), visual analogue scale (VAS) and BS-11 Numerical Rating Scale (Beardsley et al., 2015). The findings showed that FR can reduce DOMS in a wide range of populations with different outcome measures. (Pearcey et al., 2015; Kalén et al., 2017; Hendricks et al., 2019).

While research supports FR's effectiveness, there are contrasting perspectives. For instance, some studies, such as by Healy et al. (2014) and Jones et al. (2015), have found negligible effects of FR on sprint performance and power. Additionally, MacDonald et al. (2013) noted that FR's benefits might be more pronounced for short-term recovery rather than long-term outcomes. These inconsistencies highlight the need for standardized protocols and further comparative studies to validate findings.

2.6 Gaps in the Previous Studies

2.6.1 Gaps in the type of populations used in FR research

Existing studies conducted on the effect of FR on DOMS and recovery populations includes resistance trained males (Macdonald et al., 2013), healthy populations (Mohr et al., 2014; Romero-Moraleda et al., 2017; Romero-Moraleda et al., 2019), professional soccer players (Rey at al., 2017), and recreational active college students (Zorko et al., 2017). Moreover, studies on the effects of FR on performance have been conducted on footballers(Aune et al., 2019), recreational athletes(Healey et al., 2014; Jones et al., 2015; Cavanaugh et al., 2017; Morales Artacho et al. 2017; Monteiro et al. 2018; Baumgart et al., 2019), well-trained offensive lineman (Behara & Jacobson, 2017), rugby players (Guillot et al., 2019), healthy populations (Hansen et al., 2016; Schroeder et al., 2017; Su et al. 2017; Hall & Smith, 2018; Killen et al., 2018; Macgregor et al., 2018; Smith et al., 2018; Williams & Selkow, 2019), recreational resistance trainers (Macdonald et al., 2013; Monteiro & Neto et al., 2016; Monteiro et al., 2017; Monteiro et al. 2019), volleyball players and basketball players (Richman et al., 2019). Therefore, badminton players have been an uncommon population used in FR studies.

To my best knowledge, there is only one study which focuses on badminton athletes by Lin et al. (2020) that studied the acute effects of dynamic stretching (DS) followed by vibration foam roller (VFR) on sports performance. The primary outcome measure of this study is mainly on the ROM and secondary outcome measures are on muscle stiffness, lower limb power (countermovement jump [CMJ]), and agility. So far, the effect of FR on performance, DOMS and recovery has not been studied on badminton players. Lin et al. (2020) investigated the acute effects of dynamic stretching followed by vibration foam rolling (VFR) on badminton athletes, but the study focused on performance measures like range of motion and agility rather than DOMS. The lack of research on badminton players highlights an important gap, given the sport's high reliance on lower-limb movements, which frequently induce DOMS. This study seeks to address this gap by focusing on both recreational and competitive badminton athletes.

2.6.2 Gaps in the comparison of populations used in FR research

There are a few studies reported on the effect of FR on DOMS and exercise performance. Macdonald et al. (2013) is a randomized controlled trial that randomized their healthy male subjects into an experimental group involving FR and a control group. Another study by Peacey et al. (2015) used the same 8 healthy, physically active males to perform in two conditions that is the control condition and the intervention condition involving FR. Two other studies conducted the effects of FR on muscle performance also used the same subjects into their own intervention group without comparing the two different populations (Healey et al., 2014; Peacock et al., 2015). According to the systematic reviews conducted by Hendericks et al., (2019), Cheatham et al., (2015) and Beardsley et al., (2015) showed that studies used only one population to do their research. These studies have only focused on a single population for both their control and intervention group (Beardsley et al.,

2015; Cheatham et al., 2015; Macdonald et al., 2013; Healey et al., 2014; Hendericks et al., 2019; Peacock et al., 2015; Pearcey et al., 2015). According to Zhang et al. (2024), the effectiveness of foam rolling, like other recovery methods, may differ between individuals and be influenced by the specific athletic context. Therefore, additional research is needed to examine the wider applicability and long-term advantages of foam rolling, including studies with larger and more varied participant groups across different sports environments. These studies will play a crucial role in improving athlete recovery protocols, promoting both physiological and biomechanical recovery after exercise. Based on the available information found, there has not been any studies doing the comparison between two different populations. Hence, this study will be recruiting participants from both competitive and recreational athlete to find out the effects of FR on delayed-onset muscle soreness on them.

2.6.3 Summary of findings

To my best knowledge, there is a lack of studies of FR on badminton population and there is a potential scope to compare the effects of FR on DOMS in terms of pain in both competitive and recreational players. Therefore, this study intends to study the effects of FR on delayed-onset muscle soreness in recreational athletes in comparison to competitive athletes.

CHAPTER 3: METHODOLOGY

3.1 Study Design

Repeated-measure design

3.2 Study Setting

University Tunku Abdul Rahman, Sungai Long Campus

3.3 Study Population

Competitive and recreational badminton athletes

3.4 Sample Size

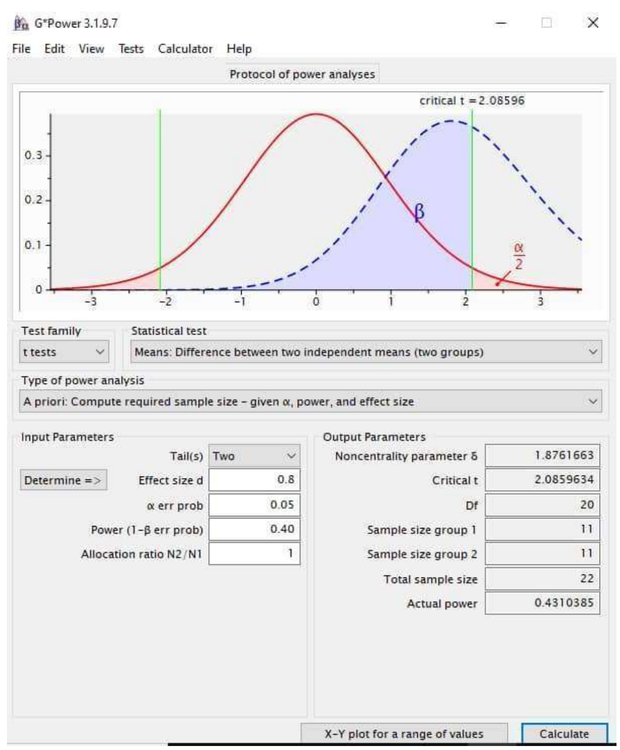

Figure 3.1 Power version sample size calculation

The sample size is calculated using G*Power version 3.1.9.7 where the test family selected is ‘T tests. The statistical test selected is ‘Means: Difference between two independent means (two groups)’. The type of power analysis is ‘A priori: Compute required sample size- given alpha, power and effect size’. The input parameters used are two-tailed, effect size d of 0.80, alpha prob of 0.05, power (1- β err prob) of 0.4 and allocation ratio N2/N1 of 1. The calculated total sample size is 22 participants with 11 participants in each sample size group. The finalized sample size after adding 10% of dropout will be 24 participants.

3.5 Sampling Method

Purposive sampling method

3.6 Inclusion Criteria

1. Students currently studying at University Tunku Abdul Rahman, Sg Long Campus.
2. Students aged between 18-30 years old.
3. Recreational badminton players that participate in unregulated competitions and are still actively participating in full badminton training about 4 hours a week.
4. Competitive badminton players that train at least 6 hours a week, emphasizes on improving performance and has participated in inter-university competitions.

3.7 Exclusion Criteria

1. Medical problems that could affect their ability to complete study such as recent ligament or tendon injuries, recent fracture or surgery to lower limb (Healey et al. 2014)
2. Those who scored one or more “Yes” in the PAR-Questionnaire (Precision Nutrition, 2012)

3.8 Instrumentation

Physical Activity Readiness Questionnaire will be given before participating the study (Pearcey et al. 2015). Refer to appendix II

