

Salivary alpha-amylase, salivary cortisol, and anxiety during a youth taekwondo championship

An observational study

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Abstract

The aim of this study was to assess the stress-related responses and the coach's capability to match perceived efforts of youth athletes during a taekwondo championship.

Using a cross-sectional study design, salivary cortisol (sC) and alpha-amylase (sAA) were measured in 6 males and 3 females young (11.0 ± 0.9 years) athletes at awakening, 5 minutes before, and 1 minute and 30 minutes after official combats. State anxiety was recorded 60 minutes before the first competition, whereas coach's and athletes' ratings of perceived exertion (RPE) were obtained at the end of the combats. Time-matched (awakening and pre-competition) salivary samples and trait anxiety were collected 7-day postcompetition during a resting day.

No effect for match outcome emerged. No difference emerged between athletes and coach RPEs. Higher ($P = .03$) state anxiety (41.6 ± 10.9 points) was shown than trait anxiety (34.8 ± 7.1 points). Time-matched sAA were similar. Peak sAA observed at the end of the combat (114.2 ± 108.1 U/mL) was higher ($P < .01$) than the other samples (range: 20.6–48.1 U/mL), whereas sC increased ($P < .05$) from awakening (8.0 ± 1.5 nmol/L), with peak levels observed at 30 minutes into the recovery phase (19.3 ± 4.3 nmol/L). Furthermore, pre-competition sC (16.5 ± 4.5 nmol/L) values were higher ($P < .01$) with respect to time-matched samples during the resting day (4.6 ± 1.0 nmol/L). The 3 athletes engaged in consecutive matches showed a tendency toward increasing sAA and sC.

Taekwondo combats pose a high stress on young athletes, eliciting a fast reactivity of the sympathetic-adreno-medullary system relative to the hypothalamic-pituitary-adrenocortical system. Understanding the athlete's efforts during combats, coaches are recommended to apply effective recovery strategies between matches.

Abbreviations: ES = Effect sizes, HR = Heart rate, RPE = Ratings of perceived exertion, sAA = Alpha-amylase, sC = Salivary cortisol.

Keywords: combat sport, salivary hormones, stress, youth athletes

1. Introduction

Taekwondo is a combat sport included in the Summer Olympics and the Youth Olympic Games. In general, taekwondo athletes start competing around 10 years of age under rules differentiated in relation to their age, including additional protective garments, reduced duration of the matches (i.e., three 1-minute rounds with 1-minute rest in between), and limited scoring areas.^[1] Although

these rules intend to preserve children from an excessive strain, official taekwondo competitions proved to be a remarkable cardiovascular, hormonal, and psychological stressor for youth athletes,^[2,3] in line with acute effects reported for elite athletes.^[4,5]

The recent introduction of global youth competition has an increased emphasis on talent identification, often based on athletes achieving success at national competitions.^[6] Being a situational sport, success in taekwondo depends on a wide range of factors. Therefore, a multidisciplinary approach is needed to monitor the effects of youth competition regimens,^[7,8] especially in considering that qualifying taekwondo matches proved to elicit high psychophysiological responses in athletes.^[2,9,10] In particular, the psychophysiological profiles of taekwondo combats are considered crucial for success.^[11] Recently, official combat sports competitions have been considered a useful setting for the study of psychophysiological stress-related responses in youth judo^[12] and taekwondo athletes.^[2,3,9] In fact, competitions perceived as significant, with elements of uncontrollability and under conditions of social evaluation, may result in a high stress-related hormonal response, which is independent of physical load.^[13]

In taekwondo athletes, noninvasive evaluations of exercise stress-related responses have been investigated by means of increased levels of salivary cortisol (sC) and alpha-amylase (sAA), which respectively, mirror the activation of the hypothalamus-pituitary-adrenal and the sympathetic-adrenal-medullary axes.^[14,15] In

