THE EFFECT OF LOWER LIMB WEARABLE RESISTANCE ON KICKING KINEMATICS AND KINETICS DURING A MARTIAL ART'S FRONT KICK PERFORMANCE

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SHARON YEAP SZE NIE

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ABSTRACT

It is the main purpose of this study to investigate the kinematics and kinetics effect of wearable resistance (WR), when loaded on the lower limb body part during a martial arts front kick performance. Fifteen female martial arts athletes aged between 20 to 25 years old with body mass (BM) between 40kg to 55kg were recruited. Subjects were required to perform 3 trials for each condition : Unloaded (UL), Calf Loaded (CL) 3% BM and Calf &Thigh Loaded (CTL) 3% BM in a randomized order that made up total 9 trials. Kicking velocity, kicking force and kicking power were collected and used to assess the kinematic and kinetics of kicking executions using Kinovea 2D motion analysis software. Data was statistically analyzed to produce mechanical profiles of the front kick, and comparisons of the outputs was made. Repeated measure one-way Analysis of Variance (ANOVA) test and paired sample t-test were used. Overall the results showed no significant differences within 3 WR conditions. Besides, the results also showed no significant different when comparing between kicking velocity, kicking force and kicking power for all three WR conditions. Nevertheless all three kinematics and kinetics variables indicated using WR 3% BM CL and 3 % BM CTL condition greater than UL condition when compared from the mean. Evidently, loading 3% BM in our study improved the front kick kinematics and kinetics from the mean results but it's still insufficient load to observe the improvement. In summary, researcher suggested that, both loaded condition more than 3% BM might be sufficient and also effective for improving the front kick performance as well as future study should included the element of impulse-momentum to ensure the result can be more applicable to the competitive combat sports.

TINDAK BALAS DAN ADAPTASI *WEARABLE RESISTANCE (WR)* TERHADAP PRESTASI TENDANGAN DEPAN *(FRONT KICK)* DALAM SENI BELA DIRI

ABSTRAK

Tujuan utama kajian ini adalah untuk mengenal pasti tindak balas dan adaptasi *Wearable Resistance* (WR) terhadap prestasi tendangan depan (*front kick*) dalam seni bela diri apabila bebanan ditambahkan di bahagian bawah tubuh. 15 orang atlet seni bela diri yang berusia dalam lingkungan 20 hingga 29 tahun dengan berat badan (BM) 40kg hingga 55kg dipilih sebagai subjek kajian ini. Subjek dikehendaki melakukan 3 kali tendangan untuk setiap kondisi iaitu *Unloaded* (UL), *Calf Loaded (*CL) 3% BM dan *Calf & Thigh Loaded* (CTL) 3% BM, tendangan ini dilakukan secara rawak yang merangkumi jumlah 9 kali tendangan. Halaju tendangan, daya tendangan dan kuasa tendngan akan diambil kira dengan menggunakan perisian analisis pergerakan 2D Kinovea . Semua pemboleh ubah akan dinilai dalam keadaan tiada bebanan, bebanan hanya diletakkan pada bahagian betis sahaja dan bebanan diletakkan pada bahagian betis dan paha. Data akan dianalisis secara statistik untuk menghasilkan profil saraf dan kinematik tendangan depan, dan perbandingan output juga akan dihasilkan. *Repeated measure one-way* ANOVA dan Ujian-t berpasangan digunakan dalam kajian ini. Secara keseluruhan, hasil kajian menunjukkan tidak ada perbezaan yang signifikan dalam ketiga-tiga kondisi. Selain itu, tiada perbezaan yang signifikan ketika pembandingan antara halaju, daya dan kuasa untuk ketiga-tiga kondisi. Walaubagaimanapun, ketiga-tiga pemboleh ubah kinematik dan kinetik iaitu halaju, daya dan kuasa telah membuktikan bahawa WR 3% BM CL dan 3% BM CTL lebih besar daripada UL jika dibandingkan dari segi min. Ini telah membuktikan bahawa WR 3% BM dalam kajian ini telah berjaya meningkatkan kinematik dan kinetik tendangan depan tetapi beban yang digunakah masih tidak mencukupi untuk meningkatkan prestasi tendangan depan. Konklusinya, pengkaji mencadangkan bahawa kedua-dua kondisi CL dan CTL perlu menggunakan berat yang lebih dari 3% BM serta merangkumi elemen momentum impuls untuk memastikan hasilnya dapat diterapkan dalam sukan tempur yang kompetitif atau dalam bidang seni bela diri.

