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ORIGINAL RESEARCH

Effect of different specific warm-up protocols and time of day on optimum power performance in kickboxers

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Abstract

Numerous variables can affect performance before the competition. Nevertheless, it could be a subject of curiosity to find out whether a warm-up strategy has a more positive effect on the power performance of kickboxers. The purpose of this study is to evaluate the effect of different specific warm-up protocols and time of day on optimum power performance in kickboxers. Ten volunteer males performed three different warm-up routines in random order. The warm-up protocols consisted of only 20 min for each group. The groups with low-intensity aerobic running (NSWU) and specific warm-ups (SWU-20m) performed 20-min protocols. The other group followed 10 minutes of jogging and 10 minutes of specific warm-up (SWU-10m). All groups followed the warm-up randomly at two different periods of the day (i.e. morning: 09:00-10:00 and evening: 16:00-17:00) on non-consecutive days. A statistically significant difference was found between the groups in terms of Mean Propulsion (W) (F=3.518; p2=0.036). There was a statistically significant difference in Mean propulsive Power (W) between NSWU and SWU-10m (p3= 0.0007) in addition there was also a statistically significant difference in SWU-10m and SWU-20m (p3= 0.0106) and, NSWU and SWU-20m (p3= 0.415) protocols. In conclusion, mean propulsion (W) performance showed diurnal variation, and performances of the kickboxers' can be affected more positively in the evening hours, especially after SWU protocols.

Keywords: Combat sports, diurnal variation, power, pre-activity.

Introduction

Kickboxing is a combat sport inspired by karate, Thai boxing, and western boxing consisting primarily of self-defense kicks and punches. Each of the three rounds of a kickboxing fight lasts two minutes. This sport needs speed, technique, talent, as well as great strength, power, and endurance (Gartland, 2001). Studies show that

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kickboxing contests activate both aerobic and anaerobic metabolism while working for all major muscle groups (Leyk et al., 2017). The psychophysiological demands of a kickboxing tournament mean that competitors attain high levels of physical fitness in a variety of areas. No matter their skill level, kickboxers had a strong peak and mean anaerobic power production. High-level kickboxing performance requires well-developed upper and lower limb muscle strength (Slimani et al., 2017). In particular, lower body muscle strength is very important for effectively turning around the opponent and increasing the power of the hit (Fox, 1998). There are a variety of tests such as countermovement jump, Abalakov jump, squat jump (SJ), or horizontal jump which are used to evaluate the muscular strength of an athlete's lower extremities. But out of all of these tests, the SJ is one of the most practical and well-known (Loturco et al., 2015a).

The warm-up (WU) is an important part of training and/or combat that is performed prior to the physical sports performance (Safran et al., 1988). This practice aims to activate the body as best as possible to enhance physical performance and reduce the risk of injury. It is suggested that WU may increase performance by causing a decrease in the viscous resistance of the muscle, along with an acceleration of rate-limiting oxidative reactions, or an increase in oxygen delivery to the muscles (McArdle et al., 2010). Since a high muscle temperature during WU makes the practice easier, it is suggested that WU may increase performance in one of these three ways (Bishop, 2003). After a proper WU, an increase in performance can be attributed to a vasodilation of the blood capillaries in the muscle as well as a shift to the right in the oxyhemoglobin-dissociation curve (McCutcheon et al., 1999). At 41ºC, hemoglobin releases almost twice as much oxygen as it does at 36ºC, and the oxygen dissociates at a rate that is also twice as fast (Barcroft et al., 1909). The dissociation curve of myoglobin has an effect that is very similar to this one. In addition, a rise in body temperature causes vasodilation, which in turn leads to an increase in blood flow to the muscles (Barcroft et al., 1909; Bishop, 2003).

