Original Article

The effect of lower limb wearable resistance on kicking kinematics and kinetics during a martial art's front kick performance

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Abstract

Background: Wearable resistance works best with lighter load, but appropriate loading range is debatable.

Objective: 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.

Materials and Methods: Fifteen female martial arts athletes aged between 20 and 25 years old with body mass (BM) between 40 kg to 55 kg were recruited. Subjects were required to perform three repetitions for each condition: Unloaded (UL), calf loaded (CL) 3% BM and calf and thigh loaded (CTL) 3% BM in a randomised order that made up total 9 repetitions. Velocity, force and power were collected and used to assess the kinematic and kinetics of kicking executions using Kinovea Two-dimensional Motion Analysis Software. Data were statistically analysed to produce neural and mechanical profiles of the front kick, and comparisons of the outputs were made by using repeated-measure one-way analysis of variance test.

Results: Overall, the results showed no significant differences within three WR conditions. Besides, the results also showed no significant difference when comparing between velocity, force and power for all three WR conditions.

Conclusion: Evidently, 3% BM loading is still insufficient to observe the improvement. Most important, similar results obtained regardless of WR load placement location on the leg during front kick performance.

Recommendation: In summary, researcher suggested that both loaded conditions more than 3% BM and below 30 kg might be sufficient and also effective for improving the front kick performance as well as future study should include the element of impulse–momentum to ensure the result can be more applicable to the competitive combat sports.

Key Words: Front kick, kinematics, kinetics, martial arts, wearable resistance

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INTRODUCTION

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 et al. 2011; Aandahl et al. 2018; Boyat et al. 2017; Branco et al. 2016). 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 et al. (2006). Thus, in the article of Koropanovski et al. (2011)

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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 et al. (2002).

Kicking in martial arts can be divided into three groups as in linear, circular and spinning (Bercades and Pieter, 2006; Mailapalli et al. 2015; Portela et al. 2014; VencesBrito et al. 2014; Wąsik and Shan 2015; Wasik et al. 2015; Witte et al. 2012). The front kick which falls into linear motion group, are the easiest to be analysed for mechanical efficiency, due to its movement in straight line and involving only one spatial dimension (Busko et al. 2016; Cynarski et al. 2018; Grymanowski et al. 2019; Wasik et al. 2019; 2018). 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 et al. 2011; Falco et al. 2009; Pozo et al. 2011; Vecchio et al. 2019). Power can be regarded as an 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.

As speed and power derive from strength ability, no doubt strength and conditioning training become highly vital for combat athletes. Improving muscle strength and hence the movement it produce ensure overall performance enhancement (Barr et al. 2015; Carlos et al. 2019; Cobar and Madrigal 2016; Vagner et al. 2020). Building muscle for movement enhancement needs to be balanced in terms of agonist and antagonist, or between posterior and anterior motion. But again, motion is produced mostly by posterior musculature, and thus most strength training emphasis on this, in order to avoid injury (Turner 2009).

In an earlier article, it was proposed by Mcbride et al. (2002) on the effect of an 8-week training program with heavy load versus light load that light load plays a main role in increasing movement velocity performance, whereas Schoenfeld et al. (2016) suggested that resistance training with combination of heavy and light load will give better results in muscular adaptation, and a recent study on recreational trained males to quantify the kinetic effects of wearable resistance (WR) on power clean performance shows that using WR of 5% and 12% body mass (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 et al. 2018; Marriner et al. 2017). Furthermore, WR help allow individuals to perform a full movement in a fast-eccentric loading stimulus, where Olympic lifts only allow individuals focus on certain movements. In conclusion, WR is an alternative option for individuals to apply an appropriate overload stimulus during their future training sessions (Bustos et al. 2020; Couture et al. 2020; Feser et al. 2018; Field et al. 2019; Hurst et al. 2018; Kravitz and McCormick 2014). Therefore, in this study, WR on lower limbs was used to examine the velocity, force and power on the front kick performance.