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LIST OF ABBREVIATIONS

%	Percent
2D	Two dimensional view
3D	Three dimensional view
5RM	Five repetition maximum
ANOVA	Analysis of Variance
BM	Body Mass
BMI	Body Mass Index
CL	Calf loaded
CMJ	Countermvement Jump
CTL	Cald and thigh loaded
G	Gram
GRF	Ground reaction force
IF	Impact force
ITF	International Taekwondo Federation
Kg	Kilogram
M	Metre
Ms^{-1}	Meter per second
N	Newton
S	Seconds
SD	Standard Deviation

Sig	Significant
SPSS	Statistical Package for Social Science
UL	Unloaded
UPSI	Universiti Pendidikan Sultan Idris
VJ	Vertical Jump
W	Watt
WR	Wearable Resistance
WTF	World Taekwondo Federation

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Kinesiology is a physical activity that focuses on discipline or body of knowledge. This kinesiology words was originated from Greek where kinesis means motion or movement and logos means the study of movement. In other words, kinesiology is the scientific study of the principles and the effects of structured exercise processes on the human body (Sporis, Badric, Prskalo, & Bonacin, 2013). There are three different sources yet related discipline in physical activities which is the theoretical base, conceptual bases and profesional practice centered in physical activity. The general categories that focus in kinesiology are the exercise and the skill movements. People engage in exercise to improve performance, health appearance and running or lifting weights to increase fitness level and to lose body fat. As well as a weight training by bodybuilders hoping to increase the size of their muscles to achieve an “ideal” look

and for those who is working out to increase their strength and cardio respiratory endurance is to gain a healthy living (Sporis et al., 2013). In this study, the focus is on the kinematics and kinetics effect of WR, when loaded on the lower limb body part using the terminology and the technique of karate front kick (mae-gari) performance.

Kicking in martial arts can be divided into three groups as in linear, circular and spinning. The linear kicks or is known as front kick are the simplest in terms of mechanical efficiency analysis (Bercades & Pieter, 2006). A perfect attack is the combination of strategy, speed, timing, deception and knee judgement. Therefore, power, speed, and timing are part of the important factors for martial arts striking performance (Chang, Evans, Crowe, Zhang, & Shan, 2011). Power can be regards of as explosive force for an athlete exerting his/her strength quickly. Whereas, speed and timing include both muscular speed and reaction time. In this study, the main purpose is to know the suitable weight that is vital to contribute in increasing the speed of the kicks.

Karate is a martial art and combat sport present on the Combat Games developed by Sportaccord, and a recognized sport by the International Olympic Committee. This sport include striking techniques and must be performed in a fast, accurate and powerful manner, respecting rules in karate. Kicking techniques are the basic to perform in the sport and one of the simple basic kick is the mae-geri or is called as the front kick. Mainly in competition, mae-geri (front kick) is executed as a ballistic action when trying to reach an opponent's body target with the foot to performed as fast as possible in a short duration of the movement to impose serious limitations to proprioceptive and visual correction. Front kick

requires a dynamic joint action sequence with the combination of torso, pelvis, knee, ankle and foot, allowing the use of energy that moves from the hip to the foot and resulting from muscle contraction in a mutual combine process (VencesBrito et al., 2014). As stated on the research that, front kick is the most simple basic kick and it can be predict that the front kick technique in karate can perform by any martial arts practitioner as long as the terminology of the kick is being familiarize to the martial arts practitioners. Therefore, this study using the technique of front kick is refer to karate terminology but the participants in this study can come from various martial arts as long as they have the basics of martial arts.

In relative with the research of lower limb angle and angular velocity peaks on the execution of the front kick were spotted among the international athletes in karate Shotokan. Furthermore, the execution of the front kick showed higher repeatability of execution time and lower limb kinematics from the research and this can be useful in selecting top-level karate athletes and monitoring their training status (Pozo, Bastien & Dierick, 2011). According to meta-analysis by Marques Junior (mae geri = 15.8 ± 5.4 m.s-1 versus mawashi geri = 8 ± 3.2 m.s-1), the front kick or known as mae-geri is the second fastest, also one of the strongest and with higher linear velocity kick perform in karate. Therefore, this execution movement was selected because front kick is a complex whole body movement without longitudinal rotations (Witte, Emmermacher, Langenbeck, & Perl, 2012). So, which means that front kick is also an optional kick that can use to defence and attack. Thus, knowing the key to improve the velocity of the karate front kick is important where it can reach the target in the fastest and shortest time.