3.9 Procedure

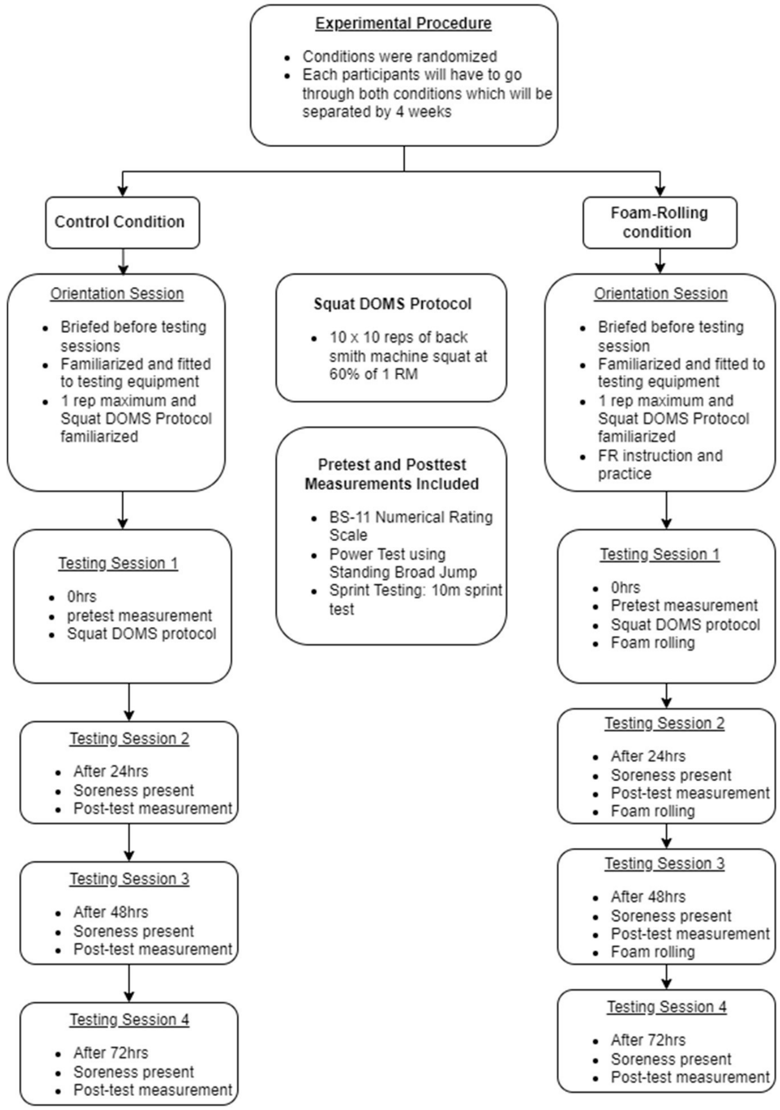

Figure 3. 2 The flowchart on the experimental procedure.

All participants will go through both control and FR conditions where DOMS will be induced through squatting at 60% of their 1RM for 10x10. After each training session, measurements will be taken using BS-11 NRS, Power Test and Sprint Testing.

The participants will be recruited through social media, such as Facebook, Instagram, WhatsApp and directly from UTAR Sungai Long Sport Club. The participants that are willing to volunteer and meets the inclusion criteria will be given an information sheet and a consent from to sign. Prior to the recruitment of the study's participants, the ethical approval shall be obtained. The participants will be advised not to perform heavy lifting 24 hrs prior and throughout experiment to prevent muscle soreness (Pearcey et al., 2015). They will also be advised to not consume caffeine or alcohol as it might affect muscle performance (Pearcey et al., 2015).

3.9.1 Foam Rolling

The FR protocol will be following Pearcey et al. (2015)'s study. Participants (describe the foam roller). They were instructed to start with the foam roller placed at the most distal part of the muscle and were asked to apply as much body weight as comfortably tolerated onto the foam roller, rolling back and forth smoothly at a pace of 50 beats per minute. The foam rolling lasted 30 seconds per muscle group, followed by a 10-second rest. This process was repeated for each muscle group in both lower limbs, with one full cycle performed. Including rest periods, the total foam rolling time was 20 minutes. Foam rolling took place immediately after test measurements were recorded in session 1 (DOMS). The protocol included three testing sessions: 1 (immediately after the DOMS protocol), 2 (24 hours post-DOMS protocol), and 3 (48 hours post-DOMS protocol). Although DOMS was not immediately noticeable after the first testing session, foam rolling was performed at this time because massage has been shown to aid in the removal of blood lactate and promote tissue healing (Pearcey et al., 2015). Foam rolling was also conducted after sessions 2 and 3, as DOMS tends to intensify within the first 24 hours and peaks around 48 hours post-exercise. According to Pearcey et. al (2015), these specific time points were chosen due to the lack of empirical evidence on the optimal timing and duration for post-exercise foam rolling. The foam rolling session has been done on the following muscle of the lower limb as sequenced: (1) Quadriceps (2) Adductors (3) Hamstrings (4) Iliotibial band (5) Gluteus. The foam roller technique for each muscle is outlined below:

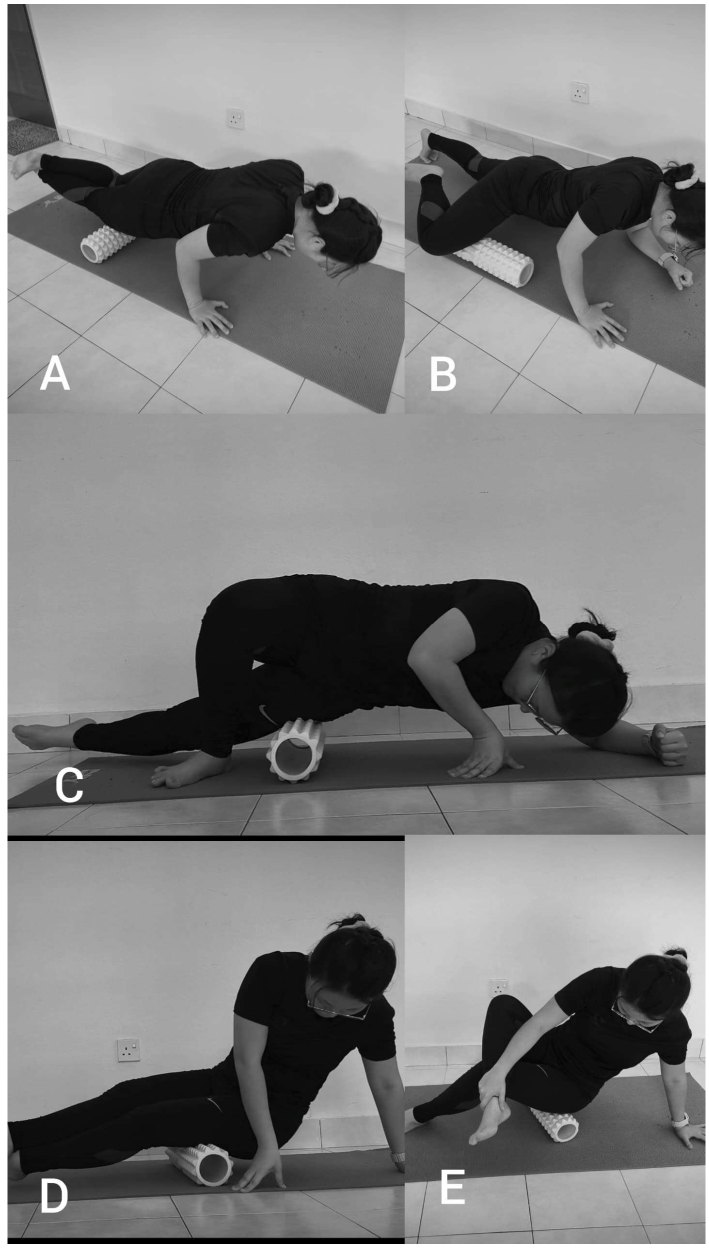

Figure 1.3 This participant shows the foam rolling technique done on the 5 muscle groups individually. The muscles are ordered as shown in the following order: (A) quadriceps (B) adductors (C) hamstrings (D) iliotibial band (E) gluteal. The total foam-rolling session.

Quadriceps:

In a prone position, with the roller placed about 3 inches (7.62 cm) below the anterior-superior iliac spine, participants crossed one leg over the other (Figure 3A). They rolled from this starting position down to just above the patellar tendon and back, using their elbows to guide the movement.

Adductors:

In a prone position with the hip flexed and externally rotated, participants placed the proximal portion of the adductors just below the inguinal area on the roller (Figure 3B). They rolled from this position down to just above the medial condyle and back, shifting their body weight from side to side to guide the movement.

Hamstrings:

Starting just below the gluteal fold with the hips unsupported, participants crossed one foot over the other (Figure 3C). They used their hands, positioned behind the body, to support and maneuver their body mass. They rolled from the starting position down to the superior portion of the popliteal fossa and back.

Iliotibial Band:

In a side-lying position, with the roller placed just below the greater trochanter, participants placed the free leg in front of the supported leg (Figure 3D). They rolled from this position down to just above the lateral condyle and back, using the free foot to guide the movement.

Gluteals:

Starting just below the posterior part of the iliac crest on the lateral gluteal region, participants crossed one foot over the opposite knee in a figure-4 position, supporting their body with one hand (Figure 3E). They used their support hand to roll from this starting position down to just above the gluteal fold and back.

3.9.2 Criterion Variables

Numerical Rating Scale (NRS)

The NRS is used to assess the level of muscle soreness. Participants rate their muscle soreness on a scale from "0" (indicating "no muscle soreness at all") to "10" (representing "the worst muscle soreness you have ever felt"). It is assessed before each testing session. During the sessions, participants will perform bodyweight squats, lowering until their thighs are parallel to the floor. Once in the squat position, participants will assess and rate their muscle soreness.

Sprint Speed

Participants performed a 10- meter sprint test. In this test, participants performed two 10-meter sprints, with the starting point marked by tape and cones. They sprint as fast as possible, with a 2-minute rest between the two trials. A stopwatch is used to record the sprint times. Participants began in a 3-point stance, with their dominant foot slightly behind the non-dominant foot. They are instructed to start and encouraged to sprint at maximum effort, with the fastest time recorded for analysis. Sprint testing will be conducted during the pre-test in the first session and the post-test in the second through fourth sessions to evaluate. During the break, participants pursued a semiactive recovery as they walked slowly back to the starting line.

