THE EFFECTS OF WEARABLE RESISTANCE LOADING DISTRIBUTION ON BIOMECHANICAL AND MOOD RESPONSES DURING JUMPING KICKS IN PENCAK SILAT

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ABSTRACT

Wearable resistance (WR) is increasingly used in sports training to enhance performance by adding external loads to sport-specific movements. However, limited research has explored WR applications in Pencak Silat, particularly during jumping kicks. This study aimed to (1) determine and compare the biomechanical effects of WR loading distributions (3% of body mass at shank, thigh, combined shank and thigh, and 0% without load) on jumping front and back kicks, (2) examine the psychological effect of WR on mood responses during warm-up, and (3) evaluate the chronic effects of WR loading distributions on kicking performance after six weeks of training. A total of fifteen (N=15) athletes participated in the biomechanical analysis, sixty (N=60) in the mood response study, and forty (N=40) in the training intervention. Kinematic data, including kicking velocity, kicking time, kicking height, hip angle, and leg displacement, were analyzed using Kinovea software, while the Brunel Mood Scale measured mood responses. Results indicated significant changes in kinematic parameters, with longer kicking time, reduced kicking velocity, shorter kicking distance, and lower hip angle and leg displacement in WR conditions. Mood responses showed significant increases in anger, depression, and fatigue during warm-up with WR. After six weeks, WR training significantly improved kicking velocity and kicking time. These findings provide insights into optimizing WR loading distributions to enhance Pencak Silat performance, though future studies should further investigate the long-term psychological and performance effects.

KESAN PENGAGIHAN PEMBERAT RINTANGAN YANG BOLEH DIPAKAI KE ATAS GERAK BALAS BIOMEKANIKAL DAN MOOD SEMASA TENDANGAN LOMPAT DALAM PENCAK SILAT

ABSTRAK

Pemberat boleh pakai (WR) digunakan dalam latihan sukan untuk meningkatkan prestasi dengan membenarkan pergerakan spesifik sukan berlaku dengan tambahan beban. Namun, kajian mengenai penggunaan WR dalam tendangan lompat Pencak Silat masih terhad. Kajian ini bertujuan untuk (1) menentukan dan membandingkan kesan biomekanik akut pengagihan beban WR (3% BM pada betis, paha, gabungan betis dan paha, serta 0% BM tanpa beban) terhadap tendangan lompat hadapan dan tendangan lompat belakang, (2) menentukan kesan WR terhadap tindak balas mood semasa sesi pemanasan badan, dan (3) menilai kesan latihan WR selama enam minggu terhadap prestasi tendangan. Seramai lima belas (N=15) atlet menyertai kajian akut, empat puluh (N=40) bagi kajian kronik, dan enam puluh (N=60) bagi kesan mood semasa pemanasan badan. Data kinematik seperti halaju tendangan, masa tendangan, ketinggian tendangan, sudut pinggul, dan sasaran kaki dianalisis menggunakan perisian Kinovea, manakala soal selidik Skala Mood Brunel digunakan untuk mengukur tindak balas mood. Keputusan menunjukkan perubahan ketara dalam kinematik tendangan, dengan masa tendangan lebih lama, halaju tendangan menurun, jarak tendangan lebih pendek, sudut pinggul dan sasaran kaki berkurang di bawah beban WR. Tindak balas mood menunjukkan peningkatan ketara dalam kemarahan, kemurungan, dan keletihan semasa pemanasan badan dengan WR. Selepas enam minggu latihan, terdapat peningkatan ketara dalam halaju dan masa tendangan. Implikasi kajian ini boleh digunakan sebagai garis panduan untuk memilih pengagihan beban WR yang betul dengan beban tertentu untuk digunakan dalam latihan. Walaupun memberi kesan pergerakan secara mekanikal, kajian akan datang dicadangkan untuk menyiasat kesan kronik pengagihan bebanan dengan beban yang spesifik terhadap tindak balas mood dan prestasi.

