DOI: 10.4025/jphyseduc.v29i1.2913

Original Article

PRE-COMPETITION PHYSICAL, PHYSIOLOGICAL AND PSYCHOSOCIAL STATES OF TAEKWONDO ATHLETES

ESTADO FÍSICO, FISIOLÓGICO E PSICOSSOCIAL DE ATLETAS DO TAE KWON DO NA PRÉ-COMPETIÇÃO

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RESUMO
Os aspectos físico, fisiológico e psicossocial no tae kwon do em um período pré-competitivo ainda não foram investigados concomitantemente. Portanto, o objetivo do presente estudo foi analisar os estados físico, fisiológico e psicossocial de atletas de tae kwon do em período pré-competitivo para o campeonato brasileiro. Em um estudo pré-experimental, cinco atletas da seleção masculina de tae kwon do da Paraíba (26±8 anos; 1,76±0,04m) foram submetidos a avaliações antropométricas, dosagens de marcadores de dano muscular, inflamação sistêmica e estresse oxidativo, estados de humor, estresse e recuperação e potência de membros inferiores em dois momentos: 30 (pré) e dois (pós) dias antes do campeonato brasileiro. A análise dos dados foi efetuada pelo teste de Wilcoxon (95% de confiança), cálculo da diferença percentual (Δ) entre os momentos e tamanho do efeito de Cohen (*d*). Foram verificados efeitos percentuais no dano muscular (Δ= −25,7% na CK; *d*= 1,10) e atividade oxidativa (Δ= +22,7% na MDA; *d*= 2,56). Os estados de Conflitos/Pressão e Depressão aumentaram 40% (*d*= 1,11) e 100% (*d*= 1,30), respectivamente, e a potência de membros inferiores aumentou 9,05% (*d*= 4,24). Conclui-se que os atletas aumentaram o estresse psicossocial, no entanto melhoraram a força explosiva de membros inferiores e mantiveram o estado fisiológico esperado para competição.
Palavras-chave: Tae kwon do. Atletas. Fisiologia.

ABSTRACT
Combined analysis of pre-competition physical, physiological and psychosocial features in taekwondo has not been performed. Therefore, this study examined the pre-competition physical, physiological and psychosocial states of taekwondo athletes participating in the Brazilian Taekwondo Championship. In a pre-experimental study, five athletes of the men's Paraíba taekwondo team (26±8 years old; 1.76±0.04 m) underwent anthropometric assessments, measurement of markers of muscle damage, systemic inflammation and oxidative stress, and evaluation of mood and recovery-stress states and of explosive power of lower limbs at two time points: 30 (pre) and 2 (post) days before the Brazilian Championship. Data were analyzed by the Wilcoxon test (95% confidence). The percent difference (Δ) between time points and Cohen's effect size (*d*) were calculated. Percent effects were observed on muscle damage (Δ= −25.7% in CK, *d*= 1.1) and antioxidant activity (Δ= 22.7% in MDA, *d* = 2.56). Conflicts/Pressure and Depression states increased by 40% (*d*= 1.11) and 100% (*d*= 1.30), respectively, while lower limb explosive power increased by 9.05% (*d*= 4.24). We conclude that athletes exhibited increased Conflict/Pressure and Depression states, but improved the explosive power of lower limbs and maintained the physiological state expected for competition.
Keywords: Taekwondo. Athletes. Physiology.

Introduction

The physical, physiological and psychological states of athletes on the eve of a competition are important aspects of physical and competitive performance[1,2]. In taekwondo, in addition to the high inherent physical and psychological demands of performance training, athletes are required to maintain a certain body weight until the time of competition[3,4]. As a consequence, they usually resort to a strategy such as rapid dehydration, which can cause physical[5], physiological and psychological stress[5,6]. However, this strategy may lead the athlete to participate in the competition exhibiting fatigue buildup and physical wear, which can reduce physical and competitive performance[5-7].

These factors highlight the need to monitor both the physiological and psychological conditions of athletes during the season and especially on the days prior to the main events of the sport. It is well established in the literature and in sporting practice that physical and competitive performance is optimized mainly by reducing the training workload for a predetermined period prior to the main competitions (taper)[7]. However, it is common to find athletes affected by excessive training workloads and/or inadequate recovery periods over a season[8].