Power

A SBJ was used to measure dynamic power. Participants were instructed to stand with their feet 1 shoulder-width apart, jump out as far as they could, and land in a controlled manner on 2 feet without taking a step to maintain balance. We measured the jump from the toes of the starting position to the closest heel of the landing position. Each participant completed 2 trials that were separated by 2 minutes of rest. The farthest of the 2 jump trials was used for analysis.

3.9.3. DOMS protocol

The exercise protocol involved participants performing 10 sets of 10 repetitions of barbell back squats at 60% of their 1RM reaching a squat parallel to the floor. The squat technique is obtained from Pearcey et al. (2015). Each repetition had a tempo of 5 seconds for the eccentric phase, with no pause at the bottom, followed by a 1-second concentric phase. Participants rested for 2 minutes between sets. The total time spent on squats was 9 minutes and 30 seconds, with 18 minutes of rest in between. More emphasis was placed on eccentric contractions, as research has shown that repeated eccentric exercise leads to more delayed onset muscle soreness (DOMS) compared to conventional weight training that focuses on concentric contractions.

All participants 2 conditions: control and foam rolling which are separated by 4 weeks. The order of the condition will be assigned randomly. Each condition will have one orientation session and 4 testing session. The following are the conditions:

Control condition: There will be one orientation session that will test the 1 RM squat and practice familiarize will all the testing equipment and assessment methods and there will be 4 testing sessions: o Testing session 1: pretest measurements and DOMS protocol o Testing session 2: after 24hrs, post-test measurements o Testing session 3: after 48hrs, post-test measurements o Testing session 4: after 72hrs, post-test measurements

Foam rolling condition: will be the same as the control condition but FR will be added towards the end of the testing session.

Pre-test and post-test measurements:

1. The muscle soreness using NRS will be asked first.
2. The following assessments will be conducted in a random manner: Power and Sprint speed.

3.10 Data Analysis

Based on our parent article's data analysis from Pearcey et al. (2015), a magnitude-based inferences will be used as the data analysis strategy for this study. We will determine the magnitude-based inferenced on the interaction effects in the mean changes between FR and control conditions. The interaction effect of time and FR will be calculated form the mean difference between pre-exerise and each time point for the control and FR trial (pre-exercise, 24, 48 and 72 hours postexercise). The differences between the two trials will be subtracted to estimate the effects of FR at each time point (Pearcey et al. 2015). We will be using IBM SPSS, Excel and ANOVA for the data analysis tool.

3.11 Ethical Consideration

This study is ethically approved by the Scientific and Ethical Review Committee (SERC) of Universiti Tunku Abdul Rahman (UTAR) (U/SERC/78-363/2024) refer to appendix B on ethical approval. Participants were provided with a brief overview of the research study, including its purpose, procedures, potential risks, and benefits. They then signed a consent form and a personal data protection agreement before taking part in the study. Participants retained the right to withdraw from the study at any time. Additionally, the researcher guaranteed that all participant information would remain confidential and be used solely for research purposes.

CHAPTER 4: RESULTS

4.1 Chapter Overview

The results chapter provides a comprehensive analysis and interpretation of the data gathered during the research, offering valuable insights into the key findings. Using statistical methods, visual representations, and in-depth discussions, this chapter aims to address the research questions, objectives, and hypotheses outlined in the earlier chapters. It begins by detailing the characteristics of all participants to illustrate the demographic composition of the sample and explore how variables might be influenced by factors such as age. Subsequently, the chapter interprets inferential analysis tests, including independent t-tests and hypothesis testing using two-way ANOVA, to examine the relationships and significance between variables. The next section focuses on impact of DOMS on the 3 outcome measures for the time elapsed 24h, 48h and 72h post-exercise comparing between foam rolling and control group. The two tables each represent competitive and recreational badminton athletes. All results are presented as mean and standard deviation (SD).

4.2 Participants Characteristics

A total of 25 participants initially volunteered to participate in this study. However, one participant withdrew during the fifth week due to an ankle injury, which prevented them from continuing with data collection. Additionally, two participants did not meet the inclusion criteria specified in Chapter 3; one had a previous ACL tear that could potentially influence the outcome measures, while the other exceeded the specified age range. Consequently, the final sample consisted of 22 participants, meeting the minimum required sample size for the study. The data were coded and analysed using Microsoft Excel and IBM SPSS version 30.0 software. This section presents the characteristics of the 22 participants, including age and gender, analysed using descriptive statistics, as shown Table 4.1

Characteristics	f	Mean ± SD
Age (years)		
18	1 (4.5%)	21.5± 2.43
20	7 (31.8%)	
21	9 (40.9%)	
22	3 (13.6%)	
23	1 (4.5%)	
25	1 (4.5%)	
Gender		
Male	15 (68.2%)	11 ± 5.66
Female	7 (31.8%)	

*f= Frequency; SD= Standard Deviation

Table 4.1 Descriptive statistics of Participants (N=22)

4.2.1. Age of Participants

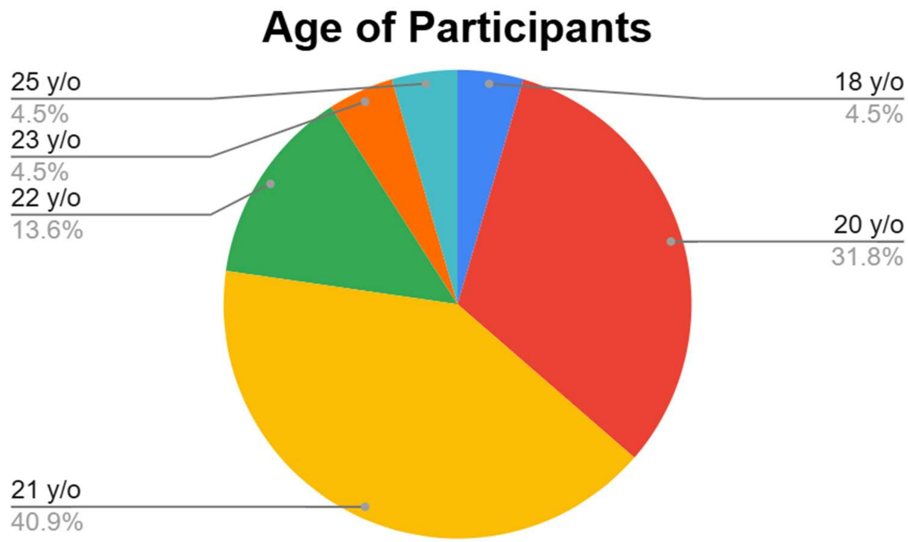

Figure 2.1 Pie Chart Distribution for Age of the Participants

The pie chart illustrates the age distribution of the participants included in the research study. According to Table 1, the mean age of the participants was 21.5 (SD = 2.43) years. Most participants were 21 years old, accounting for 40.9% of the total sample. This was followed by 20-year-olds, who comprised 31.8% of the participants. Participants aged 22 years constituted 13.6% of the sample, while those aged 18, 23, and 25 each represented 4.5%.

4.2.2. Gender of Participants

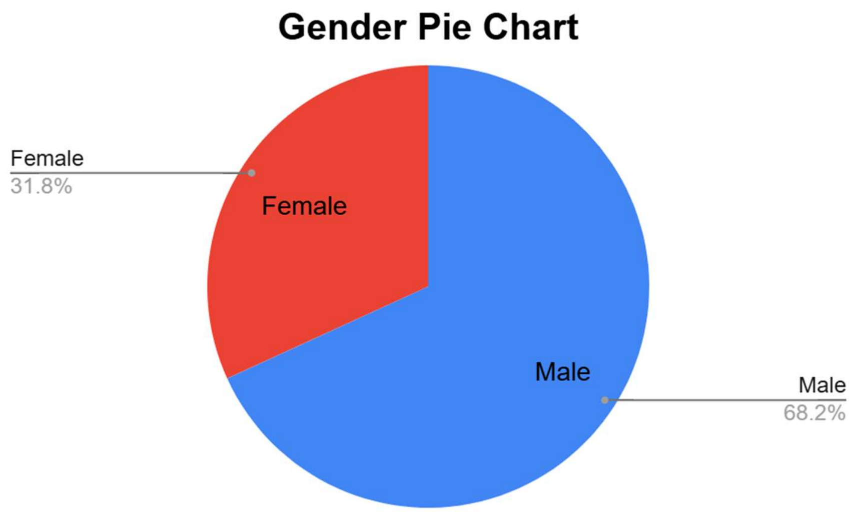

Figure 4.2 Pie Chart Distribution for Gender of Participants

The pie chart represents the gender distribution of participants in the research study. The majority of participants were male, accounting for 68.2% of the total sample, while females comprised 31.8%.

4.3 Test of Normality

The normality of the data was assessed using a predetermined significance level ($\alpha=0.05$) with a 95% confidence interval (CI). The null hypothesis, stating that the data is normally distributed, was accepted if the p-value exceeded 0.05. The distribution of variables was assessed using the Shapiro-Wilk normality test. Since the sample size was fewer than 50 individuals, the Shapiro-Wilk test was employed to evaluate normality (Mishra et al. 2019). The Shapiro-Wilk test result was not significant ($p = 0.409$) exceeding 0.05, indicating that the data followed a normal distribution. As a result, all the collected data were normally distributed, and it is eligible to utilize the independent t-test and ANOVA test to analyse the results.