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particular, psychological arousal in anticipation of athletic competition could be evaluated only with respect to basal levels recorded on noncompetitive resting days.^[10,12] As sC^[16] and sAA^[17] awakening responses demonstrate high intraindividual stability, substantial increases in these parameters in the morning of the championship with respect to a control day could better isolate the psychophysiological responsiveness to competition pressures. Furthermore, to provide a better understanding of the actual stress-related load of official competitions, combined assessments of physiological [e.g., hormonal and heart rate (HR)] and psychological (e.g., cognitive anxiety, physiological arousal) responses, and athletic performance are necessary.^[2,3,12] Despite official combat sports competitions are organized during the same day with a variable time schedule (i.e., from 30 to 120 minutes) between qualifying, semi-final, and final phases, the experimental design of previous studies included measurements related to the first qualifying combat only.^[2,9,10,12] Conversely, no information is available on winners of the preliminary phases (e.g., qualifying and semi-final) progressing toward the final match. In particular, it has been speculated that successful youth athletes might experience a cumulative psychophysiological strain progressing through the championship, especially when combats are scheduled with a cadence <90 minutes.^[3,18]

Although the athletes undoubtedly experience heightened psychophysiological arousal during competition, the response can be mediated by the contest outcome and the coach. Given the relevant role of a coach in the quality of the youth athletes' experiences in sport,^[19] he/she should be able to evaluate the psychophysiological load of a competition. Actually, the match outcome might have significant implications not only on the stress hormonal responses^[20] but also on the athletes' experience, and the coach may play a role mediating the evaluation apprehension and sport anxiety in youth athletes.^[19,21] Therefore, a coach should be able to evaluate the psychophysiological load an athlete experiences during training and competition. Although the subjective rating of perceived exertion (RPE)^[22] has been used to summarize the psychological and physiological load experienced by youth taekwondo athletes during training,^[23,24] the high cognitive and technical and tactical demands that effectively interact with the opponents might reduce the athletes' perception of their efforts during combats.^[4,6,9] At present, no information is available on the coaches' capability to accurately identify the psychophysiological load of official youth matches, which is crucial to allow the implementation of proper strategies aimed to encourage sport commitment in this population.

Therefore, this study aimed to evaluate the hormonal (i.e., sC, sAA) and anxiety responses of young Taekwondo athletes during an official competition relative to a control resting day; investigate whether a relationship exists between sAA, sC, and RPE and anxiety scores before and after the combat; describe the hormonal responses of athletes engaged in multiple competitions on the same day; and evaluate the coach's capability to match RPEs of athletes after the combats. It has been hypothesized that youth athletes would experience a pre-competition arousal and cumulative stress-responses while progressing toward the final stages of the championship; and discrepancies between coaches' and athletes' perception of match load will occur.

2. Methods

2.1. Study design

The local Institutional Review Board approved the study with the athletes serving as their own control. To avoid confounding

effects due to the coach's level of education^[11] and differences in type, intensity, and frequency of training programs, a certified coach Master 6th DAN with a PhD in sport sciences and his youth taekwondo team competing at the National "Cadetti B" (10–12 years) Taekwondo Championship (i.e., matches consisting in three 1-minute rounds with 1-minute rest in between) participated in the study. Before the investigation, written informed consent from the children, their parents, and their coach was obtained.

To explore the relationship between psychological aspects of taekwondo competitions, 2 components of cognitive anxiety were investigated by means of the 20-item State-Trait Anxiety Inventories.^[25] Specifically, state anxiety mirrors a transitory emotional state characterized by subjective feelings of tension, whereas trait anxiety indicates a stable disposition to respond to stress with anxiety and a tendency to perceive a wider range of situations as threatening, respectively. Because no coach would allow researchers to interrupt his/her competition plan, to measure the athlete's temporary condition (i.e., state) of anxiety, the administration of the state anxiety inventory was planned approximately 60 minutes before their first match. To minimize potential confounding effects due to competition, the administration of the trait anxiety inventory was planned during a rest day 1 week after the championship and time-matched with respect to the collection of state anxiety. In considering that high and low scores mirror psychological stress and relaxation, respectively, variations between state and trait anxiety scores highlight the magnitude of anxiety experienced during the competition day.

