EFFECTS OF A SONGAHM TAEKWONDO TOURNAMENT ON VERTICAL JUMP AND TECHNICAL-TACTICAL PERFORMANCE IN ATHLETES OF THE BRAZILIAN NATIONAL TEAM

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ABSTRACT

Purpose. The study aimed to verify the effects of a simulated taekwondo tournament on vertical jump as well as technical and tactical performance in athletes of the Brazilian national team. **Methods.** The study involved 10 male Songahm taekwondo athletes. They took part in a simulated tournament in sparring modality, comprising four 2-minute fights with different opponents. Before and after each fight, the athletes performed the Sargent Jump Test and were asked to indicate the rate of the perceived exertion (RPE). In addition, the fights were recorded and some technical and tactical variables were analysed, namely the number of kicks, effectiveness, and technical variety. The analysis of variance for repeated measures with the Bonferroni post hoc test was used, with the significance level set at p < 0.05. **Results.** No significant differences in the jump height were observed throughout the fights (p = 0.22, trivial effect). The RPE increased over the fights (p < 0.01, large effect); however, no significant differences were obtained after each fight (p > 0.05, trivial effect). All technical and tactical variables remained unchanged over the fights (p > 0.05, trivial-to-small effect). **Conclusions.** The simulated taekwondo tournament had no effect on vertical jump or technical and tactical performance throughout the fights. The athletes were able to recover the effort perception before each new fight.

Key words: combat sports, stretch-shortening cycle, rate of perceived exertion, motion analysis

Introduction

Songahm taekwondo is a martial art derived from traditional Korean taekwondo and developed in United States by Gran Master H.U. Lee. Songahm taekwondo competitions are divided into three rounds: weapons, poomse, and sparring (fight) [1]. During the final circuit in international competitions, the modalities occur separately, and in competitions for national teams it is common to have only the sparring, which consists of a single 2-minute round (fight). The fight can be concluded by timeout or by reaching five points by one of the athletes [2].

Taekwondo fights comprise high-intensity activities, such as sequences of kicks, and long low-intensity periods (hops), in which opponents approach one another and prepare attacks [3]. The intermittent period presents an effort:pause ratio of 1:6 for athletes of the Songahm taekwondo [1], 1:7 in the the World Taekwondo Federation (WTF), and 1:3 or 1:4 in the International Taekwondo Federation (ITF) [4]; i.e., for each intense effort during the fight the athletes spend a long time approaching their opponent and preparing for a new attack. Therefore, during the fight in all modalities, athletes are subjected to moderate-to-high aerobic demands [5] and high demands on the anaerobic pathways with degradation of phosphocreatine and moderate glycolysis activation [6–8].

To ensure the quality of attacks and the most favourable scores, taekwondo athletes require high levels of muscle power in the lower limbs for each attack and high levels of strength endurance (power) to sustain the intensity of the attacks over the round [9, 10]. According to Marković et al. [11], the power in taekwondo kicks depends on the ability to use the stretch-shortening cycle (SSC) correctly. The literature has shown that prolonged or intense exercise that involves the SSC mechanisms can potentially cause muscle damage [12-14]. Therefore, it is reasonable to think that despite the pause periods and low-intensity actions during the round, the sequence of fight with variable time intervals may induce adverse metabolic conditions, leading to a decrease in power-production ability due to the fatigue. This condition could compromise the performance throughout the tournament, especially in the final periods of fight. Previous studies have analysed WTF athletes and observed no impairment for youth [15] or elite [16] taekwondo athletes in vertical jump performance after three 2-minute rounds, but there are no studies analysing the effects of combat simulation in athletes of the Songahm modality. Thus, there are few studies and no conclusive results regarding the neuromuscular demand during a taekwondo fight.