4.4 Data analysis

Data are expressed as means with standard deviations (±SD) for all measurements across recreational and competitive athletic populations. These calculations were performed using Excel. Comparisons between athletic populations were made using two-way analysis of variance (ANOVA), considering factors of time, recovery, and their interaction.

The interaction effect of time and foam rolling was determined by analyzing the mean differences between pre-exercise values (0 hours) and each subsequent time point (24, 48, and 72 hours post-exercise) for both control and foam-rolling trials. The difference between these two sets of mean differences was used to estimate the effect of foam rolling at each time point. IBM SPSS Analysis was used to formulate mean difference, cohen's d and upper and lower 95% confidence interval between 0hours (pre- exercise) to 24, 48 and 72 hours (post-exercise).

Standardized effects were categorized using qualitative descriptors based on the following criteria: trivial (<0.2), small (0.2–0.5), moderate (0.5–0.8), and large (>0.8). Effects were deemed unclear if their 95% confidence limits (CLs) overlapped thresholds for small positive and negative effects (i.e., exceeding 0.2 standard deviations on either side of the null). Conversely, small or larger effect sizes with clear 95% CLs were considered substantial.

Competitive players	Foam Rolling (Mean ± SD)				Control (Mean + SD)			
Parameter	0	24	48	72	0	24	48	72
PAIN SCALE	0 ± 0	3.8 ± 1.8	3.6 ± 2.5	1.9 ± 2.2	0 ± 0	3.2 ± 1.8	2.5 ± 2.1	1.2 ± 1.5
10M SPRINT	2.2 ± 0.2	2.4 ± 0.2	2.4 ± 0.4	2.3 ± 0.3	2.2 ± 0.2	2.3 ± 0.2	2.3 ± 0.3	2.2 ± 0.2
BROAD JUMP	201 ± 32	184 ± 27	181 ± 41	195 ± 30	194 ± 32	193 ± 32	192 ± 37	197 ± 36

Table 4.2 Raw data for all dependent variables throughout the experimental conditions in competitive players. All raw data (Mean ± SD) collected throughout experimental conditions are presented in the Table.

Recreational players	Foam Rolling (Mean ± SD)				Control (Mean + SD)			
Parameter	0	24	48	72	0	24	48	72
PAIN SCALE	0 ± 0	2.5 ± 1.4	2.2 ± 1.8	1.2 ± 1.5	0.2 ± 0.4	2.5 ± 1.6	2.3 ± 1.2	0.7 ± 0.9
10M SPRINT	2.6 ± 0.2	2.5 ± 0.3	2.6 ± 0.2	2.5 ± 0.2	2.6 ± 0.2	2.5 ± 0.3	2.5 ± 0.2	2.4 ± 0.1
BROAD JUMP	146 ± 20	142 ± 22	146 ± 22	152 ± 24	153 ± 34	155 ± 28	156 ± 32	162 ± 28

Table 4.3 Raw data for all dependent variables throughout the experimental conditions in recreational players. All raw data (Mean ± SD) collected throughout experimental conditions are presented in the Table.

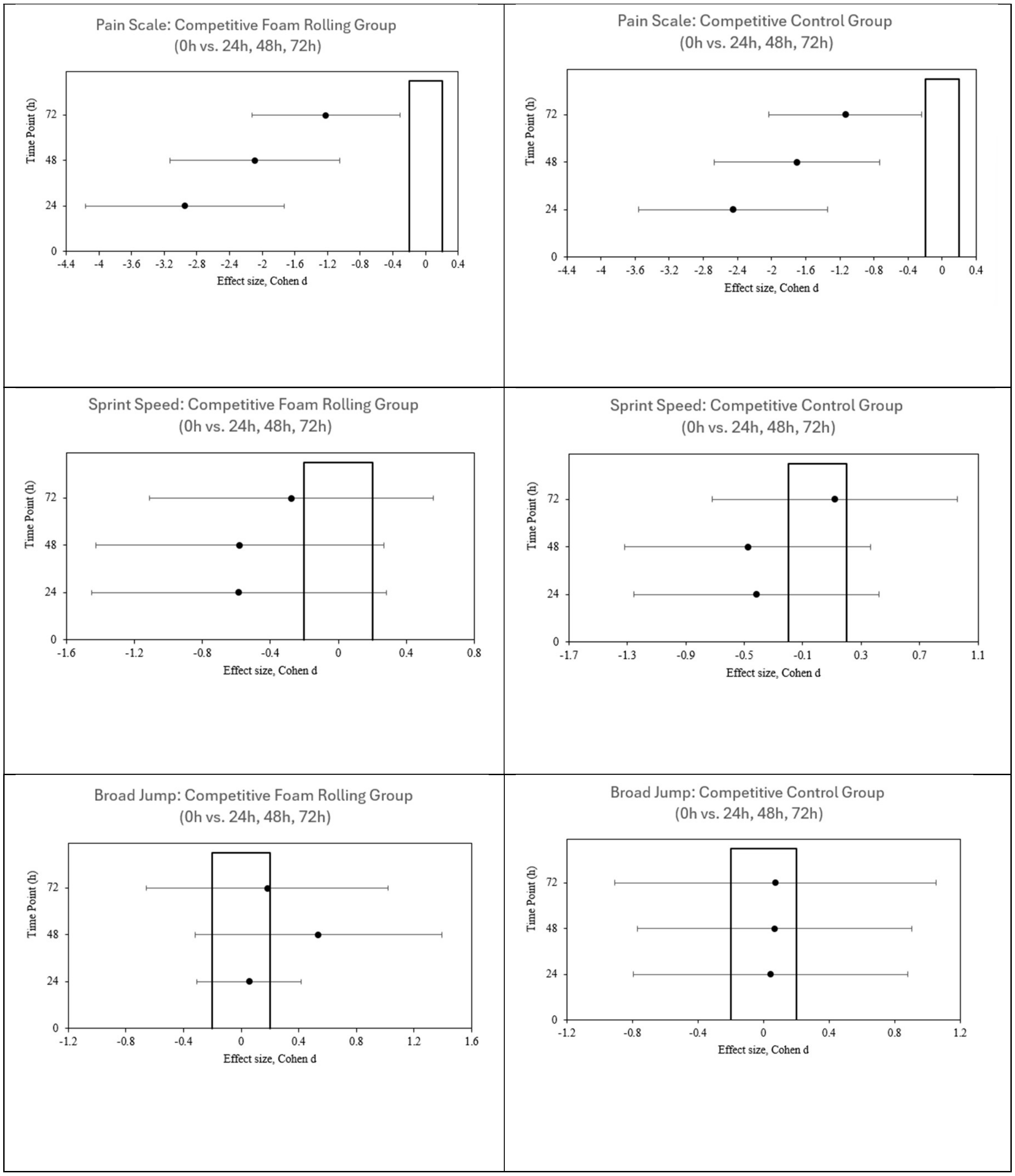

Figure 4.3 Magnitude-based inferences demonstrating the effect of foam rolling on pain scale, sprint speed, broad-jump distance in competitive athletes. Points represent the effect size (Cohen d) describing the interaction effect of foam rolling to rolling to control between each time point and pre-DOMS protocol. Error bars represent 95% confidence limits for the mean effect. Bar represents clinically trivial effect.