1.2 Background of the Study

Martial arts is one of the sports that stimulates scientific research in several areas of knowledge that including biomechanics study base on the techniques of punching and kicking on the strength, power, reaction time, speed, agility and balance, among other elements (Fernandes, Wichi, Silva, Ladeira, & Ervilha, 2011). A study to identify the 'motor structures' of karate athletes which is relevant for competition success in kumite and the results shows that speed and power were the most important abilities during martial arts competition by Blazevic, Katic, and Popovic (2006). Thus, in the article of Koropanovski et al (2011) stated that higher movement speed and greater explosive power could be beneficial for kumite competitors due to the needed rapid performance. Therefore, it is important for karate athletes to defend and strike before their opponents are able to defend the attack or counter attack themselves at very high speeds in the statement of Mori, Ohtani, and Imanaka (2002).

In order to increase the speed and power, strength and conditioning training is important. Strength and conditioning training has been applicability to increase the muscle and movement performance. Most significant performance from the researchers shows that by increasing antagonist muscle strength may increase movement speed and accuracy of movement. Performance may be compromised when one muscle or movement action is stronger than its antagonist's. Strength balance is needed to break the agonists muscle for rapid limb movements. Therefore, to avoid the athlete from the risk of injury and provide greater source of motivation, it is important to develop strength and conditioning training on the posterior musculature. Jaric, Ropert, Kukolj, & Ilic, 1995 (as cited in Turner, 2009).

In an earlier article, it was proposed by Mcbride, Triplett-Mcbride, Davie & Newton, (2002) on the the effect of an 8-week training program with heavy-load versus light-load shows that light-load plays a main role in increasing movement velocity performance. Whereas, Schoenfeld, Wilson, Lowery, & Krieger, (2016) suggested that resistance training with combination of heavy and light load will give better results in muscular adaptation and as in the recent study on recreational trained male to quantify the kinetic effects of WR on power clean performance shows that using WR of 5% and 12% BM is a good equipment for recreational trained young males when they doing power clean exercise because it is safer and easier for recreational lifters to capture the correct technique (Cronin, Macadam, & Storey, 2018). Furthermore, WR help allow individuals to perform full movement in a fast-eccentric loading stimulus where Olympic lifts only allow individuals focus on certain movements. In conclusion, WR is a alternative option for individual to apply an appropriate overload stimulus during their future training session. Therefore, in this study WR on lower limbs was used to examine the kicking velocity, kicking force and kicking power on the front kick performance.

Another study about WR by Macadam, Simperingham, Cronin, Couture, and Evison (2017) investigated acute changes of vertical jump (VJ) performance on lower limb WR and upper limb WR of (3% or 6% BM) with vary load magnitudes and load placements shows that WR of 3% or 6% BM is an appropriated equipment for a specific overload movement training and maximizing force to sporting performance for a specific strength exercise. In karate, an athlete need an effective training for their lower limb to perform a good kick. Referring to Chang et al. (2011) power, speed, and

timing are part of the important factors for martial arts striking performance. Related to this research, speed is believed to influence by force. As most of the research were using external loaded training and in this research, WR was used to see the acute responses of maximum kicking velocity, kicking force and kicking power of the kick.

Another interesting approach to scam Pozo et al. (2011), which are the front kick that focused on the lower limb kinetics and kinematics, and repeatability in the mae-geri kick between national and international standard athletes, suggested by the researcher that the duration of the kick and repeatability of lower limb kinematics could be useful in selecting top-level karate athletes. A powerful mae-geri in karate technique partially depend on the coordinated momentum of several parts of the body. This is supported by a strong muscular contraction to produce a maximum speed to the distal extremity during the time of contact with the target. Thus, the general purpose of this study was to provide a better comprehension of the acute responses to the muscle adaptation and speed of movement when loading with WR on the lower limbs of the body on the front kick performance. In general, resistance training applicability to increase movement speed, muscle activation and accuracy of movement either using heavy load or light load depending on sport specific. There are several types of resistance training such as weight lifting, functional training, kettle bell, barbell, medicine ball, and etc. Currently, WR is an alternative option for individual to apply an appropriate overload stimulus and WR allow individuals to perform full movement in a fast-eccentric loading stimulus where Olympic lifts only allow individuals focus on certain movements. To achieve the general purpose, this exploratory research was to quantify the acute

response of lower limb WR on kicking kinematics and kinetics during a martial art's front kick performance.