The CR-10 RPE scale modified by Foster et al^[26] was used to investigate the athletes' and their coach's subjective perception of the efforts at the end of each match. Variations between the athletes' and coach's scores was considered mirroring a lack of correspondence of the coach's capability to accurately identify the psychophysiological distress experienced by youth athletes during combats.

The possible stress-related hormonal responses to the National "Cadetti B" Taekwondo Championship were examined by means of sAA and sC samplings, considering sAA mirroring fast stress responses of the sympathetic nervous system and sC the principal hormone of the hypothalamic-pituitary-adrenal axis, respectively.^[14] Salivary samples were collected awakening, 5 minutes before (pre-match) and 1 minute after (post-match) the competition, and at 30 minutes into the recovery phase with the athletes resting. In case winners of preliminary phases (e.g., qualifying, semi-final) had to perform a successive match scheduled with a 30-minute cadence, only pre-match samples for the subsequent competition were obtained. To consider the potential impact of psychological arousal in anticipation of athletic competition, time-matched samples awakening and before the first match were collected 7 days after the competition during a weekly resting day (Table 1). To avoid effects of the circadian rhythms on sC^[27] and sAA,^[28] only the first matches scheduled between 1000 and 1200 hours were examined. According to the literature,^[3,4] the potential impact of exercise intensity upon the stress-related responses was evaluated by means of HR recordings and expressed as a percentage of athletes HRpeak value observed during matches. In the present study, HRpeak values were considered only when yielded values similar to those reported in the literature for coaged children during exhaustive treadmill tests.^[29] Then, the frequency of occurrence (%) of HR >85% of individual HR peak was considered related to high-intensity activities.^[3]

Table 1**Fighting times (h:min) and competition phases (i.e., qualifying, semi-final, final) of the participants.**

| | Gender | Weight division, kg | Start time (h:min) | | |
|-----------|--------|---------------------|--------------------|------------|-------|
| | | | Qualifying | Semi-Final | Final |
| Athlete 1 | M | -38 | 10:01 | | |
| Athlete 2 | M | -59 | 10:05 | | |
| Athlete 3 | F | -45 | 10:08 | 10:33 | 11:22 |
| Athlete 4 | M | -38 | 10:10 | | |
| Athlete 5 | M | -38 | 10:15 | | |
| Athlete 6 | F | -33 | 10:25 | 10:47 | |
| Athlete 7 | M | -38 | 10:39 | | |
| Athlete 8 | M | -42 | 11:03 | 11:44 | 12:08 |
| Athlete 9 | F | -51 | 11:57 | | |

One week before the championship, participants were familiarized with the experimental procedures and any questions or ambiguities regarding the measures were resolved during individual interviews.

2.2. Subjects

Nine young (11.0 ± 0.9 years), blue belt taekwondo athletes ($M = 6$, $F = 3$) and their certified taekwondo coach volunteered for this study. They belonged to the same team and had at least 2 years of previous training experience of three 1.5-hour sessions/week. The female athletes competed in the -33 kg ($n = 1$), -45 kg ($n = 1$), and -51 kg ($n = 1$) weight divisions, whereas the male athletes competed in the -38 kg ($n = 4$), -42 kg ($n = 1$), and -59 kg ($n = 1$) divisions. A total of 14 matches were analyzed (air temperature $28 \pm 2^\circ\text{C}$, relative humidity $34 \pm 3\%$). In particular, 6 athletes engaged in 1 match only, 1 athlete in 2 matches, and 2 athletes in 3 matches (Table 1). At the end of the championship, data referred to 6 winners (qualifying: $n = 4$; semi-final: $n = 1$; final: $n = 1$) and 8 nonwinners (qualifying: $n = 6$; semi-final: $n = 2$). Because combats followed a ≤ 30 -minute time-schedule, collection of recovery values was possible only for the last match of each athlete.