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LIST OF ABBREVIATION

ANOVA	Analysis of Variance
PAR-Q	Physical Activities Readiness Questionnaire
PERSILAT	Persekutuan Pencak Silat Antarabangsa/ International Pencak Silat Federation
SEA Games	South-East Asian Games
UPSI	Sultan Idris Education University
WR	Wearable Resistance
WRT	Wearable Resistance Training

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Pencak Silat is a type of martial art originating in the South-East Asian region of the ethnic Malays (Mustaffa, Ahmad, & Wong, 1978) and according to Shapie and Elias (2016) pencak silat is originated from Indonesia. Pencak Silat has since developed into a structured competitive combat sport, with sanctioned competitions like the South-East Asian Games (SEA Games), European and World Championships, historically used for self-defense during colonial times and following incorporated as a cultural art form in the post-colonial period. Indeed, the recent growth of this sport has been huge, with 37 countries officially participating in the 2016 World Championships last year (European Pencak Silat Federation, 2016).

Similar to other Asian martial arts such as Karate and Taekwondo, Pencak Silat has gained prominence among the western nations, as the participating countries included the Netherlands, Belgium, the United Kingdom, the United States and Australia since (2016) World Championships. Due to their inclusion in the (2016)

World Championships, and also the inauguration of this sport in (2018) Asian Games, influential martial arts nations such as Japan, China and Korea have adopted this art form throughout the eastern hemisphere.

Pencak Silat, as a sport, is divided into two categories: artistic (seni) and combat (tanding). The artistic category emphasizes choreographed movements and patterns, while the combat category involves full-contact duels that are weight-categorized and take place on an 8-meter diameter circular mat (International Pencak Silat Federation, 2013). A combat match consists of three rounds, each lasting 2 minutes, with a 1-minute rest between rounds. The style of combat typically involves attacking, counterattacking, and defensive maneuvers, which include striking techniques (such as kicks and punches), sweeps (a ground kicking action aimed at the ankles where the leading foot sweeps in a wide arc), and takedowns (Anuar, 1992).

Strikes, sweeps, and takedowns can be employed in attacking, counterattacking, or defensive maneuvers. This variety of combinations leads to a highly intricate sequence of movements, with a scoring system enforced by the referee and/or a jury of five judges who evaluate the effectiveness of these actions. According to the International Pencak Silat Federation (PERSILAT; International Pencak Silat Federation, 2013), points are awarded as follows: one point for a target punch, two points for a target kick, and three points for a successful takedown. An additional point is granted if a successful technique is immediately followed by a blocking or escaping move from the opponent. Legal scoring areas include the front and back of the trunk, excluding the neck. A victory can occur through a knockout or if an athlete is unable to continue.

Previous research by Hariono (2006) indicated that the energy systems utilized in martial arts competitions require approximately 73.75% from the anaerobic/alactic/phosphocreatine energy system, 16.25% from the lactic anaerobic energy system, and about 10% from the aerobic energy system. This suggests that the phosphocreatine energy system (ATP-PC) is the most dominant during competitions in Pencak Silat. Characteristics of the martial arts competition category include quick and powerful movements such as kicking, punching, falling, dribbling, and executing strikes with maximum force. Chan (2019) supported this by noting that anaerobic exercise emphasizes high explosive muscle strength and typically lasts for short durations. The movements involved in this sport require a combination of speed, strength, and power.

Aziz, Tan, and Teh (2002) were the first to define the physiological demands and physical profiles of elite Silat competitors. Considering the complexity of movement patterns involved in combat—such as attacking, counterattacking, and defensive maneuvers analysing the relevant performance indicators can help coaches develop representative learning activities during training, formulate competition strategies to enhance the likelihood of success, and optimize strength and conditioning prescriptions (Shapie, Oliver, O'Donoghue, & Tong, 2013).