Another important aspect is the tournament effects on technical and tactical performance, since the processes described above may provoke changes in the number and quality of attacks and consequently impair the results of the fight. Recently, an increase has been observed in the number of attacks in the final rounds as compared with the initial rounds [3]; however, this seems to be characteristic of non-winning

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athletes [1]. In addition, the perception of effort is another variable that provides important information for comprehending the effort of internal load during the competition [17, 18]. To our knowledge, no studies have investigated the effects of a simulated Songahm taekwondo tournament on the technical and tactical performance, vertical jump test (neuromuscular demand), or perceptual responses. The comprehension of these indicators during a simulated tournament will provide important information that may help specify the result of a fight or a competition, especially in elite athletes, with very similar physical and technical levels. Thus, this study aimed to verify the effects of a simulated tournament of Songahm taekwondo on the technical and tactical performance, vertical jump test, and perceptual responses in Brazilian national team athletes. The main hypothesis is that the simulated tournament will induce a decrease in vertical jump performance and changes in the technical and tactical variables, especially in the number of attacks. Also, it will provoke a progressive increase of the perceived effort over the fights.

Material and methods

Participants

The study involved 10 male Songahm taekwondo athletes (age, 21.7 ± 5.3 years; body mass, 73.5 ± 6.5 kg; height, 1.78 ± 0.09 m). Their experience in practicing Songahm taekwondo was 11.7 ± 6.7 years. All the athletes were black belts and participated with the Brazilian national team in the current year. They had already taken part in several national and international tournaments and were associated with the American Taekwondo Association (ATA). The participants were training regularly (technical and tactical training), 5-6 times a week during the evaluation period, and were selected on the basis of the following criteria: no reported musculoskeletal disorder or injury influencing the maximal physical performance, and participation in at least one national and international competition in the current year. The subjects were in the competition preparatory phase for the World Tournament of Champions of Songahm Taekwondo. All of them were informed about the study procedures and signed the informed consent form in accordance with the Declaration of Helsinki. The study was approved by the local Research Ethics Committee of the centre where the study was conducted.

Experimental design

Songaham taekwondo athletes participated in a simulated tournament, only in the sparring modality, consisting of four 2-minute fights separated by 13 minutes of passive rest. The Sargent Jump Test (SJT) and rate of perceived exertion (RPE) were assessed before and after each fight in order to determine the effects of the simulated tournament on muscle power in the lower limbs and perceptual responses. Also, all fights were recorded for further technical and tactical analysis. The simulated tournament was performed in the afternoon (3:00–5:00 p.m.), in room temperature, ranging from 22 to 24°C. The participants were instructed to maintain normal diets and to avoid drinking alcohol 24 hours prior to the assessments and training session. Also, it was recommended to avoid any physical training 48 hours prior to data collection in order to prevent possible muscle damage.

Songahm taekwondo tournament

The athletes performed four 2-minute fights in the sparring modality, separated by 13 minutes of passive rest (each fight consisted of 1 round of 2 minutes). The interval time between the fights was defined in a pilot study to ensure the same recovery time for all athletes, since in each of the four fights they fought with a different opponent. According to Matsushigue et al. [1], in official competitions of Songahm taekwondo the interval time varies from 10 to 20 minutes. The simulated tournament followed the protocol of an official tournament, i.e. all fights were arbitrated by three official referees, according to the ATA rules [2]. The athletes were informed that they must complete all four fights - win or lose. This procedure ensured a more accurate simulation of a real competition. Songahm taekwondo competition generally occurs in a single-elimination system, with a starting fight of 16 athletes (maximum), followed by quarterfinals, semifinals and a final. Thus, the finalists perform up to four fights per day.

Measurements before and after the fights

Before and after each fight, the athletes performed the SJT and were asked to indicate their RPE. In addition, all fights were filmed in order to obtain technical and tactical variables.

Prior to the fight, the participants performed familiarization/warm-up exercises, consisting of 1 minute of hopping, three series of 10 hops on the ground, and 5-7 submaximal countermovement jumps similar to the protocol. After a 3-minute resting period, they performed three maximal jumps on the ground. The protocol of the SJT consisted of a countermovement jump with free movements of the upper limbs and total freedom in joint flexion of the lower limbs [19]. The SIT showed high validity (agreement) and reliability for intra-evaluator measures (r = 0.99; p = 0.001) [20]. The procedure assessments followed the recommendations proposed by de Salles et al. [20]. The participants had their right hand fingers marked with orange chalk. They stood beside a wall on their right side, with their right arm raised above the head. The evaluator performed the first mark on the wall. Prior to the jump, the participants could freely flex their knees, as well as prepare

the upper limbs for a sudden upward thrust in an effort to promote the highest vertical jump possible. At the highest point of the jump, the athletes were to mark the maximum height jumped. The jump height was defined by the difference between the two points marked on the wall. Three vertical jumps were performed, with 30 seconds of interval between them. The mean height of the jumps was considered for analysis.