2.3. Methodology

Saliva samples ($>0.05 \mu\text{L}$) were obtained by means of cotton swabs and saliva collecting tubes (Salivette, Sarstedt, Germany). The athletes were instructed to place the cotton swab into their mouths for 2 minutes and to chew 20 times, under the supervision of an investigator. The absence of blood contamination was checked with a salivary blood contamination kit (Salimetrics LLC, State College, PA). The saliva collecting tubes were centrifuged at 3000 rev/min for 15 minutes at 4°C . Samplings were stored at -80°C until they were assayed and tested in the same series and in duplicate to avoid any variations between tests. An enzyme immunoassay kit (Salimetrics, LLC, Carlsbad, CA) was used to measure salivary-free cortisol concentrations. A kinetic reaction assay kit (Salimetrics, LLC, Carlsbad, CA) was used for sAA measurements. Intra-assay coefficient of variation of $3.5 \pm 0.5\%$ and an inter-assay reproducibility of $5.08 \pm 1.33\%$ were accepted for sC, whereas intra-assay coefficient of variation and inter-assay reproducibility of $5.47 \pm 1.49\%$ and $4.7 \pm 0.15\%$, respectively, were accepted for sAA. A standard plate reader (PowerWave XS; Bio-Tech Instruments, Winooski, VT) was used for salivary determination by 450 and 405 nm filters for sC and sAA, respectively.

Regarding the psychometric self-reported instruments, for the state anxiety, athletes were requested to answer “how you feel right now,” whereas for the trait anxiety, athletes responded to “how you generally feel.” Furthermore, immediately after each match, the CR-10 RPE scale modified by Foster et al^[26] was administered to athletes and their coach. The questionnaires were completed individually under the supervision of an investigator, who ensured confidentiality and specified that there were no right or wrong responses.

A HR transmitter belt (Polar Team,^[2] Polar, Kempele, Finland) was placed on the athlete’s chest under the body armour before the match. Values over 1-second HR samplings were recorded during the match and stored in the belt for subsequent download onto a portable computer using the specific software (Polar Team^[2] software version 1.4.3; Polar, Kempele, Finland).

2.4. Statistical analysis

After selecting a 0.05 level of confidence, data were analyzed using the Statistical Package for the Social Science, version 23.0 (SPSS Inc., Chicago, IL). The Kolmogorov–Smirnov test (with Lilliefors correction) was used to verify normal distribution of the data. An analysis of variance was applied to sC, sAA, and RPE values. When significant differences emerged, post hoc Fisher protected least significant difference comparisons were used. The Cohen effect sizes (ES) were calculated for significant differences, considering $ES < 0.2$ trivial, from 0.2 to 0.6 small, from 0.61 to 1.2 moderate, and > 1.2 large. Pearson product-moment correlations (r) as well as coefficients of determination (R^2) were calculated to ascertain the relationships between hormonal values with respect to anxiety scores, RPE values, and time spent at $HR > 85\%$ of HR peak. *T*-tests were applied to the coach’ and athletes’ RPE scores, and to the athletes’ state and trait anxiety scores collected during the competitive and rest days, respectively.

3. Results

No effect emerged for match outcome. During the competition, athletes spent $85 \pm 11\%$ of combat time working at $HR > 85\%$ of HRpeak (203 ± 4 bpm). Exercise intensity $HR > 85\%$ of HRpeak showed low and nonsignificant correlations with respect to post- and pre-match delta hormonal values (sAA: $r = -0.15$; sC: $r = 0.04$). In general, efforts were scored around “somewhat hard” and “hard,” with no difference ($P = .42$) in RPEs between athletes (5.8 ± 1.4 points) and their coach (6.4 ± 1.8 points).

Figures 1 and 2 depict sAA and sC (mean \pm SEM) values recorded during the rest day, time-matched sampling of the

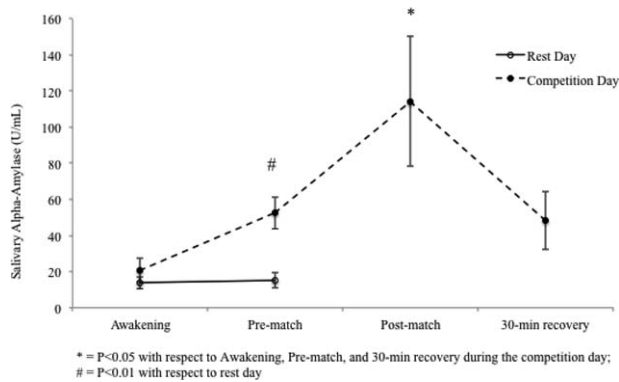


Figure 1. Salivary alpha-amylase values recorded during the rest day, time-match samples of the competition day, and post-match and recovery of the last combat.