Previous studies have analyzed physical[2,3], physiological[9], and psychosocial factors in taekwondo[1,10]. However, combined analysis of pre-competition features has not been investigated. Thus, elucidating this problem will increase our knowledge about training workloads in combat athletes, particularly when we consider that the athletes of the present study were evaluated during one of the most important periods for sporting performance.

The identification of the pre-competition physical, physiological and psychosocial states of athletes is fundamental since they determine athletic performance[8]. Within this context, the objective of the present study was to analyze the pre-competition physical, physiological and psychosocial states of taekwondo athletes participating in the Brazilian Championship. The hypothesis of this study was that a taper would restore the physiological and psychosocial states of athletes, with consequent improvement in their physical performance.

This study has the potential to provide practical information for the monitoring of training workloads in taekwondo and to help coaches and athletic trainers of this modality to better manage training workloads, favoring an increase in athletic performance and contributing to future studies in the field of sports training.

Methods

Participants

Five male taekwondo athletes from the Paraiba team (26±8 years old, 1.76±0.04 m) were intentionally selected. These athletes were champions of Paraiba-PB, Brazil, and occupied the first position in the state ranking. The following inclusion criteria were applied: a) black belt level athletes; b) athletes who practiced the modality for 3 or more years; c) holders athletes from the Paraiba team preparing for the 2014 Brazilian Championship, which was held at the end of the competitive season, and d) athletes that trained 3-5 times per week, 60-90 minutes per day. Excluded were athletes: a) with two consecutive absences from training in one week; b) who acquired infectious-contagious diseases during the collection period, and/or c) who did not attend one of the data collection procedures. During data collection at the post time point, one athlete was excluded from the study because he did not complete all assessment procedures.

Procedures

This is a pre-experimental study with an *ex post facto* design. The Human Research Ethics Committee of the Federal University of Paraiba approved the study (No. 568.551; CAAE: 25641513.7.0000.5188). All athletes were informed about the procedures and signed an informed consent form according to Resolution 466/12 of the National Health Council.

Study design

After application of the ethical procedures, the athletes were submitted to physical, physiological and psychological assessments at two time points: 30 days before (pre) and 2 days before (post) the competition. Data were collected at the training site on the same weekday (Thursday) and at the same time (16-18 h) before the training session. The Profile of Mood States questionnaire and the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) were applied. Anthropometric measurements (body mass, height, and skinfolds) were performed and blood samples were collected for the determination of creatine kinase (CK), high-sensitivity C-reactive protein (hs-CRP) and malondialdehyde (MDA). Finally, an explosive strength of lower limb test was applied. The study design is illustrated in Figure 1.

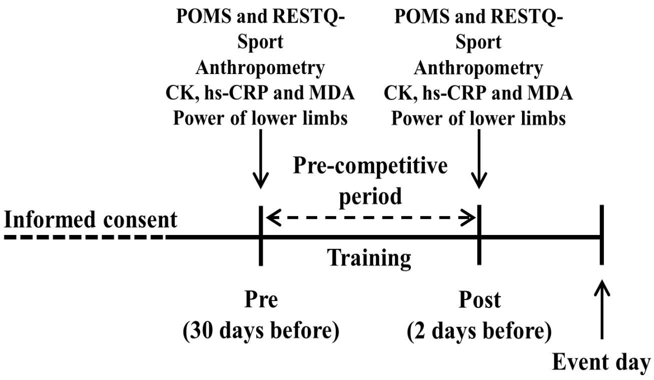

Figure 1. Study design. POMS, Profile of Mood States; RESTQ-Sport, Recovery-Stress Questionnaire for Athletes; CK, creatine kinase; hs-CRP, high-sensitivity C-reactive protein; MDA, malondialdehyde
Source: The authors

Evaluation of mood and recovery-stress states

Mood states were evaluated using the Portuguese version of the POMS questionnaire[11]. This is a self-administered questionnaire consisting of 42 adjectives on a 5-point scale ranging from 0 (not at all) to 4 (very much so) that assesses six mood states: Tension, Depression, Anger, Vigor, Fatigue, and Confusion. This questionnaire assesses the mood states experienced during the last week.

Recovery-stress states of the training workloads were evaluated using the Recovery-Stress-Questionnaire for Athletes (RESTQ-Sport)[12], validated for the Portuguese language. The RESTQ-Sport consists of 77 items (19 scales with four items each plus one warm-up item), which are answered retrospectively by the participants. A Likert-type scale ranging from 0 (never) to 6 (always) is used, indicating how often the respondent participated in various activities during the past 3 days/nights.

