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Comment 1
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General comment (originality, scientific accuracy, strengths and/or weaknesses): General Comments:
The authors should be commended for conducting a quality and practical study. The over flow and writing is high quality throughout the manuscript. In my opinion the manuscript is suitable for publication once a few minor revisions are addressed.

Major corrections (main criticisms): I have only minor revisions for the manuscript.
Minor corrections (page, paragraph, line where the author must make the corrections): Introduction

The introduction leads to a clear purpose of the study and is well written.

Methods
Page 6, Line 87: Please check the effect size reference (23) for Cohen as the effect size listed appear s to be from Hopkins.
Hopkins, W. G. (2006). Spreadsheets for analysis of controlled trials, with adjustment for a subject characteristic. Sportscience, 10, 46–50.
Answer: according to the reviewer's comment, we rephrased the entire period, citing the suggested reference (and adding it into the final reference list). Therefore, this part of the paper has been rephrased as follows:
"For all significant findings, effect sizes were determined with values (negative or positive) of.2, .6, 1.2, and >1.2 indicating trivial, small, moderate, and large effect sizes, respectively.[23]"

Results
Page 7, Line 18: Although no significant difference for gender I would suggest reporting a 'p value'.
Answer: the requested information has been implemented in the "Results" section ("*Because no statistically significant difference emerged for gender (Edwards, p = .50; session RPE-1, p = .70; session RPE-30, p = .42), the data were pooled.*").

Page 7, Line 67: Classify what is considered high and moderate in the 'Statistical Analysis' for the correlation coefficient and provide a reference.
Answer: according to the reviewer's request, we rephrased "moderate" into "less elevated", considering that only a sentence reported this expression ("*However, a high relationship between the two methods was reported only for PC at 30min (Figure 4), whereas the other ones resulted less elevated (Table I)*)". However, in the "Statistical Analysis" section, we specified the meaning and the threshold related to the term "high" (correlation), even citing the reference of an adjacent study (*"In particular, coherently to previous studies on session-RPE related to situational sports[24], high correlations were identified with r ≥ .7."*).

Discussion
Overall the authors do an excellent job driving home the main take home points of the study and the practical impact of the results.

Page 10, Line 28: I would suggest omitting the word 'guarantee' in replace of additional wording that has a softer tone.
Answer: according to the reviewer's suggestion, we rephrased the mentioned word as follows: *"To favor ecological conditions, in this study …"*

References
There are several references that are not consistent throughout (i.e., reference 8,10,28)
Answer: we agree with the reviewer and we deleted the references 8 and 28. However, we maintained the reference 10 because it is pertinent to the experimental design of our study, being focused on session-RPE of youth taekwondo athletes, and, in particular, with the RPE evaluation at the end of the training sessions.

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Comments 2
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General comment (originality, scientific accuracy, strengths and/or weaknesses): This is a well prepared and interesting study. The information reported in this study would attract the attention in the relevant field. It would be better if the authors can do a more clear figures in this paper.
Answer: thanking the reviewer for his/her comment, we made clearer the figures of the paper, reprinting the figure from JPG (and not from WORD) to PDF format, and thus making clearer the titles of axes.

Major corrections (main criticisms): Here are some points to suggest to the authors to revise the paper:
1. In Abstract you said "Although all training typologies and data collections achieved significantcorrelations between Edwards' and session-RPE methods, a large relationship (r = .71, P < .001)emerged only for PC sessions evaluated at 30 minutes of the recovery phases.", however there are no explanation in results part.
Answer: we thank the reviewer for his/her suggestion, reporting the abstract period also in the "Results" section. However, the explanation of these effects were reported in the "Discussion" section ("*Although the ITL of PC resulted lower than that of C according to Edwards' as well as RPE and session-RPE (both at RPE-1 and RPE-30) values, it could be speculated that the first type of taekwondo training could be more appropriate in relation to the pre-pubescent ability to perform combats and to adapt to training load. In fact, according to previous studies, the elevated focus on the opponents' actions11,15 or the high intermittent intensity occurring during youth taekwondo trainings,8,9 mainly characterizing C training, can crucially alter the session-RPE reliability similarly to other open skill sports.24,25,27 Nevertheless, in our study, the satisfactory relationships with respect to the Edwards' method emerged both for C and PC suggest that the opponents' actions and the high intermittent intensity weakly influenced the validity of the session-RPE method, inferring that session-RPE can be effectively used in both types of training.*").

2. If the authors can do a more clear figures of different relationship in this paper. Maybe, the figures is better than tables for relationships.
Answer: actually, we reported only figure 4 about the relationships between the Edwards and session-RPE values of PC at RPE-30 because it is the most effective conditions for the reliability of RPE method related to the youth taekwondo athletes. In addition, we used table 1 to summarize all results of this study (i.e., correlation coefficients, confidence intervals, and coefficients of determination between Edwards's HR and session-RPE values, which were reported for all individual training sessions, and pre-competitive and competitive athletes, in relation to the RPE data collection at the end of the training session and 30 minutes of the recovery phase), supporting any specific reference for the comprehension of the reader on the session-RPE reliability.