As a way to improve physical abilities which has been proven to be important in sports including Silat, resistance training has been suggested to be included in the training program. Strength and conditioning researchers continue arguing that a better training transfer can be achieved from exercises that display mechanical specificity to the movement performed in competition (Haff & Triplett, 2015; Moir, Brimmer, Snyder, Connaboy, & Lamont, 2018) and specificity of velocity of movement Gonzalez-Badillo, Rodriguez-Rosell, Sanchez-Medina, Gorostiaga, & Pareja-Blanco (2014).

The evidence suggests that, particularly during the early stages of an athlete's career, or during in-season phases in professional teams, heavier training loads (>80% of 1RM) are beneficial for enhancing performance. According to Morin (2016), the key objective is to improve the force/velocity and power/velocity relationships, as outlined by Iacono et al. (2018). This focus on optimizing neuromuscular adaptations encourages the use of loadings that support movements specific to the sport. Training tools are increasingly popular for enhancing athletic performance by providing the necessary feedback to optimize these adaptations.

Wearable resistance training can be incorporated into plyometric exercises, as it provides a method for overloading movements in a sport-specific manner, which is believed to enhance the transfer to dynamic athletic performance (Macadam, Cronin, & Simperingham, 2017). A variety of training options exist to target specific adaptations needed for different sports. According to Campos et al. (2002), one key principle that influences the extent of adaptive responses, from the macro level down to the micro-myofibrillar level, is the specificity of training.

Training tools become more popular to enhance performance in any sports. Wearable resistance training can be added to plyometric exercise because wearable resistance training provides a means of activity or movement specific overloading, supposedly resulting in better transference to dynamic sporting performance Macadam, Cronin, & Simperingham (2017). Several training options are available to produce specific adaptations to specific requirements of the sports. According to Campos, Luecke, Wendeln, Toma, Hagerman, Murray, Ragg et al (2002), fundamental principle of an athlete's prescribed exercise program that can affect the magnitude of the adaptive response from the macro- to micro-myofibrillar level is known as specificity of training.

Besides that, wearable resistance training involves attaching external loads to specific body parts during various sports movements. This method applies the concept of training specificity, aiming to boost power output and performance by adding load to targeted movements without negatively impacting the technical execution of the action (Hrysomallis 2012). Wearable resistance training is introduced as a way to provide athletes the optimum training load that gives the greatest training stimulus without inducing undesirable changes in sporting technique. Besides, wearable resistance training apply the concept of training specificity that is resisted movement training due to the addition of external loads applied to specific body segments during movements (Macadam,Cronin & Simperingham 2017).

Wearable resistance training refers to a type of resistance training in which weight is applied directly to the body via a specially designed garment, either by incorporating built-in weights or by attaching additional load. This method emphasizes training specificity, tailored to the sport and the unique needs of the athlete. By applying resistance directly to the body, this approach targets specific movements under the exact demands of the sport or competitive setting, with minimal impact on the athlete's speed, range of motion, or technical skills (Dolcetti, Cronin, Macadam, & Feser, 2019).

From a mechanical perspective, wearable resistance offers distinct advantages compared to traditional training methods. It generates high forces that strength and conditioning coaches can use to enhance athletes' force-generating capabilities. While speed and agility training typically emphasize ground reaction forces, wearable resistance introduces an alternative approach, utilizing lighter loads (ranging from grams to kilograms) to achieve high movement velocities and accelerations, thereby developing significant forces in a different manner (Chelly et al., 2009).

According to the Macadam, Cronin, Simperingham (2017), Macadam, Simperingham, Cronin, (2017), and Macadam, Simperingham, Cronin (2019) loads that attached to compression garments on the arms or legs is a recent advancements in wearable resistance equipment. Fixing wearable resistance by applying targeted rotational overload to the limbs during sports movements, this approach bridges the gap between weight room training and on-field performance. In addition, it seems not to have adverse effects on technique that loads on the body (Young, 2006).