competition day, and post-match and recovery of the last combat of the participants, respectively. Despite similar time-matched values at awakening, with respect to rest day, increases in pre-match sAA (50%, $P=.18$) and sC (258%, $P=.003$, $ES=1.21$) values were observed during the competition day. A main effect ($P=.001$, $ES=0.83$) emerged for sAA. Post hoc analysis established differences between peak sAA values recorded at the end of the combat (114.2 ± 36.0 U/mL) and the other samplings. On average, at the end of the competition, sAA increased 132% from pre-exercise. A main effect also emerged for sC ($P=.001$), with peak values (19.3 ± 4.3 mmol/L) registered at 30 minutes of the recovery phase. Post hoc analysis established differences (P ranging from .03 to .005, ES ranging from 0.84 to 1.14) between values at awakening and the other sC samplings, with 136%, 152%, and 196% increments for pre-match, post-match and 30-minute recovery values, respectively.

A tendency toward hormonal increases was observed (Figs. 3 and 4) in consecutive combats, especially evident in the athlete entering the final phase.

Higher ($P=.03$, $ES=0.74$) state anxiety (41.6 ± 10.9 points) scores were found with respect to trait anxiety (34.8 ± 7.1 points) ones. Athlete's RPEs showed low correlations (range = 0.35–0.43) with respect to peak hormonal values and time spent at $HR > 85\%$ of HR_{peak} . Similarly, low correlations (r range: 0.35–0.43) emerged between time spent at $HR > 85\%$ of HR_{peak} and peak hormonal values (sAA $r=-0.15$; sC $r=0.04$).

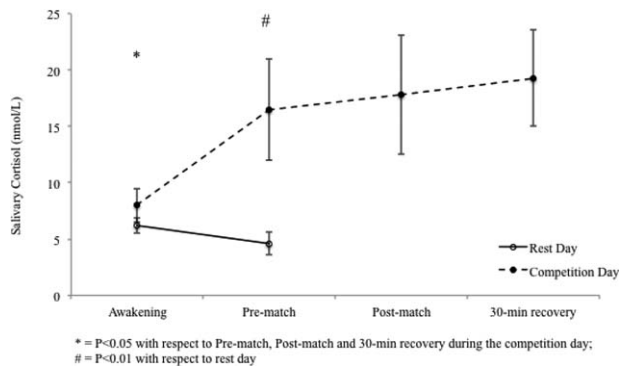


Figure 2. Salivary cortisol values recorded during the rest day, time-match samples of the competition day, and post-match and recovery of the last combat.

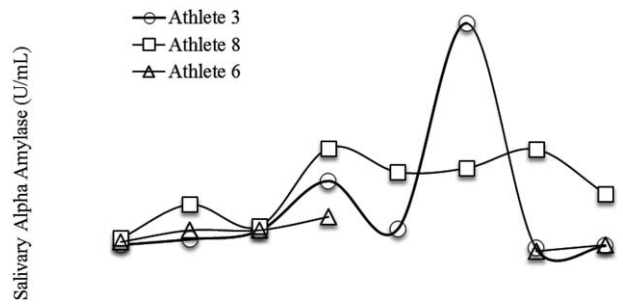


Figure 3. Salivary alpha-amylase values recorded during subsequent matches of the taekwondo championship. Two athletes engaged in 3 matches (Athlete 3=qualifying, semi-final and final phases; Athlete 8=qualifying 1, qualifying 2, and semi-final phases) and 1 athlete (Athlete 6) engaged in 2 matches (qualifying and semi-final phases).

Conversely, a significant correlation emerged for state anxiety scores with respect to peak sAA ($r=0.77$, $R^2=0.60$, $P=.02$) and sC ($r=0.75$, $R^2=0.56$, $P=.02$) values.