It is possible to prepare physically in various WUs before a kickboxing competition or match. On the one hand, some approaches may use post-activation potentiation and post-activation enhancement to increase the muscle's power output because of an increase in contraction force and neurological enhancements (Blazevich et al., 2019; Prieske et al., 2020; Zimmermann et al., 2020). On the other hand, other approaches could utilize inspiratory muscle training (IMT), which may find its way into the routine of athletes as a promising way to improve respiratory function combined with normal training (Alnuman et al., 2022). Finally, another way is to apply proprioceptive neuromuscular facilitation stretching and massage promoting mobility, with possible effects on flexibility (Eken & Bayer, 2022). In addition, there are many other WU types can effect force like ischemic preconditioning as a WU, comprehensive WU, active WU and so on (Behm et al., 2021; Guilherme da Silva Telles et al., 2020; Pullinger et al., 2019).

Furthermore, time of day also plays a significant role, as it is associated with circadian rhythm and the biochemical and hormonal responses to this pattern (Ayala et al., 2021). Obviously, sleep quality and athletic performance may function as mediators or moderators for these differences; still, it appears that the time of day is crucial for peak physical and physiological performance in kickboxing and other sports (Thun et al., 2015). The majority of biorhythmic investigations on force output are typically conducted between 4 and 6 times when data is collected (Gauthier et al., 2001; Teo et al., 2011). Increasing the number of sampling times could deteriorate sleep disturbances and cause confusion regarding performance outcomes (Reilly et al., 2009). Furthermore, numerous studies have investigated the impact of different WU times throughout the day (e.g. 01:00, 08:00, 12:00, 13:00, 16:00, and 20:00) to investigate differences in performance at times when practice is usually done and when resting core temperature is at its highest, which may have an effect on muscular performance (Deschenes et al., 1998; Gauthier et al., 2001; Teo et al., 2011; Waterhouse et al., 2005).

The force represents a characteristic of the muscle that determines its power production capacities and therefore, it is considered as the basis of mechanical power output in movements (Cormie et al., 2011). It has been stated that the interaction between force is an important indicator for successful athletic performance in explosive sports (Izquierdo et al., 2002). Studies on force are carried out especially for athletes engaged in combat sports such as boxing, kickboxing, taekwondo and judo and athletes engaged in team sports such as handball and volleyball (Buśko, 2016; Nikolaidis et al., 2016). However, in research, there are limited studies considering elite, national team or amateur athletics levels in kickboxing in which the power parameters obtained during the concentric phase of the SJ movement are evaluated or compared (Can et al., 2020; Can et al., 2019).

It is important to evaluate performance throughout the day and the role of different specific types of WUs in this context in order to determine whether force performance is really impaired during certain training hours. Such a design may assist coaches in identifying the optimal situation and WU that favorably influence the fighting readiness of kickboxers. In addition, power performance can be obtained with specific WUs (Hawley et al., 1989). This study has two objectives: (i) to examine the impact of three different WU procedures on the anaerobic performance of kickboxers as measured by power (i.e., mean power [MP], mean propulsive power [MPP], and peak power [PP]); and (ii) to find the probable interactions between WUs and time of day. In this direction, the hypothesis of the study is that the SWU-10m protocol will increase the MPP performance more than other warm-up protocols.

Method

Participants

Ten amateur male kickboxers who exercised regularly for three days a week, and did kickboxing for at least 3 years participated in this study. Table 1 contains descriptive statistics regarding the sociodemographic data of the participants. In spite of the fact that they had not taken part in any of the competitions, male amateur kickboxers from Turkey had placed in the finals of their separate national championships in each of the previous two seasons. The power analysis program G*Power (version 3.1.9.3, Germany) was used to obtain the research group. As a result (alpha value = .05 and test power (1-beta value)= .80, $\eta p^2 = .25$, it was reported that at least 9 kickboxers should be included in the study (Faul et al., 2007). Accordingly, the minimum sample size was found to be 9 kickboxers. Before starting the study, kickboxers were informed in detail about the content, purpose and methodological model of the research. An Informed Consent Form was signed by the athletes who stated that they volunteered to participate in the training. Athletes who volunteered for the study signed an Informed Consent Form. The study was approved by the ethics committee of the Institute's Clinical Research Ethics Committee (register no. 2021/2721).