Studies have examined the role of different joints and muscles in the kicking motion, as well as the importance of kinematics stages of kicking (Moreira et al.,2021; Thibordee & Prasartwuth 2014; Guo 2013 ; Gavagan & Sayers 2017 & Lin et al., 2023). Other than that the comparisons of interdisciplinary performance by Diniz et al.,(2021), and physical determinants of kicking performance (Moreira et al., 2015 ; Goulart et al., 2016). Furthermore, numerous studies have explored injury and injury prevalence in combat sports involving kicking (Gartland et al., 2001) ; Hammami et al., 2018). Referring to the previous study examined specifically on running performance which the effects of upper and lower body wearable resistance on spatio-temporal and kinetic parameters during running (Couture et al 2020), acute metabolic changes with thigh-positioned wearable Resistances during submaximal running in endurance-trained runners (Field et al., 2019). To date, no literature review has investigated the wearable resistance training with difference load placement across the range of jumping kicks in sports specifically in Silat.

1.2 Problem Statement

With the increasing popularity of Silat, it is crucial to identify effective training methods that enhance physical performance for both coaching and athlete development. Resistance training plays a key role in training programs aimed at improving muscle power and strength. It is a fundamental exercise strategy that has been shown to enhance performance across various sports, especially those requiring strength, muscular endurance, power, and speed (Suarez et al., 2019).

Based on the literature searches on the Google Scholar, Scopus and Web of Science databases, lack of study has been done on the effects of loading distributions using wearable resistance on the biomechanical responses during jumping kicks in combat sport, specifically in Pencak Silat. According to International Pencak Silat Federation (PERSILAT) Pencak Silat Competition Rules & Regulation (9th October 2023, Version 7) which indicates jumping kicks are permitted in competitions, provided they are executed with control and do not endanger the safety of the participants. The IPSF emphasizes that all techniques, including jumping kicks, must be performed within the framework of the sport's rules and regulations to ensure fair play and the well-being of all competitors.

Researching sport-specific performance presents significant challenges due to the complexity of identifying key factors and predictors of success in competitive sports (Makaruk et al., 2024).The selection of tools and techniques can be specifically tailored to enhance particular muscle groups. Improve overall strength, increase power or build endurance, depending on the athlete's sport and individual requirements. (Schoenfeld et al., 2019).This diversity also poses a challenge in identifying the most effective training regimen for each athlete, requiring a deep understanding of the sport's specific physical demands and the athlete's personal performance goals (Harries et al., 2012; Thiele et al., 2020).

Performing jumping kicks in Pencak Silat is important, as it challenges the muscle to produce explosive power vertically and horizontally. As jump kicks are important in the majority of combat sports, performing specific exercises during resistance training to improve kicking is deemed to be one of the needs. During jump kicks training, it is hard for the individuals to load themselves with traditional loadings such as dumbbells and barbells or more advanced equipment such as cable machines. Thus, practitioners chose to use just their bodyweight as the training loads. The uncomfortable features of using traditional loads during the exercise execution might affect their biomechanical and psychological effects when performing the training.

As a way to induce more loadings rather than just bodyweight, a fixable and attachable equipment should be a great alternative. Compared to the traditional resistance training, wearable resistance allows the performer to train more specific to the main movements involved in the sport. Previous studies on wearable resistance had proven it to become one of the effective tools to be used in training programs (Macadam et al., 2017). It should be noted that the researchers worldwide are actively conducting research to find the optimal load and position to be worn by athletes in various movements. Based on a study published in the ACSM journal (Thompson, 2020), it was found that wearable technology for the third time in a row has become the fitness trend worldwide. Thus, as a sport that is originally from Southeast Asia, Pencak Silat should not be left behind.

To enhance our understanding on the effectiveness of wearable resistance, it is a need for us to do research in this. Lack of study was found on examining the biomechanical effects of loading distribution during different loads distributions. Besides, lack of studies has also been conducted on examining the effects of using wearable resistance during warm up sessions and effects on moods states of the athletes. Understanding of biomechanical and psychological responses during the exercise's execution will contribute to the new knowledge on wearable resistance during Pencak Silat training while also considering the loading position effects and psychological response.