The RPE scale proposed by Foster et al. [21] was used to identify the effort of internal load. The assessment was carried out before the first fight, 1 minute after the end of each fight, and 1 minute before starting the next fight. As for the RPE measurement, the participants were asked to indicate their effort on a 0–10 scale, with 0 indicating no exertion and 10 pointing at maximum exertion [21]. A research assistant performed a familiarization of the scale with the athletes.

All fights were filmed with a digital camera (Canon PowerShot ELPH 500, Tokyo, Japan), operating at the frequency of 30 Hz. The aim was to identify the technical and tactical variables, as follows: (a) the total number of kicks; (b) effectiveness: the number of attacks that resulted in a score; (c) technical variety: the total number of techniques used. The analysis was conducted with the Kinovea software (model 0.8.15); the authors followed the technical standards and respected the judges' decisions and interpretations during the fights.

Statistical analysis

Data were reported as means and standard deviations. The Shapiro-Wilk test was used to verify the normality of the residual data. The sphericity of data was assumed according to Mauchly's test results. The analysis of variance for repeated measures (withinsubjects ANOVA) and Bonferroni *post hoc* tests were used to compare the jump height, perceptual responses, and technical and tactical variables over the fights. The effect size was determined with the partial etasquared (η^2) values. The authors adopted the criteria of Rhea [22] for highly trained individuals (regular training for at least 5 years) in the analysis of effect magnitude.

Results

Table 1 shows the mean and standard deviation values for jump height and RPE before and after each

fight (1, 2, 3, and 4). The analysis of variance showed no significant differences in jump height (F = 1.59; p = 0.22; $\eta^2 = 0.15$ – trivial effect) over the fights. The RPE presented significant differences throughout the fights (F = 70.79; p < 0.01; $\eta^2 = 0.1$ – large effect). The *post hoc* analysis pointed at an increase of RPE between the beginning and end of each fight (p < 0.05), reaching higher values in the final of the four fights (RPE – very hard). However, no significant changes between postfight measurements were verified (p > 0.05), indicating that the athletes could recover before starting the next fight.

Figure 1 presents the technical and tactical variables in individual values and the mean of the group over the four fights (rounds). No significant changes were found in any variable: number of kicks (F = 0.75; p = 0.50; $\eta^2 = 0.07$ – trivial effect), effectiveness (F = 0.87; p = 0.47; $\eta^2 = 0.09$ – trivial effect), or technical variety (F = 2.24; p = 0.14; $\eta^2 = 0.20$ – small effect).

Discussion

The main finding of this study was that the simulated taekwondo tournament induced no changes in the jump height or the technical and tactical performance throughout the fights. In addition, there were no differences in the RPE after fights 1, 2, 3, and 4, indicating that the athletes were able to recover the effort perception before each new fight started. Thus, the hypothesis of the study was rejected. To our knowledge, this is the first study that has investigated the neuromuscular and perceptual responses during a simulated tournament in elite athletes of Songahm taekwondo.

The jump height did not differ between the fights, showing that the effort was not sufficient to provoke reduction in the power production by the lower limb muscles. Previous studies have shown that Songahm taekwondo fights contain high-intensity actions followed by long periods of low intensity and breaks, with an effort:pause ratio close to 1:6 [1]. Thus, there is high demand on the phosphocreatine system and moderate demand on the glycolytic pathway during rounds [6–8]. The low-intensity activities and pauses during the rounds probably induce resynthetization of the phosphocreatine sources through increases of aerobic activation [23, 24], thereby maintaining the intensity

Table 1. Jump height and rate of perceived exertion before and after each fight of the taekwondo tournament