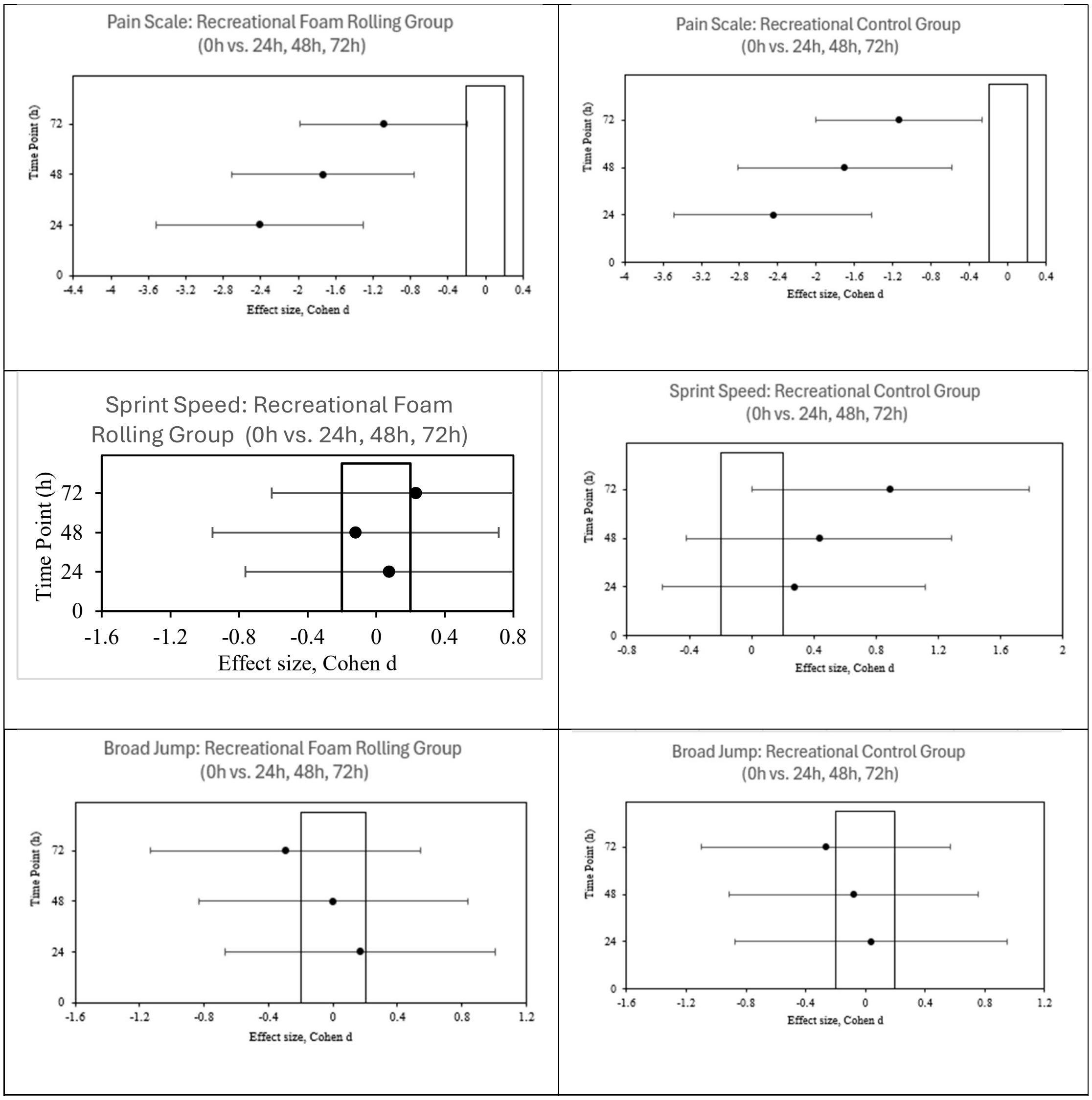

Figure 4.4 Magnitude-based inferences demonstrating the effect of foam rolling on pain scale, sprint speed , broad-jump distance in recreational athletes. Points represent the effect size (Cohen d) describing the interaction effect of foam rolling rolling to control between each time point and pre-DOMS protocol. Error bars represent 95% confidence limits for the mean effect. Bar represents clinically trivial effect.

4.3.1 Effects of Foam Rolling in DOMS on pain

Competitive players

For competitive players, foam rolling demonstrated a substantial reduction in pain over time. At 24 hours post-exercise, the mean difference was -3.82 (95% CL: -4.97 to -2.66), with a standardized effect size (Cohen's d) of -2.944 (95% CL: -4.16 to -1.694), categorized as large. At 48 hours, the pain continued to decrease, with a mean difference of -3.64 (95% CL: -5.18 to -2.09) and a large, standardized effect size of -2.09 (95% CL: -3.128 to -1.019). By 72 hours, the reduction in pain was smaller but still notable, with a mean difference of -1.91 (95% CL: -3.3 to -0.52) and a standardized effect size of -1.221 (95% CL: -2.125 to -0.292), indicating a large effect.

For the control group, where foam rolling was not applied, the pain scale also showed decreases, though of lesser magnitude. At 24 hours, the mean difference was -3.18 (95% CL: -4.34 to -2.03) with a standardized effect size of -2.453 (95% CL: -3.563 to -1.310), categorized as large. At 48 hours, the mean difference was -2.55 (95% CL: -3.88 to -1.22), with a standardized effect size of -1.702 (95% CL: -2.673 to -0.7), still a large effect. By 72 hours, the mean difference dropped to -1.18 (95% CL: -2.11 to -0.26), with a standardized effect size of -1.136 (95% CL: -2.030 to -0.218), categorized as moderate.

Recreational players

For recreational players, foam rolling also significantly reduced pain across all time points. At 24 hours post-exercise, the mean difference was -2.45 (95% CL: -3.36 to -1.55), with a large effect size (d = -2.411, 95% CL: -3.512 to -1.276). At 48 hours, the mean difference was -2.18 (95% CL: -3.3 to -1.06), with a large effect size (d = -1.735, 95% CL: -2.711 to -0.728). By 72 hours, the mean difference was -1.18 (95% CL: -2.15 to -0.215, d = -1.087, 95% CL: -1.976 to -0.175). In the recreational control group, similar reductions in pain were observed but with smaller magnitudes. At 24 hours, the mean difference was -2.36 (95% CL: -3.37 to -1.36, d = -2.088, 95% CL: -3.125 to -1.017). At 48 hours, the mean difference was -2.18 (95% CL: -2.95 to -1.41, d = -2.512, 95% CL: -3.633 to -1.356). At 72 hours, the mean difference was -0.64 (95% CL: -1.236 to -0.037), with a moderate effect size (d = -0.944, 95% CL: -1.818 to -0.049).

4.3.2. Effects of foam rolling on Sprint Performance

Competitive players

In sprint performance, foam rolling resulted in small but unclear changes. At 24 hours, the mean difference was -0.11 (95% CL: -0.276 to 0.061), with a standardized effect size of -0.585 (95% CL: -1.453 to 0.299), categorized as moderate. At 48 hours, the mean difference increased slightly to -0.175 (95% CL: -0.443 to 0.0934), with a moderate effect size of -0.579 (95% CL: -1.427 to -0.282). By 72 hours, the mean difference was smaller at -0.0627 (95% CL: -0.265 to 0.139), and the standardized effect size reduced to -0.276 (95% CL: -1.11 to 0.567), categorized as small.

The control group exhibited trivial effects on sprint performance across all time points. At 24 hours, the mean difference was -0.077 (95% CL: -0.243 to 0.088), with a standardized effect size of -0.416 (95% CL: -1.256 to 0.435). At 48 hours, the mean difference was -0.114 (95% CL: -0.3254 to 0.0982), and the effect size was -0.477 (95% CL: -1.32 to 0.377). By 72 hours, performance slightly improved (mean difference = 0.024; 95% CL: -0.154 to 0.202), with a trivial standardized effect size of 0.118 (95% CL: -0.72 to 0.953).

Recreational players

The effects of foam rolling on sprint performance differed between recreational and competitive players. For recreational players, foam rolling yielded trivial to small improvements in sprint performance across all time points. At 24 hours postexercise, the mean difference was 0.018 (95% CL: −0.198 to 0.235), with a trivial standardized effect size (Cohen’s d) of 0.075 (95%

CL: −0.762 to 0.910). At 48 hours, the mean difference was −0.027 (95% CL: −0.22954 to 0.175), with a trivial effect size of −0.12 (95% CL: −0.9555 to 0.718). By 72 hours, the mean difference increased to 0.5091 (95% CL: −0.144 to 0.246), with a small standardized effect size of 0.232 (95% CL: −0.610 to 1.068).

In contrast, the control group for recreational players demonstrated trivial to small effects, with a mean difference of −0.067 (95% CL: −0.152 to 0.287) at 24 hours (Cohen's d = 0.273, 95% CL: −0.570 to 1.11), 0.09364 (95% CL: 0.0984 to 0.286) at 48 hours (Cohen's d = 0.434, 95% CL: −0.418 to 1.275), and 0.166 (95% CL: 0.00045 to 0.33227) at 72 hours, categorized as a moderate to large effect (Cohen's d = 0.892, 95% CL: 0.002 to 1.762)

4.3.2. Effects of foam rolling on Broad Jump Performance

Competitive players

Foam rolling resulted in small improvements in broad jump performance, but the effects were largely unclear. At 24 hours, the mean difference was 16.55 cm (95% CL: -9.97 to 43.06), with a standardized effect size of 0.555 (95% CL: -0.305 to 1.401), categorized as moderate. At 48 hours, the mean difference further increased to 19.73 cm (95% CL: -12.96 to 52.41), with a moderate effect size of 0.537 (95% CL: -0.321 to 1.382). By 72 hours, the improvements diminished (mean difference = 5.64 cm; 95% CL: -22.13 to 33.41), and the standardized effect size was 0.181 (95% CL: -0.659 to 1.016), categorized as trivial.

In the control group, broad jump performance showed no meaningful improvements. At 24 hours, the mean difference was 1.36 cm (95% CL: -27.09 to 29.8), with a trivial effect size of 0.043 (95% CL: -0.794 to 0.878). At 48 hours, the mean difference was 14.74 cm (95% CL: -28.48 to 33.02), with a trivial effect size of 0.066 (95% CL: -0.771 to 0.901). By 72 hours, the mean difference decreased to -2.54 cm (95% CL: -32.74 to 27.83), with an effect size of 0.072 (95% CL: -0.907 to 0.765).