These questionnaires were applied before the training, always by a single experienced evaluator in a quiet environment after verbal explanation and reading of the instructions contained in the questionnaires for better assimilation. One of the researchers remained in the environment to clarify any doubts.

Anthropometry and body composition

Height was measured with a portable stadiometer (Holtain, Harpenden, UK) to the nearest 0.1 cm, only at 30 days before the main event. Body mass was measured using a digital scale (MEA-02550, Plenna Lumina, Brazil) to the nearest 0.1 kg. Seven skinfolds (triceps, subscapular, iliac crest, chest, abdominal, front thigh, and medial calf) were taken in triplicate using a scientific skinfold caliper (Cescorf, Brazil) to the nearest 0.1 mm. Median values were used for data analysis. Body density was estimated according to Jackson and Pollock[13] and fat mass (absolute - kg and relative - %) and absolute lean mass (kg) were calculated. All measurements were carried out following standard procedures[14] by a single previously trained evaluator. The participants were instructed to be barefoot and to wear minimal clothing.

Measurement of creatine kinase, high-sensitivity C-reactive protein and malondialdehyde

For CK, hs-CRP and MDA, 5 mL of venous blood was collected from the antecubital vein. The samples were centrifuged at 3000 rpm for 15 minutes and the supernatant was refrigerated at −20°C until the time of analysis. All analyses were performed between 24 and 96 hours after blood collection according to the recommendations of each kit.

CK was determined according to the International Federation of Clinical Chemistry and Laboratory Medicine[15] using a commercial kit (CK-NAC Liquiform®, Labtest, Brazil). The measurement was performed in an ultraviolet spectrophotometer (SP-220, Biospectro, Brazil) at a wavelength of 340 nm.

hs-CRP was quantified by immunoturbidimetry in serum samples. The Calibra Plus series calibrator (Calibra PCR Ultra, Ref. 345, Labtest, Brazil) was used. Absorbance was measured in an automated analyzer (Labmax 240 Premium, Labtest, Brazil) at a wavelength of 540 nm.

MDA was measured as a quantitative indicator of lipid peroxidation, which is indicative of nonspecific oxidative stress. MDA was analyzed by the thiobarbituric acid reaction (TBARS). The samples were incubated in a water bath at 37°C for 60 minutes and the mixture was precipitated with 35% perchloric acid and centrifuged at 14,000 rpm for 10 minutes at 4°C. The supernatant was transferred to fresh aliquots, 400 μL of 0.6% thiobarbituric acid was added, and the mixture was incubated for 60 minutes at 95-100°C. After cooling, the material was read in an ultraviolet spectrophotometer (SP-220, Biospectro, Brazil) at a wavelength of 532 nm at room temperature.

Assessment of explosive power of lower limbs

Horizontal standing broad jump (standing long jump) was used to assess the explosive power of lower limbs[16] with a 3-m tape measure (Master-43156, Tramontina, Brazil). The participant stood behind the starting line, with the feet together, and performed a countermovement jump forward as far as possible. The distance was measured from the take-off line to the point where the back of the heel nearest to the take-off line lands on the nonslippery floor. The participants performed three trials and the mean in meters was used for analysis.

Training description

The athletes were instructed to maintain their respective training routines previously defined by the team coach, which consisted of two phases: 1) vigorous activities (1st to 3rd week) and 2) light activities and total interruption of training (4th week).

In the first phase, athletes performed initial warm-up techniques (front kicks, side kicks, and roundhouse kicks) combined with running for 15 minutes. After the warm-up, 10 sprints were executed followed by kicks in rackets (2 to 3 kicks). Combinations of three or more kicks for attack and counterattack were then made in the thorax and head regions (20-30 minutes). The same techniques were reproduced in kick pad targets and kicking shields (specific taekwondo material) for 20-30 minutes, combined with 20-30-second intervals. At the end of the training, dynamic stretching exercises were performed for 20-25 minutes.

During the second phase, tapering was performed in which the duration and intensity of the training were gradually reduced. On the first day of training in this phase, the total duration was reduced to 30 minutes and training involved the application of specific fighting techniques, with reductions in speed and strength during the execution of the techniques. Over the next two days, no training was conducted (total interruption of training).