Table 1
Descriptive characteristics of the subjects (n=10).

Variable	Mean ± SD
Age	22.1 ± 0.73
Height	175.5 ± 6.48
Weight	73.65 ± 11.3
BMI	23.98 ± 2.82
Body fat ratio	16.33 ± 4.59

SD: Standard deviation; BMI: Body mass index.

Experimental Procedures

The participants' power (MP, MPP, and PP) was measured after they completed three different WU protocols at two different times of the day (morning: 09:00-10:00h, and evening: 16:00–17:00h), with at least two days in between each test. The morning test took place from 9:00 to 10:00 hours, and the evening test took place from 16:00 to 17:00 hours. Also, these times of the day were selected for the study because kickboxers follow a path that goes from morning (eliminations) to evening (finals). This helped explain why these times of the day were chosen for the study (finals). The study consisted of three WU protocols as non-specific WU (NSWU) (only 40% of heart rate reserve (HRR) during 20 minutes of jogging), 10 minutes of specific WU (SWU-10m) (40% of HRR during 10 min. jogging + SWU-10m (stationary spider-man, inchworm, backward and forward lunge walks, backpedal, straight-leg skip, heel-ups and high knee run)), and 20 minutes of specific WU (SWU-20m) (stationary spider-man, inchworm, backward and forward lunge walks, backpedal, straight-leg skip, heel-ups and high knee run)). The Karvonen formula was used to calculate the heart rate reserves of the kickboxing athletes before NSWU, SWU-10m, and SWU-20m sessions (Karvonen & Kentala, 1957). A heart rate monitor chest strap (Polar H10) connected to the IPAD Polar Team application was used to monitor HR during the WU protocols. All of the protocols consist of 20 minutes. This study continued for approximately 20 days with familiarization sessions (two nonconsecutive days for familiarization sessions and three nonconsecutive days for three different warm-up protocols). All protocols continued for consecutive days. The experimental design for the WU protocols of the research is visually reported in the flowchart below (Figure 1). Before the study, kickboxers were asked to sleep at least 8 hours before each test session and to come on a full stomach, provided that they had food at least two hours before the morning and early evening sessions The study was conducted 3 weeks after the national championships (July-2021). The air temperature during the WU and fitness tests was 26ºC-28ºC (using the Kestrel 4500 Pocket Weather Tracker, Nielsen-Kellerman Co., USA). In addition, the study was carried out according to international ethical standards for human biological rhythm research (Portaluppi et al., 2010). Finally, the participants were given the necessary information about maintaining their usual kickbox training, not doing high-intensity exercise, and not using substances such as alcohol and caffeine (Reilly et al., 2007). The inclusion criteria were as follows: 1) active and regular participation in all phases of the study, 2) not suffering any disease or injury that could affect the results, and 3) participants were not allowed to do additional exercises such as high-intensity exercise and high-intensity resistance training.