1.3 Purpose of the Study

The purpose of this study is to determine the effects of wearable resistance loading distribution on biomechanical and mood responses during jumping kicks in Pencak Silat.

1.4 Significant of the Study

The outcome from this study will provide guidelines for coaches, practitioners, athletes, and various involved parties on the use of more specific types of resistance training. In the view of implementation level, present study can assist coaches in determining how loading distributions used in wearable resistance could affect the movement during skill execution. In terms of sport development, present study is beneficial to the coaching studies and encourages the coach to plan and include systematic approach and sophisticated training tools which undergo research study to their training schedule.

Besides, the present study will provide guidelines for the chronic study in wearable resistance with WR load distributions. Understanding how the specific loading distributions affects the biomechanics of movement will provide information on the possibility of adaptations occurring after several weeks of training. With its compression base and its ability to progressively apply light anatomical weights almost anywhere on the body, wearable resistance could transfer resistance training to actual human performance is immediate and unique.

It is the mission of the Ministry of Youth and Sports to ensure high performance sports continue to emerge and develop, and that later will improve the achievement of Malaysian athletes at international level. As the steps to achieve this, researchers need to understand how adopting the training tools will affect patterns of movement during execution.

Traditional resistance training equipment often restricts the user to equipment-dictated movements, requiring athletes to adjust their technique to suit the machine.

This can potentially have a negative impact on technique and fails to replicate the complex, sport-specific demands of performance, which typically involve multi-joint, multi-directional movements in a dynamic load environment.

Wearable resistance provides an opportunity for freedom of movement during training sessions. Understanding the concept of biomechanics, training adaptations of specificity of the movements and mood states of training used in the sport while wearing wearable resistance will provide insight into the effectiveness of more flexible methods of resistance training.

Besides that, understanding the process of increment of loading distributions affects the mechanics of movement will provide valuable insight into the stimulus imposed on the physiological system during training, which can then influence the adaptive process. The different effects will provide information on the training specific responses, such as differences in muscle and performance variables. Overall, findings of the present study will contribute to a richer understanding for coaches, practitioners, athletes, and various involved parties to choose the right practice and understanding of resistance training particularly on the specificity of exercise selection and prevent from overreaching and overtraining.

With this research, wearable resistance may offer the coach a technology option that not only requires much less time wasted on the speed bump of transference, but a unique and specific coaching tool to enhance those most primary coaching objective skills.

1.5 Objectives

i. To determine and compare the biomechanical effects WR with 3% of body mass and without load (0% of BM) placed at (shank, thigh, combined shank, and thigh), WR and control (0% of body mass) on joint kinematics (kicking height, kicking velocity, kicking time, leg displacement and hip angles) during Pencak Silat jumping kicks.

ii. To determine and compare the acute effects of warm up on psychological responses (moods states) WR with 3% of body mass placed at (shank, thigh, combined shank, and thigh), WR and without load (0% of body mass) on joint kinematics (kicking time and kicking velocity) of the kicking limb during jumping kicks in Pencak Silat.

iii. To determine and compare the chronic effects of WR with 3% of body mass placed at (shank, thigh, combined shank, and thigh), WR and without load (0% of body mass) on joint kinematics (kicking time and kicking velocity) and performance (standing broad jump) of the kicking limb during jumping kicks in Pencak Silat.