Statistical analysis

Data are expressed as median and first and third quartiles, except for age and height which are reported as mean and standard deviation. Pre- and post-measurements were compared by the Wilcoxon test. The percent difference (Δ) between time points was calculated by the formula: $\Delta = [(\text{Post} - \text{Pre}) \div \text{Pre}] \times 100$. Cohen's effect size (*d*) was calculated for the main variables of the study (physical, physiological and psychosocial states) and defined by the value of the statistical test using the Psychometrica software[17], considering d= 0.2 to 0.49 as a small effect, d= 0.5 to 0.79 as a moderate effect and $d \geq 0.8$ as a large effect[18]. The relationship between variables was verified using Spearman's correlation coefficient (*Rho*). All analyses were performed using the IBM SPSS Statistics® 18.0 software (IBM SPSS, Inc., USA), with 95% confidence ($P \leq 0.05$).

Results

The athletes had nine months of training in the season on the occasion of the first evaluation and were reevaluated after 30 days. The anthropometric characteristics and body composition of taekwondo athletes during a pre-competitive period are described in Table 1. Although no significant difference was observed in the anthropometric variables ($P > 0.05$), there was a large effect size of the pre-competitive period on body adiposity (absolute and relative).

Table 1. Anthropometric characteristics and body composition of taekwondo athletes during a pre-competitive period (n= 5)

Variable	Pre	Post	Δ (%)	*P*
Body mass (kg)	68.4 (61.1 - 76.2)	67.0 (61.0 - 76.5)	−1.76	0.813
Lean mass (kg)	59.8 (54.6 - 63.3)	58.9 (55.1 - 63.6)	−1.50	0.875
Absolute fat mass (kg)	8.6 (6.3 - 12.9)	8.1 (5.8 - 12.7)	−5.81	0.375
Relative fat mass (%)	13.0 (10.0 - 16.6)	12.2 (9.3 - 16.4)	−6.15	0.250

Legend: Data are expressed as median and 1st – 3rd quartiles. Pre, 30 days before the Brazilian Championship. Post, Two days before the Brazilian Championship. $\Delta = [(\text{Post} - \text{Pre}) \div \text{Pre}] \times 100$.
Source: The authors

The results of the physiological states are shown in Table 2. No significant difference was found in the physiological variables between time points ($P > 0.05$), although CK and MDA exerted a large effect, with increases greater than 22.0%.

Table 2. Markers of muscle damage, systemic inflammation and oxidative stress of taekwondo athletes during a pre-competitive period (n= 5)

Variable	Pre	Post	Δ (%)	*P*	*d*
Creatine kinase, CK (U/L)	468.5 (253.25 - 540.5)	348.0 (97 - 503.5)	−25.7	0.375	1.12
High-sensitivity C-reactive protein, hs-CRP (mg/L)	0.06 (0.01 - 0.17)	0.06 (0.06 - 0.06)	0.0	1.000	0.00
Malondialdehyde, MDA (μM)	2.20 (2.20 - 2.25)	2.70 (2.40 - 3.00)	22.7	0.125	2.56

Legend: Data are expressed as median and 1st – 3rd quartiles. Pre, 30 days before the Brazilian Championship. Post, Two days before the Brazilian Championship. $\Delta = [(\text{Post} - \text{Pre}) \div \text{Pre}] \times 100$. *d*, Cohen's effect size.
Source: The authors

Except for Tension and Anger, there was a large effect of the pre-competitive period on the other mood states (Table 3).

Table 3. Mood states of taekwondo athletes during a pre-competitive period (n= 5)

Variable	Pre	Post	Δ (%)	*P*	*d*
Tension	−4.0 (−4.0 - 1.0)	−4.0 (−6.0 - 1.0)	0.0	1.000	0.00
Depression	1.0 (0.0 - 1.5)	2.0 (0.0 - 11.0)	100.0	0.223	1.30
Anger	2.0 (0.50 - 6.5)	2.0 (0.0 - 13.0)	0.0	0.285	1.08
Vigor	25.0 (24.0 - 26.0)	24.0 (22.0 - 24.0)	4.0	0.066	2.90
Fatigue	2.0 (0.0 - 4.0)	1.0 (0.0 - 9.5)	−50.0	0.285	1.08
Confusion	−8.0 (−8.0 - −6.5)	−7.0 (−8.0 - 0.0)	−12.5	0.285	1.08
Total mood disturbance	69.0 (64.0 - 78.5)	68.0 (65.0 - 110.5)	−1.4	0.197	1.41