MATERIALS AND METHODS

Participants

Fifteen female martial arts athletes aged between 20 and 25 years old with BM between 40 kg and 55 kg participated in the study. All of whom must have a background of martial arts. Exclusion criteria consisted of an injury of the musculoskeletal system such as quadriceps, hamstring, gastrocnemius, soleus and lower back injuries from the current study conducted in order to participate by screened prior to the testing using Pre Activity Readiness Questionnaire. All participants provided informed written consent, and the study received approval from the University Ethics Committee.

Procedures

First, anthropometrical data was collected. Then, the researcher and subjects had a direct interaction in a familiarisation session to familiarise them with the technique execution and gave an immediate feedback on kicking technique. After that, the participants started with a warm-up session for 10–15 min including stretching and kicking practice. Each session has three subjects and the data were collected on video recording using iPhone XS Max at a distance of 2 m, perpendicular to the plane of movement (Balsalobre et al. 2015; Haynes et al. 2019). The tests only run once for data to obtain raw scores and analyse the data without any treatment given to the subjects in Kinovea Two-dimensional (2D) Motion Analysis Software. Subjects performed three repetitions for each condition (unloaded [UL], calf loaded [CL] with 3% BM and calf and thigh loaded [CTL] with 3% BM) in a randomised order that made up a total of 9 repetitions for each participant.

Protocols

The test runs on wearable without weight, WR with weight (3% BM) on the calf and WR with weight on thigh 2% BM and calf 1% BM that equal to 3% BM. The participants were asked to adopt the same initial stance (in karate terminology called kumite dachi (guard stance) and perform the front kick (mae gari) three times that covered nine attempts altogether. Verbal instruction gave to the subject to perform the kick. After performing three repetitions, the subject needs to back to the standard guard stance position for 5 s. All kicks will have an interval of 10 min before the next session start.

Data and statistical analyses

Video recordings were recorded and obtained the results with Kinovea 2D Motion Analysis Software and further analysed using Statistical Package for Social Science (SPSS) version 20.0 (IBM Corp., Armonk, New York, USA) to get mean and standard deviation. Repeated-measure one-way analysis of variance (ANOVA) test was used to analyse the velocity, force and power data either significant exist between three tests.

Table 1: Comparison between velocity, force and power during front kick test

Parameters	Unloaded	Calf loaded	Calf and thigh loaded	Significant
Velocity (m.s)	2.21±0.81	2.30±0.84	2.43±0.88	0.755
Force (N)	134.73±54.66	135.21±63.11	148.32±64.71	0.627
Power (W)	346.31±244.53	359.34±305.06	412.81±299.91	0.703

Table 2: Pairwise comparison of velocity, force and power within three wearable resistance conditions during front kick test (repeated-measures ANOVA)

Set	Condition	Velocity (mean±SD)	Significant	Force (mean±SD)	Significant	Power (mean±SD)	Significant
Set 1	Unloaded versus calf loaded	2.27±0.81 versus 2.30±0.84	1.000	134.73±54.66 versus 135.21±63.11	1.000	346.31±244.53 versus 359.34±305.06	1.000
Set 2	Unloaded versus calf and thigh loaded	2.27±0.81 versus 2.43±0.88	1.000	134.73±54.66 versus 148.32±64.71	0.904	346.31±244.53 versus 412.81±299.91	1.000
Set 3	Calf loaded and calf and thigh loaded	2.30±0.84 versus 2.37±0.87	1.000	135.21±63.11 versus 148.32±64.71	1.000	359.34±305.06 versus 412.81±299.91	1.000

SD: Standard deviation

RESULTS AND DISCUSSION

A repeated-measures ANOVA with a sphericity assumed was used to answer the research question which investigated the significant differences of velocity, force and power in three conditions which are UL, calf loaded and CTL during front kick test. Table 1 indicates the results for the velocity, force and power throughout the WR conditions during front kick test. Results for velocity showed f (2.28) = 0.755, $P > 0.05$, which means this result showed there were no significant differences for velocity across this front kick test. Subsequently, force results showed f value, f (2.28) = 0.627, $P > 0.05$ and the mean force showed that there were no significant differences across the front kick test. Meanwhile, the result for power showed f (2.28) = 0.703, $P > 0.05$. This result, same as velocity and force, showed that there were no significant differences for power across this front kick test.