Recreational players

Foam rolling had no meaningful effect on broad jump performance for recreational players. At 24 hours, the mean difference was 3.545 cm (95% CL: -15.44 to 22.53), with a trivial effect size of 0.166 (95% CL: -0.673 to 1.001). At 48 hours, no change was observed (mean difference = 0.0 cm; 95% CL: -

18.68 to 18.68). At 72 hours, the performance declined slightly (mean difference = -6.64 cm; 95% CL: -26.54 to 13.27), with a small effect size of -0.297 (95% CL: -1.134 to 0.548).

For the control group, no substantial changes were detected across time points.

4.4 Hypothesis Testing

SUMMARY	1) Recreational	2) Competitive	Total
24h pain scale			
Count	11	11	22
Sum	27	42	69
Average	2.454545455	3.818181818	3.13636
Variance	2.072727273	3.363636364	3.07576
48h pain scale			
Count	11	11	22
Sum	24	40	64
Average	2.181818182	3.636363636	2.90909
Variance	3.163636364	6.054545455	4.94372
72h pain scale			
Count	11	11	22
Sum	13	21	34
Average	1.181818182	1.909090909	1.54545
Variance	2.363636364	4.890909091	3.59307
Total			
Count	33	33	
Sum	64	103	
Average	1.939393939	3.121212121	
Variance	2.683712121	5.234848485	

Table.

Table 4.4 ANOVA data on pain scale of recreational athletes and competitive athletes.

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	32.5757576	2	16.28788	4.460581	0.01563	3.150411
Columns	23.0454545	1	23.04545	6.311203	0.014705	4.001191
Interaction	1.72727273	2	0.863636	0.236515	0.790107	3.150411
Within	219.090909	60	3.651515			
Total	276.439394	65				

Table 4.5 ANOVA results on pain scale effects of foam rolling on DOMS in terms of pain in recreational athletes and competitive athletes.

Assuming that there are no control group and data is only obtained from the pain scale outcome, two-way ANOVA was done to the pain scale of the time point 0, 24, 48, and 72 hours of the foam rolling group of both recreational and competitive athletes. Hypothesis testing was conducted to address the third objective, which aimed to determine whether there is a significant difference in the effects of foam rolling on DOMS-related pain between recreational and competitive athletes. The null hypothesis (H_0) proposed that no significant difference exists between the effects of foam rolling on DOMS-related pain in these two groups, while the alternative hypothesis (H_1) posited that a significant difference does exist.

The analysis of variance (ANOVA) yielded $F(1,60) = 6.31$, $P = 0.015$ as shown in Table 4.5 for the 22 participants that has done foam rolling. Since this p-value is below the significance threshold of 0.05, the null hypothesis was rejected. This result indicates that there is a statistically significant difference in the effects of foam rolling on DOMS-related pain between recreational and competitive athletes.

CHAPTER 5: DISCUSSION

5.1. Chapter Overview

This chapter provides an overview and analysis of the key findings from the previous chapter, examining their relevance to the research question and objectives. It also evaluates how the current study aligns with existing literature and contributes to the body of knowledge. Furthermore, the chapter addresses the study's limitations and suggests recommendations to overcome them. Finally, it concludes the thesis, marking the completion of the research.

5.2. Discussion

Foam rolling is widely used to alleviate muscle fatigue and soreness following intense physical activity. In this study, we investigated its effects following a DOMS-inducing 10 × 10 squat protocol, focusing on differences between recreational and competitive athletes. The aim was to determine whether the recovery benefits of foam rolling vary based on athletic experience and training level. Our findings provide valuable insights into its effectiveness in alleviating DOMS and supporting muscle recovery across these two groups. Our study contributes to the body of literature, as described by Zhang et al. (2024), that the effectiveness of recovery methods, including foam rolling, may differ between individuals and be influenced by the specific athletic context and more varied participant groups. These studies will play a crucial role in improving athlete recovery protocols, promoting both physiological and biomechanical recovery after exercise. Furthermore, to our best knowledge, this is the first study to directly compare the effects of foam rolling on DOMS in recreational and competitive athletes, addressing a notable research gap, particularly among badminton players. These results have important implications for optimizing recovery protocols and enhancing both physiological and biomechanical recovery in diverse athletic populations.

The key findings were (1) effects of foam rolling on DOMS were present in recreational athletes (2) the effects of foam rolling on DOMS in competitive athletes were present and were more pronounced (3) there is significant difference between the effects of foam rolling on DOMS in terms of pain in recreational athletes and competitive athletes.

5.2.1 Effects of Foam Rolling on Pain

Foam rolling had a significant and positive effect on reducing Delayed Onset Muscle Soreness (DOMS) in recreational athletes. At 24 hours post-exercise, the pain scale decreased with a mean difference of -2.45 (95% Confidence Limits: -3.36 to -1.55) and a large standardized effect size of -2.411 (95% CL: -3.512 to -1.276), indicating substantial pain relief. At 48 hours, the mean difference was -2.18 (95% CL: -3.3 to -1.06) with a standardized effect size of -1.735, which remains a large effect. By 72 hours post-exercise, the effect of foam rolling reduced slightly, with a mean difference of -1.18 (95% CL: -2.15 to -0.215) and a moderate standardized effect size of -1.087. These results demonstrate that foam rolling provided significant short-term relief of DOMS, particularly within the first 48 hours, after which the effects tapered off but remained moderate.

Likewise, foam rolling also had a significant effect on reducing DOMS in competitive athletes, but the magnitude of relief was greater compared to recreational athletes. At 24 hours post-exercise, the mean difference in the pain scale was -3.82 (95% CL: -4.97 to -2.66), with a very large standardized effect size of -2.944 (95% CL: -4.16 to -1.694). At 48 hours, the mean difference was -3.64 (95% CL: -5.18 to -2.09) with a standardized effect size of -2.09, still reflecting a large effect. By 72 hours post-exercise, the effects diminished to a moderate level, with a mean difference of -1.91 (95% CL: -3.3 to -0.52) and a standardized effect size of -1.221. These results show that competitive athletes experienced a greater reduction in DOMS compared to recreational athletes, particularly in the first 48 hours after exercise.

Based on the study's comparison between the foam rolling group and the control group in both recreational and competitive athletes, foam rolling appears to be beneficial in reducing DOMS. Foam rolling effectively reduces pain perception from the NRS-11 pain scale, particularly within the first 24–48 hours post-exercise. That is the period when DOMS typically peaks (Arbiza et al., 2024). This benefit is attributed to foam rolling's ability to increase blood flow, facilitating nutrient delivery and the removal of metabolic waste products, as well as myofascial release, which reduces muscle tightness and adhesions (Arbiza et al., 2024). Physiologically, foam rolling enhances circulation, alleviates tension in connective tissue, and modulates pain perception through mechanisms like the Gate Control Theory. (Aggarwal et al., 2024). Mechanical stimulation by foam rolling is believed to improve circulation and aid in clearing inflammatory mediators and metabolic waste from muscles. (Zhang et al., 2024). In contrast, the control group, which did not engage in any recovery intervention, experienced prolonged soreness and slower recovery. Over time, the foam rolling group demonstrated consistent reductions in DOMS, while muscle soreness persisted longer in the control group.

Foam rolling has been found to alleviate muscle soreness and elevate the pain threshold, contributing to neural inhibition and minimizing the impact of neuromuscular fatigue. (Aggarwal et al., 2024). Previous studies have also highlighted its role in reducing delayed onset muscle soreness (DOMS) and muscle damage, as well as enhancing range of motion (Beardsley et al., 2015; Pearcey et al., 2015; Cheatham and Stull, 2019). These findings align with the current study's observations, supporting the effectiveness of foam rolling as a recovery tool for reducing pain. However, when we put the two different population into comparison competitive athletes experienced a greater reduction in DOMS compared to recreational athletes, particularly in the first 48 hours after exercise. This aligns with the findings of the meta-analysis revealed that utilizing foam rolling (FR) as a post-exercise relaxation method had a moderate to substantial impact on reducing muscle soreness within 24 to 72 hours after exercise, particularly at 24 and 48 hours following the FR intervention (Zhou et al., 2024).

In contrast to this study, some studies suggest that foam rolling may yield greater benefits over longer recovery periods, as significant pain reductions were not consistently observed at earlier time points is most effective as a recovery tool over extended periods, particularly during rest or lower-intensity training phases, rather than for immediate recovery needs. (Zhang et al., 2024; MacDonald et al., 2013). Their different category of participants, outcome measure such as the use VAS and having an extended timepoint of 96h post exercise may have led to the difference in results. These inconsistencies raise questions about whether foam rolling is more beneficial acutely or over extended durations. Notably, this study focused on the short-term effects of foam rolling within a 72-hour post-exercise timeframe, leaving the long-term implications—such as its effects on chronic use, athletic performance, and sustained muscle recovery—largely unexplored. Future research should address these gaps by investigating the long-term benefits and potential drawbacks of regular foam rolling, providing a more comprehensive understanding of its impact on recovery and performance.