Legend: Data are expressed as median and 1st – 3rd quartiles. Pre, 30 days before the Brazilian Championship. Post, Two days before the Brazilian Championship. Δ= [(Post−Pre)÷Pre]×100. *d*, Cohen's effect size.
Source: The authors

Recovery-stress state scores are reported in Table 4. No significant differences were found in any of the self-reported recovery-stress states between the pre and post time points (*P*>0.05). However, the pre-competitive period exerted a large effect on Conflict/Pressure, Lack of energy, Physical complaints, General well-being, Being in shape, and Self-efficacy (Table 4).

Table 4. Recovery-stress state of taekwondo athletes during a pre-competitive period (n= 5)

Variable	Pre	Post	Δ (%)	*P*	*d*
General stress	1.50 (0.87 - 2.62)	2.50 (0.37 - 3.37)	66.7	0.688	0.50
Emotional stress	2.25 (0.75 - 2.87)	2.25 (1.12 - 3.50)	0.0	0.875	0.33
Social stress	1.00 (0.75 - 4.25)	2.00 (0.87 - 3.12)	100.0	1.000	0.10
Conflicts/Pressure	2.50 (2.25 - 3.50)	3.50 (2.12 - 4.12)	40.0	0.375	1.11
Fatigue	1.75 (1.25 - 3.12)	3.00 (1.12 - 3.37)	71.4	1.000	0.16
Lack of energy	1.75 (1.00 - 2.50)	2.00 (0.25 - 2.50)	14.3	0.500	0.95
Physical complaints	2.25 (1.12 - 3.37)	2.00 (0.87 - 2.75)	−11.1	0.250	1.32
Success	4.25 (3.00 - 5.12)	4.50 (3.00 - 5.00)	5.9	1.000	0.12
Social recovery	4.75 (3.87 - 5.00)	4.75 (3.75 - 5.50)	0.0	0.563	0.79
Physical recovery	3.50 (3.00 - 5.50)	3.75 (3.12 - 5.25)	7.1	1.000	0.00
General well-being	4.50 (3.50 - 5.00)	5.25 (3.00 - 5.75)	−5.6	0.813	2.20
Sleep quality	4.00 (2.75 - 4.50)	3.00 (2.50 - 5.00)	−25.0	1.000	0.24
Disturbed breaks	1.50 (1.12 - 2.62)	2.50 (0.87 - 3.25)	66.7	0.625	0.24
Emotional exhaustion	1.25 (0.37 - 2.25)	1.00 (0.50 - 2.12)	−20.0	1.000	0.34
Injury	2.00 (1.37 - 3.12)	2.50 (1.37 - 3.12)	25.0	0.938	0.24
Being in shape	4.25 (4.00 - 5.00)	4.50 (4.12 - 5.50)	5.9	0.125	3.16
Personal accomplishment	3.75 (3.12 - 4.62)	4.50 (3.50 - 4.62)	20.0	0.750	0.49
Self-efficacy	5.00 (3.37 - 5.12)	5.25 (4.12 - 5.87)	5.0	0.125	2.82
Self-regulation	4.75 (3.62 - 6.00)	5.00 (4.12 - 5.75)	5.3	0.875	0.33

Legend: Data are expressed as median and 1st – 3rd quartiles. Pre, 30 days before the Brazilian Championship. Post, Two days before the Brazilian Championship. Δ= [(Post−Pre)÷Pre]×100. *d*, Cohen's effect size.
Source: The authors

Explosive power of lower limbs increased by 9.05% (*P*= 0.043, *d*= 4.24) during the pre-competitive period (Figure 2).

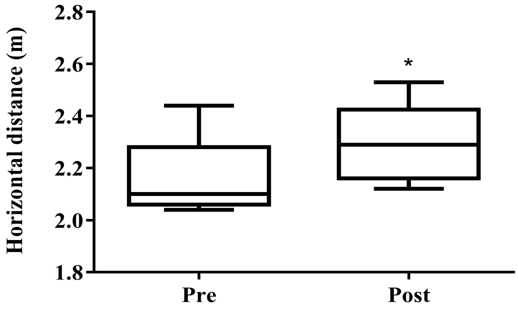

Figure 2. Explosive power of lower limbs of taekwondo athletes during a pre-competitive period (n= 5). Pre, 30 days before the Brazilian Championship. Post, Two days before the Brazilian Championship
Legend: *Significant difference between time points (*P*= 0.043, *d*= 4.24)
Source: The authors

Table 5 shows only the variables for which significant correlations ($P \leq 0.05$) were obtained. Moderate and strong correlations were observed between body adiposity and mood and recovery-stress components. Horizontal jump (explosive power) showed a strong correlation with the Vigor state. The physiological markers were not significantly correlated with any of the variables ($P > 0.05$).