In repeated-measures ANOVA, pairwise comparisons showed that there were no significant differences for velocity, force and power within three conditions [Table 2]. All the pairwise results showed no significant difference with *P* value, $P > 0.05$. As it happens, there were no significant differences within three conditions, but in particular, the mean velocity for CL (2.30 ± 0.84 m/s) and mean velocity of CTL (2.43 ± 0.88 m/s) showed higher results compared to UL (2.27 ± 0.81 m/s) with *P* value, $P = 1.000$, respectively. Another pairwise comparison showed there were no significant force changes for set 1 and set 3, with *P* value, $P = 1.000$, respectively. The mean force of CTL was also highest among three conditions. Similarly, the mean power of CTL (412.81 ± 299.91 W) was higher than UL (346.31 ± 244.53 W) and CL (359.34 ± 305.06 W), with *P* value of $P = 1.000$, respectively.

The results clearly indicated effect of WR remains the same regardless of placement locations on the leg during front kick performance. Notably, this means that when force increases and the mass remains, then the velocity will increase as predicted according to Newton's second law with the formula a = F/m. Somehow in this study, all loads are still insufficient to provide a stimulus for mechanical responses that is important for significant positive longitudinal adaptation. In conclusion, it is suggested that an external load of more than 3% BM and <30 kg is required which may give better improvement to the kinematics and kinetics of front kick performance. Furthermore, looking into the target subject, the level of experience and gender are also important in determining the sufficient load yet without interfering the posture stability and the kicking mechanics.

On top of that, adding heavier loads than initially thought are needed to overload strength and power, but the effect of such loading on kinematics or kinetics needs investigation. In the present study, light loads on WR showed ineffective results on velocity, force and power output during front kick. The relationship between external loads with kinematics and kinetics variables of front kick highlights an interesting phenomenon. Vest loading may have a place in the preparation of the athlete; however, understanding when and for what reason it should occur in the athlete plan is fundamental to targeted individualised programming. (Cross et al. 2014; Macadam et al. 2020; 2019; 2017). Furthermore, achieving a successful kick or effective kick is a complex interplay within a number of different variables (Vagner et al. 2018).

CONCLUSIONS

Overall, the results of kicking velocity, force and power were no significant differences within three WR conditions (UL, CL and CTL). Besides, the findings also showed no significant differences when comparing velocity, force and power for all three WR conditions. Nevertheless, all three kinematics and kinetics variables indicated using WR with 3% BM CL and CTL condition produced greater effect than UL condition. As predicted, these results were related to the physic of Newton's second law with the formula a = F/m. Newton's second law implies that acceleration can be improved by increasing force capability or decreasing BM. However, reducing body mass will influence force output capacity negatively, thus in order to increase the velocity of the kicks, the best way is to increase the force capability by loading the athletes externally. When force is increasing, acceleration or velocity will increase. Evidently, loading 3% BM in our study improved the front kick kinematics and kinetics from the mean results, but it is still insufficient load to observe the improvement of kicking velocity, force and power, respectively. The practical implications of current findings suggest that CL and CTL more than 3% BM and below 30 kg might be sufficient and also an effective training practice for improving the front kick performance.Lesser load usage is to ensure technical quality of a movement remained intact in the process, similarly with what was found by Simperingham et al. (2016). Thus future kicking research may consider to tests further at which range of 3-6% BM or above, the technical qualities as depicted by kinematics variables will be negatively affected. In addition, one of the lacking elements from this study is that there is no focus on assessment in impulse. Actually, an impulse is high importance for the execution of kicking and effective kicking in accordance with the rules of the game. Power and strength are related to a powerful kicking, but in combat sports or martial arts, they just focus on an effective kicking to get a point. This means that the impulse of kicking may be one of the elements that researcher can look into to achieve the best kicking performance in the rules of the games. Therefore, future studies should include the element of impulse–momentum to ensure the result can be more applicable to the competitive combat sports for more improvement and to scrutiny on all suggestion for better outcomes.

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Conflicts of interest

There are no conflicts of interest.

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