1.3 Problem Statement

Speed of movement is important to gain point during a martial art match especially in sparing event or Kumite event. There were few studies conducted in such area of interest involving training methods to improve kicking technique, kicking kinematics and kinetics (Pozo et al., 2011; Moreira et al., 2015; Cynarski et al., 2018; Vagner et al., 2019), biomechanics of kicking quality (Kim et al., 2011; Portella et al., 2014; Mailapalli et al., 2015) and also internal and external determinants during the kicking performance Busko et al., 2016; Wasik et al., 2016; Wasik et al., 2018; Wasik et al., 2019; Grymanowski et., 2019). Besides, strength and conditioning training is equally important as believe that the force will increase the speed of movement and also power of the kicks may also influence kicking performance. Most of the researcher, only test on the kicking force and kicking velocity movement of the kicks but very lack of researcher use WR on the responses of the kicking force and kicking velocity of the movement. Most of the WR were used in sprinting and jumping research. A research from Bustos, Metral, Cronin, Uthoff, and Dolcetti (2020) suggested WR provided improvement in acceleration, sprinting and horizontal jumping performance. Likewise, Macadam et al. (2017) suggested 3% WR enhance sprint acceleration without affect sprint running technique. Similar outcome from Cross, Brughelli, and Cronin (2014) vest loading offers little horizontal vector-training stimulus and compromises horizontal power output. Contradictory, Barr, Gabbett, Newton, and

Sheppard (2015) said that inaffective at improving sprinting speed in rugby training. Due to lack of researcher using WR to help the martial arts athletes to improve their velocity of movement on their kick and the reasonable WR weight to put on the body suit that can improve their speed and yet did not effected their biomechanics of kicking technique. Therefore, our problem now is how to improve kicking force, kicking power and kicking velocity by using WR during actual movement in front kick performance.

1.4 Purpose of the Study

The main purpose of this study is to determine the kinematics and kinetics responses of WR body suit on martial arts front kick performance.

1.5 Research Objectives

a) To determine the kicking velocity, kicking force, kicking power during the front kick movement in martial arts performance with and without load WR.
b) To investigate whether there will be a significant differences or not, in term of velocity of movement during the front kick movement in martial arts with and without load WR.
c) To investigate whether there will be a significant differences or not, in term of force of movement during the front kick movement in martial arts with and without load WR.

d) To investigate whether there will be a significant differences or not, in term of power of movement during the front kick movement in martial arts with and without load WR.

e) To determine the relationship between kicking velocity, kicking force and kicking power during the front kick movement in martial arts with and without load WR.

1.6 Research Questions

a) What will be the kicking velocity, kicking force, kicking power during the front kick movement in martial arts performance with and without load WR?

b) Will there be a significant differences in term of velocity of movement during the front kick movement in martial arts with and without load WR?

c) Will there be a significant differences in term of force of movement during the front kick movement in martial arts with and without load WR?

d) Will there be a significant differences in term of power of movement during the front kick movement in martial arts with and without load WR?

e) Will there be a significant correlation between kicking velocity, kicking force and kicking power of movement during the front kick movement in martial arts performance with and without load WR?