Table 5. Spearman's correlation (*Rho*) among body adiposity, horizontal jump, mood state and recovery-stress state of taekwondo athletes during a pre-competitive period (n= 5)

	Vigor	Success	Emotional exhaustion	Being in shape	Self-efficacy
Relative fat mass (%)	0.583	−0.280	0.785*	−0.611	−0.355
Absolute fat mass (kg)	0.584	−0.303	0.800*	−0.638*	−0.405
Horizontal jump (m)	−0.815*	−0.128	−0.163	0.065	−0.049

Legend: *Significant correlation ($P \leq 0.05$).
Source: The authors

Discussion

The present study investigated the influence of the pre-competitive period (30 days) on anthropometric indicators, markers of muscle damage, systemic inflammation and oxidative stress, mood and recovery-stress states, and explosive power of lower limbs in taekwondo athletes. The main finding of the study points to a large effect of the pre-competitive period on physical, physiological and psychological variables of taekwondo athletes. Percent effects on body adiposity (−6.2% in BF%), muscle damage (−25.7% in CK), and oxidative activity (+22.7% in MDA) were verified. Although the Conflict/Pressure and Depression states increased by 40% and 100%, respectively, there was a positive effect on Fatigue (–50%). On the other hand, the explosive power of lower limbs increased by approximately 10%.

According to Batterham and Hopkins[19], percent effects are particularly appropriate for analyzing athletic performance. Improvement of physical performance in the week before a competition may be indicating success in reducing training intensity and volume during the last week of training. It is well established in the literature and in the sporting practice that physical and competitive performance is optimized mainly by a reduction in training workload prior to a competition (tapering period)[8]. Papacosta, Gleeson, and Nassis[20], who investigated judo athletes after one month of specific training in the modality, found that athletes also improved physical performance in vertical jump and handgrip strength, but maintained body fat after 2 weeks of intense training followed by 2 weeks of tapering.

The results of the present study have important theoretical and practical applications. Taekwondo trainers and coaches often use empirical knowledge, increasing training workloads in the final days before a competition, a fact that can lead to a decrease in the physical and competitive performance of the athletes. In general, this inadequate strategy is due to the need of combat athletes to maintain or reduce a certain body weight until the competition. In addition, there is a factual grievance for procedures to restrict food consumption, dehydration and improper medication use[9,21]. Thus, uncontrolled factors such as diet and the use of supplements and medications can modulate the responses of the variables investigated in the present study. Biochemical markers have been proposed as tools for reporting the physiological state of athletes. According to the theory of Smith, which is considered the most acceptable to explain overtraining, both physiological overreaching and overtraining are accompanied by the presence of muscle enzymes in the bloodstream, systemic inflammation, and oxidative stress[22]. For these reasons, we adopted some of these variables to verify the physiological behavior of the athletes during the period investigated.

If, on the one hand, a one-week taper may have favored improvement of physical performance, a percent decrease in CK was observed during the period studied. It is speculated that a longer tapering period may induce a greater reduction in this marker of muscle damage. Within this context, although there is evidence showing good results with a one-week taper[23,24], a larger number of studies demonstrated 2 weeks as the ideal[25-27]. CK has been shown to be a better marker of muscle damage[28]. Therefore, the reduction observed in this marker can be interpreted as a muscle damage-repair process promoted by the week of tapering and can contribute in an important approach to the physical performance in the competition. An increase of muscle damage in athletes who did not perform tapering before the competition has been demonstrated by Marin et al.[29] for 10 handball players evaluated before a competition and after 6 months of specific training. Likewise, Detanico et al.[30] found an increase of muscle damage in 20 judo athletes. However, the athletes were evaluated after sessions of simulated fights, a fact that only permitted to evaluate the acute physiological responses.