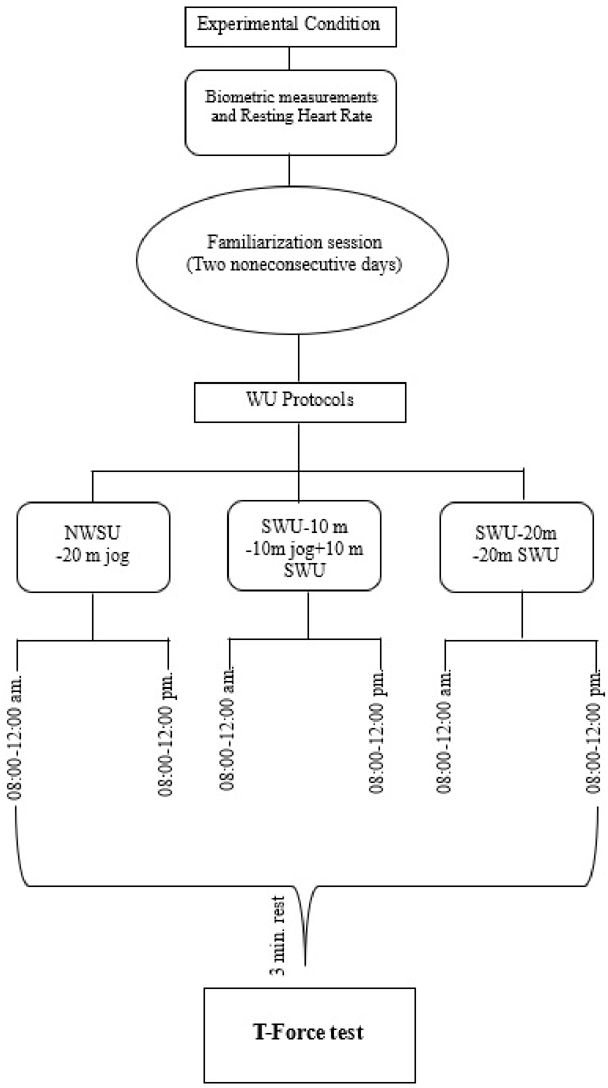

Figure 1. Experimental design.
WU: Warm-up; NSWU: Non-specific warm-up; SWU: specific warm-up

Assessment of mean power, mean propulsive power, and peak power

After three different WU protocols, an SJ exercise was performed on a smith machine (Technogym Equipment, Cesena, Italy) for the optimum power values (MP, MPP, PP) of the participants. At first, the weights that were linked to the bar were proportional to 40% of the total body weights of the participants (the weight of the bar was calculated as 20 kg). It was requested that the participants stand while carrying the bar on their shoulders. The participants were asked to squat until approximately 90º knee flexion was reached and, after holding this position for 2 seconds, jump upwards as fast as possible. During the jump, the participants were asked to maintain downward pressure on the bar so as not to lose contact with the bar's shoulders. The SJ exercise, applied with an external load equivalent to 40% of the participants' body weight, was gradually increased by 10% with each set until a decrease in MP, MPP, and PP was observed (≥5%). The subjects did three repetitions for each load at maximum speed, with a 5-minute rest between sets. The outputs power values were measured by an isoinertial velocity indicator (T-Force Dynamic Measurement System; Ergotech Consulting, Murcia, Spain) attached to the smith-machine barbell (Loturco et al., 2020; Loturco et al., 2015b; Valenzuela et al., 2020). Particularly, the use of this system is suitable for typical weight lifting exercises or any resistance training where necessary to overcome, against gravity, a load that moves along the vertical axis. The T-Force device consists of a cable-extension linear velocity transducer interfaced to a computer by means of a 14-bit resolution analog-to-digital data acquisition board and specific software (T-Force Dynamic Measurement System; Ergotech Consulting S.L., Murcia, Spain), able to automatically calculate the relevant mechanical parameters of each repetition, providing real-time information about the lifting, and storing kinetic and kinematic data for further analysis. The collection of information takes place at a sampling frequency of 100 hertz (Hz), which means that you receive data on the instantaneous velocity of the object once every millisecond. The software calculates the force, power, and velocity characteristics of each repetition of resistance training and presents them graphically and mathematically on the screen (Sanchez-Medina et al., 2010).

Warm-up protocols

Non-specific warm-up: The WU rate was determined according to the 40% HRR of each subject (Karvonen &

Kentala, 1957). Subjects were light jogging for only 20 minutes under the control of the experts. In this way, both WU intensity and WU differences between participants in the training were eliminated. After 20 minutes of light jogging, subjects performed the force test. The participant rested between the WU and the power test for 3 minutes (Fox, 1998).