1.7 Conceptual Framework of Research

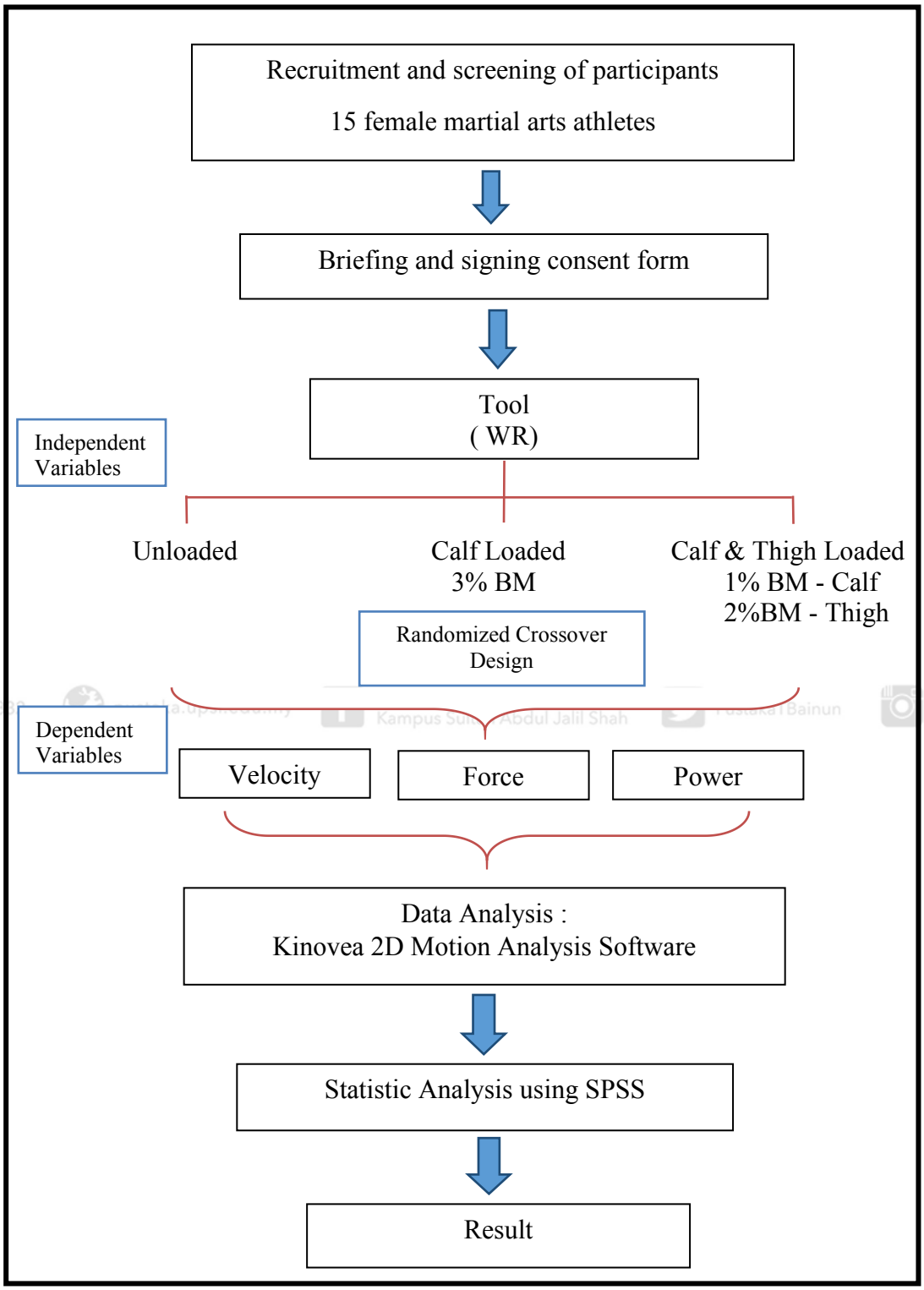

Figure 1.1. Conceptual Framework of Research Diagram

1.8 Significance of Study

This study is conduct by researcher to help teachers, sport practitioners', sport institutions, personal trainers, instructors, department of education district and state level and others relevant agencies planning to introduce WR as a potential stimulus for enhanced growth and function in a safe manner. Also, the result from this study may offer additional strategies for effecting performance outcomes. Besides, the result of this study also provides motivation for players to constantly strive to improve their skills and strength especially related to lower limb performance and injury prevention to all athletes and sports practitioners. This study provides objective information which can be used by coaches to help prepare their athletes for their periodised training programmes.

Among many other training, performance and rehabilitative uses, WR may be useful for targeted movement training to improve running economy, increasing muscular stimulus, or increasing forces for specific loading adaptations. Therefore, the researcher hopes that the outcomes from this study will help to promote this resistance training to all sports fraternity. It helps them to train their specific muscle group and share new input or knowledge regarding exercise that could help to improve strength, speed and indirectly reduce the risk percentage of the muscle groups in the future for better performance.

1.9 Limitations of the Study

There are several limitations to the current study. First, the study subjects were advised to maintain the same daily diet as to avoid the effect of supplemental diet or new dietary intake on the findings of this study. Next, the test is need to be conduct in an indoor environment with an open space due to the attack of current Covid19 situations. It only involve a small size of the population who are active in martial arts. Therefore, to generalize the result to larger groups, additional research require with a greater sample size and involves different levels athletes. Besides, the environmental and psychological factors such as emotional instability, health, muscle tension experienced by athletes during testing also affect the data of this study. Thus, the tightness of the WR suits may also effect the data of this study. Additionally, the athlete's attitude, enthusiasm and understanding of the test can't control by researcher. Finally, the different experience levels and characteristics' among the subjects participated in this study also might affect the study results and indirectly result for both exercises.