4. Discussion

The present study provides novel information on the psychophysiological responses to real-life youth taekwondo championship. The main findings substantiated a significant stress-related response to the youth competitions, which tended to increase in the athletes involved in multiple matches. Highlighting the important role of trait/state anxiety as well as of rest-day and awakening hormonal responses, the present findings complement and extend the current knowledge on stress-related psychophysiological aspects of youth taekwondo competitions. Moreover, the similarities between the athletes' and their coach's RPEs support the value of sport education for coaches,^[11] especially at youth level.^[8]

Under basal conditions, the youth taekwondo athletes exhibited the expected circadian rhythm of sC^[30] and sAA,^[28,31] with values in the range of that reported for healthy children.^[17] The observed increases in sC and sAA on the morning of the competition indicate an anticipation of the competition, also substantiated by higher state anxiety relative to trait anxiety. In the literature,^[12] pre-competition sC rise has been considered physiologically beneficial in judo athletes to provide energy availability in preparation for the combat. In this study, the lack of association between state anxiety and

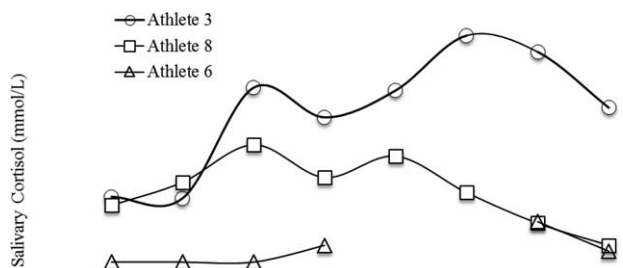


Figure 4. Salivary cortisol values recorded during subsequent matches of the taekwondo championship. Two athletes engaged in 3 matches (Athlete 3=qualifying, semi-final and final phases; Athlete 8=qualifying 1, qualifying 2, and semi-final phases) and 1 athlete (Athlete 6) engaged in 2 matches (qualifying and semi-final phases).

psychophysiological arousal could indicate that youth athletes perceived the demands of the taekwondo championship not exceeding their ability to effectively cope with it, in line with what has been reported for elite athletes.^[32]

The format of the youth match seems to replicate the intermittent nature of children's play, characterized by alternation of all-out activity bouts with short recoveries. Actually, the stringent time constraints of the match format (e.g., 3 three 1-minute rounds with a 1-minute rest in between) seem to induce 10-year-old children at their first experience in official competitions at National level to engage in sparring from the very beginning of the competition.^[33] The high frequency of occurrence of $HR > 85\%$ of HR_{peak} confirms that official taekwondo competitions request high efforts of youth^[2,3] and elite^[4,5] athletes, also similar to that reported from coaged children during exhaustive laboratory tests.^[29] It is well known that physical exercise induces relevant sAA^[34] and sC responses.^[15] During incremental aerobic tests, increases in sC levels corresponded to exercise intensity,^[35] whereas sAA showed no clear relationship with cardiovascular and RPE parameters.^[36] In this study, a low correlation between RPE and hormonal responses emerged, probably due to the short duration and high intensity of a taekwondo match. Furthermore, the significant relationship between peak hormonal responses and state anxiety might indicate that situational sports with high technical-tactical demands pose a concomitant psychophysiological strain. Because determining the exact nature of the relationship between exercise type and hormonal responses was beyond the aim of this investigation, further research is highly recommended. In agreement with the literature,^[2,37] distinct sAA and sC patterns emerged in the context of competition. Specifically, sAA showed a fast response with peak values at the end of fighting and a fast recovery, reflecting changes in sympathetic activity under a variety of stressful conditions,^[34] whereas sC increased from basal values and remained significantly elevated at 30 minutes of the recovery phase, leading to a catabolic-type circulating hormonal response.^[38] The physiological demands of official taekwondo competitions maximized the acute effects of combat on hormonal responses and suggest that sC and sAA can provide valuable information for coaches regarding athletes' responses to competition.