Specific warm-up of 10m: Subjects were light jogging for only 10 minutes under the control of the experts according to the 40% HRR of each subject (Karvonen & Kentala, 1957). After light jogging, SWU-10m exercises were made. This SWU consisted of 8 distinct exercises (Table 2) (Boyle, 2004). After SWU-10m, subjects performed a force test. The participant rested between the WU and the power test for 3 minutes (Fox, 1998).

Specific warm-up of 20m: SWU-20m exercises were made by subjects. This warm-up consisted of 8 SWU exercises (Boyle, 2004; Table 2). After SWU-20m, subjects performed the force test. The participant rested between the WU and the power test for 3 minutes (Fox, 1998).

Study variables

We used an electronic scale (Tanita SC-330S, Amsterdam, Netherlands) that has an accuracy of 0.1 kilograms (kg) to measure the individual's body weight. A stadiometer (Seca Ltd., Bonn, Germany) with a measuring precision of 0.01 meters was used to determine each participant's height as part of the measurement process. An electronic scale (Tanita SC-330S, Amsterdam, Netherlands) was used to measure and record the body mass index as well as the body fat ratios of all of the volunteers (American College of Sports Medicine, 2018).

Statistical Analysis

The conformity of the quantitative data to the normal distribution was evaluated with the Shapiro-Wilk test. Since the demographic data of the participants showed a normal distribution, the demographic data were summarized as mean ± standard deviation. The multivariate normal distribution assumption regarding the measurements was evaluated with the Henze-Zirkler test. Since the assumption of multivariate normal distribution could not be achieved, the measurements were summarized as median (IQR). Two-way PERMANOVA (Permutational Analysis of Variance) analysis with Euclidean distance as a similarity matrix was used to examine the difference and interaction effect between the groups. Statistical tests with a p-value of less than 5% were considered significant. Analyses were performed using Python 3.9 and IBM SPSS Statistics for Windows version 26.0 (New York; USA).

Table 2
Specific warm-up protocol.

SWU protocol	Description
Stationary Spider-Man	In the stationary Spider-Man, assume a push-up position and step forward as if to try to step just outside of the right hand with the right foot
Inchworm	Begin in a push-up position. From the push-up position, drop the hips to stretch the abdominal area and then walk the feet up as close to the hands as possible while keeping the legs straight. This is done with small steps and no knee bend.
Backward and Forward Lunge Walks	The backward and forward lunge walks are exercises that stretch out the anterior hip while warming up all of the leg and hip extensors.
Backpedal	The backpedal is another backward movement, but it is used to warm up the quadriceps, not the hamstring.
Straight-Leg Skip	The straight-leg skip in- creases the dynamic stretch on the hamstring while also activating the hip flexor.
Heel-Ups	The heel-up, or butt kick as it is some- times called, shifts the emphasis from the hip flexor to the hamstring.
High Knee Run	In the high knee run, the load on the hip flexor group is enhanced. This activity is comparable to jogging in place with minimal forward motion.

SWU: Specific warm-up.

Results

Table 3 shows the changes in the MP (W) parameter of the participants. According to the data of the study, there was no statistically significant difference between the measurements in terms of Mean Power (W) (F=1.083, p1=0.305). There was no statistically significant difference between the groups (NSWU, SWU-10m, and SWU-20m) in terms of MP (W) (F=0.815; p2=0.439). In addition, the difference between the groups according to time was not statistically significant (F = 0.401; p = 0.669). The interaction effect was not statistically significant (p>0.05).

Table 4 shows the changes in the MPP (W) values of the participants. According to the data of the study, there was no statistically significant difference between the measurements in terms of MPP (W) (F=0.624; p1=0.43). A statistically significant difference was found between the groups in terms of MPP (W) (F=3.518; p2=0.036). While there was a statistically significant difference in MPP (W) between NFWU and FWU-10m (p3<0.001) or FWU-10m and FWU-20m (p3= 0.0106) groups, NFWU and FWU-20m (p3= 0.415) There was no statistically significant difference between the) groups. According to the data obtained in the study, the interaction effect was not found statistically significant (p>0.05).