The ANOVA test further shows a significant difference ($P=0.015$) effect of foam rolling on DOMS-related pain between recreational athletes and competitive athletes. Overall, the above information suggests that foam rolling is effectively reduces DOMS in both groups, but its effects are more pronounced and sustained in competitive athletes, particularly within the first 48 hours post-exercise. The possible reasons that Foam rolling benefits competitive players more than recreational players due to differences in their physiological adaptations, training intensities, and recovery needs (Fernández-Lázaro et al., 2023). Competitive athletes often undergo higher training loads, leading to more pronounced muscle damage and inflammation post-exercise. (Fernández-Lázaro et al., 2023; Franchini et al., 2018). Consequently, they may benefit more significantly from foam rolling, which improves blood flow, reduces muscle tightness, and promotes myofascial release (Fernández-Lázaro et al., 2023; Arbiza et al., 2024). Competitive players have bodies are typically better conditioned to recover from exercise-induced stress (Alshehri et al., 2023), so interventions like foam rolling may have amplified effects, optimizing their already efficient recovery systems.

In contrast, recreational athletes often train at lower intensities and may not experience the same level of muscle damage as competitive players. Their neuromuscular systems may also be less adapted to the mechanical stimuli provided by foam rolling, leading to less pronounced benefits. (Alshehri et al., 2023). These factors combined suggest that foam rolling aligns more closely with the needs and recovery profiles of competitive athletes, making it more beneficial for this group.

Additionally, it is important to note that the ANOVA results, while not emphasized in the results section, provide supplementary insights into the effects of foam rolling on delayed-onset muscle soreness (DOMS). The analysis yielded a result of $F(2,60) = 4.46$, $P = 0.016$, where $P < 0.05$, indicating a significant difference in pain scale measurements between the time points of 24 hours, 48 hours, and 72 hours. This finding suggests that the impact of foam rolling on pain reduction varies across these time intervals. This information in line with the results plotted in Fig 4.3 and Fig 4.4 that was analysed with a T-test between 0h (pre-exercise) and 24h, 48h and 72h (post-exercise).

However, the interaction effects between the athlete groups (recreational and competitive) and time points showed $F(2,60) = 0.24$, $P = 0.79$, where $P > 0.05$. This result highlights that there is no significant interaction between the type of athlete and the time points, suggesting that the pain scale data for recreational and competitive athletes is independent of the measured time intervals. In other words, the differences in pain scale measurements between the two groups are not influenced by whether the data was collected at 24h, 48h, or 72h. This finding underscores the independence of group differences from temporal factors, emphasizing that the variations in foam rolling effects between these populations may arise from other underlying factors, such as physiological differences or training intensity, rather than the timing of measurements.

5.2.2 Effects of foam rolling on performance-based measures

When comparing foam rolling to a control group in terms of sprint speed recovery, the results indicate that foam rolling does not consistently lead to a clear improvement in sprint performance, particularly in competitive and recreational athletes. The data shows that for competitive players, foam rolling yielded moderate effects at 24- and 48-hours post-exercise, but these effects were in the negative direction, suggesting a slight decrease in sprint speed rather than an improvement. Specifically, at 24 hours, the mean difference in sprint performance was -0.11 with a moderate effect size of -0.585, and at 48 hours, the mean difference increased to -0.175 with a similar effect size of -0.579. By 72 hours, the effect size was smaller (-0.276), indicating only a small negative impact on performance. In comparison, the control group for competitive players showed trivial effects across all time points, with no significant change in sprint speed. This suggests that while foam rolling may influence performance, it does so in a slightly negative manner for competitive players, which raises questions about its efficacy in improving sprint speed recovery.

For recreational players, foam rolling showed even less of an impact on sprint performance. At 24 hours, the effect size was trivial (0.075), indicating almost no effect, while at 48 hours, the effect size was again trivial (-0.12), suggesting no meaningful change. Only at 72 hours did foam rolling show a small improvement in sprint performance (effect size of 0.232), but this improvement was still minimal. The control group for recreational players also showed trivial to small effects at all time points, with no significant changes in sprint speed recovery. The lack of clear improvements in the foam rolling group compared to the control suggests that foam rolling does not significantly enhance sprint performance in recreational players.

Overall, foam rolling did not consistently improve sprint speed in either competitive or recreational athletes. While foam rolling may offer some minor benefits in recovery, particularly in the later stages (e.g., 72 hours), the overall effects on sprint performance were minimal and inconsistent. In both groups, the control group exhibited trivial effects, indicating that the act of foam rolling did not provide a substantial advantage over no intervention. Therefore, it can be concluded that foam rolling, in the context of sprint recovery, does not significantly improve sprint speed compared to a control group, with the effects being either neutral or slightly negative in competitive players and mostly trivial in recreational players.

On the other hand, the overall effects of foam rolling on jump performance, as reflected in the data for both competitive and recreational athletes, suggest that foam rolling may have a slight impact on broad jump performance, but these effects are limited and variable, with most changes falling within the range of trivial to small.

In competitive players, foam rolling led to small improvements in broad jump performance, though the effects were somewhat unclear. At 24 hours, the mean difference in performance was 16.55 cm with a moderate effect size of 0.555, indicating a moderate improvement. At 48 hours, the mean difference increased to 19.73 cm, with a similar moderate effect size of 0.537. However, by 72 hours, the improvements diminished significantly, with the mean difference dropping to 5.64 cm and a trivial effect size of 0.181, indicating a minimal benefit at this time point. The control group showed no meaningful improvements in broad jump performance across all time points. The effect sizes in the control group were all trivial, ranging from 0.043 to 0.072, with no significant changes in performance, suggesting that foam rolling provided a slight advantage over no intervention.

For recreational players, foam rolling showed no meaningful effect on jump performance. At 24 hours, the mean difference was 3.545 cm with a trivial effect size of 0.166, indicating a very small improvement. At 48 hours, there was no change observed (mean difference = 0.0 cm), and by 72 hours, the performance declined slightly (mean difference = -6.64 cm), with a small effect size of -0.297. These results suggest that foam rolling did not significantly enhance jump performance in recreational athletes. The control group also showed no substantial changes across time points, reinforcing the idea that the lack of effect seen in recreational athletes was not due to a placebo effect or natural variation.

Overall, foam rolling has a small positive effect on jump performance in competitive athletes, but this improvement is small and tends to diminish over time. In contrast, foam rolling appears to have no meaningful impact on jump performance in recreational athletes, with the effects being either trivial or slightly negative. These findings suggest that foam rolling may be beneficial for certain aspects of performance recovery, but its effects on jump performance are not universally significant.

These findings align with those reported by Healey et al., who observed no significant changes in isometric force production or vertical jump height following the use of smooth foam rolling. Similarly, they are consistent with the results of Macdonald et al., who investigated the impact of foam rolling on range of motion (ROM), knee extension strength, and muscle speed and power, finding comparable outcomes. There are also several other studies where foam rolling on the lower limb has no effect on power and speed. (MacDonald et al., 2013; Behara and Jacobson, 2015; Healy et al., 2015; Jones et al., 2015; Peacock et al., 2015). Pearcey et al. (2015) suggested that the inconsistent effectiveness of foam rolling on field-based performance measures might be attributed to the complexity of the tests used to evaluate these outcomes.

Several limitations were identified during the testing process. First, participants did not consistently wear the same footwear or clothing throughout the study. Variations in attire, such as different types of shoes or tighter clothing, may have influenced biomechanics or comfort during testing, potentially affecting performance outcomes. To address this, future studies should standardize participant attire to minimize these confounding factors. Additionally, the competitive athletes in the study were engaged in ongoing training, which could have impacted their recovery and DOMS outcomes. Regular training may delay muscle healing or introduce additional fatigue, confounding the results. Future research should incorporate recovery periods or account for training schedules to mitigate this issue.

Another limitation involved the testing environment and measurement methods. Some participants performed tests in the presence of friends, which may have influenced their effort and performance due to social factors, such as increased motivation or competition. To reduce this variability, future studies should ensure individual testing conditions.

5.3 Limitations of study

This study encountered several limitations that should be acknowledged when interpreting the findings. First, the relatively small sample size may have reduced the statistical power of the analysis, thereby limiting the generalizability of the results and the ability to detect subtle differences between groups. Second, important anthropometric variables such as participants' weight, height, and BMI were not accounted for, despite their potential influence on muscle recovery and performance. These factors, particularly body composition, could have affected the pressure exerted during foam rolling and the severity of DOMS experienced by participants.

One limitation of this study is the variability in the timing of outcome measurements post-exercise. While measurements were intended to be taken at fixed intervals of 24, 48, and 72 hours post-exercise, practical constraints led to inconsistencies. For instance, baseline measurements at 0 hours were conducted at 9:00 AM, but subsequent measurements at 24 hours might occur as late as 3:00 PM the following day. This lack of uniformity in the timing of assessments introduces potential variability in the results, as physiological recovery processes may differ based on the exact time of measurement.

Additionally, the study exclusively examined foam rolling as a self-myofascial release (SMR) technique, without comparing it to other SMR methods or alternative recovery strategies, which limits the scope of the findings. The absence of participant blinding presents another limitation, as awareness of the intervention may have introduced bias, influencing perceived pain relief and recovery outcomes. Finally, external factors such as variations in attire, footwear, and testing conditions may have contributed to variability in the results. Addressing these limitations in future research will provide a more comprehensive understanding of foam rolling's efficacy and its role in recovery strategies.