1.6 Research Questions

i. Are there any differences of biomechanical effects between wearing 3% of BM at shank and without load (0 %) of BM on joint kinematics (displacement, time, velocity, angle, and peak height) of the kicking limb during jumping kicks in Pencak Silat.

ii. Are there any differences of biomechanical effects between wearing 3% of BM at thigh, and without load (0 %) on joint kinematics (displacement, time, velocity, angle, and peak height) of the kicking limb during jumping kicks in Pencak Silat.

iii. Are there any differences of biomechanical effects between wearing 3% of BM at combined shank and thigh and without load (0 %), on joint kinematics (displacement, time, velocity, angle, and peak height) of the kicking limb during jumping kicks in Pencak Silat.

iv. Are there any significant differences of acute effects between wearing 3% of BM at shank and without load (0 %), on joint kinematics (kicking time, and kicking velocity) and psychological responses (moods) of the kicking limb during jumping kicks in Pencak Silat.

v. Are there any differences of acute effects between wearing 3% of BM at thigh and without load (0 %), on joint kinematics (kicking time, and kicking velocity) and psychological responses (moods) of the kicking limb during jumping kicks in Pencak Silat.

vi. Are there any differences of acute effects between wearing 3% of BM at combined shank and thigh and without load (0 %), on joint kinematics (kicking time, and kicking velocity) and psychological responses (moods) of the kicking limb during jumping kicks in Pencak Silat.

vii. Are there any differences of six weeks of training program effects between wearing 3% of BM at shank and without load (0 %), on performance (kicking time, kicking velocity and standing broad jump) of the kicking limb during jumping kicks in Pencak Silat.

viii. Are there any differences of six weeks of training program effects between wearing 3% of BM at thigh and without load (0 %), on performance (kicking time, kicking velocity and standing broad jump) of the kicking limb during jumping kicks in Pencak Silat.

ix. Are there any differences of six weeks of training program effects between wearing 3% of BM at combined shank and thigh and without load (0 %), on performance (kicking time, kicking velocity and standing broad jump) of the kicking limb during jumping kicks in Pencak Silat.

1.7 Hypothesis

i. There are no significant differences of biomechanical responses effects between wearing (3% of BM) at shank, thigh, combination shank and thigh and without load (0% of BM) on joint kinematics (displacement, time, velocity, angle, and peak height) of the kicking limb during jumping kicks in Pencak Silat.

ii. There are no significant differences of acute effects between wearing 3% of BM at shank, thigh, combination shank and thigh and without load (0% of BM) on joint kinematics (kicking velocity and kicking time) and psychological responses (moods) during jumping kicks in Pencak Silat.

iv. There are no significant differences on six weeks of training program between wearing 3% of BM at shank, thigh, combination shank and thigh and without load (0% of BM) on joint kinematics (kicking time and kicking velocity) and performance (standing broad jump) of the kicking limb during jumping kicks in Pencak Silat.

1.8 Limitations and Delimitations

1.8.1 Limitations

There are a number of limitations in this study. Age difference and the level of experience in the sport of participants may have influenced the way of performing the skill. This study can only be generalized to trained male where females are not included in the study. Other variables included the motivation levels in the participants which were uncontrollable throughout the study and may influence their performance. However, despite the motivation and effort being uncontrollable, the researcher will still give the most effort in order to make sure participants perform the testing with best efforts. There will be some participants who drop out before the completion of the study. Therefore, participants are required to follow the group and instruction set by the researcher. Besides that, researchers could not be totally certain if the participants unintentionally exposed themselves to some historical event during the research project. For example, a wide fitness campaign in resistance training study and some of the participants doing the exercise would likely affect the study outcomes.

1.8.2 Delimitations

This study only included male experienced Silat athletes who have at least two years of training in Silat. This study involved only qualified male Silat athletes aged 19 to 25 years old. This study will only be conducted on healthy Silat athletes that have no injuries in the last 6 months. The type of kicking only delimited to the Pencak Silat jumping front kick and jumping back kick. Participants were asked to perform a maximal effort of jumping front kick and back kick. Moreover, this study will only be conducted on healthy train males that have no injuries in the last 6 months.

1.9 Definition of terms

1.9.1 Wearable resistance

Wearable resistance Exogenä Exoskeleton technology by Lilä (SportbolehSdhBhd, Malaysia) is intended to permit addition weights on specific macula's of the athlete's body to incorporate progressive muscle overload while preserving the specificity of the

sport (Macadam, Cronin, & Simperingham, 2017).