Table 3
Comparison of the measured values of mean power (W).

Groups	Median (IQR)	Between Measurements F Value p_1 Value	Between Groups F Value p_2 Value	Interaction
NSWU-Mean Power (W)-a.m.	332.6 (54.3)	F= 1.083 *p_1= 0.305*	F= 0.815 *p_2= 0.439*	F= 0.401 *p= 0.669*
SWU-10m-Mean Power (W)-a.m.	335.15 (73.05)			
SWU-20m-Mean Power (W)-a.m.	337.65 (47.3)			
NSWU-Mean Power (W)-p.m.	339.55 (62.17)			
SWU-10m-Mean Power (W)-p.m.	356.7 (64.47)			
SWU-20m-Mean Power (W)-p.m.	344.55 (47.3)			

a.m.: Ante Meridiem, p.m.: Post Meridiem, IQR: Interquartile range, NSWU: Non-specific warm-up; SWU: specific warm up; p_1 Value; significance test result between measurements, p_2 Value; Intergroup PERMANOVA significance test result.

Table 4
Comparison of the measured values of mean propulsive power (W).

Groups	Median (IQR)	Between Measurements F Value p_1 Value	Between Groups F Value p_2 Value	Interaction
NSWU-Mean Propulsive Power (W)-a.m.	477.35 (86.75)	F= 0.624 p_1= 0.43	F= 3.518 p_2= 0.036 NSWU – SWU-10m p_3<0.001 NSWU – SWU-20m p_3= 0.415 SWU-10m – SWU-20m p_3= 0.0106	F= 0.167 p= 0.84
SWU-10m-Mean Propulsive Power (W)-a.m.	481.05 (87.25)			
SWU-20m-Mean Propulsive Power (W)-a.m.	480.5 (38.47)			
NSWU-Mean Propulsive Power (W)-p.m.	499.25 (97.7)			
SWU-10m-Mean Propulsive Power (W)-p.m.	543.2 (86.05)			
SWU-20m-Mean Propulsive Power (W)-p.m.	506.95 (65.05)			

a.m.: Ante Meridiem; p.m.: Post Meridiem; IQR: Interquartile range; NSWU: Non-specific warm-up; SWU: Specific warm-up; p_1 Value: Significance test result between measurements; p_2 Value: Intergroup PERMANOVA significance test result; p_3: The results of the in-group comparison significance test.

Table 5
Comparison of the measured values of peak power (W).

Groups	Median (IQR)	Between Measurements F Value p_1 Value	Between Groups F Value p_2 Value	Interaction
NSWU-Peak Power (W)-a.m.	856.1 (79.97)			
SWU-10m-Peak Power (W)-a.m.	916.85 (312.77)			
SWU-20m-Peak Power (W)-a.m.	922.5 (254.95)	F= 2.313 p_1= 0.135	F= 1.8307 p_2= 0.1703	F= 0.0452 *p=0.954*
NSWU-Peak Power (W)-p.m.	939.1 (208.65)			
SWU-10m-Peak Power (W)-p.m.	1019.95 (261)			
SWU-20m-Peak Power (W)-p.m.	962.75 (250.12)			

a.m.: Ante Meridiem; p.m.: Post Meridiem; IQR: Interquartile range; NSWU: Non-specific warm-up; SWU: Specific warm-up; p_1 Value: Significance test result between measurements, p_2 Value: Intergroup PERMANOVA significance test result.

Table 5 shows the changes in the PP (W) parameter of the participants. According to the data of the study, there was not a statistically significant difference between measurements in terms of PP (W) (F= 2.313; p1= 0.135). There was not a statistically significant difference in terms of PP (W) between the groups (NSWU, SWU-10m, and SWU-20m) (F= 1.8307; p2=0.1703). Also, the difference between groups according to time was not statistically significant (F=0.0452; p=0.954). The interaction effect was not statistically significant (p>0.05).