	Pre-fight 1	Post-fight 1	Pre-fight 2	Post-fight 2	Pre-fight 3	Post-fight 3	Pre-fight 4	Post-fight 4
JH (cm)	54.1 ± 3.8	54.6 ± 3.9	57.4 ± 4.6	56.0 ± 5.2	56.9 ± 4.6	54.6 ± 6.7	56.6 ± 4.8	55.3 ± 6.7
RPE (a.u.)	-	6 ± 1 ^a	3 ± 1 ^b	8 ± 1^{a}	4 ± 1 ^b	8 ± 1^{a}	5 ± 1 ^b	8 ± 1^{a}

JH - jump height, RPE - rate of perceived exertion

^a, ^b Same letters show no significant difference (p > 0.05); different letters show significant differences (p < 0.05). Data are expressed as means ± standard deviations.



Figure 1. Mean ± standard deviation in individual values (A) and the group mean (B) for the number of kicks, effectiveness, and technical variety during the four rounds (fights)

of the effort. Additionally, although the attacks during the taekwondo rounds usually involve eccentric actions and SSC [9, 11], which are potential causes of fatigue [12–14], the pauses during the rounds and between them may provide for neuromuscular recovery.

The effort perception after each fight was considered 'very hard' (RPE = 8); however, the interval between the fights was sufficient for recovery before starting the next fight (RPE from 3 to 5). Previous studies analysed three 2-minute rounds and reported RPE values lower than here ('somewhat hard') [6, 25]. It is noteworthy that these studies dealt with a competition that obeyed the WTF, and not ATA rules. Another important factor is that during the fights, there is a large amount of visual (preparation for the attacks), proprioceptive (exchanges of attempts to upset balance), kinesthetic (positions of attacks), and auditive (technical and tactical orientations provided by the coach) data processing [26]. These disturbances diminish or even disappear in non-competitive situations, such as a simulated competition, which may underestimate the athletes' perceived exertion [18].

The technical and tactical variables were analysed over the course of the simulated competition, including the number of kicks, effectiveness, and technical variety. They all turned out unaffected by the number of fights. The number of kicks reported here was lower than in the findings by Bridge et al. [27] (31 ± 7 kicks), referring to a World Taekwondo Championship. According to Butios and Tasika [28], the technical and tactical demand (including attack, defence, and counter-attack) typically ranges from 15 to 20 kicks per round, similarly to the findings of the present study (20 ± 1 kicks per round). Matsushigue et al. [1] investigated the technical variety and observed eight different techniques applied during the fights in a Songahm taekwondo competition, which is a slightly higher result than that noted in the present study throughout the four fights (6 \pm 1 techniques). No studies were found analysing the technical effectiveness in taekwondo competitions. Also, we verified in our study that only 11.7% of kicks (average of four combats) resulted in scores.

The lack of difference in the technical and tactical variables over the course of the simulated competition can also be explained with the maintenance of muscle power levels (vertical jump performance). The team analysed in the study (Brazilian national team) is very homogeneous and the athletes present similar technical and physical levels, which aids in explaining the results. Santos et al. [3] observed an increase in the number of attacks in the final round as compared with the first round in WTF taekwondo; however, the increase seems to be reported only in non-winning athletes [1], which indicates that winning athletes are more efficient and do not perform a high number of attacks. In the present study, the score performance of the winning and non-winning athletes was not analysed.

Finally, it is important to highlight that the findings of the present study represent features of elite athletes of Songahm taekwondo throughout a simulated competition. Thus, some caution should be taken in extrapolating the results to athletes of lower competitive levels and other taekwondo modalities.

Conclusions

It was concluded that there were no effects of the simulated Songahm taekwondo tournament on the vertical jump performance or the technical and tactical variables throughout the fights. The effort perception increased progressively over the course of the tournament, but the athletes were able to recover before each fight started. Future studies can be conducted to analyse other parameters of internal load effort, such as heart rate and blood lactate concentrations during the competition. Additionally, a kinematic analysis can be suggested in order to investigate whether the taekwondo competition may affect the motor pattern during the attacks, since the technical and tactical variables do not seem to be influenced by the competition.

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