The increase in MDA indicated an increase in oxidative stress on the eve of competition, corroborating the view that a longer taper might be more adequate. Although the increase in training workloads on the eve of competition is cultural in fighting sports[31], a properly applied taper seems to be essential to avoid the deleterious effects induced by training. Two factors may have contributed to this. First, the culture of increasing training workloads too much in the weeks before the competition[4,9] and, second, the tapering period of only one week. In fact, high oxidative stress has been found in combat athletes[32,33]. These data should be pondered by the fact that MDA is a non-specific metabolite for the evaluation of oxidative stress[34], although it has been used in studies that evaluate this phenomenon[35,36]. Regarding hs-CRP, Garatachea et al.[37] reported a result similar to that obtained in the present study for eight kayak athletes during 42 weeks of training. After this period, the athletes no longer exhibited significant alterations in the systemic inflammatory process (CRP).

The tapering period was expected to reduce both CK and MDA. However, this period was only sufficient to reduce the former, but not the latter. This finding can be explained by the fact that, while CK is an indicator of muscle damage, representing only local inflammation according to the theory of overtraining[22], oxidative stress is the result of worsening of local and systemic inflammation. Thus, it is possible to infer that the period during which the athletes showed these modifications was sufficient to minimize muscle damage, but insufficient for complete systemic recovery.

Although physical and physiological factors are important for athletic success, psychological variables are also directly related to performance, especially in high-performance. In our study, the high percent increase in Conflict/Pressure and Depression scores supports a significant influence of competition; however, the reduction in fatigue may indicate that success is related to training planning. Increased psychosocial stress is one of the triggers of burnout syndrome in athletes[38] and should therefore be well managed by athletic trainers and coaches during competition preparation. A priori, psychometric tests allow to indirectly estimate the physiological state in relation to training workloads[10,12]. Since in the present study the athletes answered the POMS and RESTQ-Sport questionnaires at rest, the responses were not influenced by the training session. However, it should be considered that pre-competitive psychological stress may interfere with the responses because athletes generally deal with constant personal and external pressures for competitive outcomes[39].

Taekwondo athletes commonly have to cope with physical exhaustion because of the constant processes for rapid weight loss[3], which possibly cause an increase in psychological stress. This fact was evidenced especially by the strong relationships found between the anthropometric variables/body composition and the states of Emotional exhaustion/Being in shape. On the other hand, the reduction in the Vigor state seems to be related to the increase in lower limb explosive strength. This finding indicates that, despite the improvement in physical performance, the athletes did not achieve complete recovery with only one week of a taper, suggesting that the psychometric instruments converge to the physiological markers. Similar results have been reported by Chiodo et al.[10] who studied 16 taekwondo athletes during a competition. However, these athletes were evaluated only before and after a match.

During a pre-competitive period, it is essential that coaches and athletic trainers carefully evaluate the physical and physiological characteristics of athletes since these elements can directly influence competitive outcomes. Despite the need for an invasive procedure, measurement of the physiological variables examined in the present study is a direct and concise method of assessing the physiological state of athletes. Similarly, psychometric tests are important tools for detecting possible self-reported changes in physiological and psychosocial states, especially because they are practical, safe and financially accessible tools. In this respect, the variables analyzed in the present study were of high, medium or low cost and can therefore be adopted regardless of the technical-financial possibilities of the teams or athletes in taekwondo or other sports.

The main limitations of the study are related to the number of participants and the absence of cortisol measurement, which is an important marker of stress and recovery. However, the level of follow-up performed during this period, the competitive level of the athletes and the data analysis procedure have scientific merits and, most importantly, practical applications. Since competitive success depends on a balance among physical, physiological and psychosocial factors, we reinforce the importance of a multidisciplinary approach for the monitoring of taekwondo athletes, especially during pre-competitive periods, in order to improve not only the physical state but also physiological and psychosocial states.

Conclusions

Although a counterproductive behavior to athletic performance was observed, particularly regarding Conflict/Pressure and Depression states, athletes increased the explosive strength of lower limbs and maintained the expected physiological state for competition. One of the objectives of training is to improve the athlete’s physiological state, especially prior to important events, indicating that attention should be paid to the tapering process in combat athletes. The monitoring of nutritional and physiological status throughout the season is one suggestion for future investigations.

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Received on Sep, 07, 2016.
Reviewed on Jun, 03, 2017.
Accepted on Sep, 03, 2017.

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