Discussion

The aim of this study was to analyze the differences in power performance assessed at two different times of day (morning and evening) after three different WU protocols (NSWU, SWU-10m, SWU-20m). The major finding of the present study revealed that measurements of MPP (W) were insensitive to morning and evening WUs. This means that the study found no statistically significant difference in MPP (W) values between morning and evening measurements. However, there was a statistically significant difference between the NSWU, SWU-10m, and SWU-20m groups. The SWU-10m group had significantly greater MPP (W) than the NSWU and SWU-20m groups. This result indicates that the athletes' SWU-10m program will positively affect their MPP (W) value.

Some studies in the literature suggest that peak and mean power may increase after WU protocols (Eliakim et al., 2007; Hawley et al., 1989; Mujika et al., 2012; Souissi et al., 2010). Hawley et al. (1989) found that there were no significant differences in peak or mean power between a WU of an 8 min incremental continuous cycling or cold conditions. However, the fatigue index was significantly greater following the WU (Hawley et al., 1989). The findings of this study are not similar to the findings of our investigation. It is reasonable to believe that the differences are the result of differences in the participant group as well as differences in the study design. Eken et al. (2022) examined the acute effect of high-intensity functional exercises (HIFT) on circadian rhythm and anaerobic performance parameters. They found that HIFT had a better effect on vertical jump, average power, peak power, and T-line agility in the evening than morning and afternoon hours (Eken et al., 2022). It was established that there was a development in favour of the evening in the findings of our investigation, which is comparable to the findings of this study. Bayer & Eken (2021) conducted to determine the effects of massage on some anaerobic performance and diurnal variation on judokas. The protocols consisted of non-massage protocol (NM), 5 minutes of jogging, and 10 minutes of sports massage (SM). The protocols were applied in two time periods of the day (morning: 09.00-11.00, evening: 16.00-18.00). It has been reported that SM positively affects peak power and average power due to vertical jump performance compared to the NM protocol (Bayer et al., 2021). Although this study is different from our study since it incorporates massage protocols, which is one of the passive warm-up strategies, it is comparable to our study because it takes into account diurnal variation. Similar to the results in our study, evening performance values were determined better. Souissi et al. (2010) investigated the impact of active WU length on diurnal changes in anaerobic performance in adult male students. Peak and mean power improved significantly from morning to afternoon following both a 5-minute (F = 6.48, p < 0.05) and 15-minute active (F = 5.84, $p < 0.05$): WU, although the effect of WU time was only significant in the morning (Souissi et al., 2010). The results of this study indicate, in contrast to the findings of this study, that performance values that are measured in the evening are much greater after warm-up exercises. The common result found is that the diurnal variation in body temperature may lead to improved motor coordination, resulting in increased performance in the afternoon as opposed to the morning (Lericollais et al., 2009). Rather than a change in neural mechanism modification in the evening, these diurnal improvements in muscle performance have been found to result from improved muscle contraction characteristics (Racinais et al., 2005; Zarrouk et al., 2012). Mujika et al. (2012) evaluated the effects of a typical 30-minute WU with a reduced intensity to an experimental 30-minute WU on indoor rowing time-trial performance. After short WUs, rowers generated much more power in the first 7.5 minutes of the time trial, with the mean power production for the time trial being significantly higher. Long WUs induced a significantly higher mean WU HR than short WUs, as well as a greater pre-time-trial assessment of perceived exertion and blood lactate, but a comparable HR (Mujika et al., 2012). Tomaras & MacIntosh (2011) examined the effects of a traditional warm-up as well as an experimental warm-up on the 30-second Wingate test as well as electrically triggered twitch contractions. They compared and contrasted the two types of warm-ups by examining their effects on the subjects. They found that the typical warm-up for track cyclists leads to a large amount of weariness, which is directly correlated with impaired peak power production. They hypothesized that a superior performance may be achieved with a warm up that was both shorter and of lower intensity (Tomaras et al., 2011). Frikha et al. (2016) determined the impact of different active WU durations and the rest interval separating it from exercise on anaerobic performance. They found that the effect of active WU duration on mean power and peak power was significant. There was only one study about the effect of warm-up on mean propulsive power that can be found in the literature. Neves et al. (2019) investigated the influence of a specialized WU as opposed to a general WU followed by a specific WU on the performance of the bench press exercise. However, it seems that protocol B tends to generate better overall results, despite the fact that the results showed no significant differences between the conditions in the maximal values of mean propulsive power (Neves et al., 2019).