5.4 Recommendations for future research

To address the limitations identified in this study, future research should consider several recommendations. First, increasing the sample size is essential to enhance the statistical power and generalizability of findings. A larger, more diverse participant pool would allow for a more robust analysis of foam rolling's effects across various populations and contexts. Second, future studies should account for anthropometric factors, such as weight, height, BMI, and body composition, to better understand their influence on recovery outcomes and the application of foam rolling. Incorporating these variables would provide more precise insights into the relationship between participant characteristics and foam rolling efficacy.

Moreover, comparative studies should be conducted to evaluate foam rolling against other self-myofascial release techniques and recovery strategies, such as massage, stretching, or compression garments. This broader approach would help determine the relative effectiveness of foam rolling within the spectrum of recovery interventions. To mitigate the potential for participant bias, future research should implement blinding procedures wherever feasible, such as using sham foam rolling protocols or placebo conditions. To address the limitation of inconsistent timing in outcome measurements, future studies should aim to standardize the timing of data collection across all intervals (e.g., 0, 24, 48, and 72 hours post-exercise). This can be achieved by setting precise time points for assessments and ensuring participants adhere strictly to the schedule.

Finally, standardizing testing conditions, including attire, footwear, and testing environments, is crucial to reduce variability and ensure consistency across participants. Ensuring controlled, individual testing sessions would further minimize the influence of external factors, such as social dynamics, on performance outcomes. By addressing these limitations, future studies can build on the current findings and provide a more comprehensive understanding of foam rolling’s role in recovery and athletic performance.

CHAPTER 6: CONCLUSION

This study provides important insights into the effectiveness of foam rolling in alleviating delayed onset muscle soreness (DOMS) and supporting recovery in recreational and competitive athletes. By employing a 10 × 10 squat protocol to induce DOMS, we observed that foam rolling significantly reduced muscle soreness and pain perception in both groups, with more pronounced benefits in competitive athletes. The findings has fulfilled the objectives and has reveal a clear distinction between the two populations, suggesting that competitive athletes derive greater recovery benefits from foam rolling, particularly within the critical 24–48 hour post-exercise window when DOMS peaks.

The observed advantages in competitive athletes may be attributed to their higher training intensities, physiological adaptations, and recovery needs, which align more closely with the mechanisms of foam rolling. In contrast, the benefits in recreational athletes were moderate, reflecting differences in training load and neuromuscular conditioning. Foam rolling also demonstrated a modest impact on performance measures, with small improvements observed in jump performance for competitive athletes, but no consistent effects on sprint speed or jump performance in recreational athletes.

Overall, these findings highlight the value of foam rolling as a recovery tool, particularly for competitive athletes, while underscoring its variable efficacy depending on the population and recovery outcomes. While foam rolling appears effective for reducing DOMS and promoting short-term recovery, its role in enhancing performance-based measures remains inconsistent. These results provide a foundation for future research to optimize foam rolling protocols and explore its long-term implications for athletic recovery and performance across diverse populations.

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APPENDIXES

APPENDIX B- ETHICAL APPROVAL

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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Tel: (603) 9086 0288 **Fax**: (603) 9019 8868
Website: www.utar.edu.my

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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APPENDIX C- PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q)

Physical Activity Readiness Questionnaire (PAR-Q)

Name: ______________________________ Date: ______________________

A Questionnaire for People Aged 15 to 69

Regular physical activity is fun and healthy, and more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO	
☐	☐	1. Has your doctor ever said that you have a heart condition *and* that you should only do physical activity recommended by a doctor?
☐	☐	2. Do you feel pain in your chest when you do physical activity?
☐	☐	3. In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	4. Do you lose your balance because of dizziness, or do you ever lose consciousness?
☐	☐	5. Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?
☐	☐	6. Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?
☐	☐	7. Do you know of any other reason why you should not do physical activity?

If you answered YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and to which questions you answered YES.

- ☐ You may be able to do any activity you want – as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those that are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- ☐ Find out which community programs are safe and helpful for you.

If you answered NO to all of the questions →

If you answered NO honestly to *all* PAR-Q questions, you can be reasonably sure that you can:

- ☐ Start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- ☐ Take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- ☐ If you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- ☐ If you are or may be pregnant – talk to your doctor before you start becoming more active

PLEASE NOTE:
If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

PrecisionNutrition

Physical Activity Readiness Questionnaire (Precision Nutrition, 2012)

APPENDIX D- INFORMED CONSENT FORM

(Note: the information has been extracted from google form)

Research Participant Information Sheet

Universiti Tunku Abdul Rahman

Faculty of Medicine and Health Sciences

Department of Physiotherapy

Bachelor of Physiotherapy (Honours)

Information Sheet to Participate in the Study

FOAM ROLLING FOR RECOVERY: EXAMINING DOMS REDUCTION IN

RECREATIONAL VERSUS COMPETITIVE ATHLETIC POPULATIONS

Dear respondents,

I am a third-year undergraduate students of Bachelor of Physiotherapy (HONS) from Universiti Tunku Abdul Rahman (UTAR) and currently conducting a study on Foam Rolling for Recovery: Examining DOMS Reduction in Recreational Versus Competitive Athletic Populations.

Your participation in this study highly important to me as it will greatly assist me in the completion of my study and the achievement of its objectives. 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.

Please refer to this information sheet for detailed explanation of my study and consent form to ensure ethical considerations was guaranteed. It will roughly take 2-5 minutes to complete. I truly appreciate your participation in this study. If you have any inquiries, please feel free to me.

Student Email:

Personal Data Protection Statement

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.

Acknowledgement of Notice:

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

Student Investigator: Jona Kong Zong Na

Course Code and Course Name: UMFD2013 RESEARCH APPRECIATION, PROCESS

AND METHODOLOGY

Year and Semester: Year 3 Semester 2

Name of Supervisor: Ms Kamala A/P Krishnan

Background:

Foam Rolling is a type of massage therapy that could alleviate DOMS that is induced from an intense exercise. It is still an area of emerging research especially comparing the effects of foam rolling in recreational and competitive athletes.

Purpose of Research Study:

The aim of this study is to find out the effects of foam rolling on delayed-onset muscle soreness in terms of pain in recreational athletes in comparison to competitive athletes.

What are my responsibilities when taking part in this study?

1. You will be performing under two conditions that is a control and foam rolling condition, separated by 4 weeks.
2. In the beginning of both the separate conditions, back squats using the university's gym smith machine will be used to induce DOMS (soreness).
3. After that, there will be either no foam rolling or foam rolling for 3 days and data will be collected.
4. This research will require 6 weeks with the first and sixth week being the weeks for data collection.

Potential Benefits of the Project:

Knowing the benefits of using a foam roller and the application of FR to assist recovery after badminton training.

Funding of this project:

This study is sponsored by University Tunku Abdul Rahman. You will not be paid for participating in this study.

Privacy and Confidentiality:

All information collected will be treated in strictest confidence and neither the names of the school nor the names of individuals will be identifiable in any reports that are written. Research records will be stored securely and only approved researchers will have access to the records.

Voluntary Nature of the Study:

Participation in this study is voluntary. If you withdraw or decline participation, you will not be penalized 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 any time.

Contact Person:

If you have any questions, clarifications, concerns or complaints, about the research, the researcher conducting this study can be contacted at 01172356083, or by email with kongzongna@1utar.my.

My Supervisor, Ms Kamala A/P Krishnan, can be contacted at 0175820767, or by email with kamalak@utar.edu.my. It there are any concerns, or complaints about the research and wish to talk to someone other than individuals on the research team.

Please keep this information sheet for your records.

Consent form:

I have been given oral and written information for the above study and have read and understood the information given.

I have had sufficient time to consider participation in the study and have had the opportunity to ask questions and all my questions have been answered satisfactorily.

I understand that researchers, supervisors, and auditors, the sponsor or its affiliates, and governmental or regulatory authorities, have direct access to my information in order to make sure that the study is conducted correctly and the data are recorded correctly. All personal details will be treated as STRICTLY CONFIDENTIAL.

I consent voluntarily to be a participant in this study.

Signature:

IC number:

Date:

APPENDIX E- DEMOGRAPHIC DATA

(Note: the information has been extracted from google form)

Demographics

- Name:
- Age:
- How many days a week do you play badminton?
- How many hours do you play/train badminton per session?
- Have you participated in any badminton competitions?
- If you answered “yes” for the competition, have you participated in a national badminton competition?

APPENDIX F- TURNITIN SIMILARITY REPORT

fyp

ORIGINALITY REPORT

7%	5%	5%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	www.researchgate.net Internet Source	<1%
2	nectar.northampton.ac.uk Internet Source	<1%
3	Xin Zhang, Xin Li, Zhizheng Wu, Xuan Li, Guangyi Zhang, Xin Zhang. "Deciphering recovery paradigms: Foam rolling's impact on DOMS and lactate dynamics in elite volleyball athletes", Heliyon, 2024 Publication	<1%
4	Yann Kerautret, Franck Di Rienzo, Carole Eyssautier, Aymeric Guillot. "Selective Effects of Manual Massage and Foam Rolling on Perceived Recovery and Performance: Current Knowledge and Future Directions Toward Robotic Massages", Frontiers in Physiology, 2020 Publication	<1%
5	www.slideshare.net Internet Source	<1%