1.9.2 Silat

Silat means a kind of sport or game that consists of quick movements to attack and defend (Anuar, 1987).

1.9.3 Pencak Silat

Pencak Silat is a self-defence sport that combines both aerobic and anaerobic elements, requiring athletes to maintain excellent physical conditioning

1.9.4 Jumping Kick in Pencak Silat

A jumping kick in Pencak Silat refers to a technique where the practitioner leaps into the air and delivers a kick aimed at an opponent, typically targeting the head, body, or legs. This technique emphasizes agility, speed, and precision, using the elevation of the jump to gain an advantageous position and surprise the opponent. It is used both offensively and defensively, evading low strikes while creating openings for follow-up techniques. Kicks that will be studied are the jumping front kick and jumping back kick.

1.9.5 Acute Response

An immediate change (increase or decrease) in one or more of the body's systems in response to a stimulus.

1.9.6 Chronic Response

Changes that occur over an extended period, often resulting from prolonged exposure to a stimulus or condition.

1.9.7 Kinematics

Kinematics is defined as a description of motion. Kinematics in this study referred to the kicking height, kicking velocity, kicking time, leg displacement and hip angle.

1.9.8 Kicking Height

Kicking height data in this study is taken from the peak height of the kick of participant during the jumping kicks execution. The marker at the toe as a reference point for calculating the kicking height data. Kicking height refers to the vertical distance or elevation reached by a person's leg during the execution of a kick. It measures how high a leg is raised off the ground while performing a kick.

1.9.9 Kicking Velocity

The kicking velocity data in this study are obtained through the kinovea Software. The kicking velocity is defined as time divided by toe displacement. Kicking velocity refers to the speed or rate at which a kick is delivered. It measures how fast a person's leg moves during the execution of a kick. Kicking velocity was calculated by measure distance/time.

Measure Distance: Determine the distance covered by the kick. This might be the distance from the starting point of the kick to the point of impact or completion. Measure Time: Record the time it takes for the kick to be executed. Measure the duration from the initiation of the kick to the point where the kick lands or completes

$$v = d/t \tag{1.1}$$

v = velocity (m/s)
d = distance traveled by the foot (meters)
t = time taken (seconds)

1.9.10 Kicking Time

Kicking time data is recorded from the starting position and to the peak height position of participant's leg during the jumping kicks execution. It refers to the optimal moment during the jump when the kick should be executed for maximum effectiveness.

1.9.11 Hip Angle

Hip angle is obtained through the relative angle of the joint segment of the knee, hip, and ankle.

1.9.12 Displacement

The displacement data in this study are obtained from the start position and to the peak height of the participant's leg during the jumping kicks execution.

1.9.13 Mood

Mood is a psychological element of critical importance since circumstances are highly fluctuating and easily influenced. Mood was described as a collection of emotions, ephemeral in nature, varying in intensity and length, and typically involving more than one emotion (Lane and Terry 2000). Examples of moods are such feelings as elation, happiness or sadness lasting a few hours. According to Terry et al. (2003), the original Profile of Mood States (POMS) consisted of a list of 65 words or phrases that described moods or feelings. It was the primary instrument to measure changes in mood in sport and exercise before the Profile of Mood States for Adolescents (POMS-A, Terry et al., 1999) or Brunel Mood Scale (BRUMS, Terry & Lane, 2003).

1.9.14 Warming Up

Warm-up phase prior to engaging in more intense physical activity or exercise. The primary purpose of a warm-up is to gradually increase the heart rate, body temperature, and blood flow to the muscles, preparing the body for more vigorous and strenuous activity. Warming up is an important part of any physical activity or exercise routine. It involves gently increasing your heart rate, loosening up your muscles, and preparing your body for more intense exercise. This can help prevent injuries, improve performance, and enhance overall workout effectiveness. Common warm-up activities include light cardio, stretching, and dynamic movements specific to the activity you will be doing. It is recommended to spend at least 5-10 minutes warming up before engaging in any physical activity.