The results of this study are similar to our study (Frikha et al., 2016; Mujika et al., 2012; Neves et al., 2019; Tomaras et al., 2011). This situation can be summarized according to the following results. As a physiological process, the following explanations can be linked to being the cause of the rise in peak, mean and mean propulsive power that occurs after WU protocols have been completed. An increase in body temperature due to daily variation can result in passive muscle warm-up and an increase in metabolic reaction, as well as an increase in the extensibility of connective tissue, a decrease in muscle viscosity, and an increase in the rate of conduction of action potentials (Racinais et al., 2010; Shephard, 1984). Furthermore, passive and active warm-up, increased anaerobic metabolism, high oxygen uptake kinetics, and post-activation potentiation, the results of these studies may evoke effects related to temperature, metabolism, neurons, and psychology. Passive WU can increase body temperature without depleting energy substrate stores, as is the case during active WU involving physical activity. Passive and active WUs have a significant effect on subsequent exercise performance via increases in ATP turnover, muscle cross-bridge cycling rate, and oxygen uptake kinetics, which improve muscle function (McGowan et al., 2015).

This research has certain limitations. The afternoon hours were not analyzed in this study, nor were any participants other than male kickboxers considered. Replication is possible by increasing the sample size for male and female elite and upper-elite kickboxers of various ages. It can provide more specific recommendations for increasing the number of studies examining the effects of various WU protocols, stretching protocols, and circadian rhythm on various performance parameters in kickboxing, and for planning kickboxing-specific WU exercises prior to training programs. However, it can be argued that a WU to boost HR and muscle temperature can improve test performance-specific WU protocols.

Conclusion

There was a statistically significant difference between the 3 WU protocols. According to the results, the SWU-10m protocol has a much greater MPP (W) than the NSWU and SWU-20m protocols. These results indicate that the SWU-10m program of volunteer kickboxers has a beneficial influence on the MPP (W) values. The findings of this study can inform the development of training programs. This can contribute to kickboxers maximizing their kickboxing performance and lowering their injury risk prior to training and competition.

Practical Applications

Our study provides practical insights for the coaches and kickboxers. Although conclusions about the mechanisms responsible for increases in Mean Propulsive Power, Mean Power, and Peak Power cannot be drawn from the present data, the findings from this study have important practical applications. The key finding of the present investigation demonstrated that measures of MPP (W) were indifferent to morning and evening WUs. Furthermore, it has been noted that the MPP (W) results of kickboxers who perform the SWU-10m protocol can be better when compared to the results of kickboxers who perform alternative warm-up procedures (NSWU and SWU-20m). Future research might be aimed at enhancing different performance results and injury-preventative aspects of these types of warm-ups.

Abbreviations

MPP: Mean propulsive power; MP: Mean power; PP: Peak power; NSWU: Non-specific warm-up; SWU: Specific warm-up.

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Authors' Contribution

Study Design: RB, ÖE, EMP, HN, SB, HY, and HK, Data Collection: RB, ÖE, Statistical Analysis: RB, ÖE, Manuscript Preparation: RB, ÖE, EMP, HN, SB, HY, and HK.

Ethical Approval

All participants were provided with the relevant study information before providing informed written consent. The study was approved by the ethics committee of the Institute's Clinical Research Ethics Committee (register no. 2021/2721).

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Conflict of interest

The authors declare that they have no competing interests.

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