Discrepancies between near-maximal cardiovascular responses and subjective ratings of efforts were observed, similarly to reported findings on elite athletes.^[4] In fact, the children perceived match intensities corresponding to mid-point values of the CR-10 scale, comparable to those reported for coaged athletes during taekwondo training.^[24] These findings confirm the capability of youth athletes to cope with the official competition. Among the several psychological mediators influencing RPE, it is possible to speculate that the situational nature of this sport requires a high cognitive and technical-tactical focus, which modulates the effort sense of athletes. In the literature,^[39] a lack of correspondence between coaches and athletes in ratings of perceived efforts during training has been reported. Opposite to our hypothesis, the experienced coach was able to mirror the perception of his athletes. This indicates that the strict rules posed by the Italian Taekwondo Federation to control for quality of coaching^[1] enhances the coach's capability to provide effective recommendations for recovery subsequent to the competition.^[11]

Successful and less successful athletes devoted their best efforts during the competition and did not differ in terms of psychophysiological arousal. Actually, analyses of official youth

taekwondo indicated that match outcome heavily depends upon technical-tactical aspects of this sport.^[33,40] Although the present results do not contribute to the solution of the exact nature of the relationship between winning and losing a sport competition, they provide useful indications to evaluate several aspects of youth athletes at the beginning of their sport career. An inherent problem to studies performed in the unique situation of official championships is the limited number of participants and the impossibility to replicate findings.^[12] Furthermore, the high selective process toward the assignment of medals further decreases the participants entering the semi-finals and final phases of the competition, which hampers the aggregation of data for inferential statistical analyses. Despite only 3 athletes progressed from the qualifying phases, their responses to subsequent matches with a stringent cadence substantiate the speculation that youth successful taekwondo athletes experience cumulative fatigue during a tournament.^[3] In fact, from the first to the third match, they showed a tendency toward a progressive increase in hormonal levels and large inter-individual variations, in line with those reported for older athletes during a simulation competition.^[18] Actually, at the final stage of a taekwondo tournament, the selection process results in progressive demanding efforts needed to overcome the high technical and tactical levels of opponents. In fact, the only athlete who entered a final match showed a steep increase in sAA (Fig. 3). Therefore, the high exercise intensity and technical-tactical demands coupled with limited recovery between combats warrant cautions for youth athletes.

There are some limitations that should be critically discussed. First, the relatively small sample sizes may be problematic. Conversely, the inclusion of athletes belonging to different teams might increase the variability due to psychophysiological adaptations to different training regimens. Furthermore, the hectic atmosphere of official competition does not promote the cooperation of athletes, parents, and coaches. In line with the available data on elite^[4] and youth^[2] athletes, the representativeness of the findings might be debatable and further research is needed to substantiate the present results. Second, during official competitions, the sequential matches with variable time intervals in practice resulted in different match entry conditions. In particular, a match cadence ≤ 30 minutes did not allow a comprehensive collection of salivary samples during the recovery phase between competitions and might have affected the athlete's capability to achieve a complete recovery before the subsequent match.^[2,3] The present results urge the organizers of taekwondo championship to schedule youth matches with at least 90-minute cadences to allow athletes a full recovery from the high load of the previous combat.^[3] Third, the substantial variability due to different technical and tactical capabilities of opponents progressing from qualifying toward final matches might have determined potential confounding factors that affected psychophysiological responses of children involved in consecutive combats. Nonetheless, the high ecological and integrated noninvasive approach of this study, in addition to the unique chance to collect data during an official championship and a rest day, could provide a stimulus for further advancement of knowledge on sport performance and the behavior of youth athletes.^[2,3,37,41,42]

5. Conclusion

Participation in taekwondo championships elicits high stress-related hormonal and anxiety responses in youth athletes.

Therefore, there is a need of well-prepared and expert coaches capable to understand the youth athlete's responses to avoid a stressful experience resulting in disengagement from the sport. In considering the athlete's high-intensity efforts during combats, coaches are recommended to apply effective recovery strategies between matches in case the competition format presents a stringent time schedule. Providing information on the stress-related responses elicited by official taekwondo competitions in young athletes at the beginning of their sport academy, this study strongly encourages organizers of taekwondo championships to appropriately set a match schedule with an adequate rest between matches.

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