1.10 Delimitations of the Study

Delimitation refers to the scope of the study. First all the subjects participate in this research are between 20 to 25 years old. Next, second delimitation is the number of subject that participate in this research which is 15 athletes. Subjects are female martial arts athletes UPSI and Tanjong Malim with body mass 40 to 55kg. Besides, only one test that researcher conduct in this study which is front kick test. Front kick

test in this research is only use to identify the kicking velocity, kicking force and kicking power of movement during the front kick movement.

1.11 Operational Definition

WR refers to the use of load as resistance attached directly to the intended body part, by using compression sleeves which act as Velcro based for the load. This form of loading has been previously used in other sport-specific actions such as sprint-running, jumping and power cleans without unduly affecting the kinematics of the actions (Macadam et al., 2017; Cronin et al., 2018; Macadam et al., 2019). WR is used to replace the external weight by distributing the weight to the body as use in the research of Cronin et al. (2018) in power clean and it shows that WR can help in improving the skills and technique without interrupting the kinematics of the movement.

This newfound technology using Exogen suit created by Sportboleh Sdh Bhd, Malaysia method of wearable resistance training has allowed the athletes to perform movement specific, progressive resistance training where the suit is specially designed with set of upper and lower body garments intentional to alter small flat loads of 50 grams to 200 grams. These loads can be located either proximally or distally to the torso allowing the athletes to perform a greater degree of specialize movement, position and magnitude during sports training compared to the restrictions in load placement offered by gymnasium-based strength training equipment (Macadam et al., 2016; McNaughton & Kelly, 2010; Simperingham et al., 2016).

Therefore, applying this approach to combat sports athletes might be beneficial because the ability to train in loaded conditions on punching and kicking techniques at high velocities in a specific movement manner that had been difficult to achieve with traditional resistance training equipment (Del Vecchio, Stanton, MacGregor, Humphries, & Borges, 2018). For this reason, in current study, WR is use to investigate the kinetics and kinematics of front kick where the loading were distribute from the external weight to the body to perform actual kicking.

Front kick is known as *mae geri* which begins by the knee brought up and forward with a stroked shank. Then the upper leg snaps forward towards the target (keage [Japanese], snapped variant) and the ball of the foot strikes the surface. The optimal body position during this movement is a vertical posture. Front kick is one of the most used attack both in training, as in combat sporting (Witte et al., 2012). Besides, front kick technique can also define as a technique use starting from movements of ankle plantar flexion, knee extension and hip flexion to reach the opponent (Portela, Barbosa, Cavazzotto, & Tartaruga, 2014). However according to Cynarski, Wąsik, Szymczyk, and Vences (2018), front kick is relatively easy to learn, but it is difficult to master because it includes rotational movements performed to produce high-speed movement of the lower leg kinematic chain segments that should be done very precisely. Thus, in combat sports speed is an important element for an athletes to achieves their victory in the particular time given in the game (Wasik et al., 2015; Wasik et al., 2016).

Generally, there are two rudimentary principles of striking in most martial arts are power and speed. In the context of striking, power can be define as the ability to deliver enough force to imbalance or knock out an opponent. Whereas, speed is a key trait for success in combat sports competition. Stand on physics, power and velocity can be observed by the outcome of the force. Hence, speed, in this case, can be explain as quick reaction to apply on fast hand or foot movement (Chang et al., 2011). According to Barnes et al. (2005), Reaction speed is often the only difference between winning and losing a physical challenge where you need to react quickly and respond accurately especially in combat sports or martial arts.

Accordingly in our study, kicking velocity is the main parameter of kicking kinematics recorded during the front kick performance. A kicker need to increase the kicking velocity of the knee traveling towards the target and decrease the duration of the foot take off to produce maximum foot velocity and perform a good front kick technique (Wasik, Czarny, Malolepszy, & Drozdek-Malolepsza, 2015). Furthermore, when the athlete's body mass is constant, a high change of momentum on the foot velocity appeared and this remind us about a high impulse of force. Thus, the higher the velocity, the higher impulse of force affecting the object (Wasik et al., 2015).

On top of that, force is also a main parameter that relating to kinetic variables in kick performance (Falco et al., 2009). Force is a unit that has a direction vector. Force can also define in Newton's first law states that "If a resultant force acts on a zero object, then the object is stationary or will move in a straight line". Hence, when force implemented in the kicking techniques, a fighter with high and great posture will stipulate greater force to the target at the time of impact, because the great posture will

also create greater force. However, the force is also influenced by the speed. This means that the higher the speed, the greater the force applied at the time of doing the motion (Hariono, Rahayu, & Sugiharto, 2017).