Minor corrections (page, paragraph, line where the author must make the corrections): Here are some points to suggest to the authors to revise the paper:

1. In Abstract you said “Although all training typologies and data collections achieved significantcorrelations between Edwards’ and session-RPE methods, a large relationship (r = .71, P < .001)emerged only for PC sessions evaluated at 30 minutes of the recovery phases.”, however there are no explanation in results part.
2. If the authors can do a more clear figures of different ralationship in this paper. Maybe, the figues is better than tables for relationships.
Answer: the major and minor corrections have been reported in the previous answers of the first section of the revision.

Session-RPE for quantifying load of different youth taekwondo training sessions.

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Congress data. – No congress data were provided for the present study

Funding. – No grant support was provided for the present study.

Conflict of interest. – The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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Abstract

BACKGROUND: The session rating of perceived exertion (session-RPE) proved to be a valuable method to quantify the internal training load (ITL) in taekwondo. However, no study validated this method in youth taekwondo athletes performing different training sessions. Thus this study aimed at evaluating the reliability of the session-RPE to monitor the ITL of prepubescent taekwondo athletes during pre-competitive (PC) and competitive (C) training sessions. METHODS: Five female (age: 12.0 ± 0.7 y; height: 1.54 ± 0.08 m; body mass: 48.8 ± 7.3 kg) and four male (age: 12.0 ± 0.8 yrs; height: 1.55 ± 0.07 m; body mass: 47.3 ± 5.3 kg) taekwondo athletes were monitored during 100 individual sessions (PC: n = 33; C: n = 67). The Edwards' HR method was used as reference measure of ITL; the CR-10 RPE scale was administered at 1- and 30-minutes from the end of each session. RESULTS: No difference for gender emerged. The ITLs of C (Edwards: 228 ± 40 arbitrary units, AU) resulted higher than that of PC (192 ± 26 AU; $P = .04$). Although all training typologies and data collections achieved significant correlations between Edwards' and session-RPE methods, a large relationship ($r = .71$, $P < .001$) emerged only for PC sessions evaluated at 30 minutes of the recovery phases. CONCLUSION: Findings support coaches of prepubescent taekwondo athletes to successfully use session-RPE to monitor the ITL of different training typologies. However, PC training evaluated at 30 minutes of the recovery phase represents the best condition for a highly reliable ITL perception.

Key Words: rating of perceived exertion, heart rate, internal training load, situational sports, training monitoring.

Introduction

Olympic taekwondo is a combat sport officially included in the Youth Olympic Games[1]. In considering that youth taekwondo athletes start training and competing around 10 years of age, coaches are urged to structure sound training sessions aimed to assist them in acquiring and mastering technical-tactical skills, meantime avoiding potential risks due to a skill level not fully developed prior to exposing them to competitions.[2-7] In this respect, training monitoring is a precious tool to inform coaches on the internal load (ITL) of youth taekwondo training sessions.[8,10]

Based on the relationship between heart rate (HR) and maximal oxygen consumption, several methods have been proposed to assist coaches in systematically monitoring ITL. In considering that HR monitoring presents some limitations during combats, subjective ratings of perceived exertion (RPE) have been used to evaluate the training load posed on taekwondo athletes during training[8-10] and competition.[11] In fact, RPE category-ratio scale[12] summarizes the psychological and physiological load experienced by athletes, is inexpensive, could be easily administered, and could assist coaches in monitoring the ITL of their training plan when taking into account also the total duration of the training sessions (i.e., session-RPE).[13,14] In particular, session-RPE has been promoted as a valuable tool to quantify the ITL of both elite[11,15,16] and youth[8-10] taekwondo athletes. Actually, intensity of taekwondo competition ascertained by means of RPE tends to be lower with respect to that calculated by means of HR-based methods,[17,18] which might not fully represent the effects of variations in period of efforts and rest in intermittent taekwondo activities.[16] In fact, the high cognitive and technical and tactical demands to effectively interact with the opponents might reduce the athletes' perception of their efforts.[11] Conversely, in taekwondo trainings, the athletes' RPE tends to correspond to their HR responses.[15,16] This discrepancy could be due to different conditions between the closed-skill-specific taekwondo circuit training and the open-skill of fighting, which requires high levels of attentional focus on the opponent's actions.[15]

Investigating the relationship between session-RPE and HR-based methods in youth male taekwondo athletes (ranging in age from 10 to 18 yrs of age) during training sessions, Haddad and

colleagues[8-10] reported low (*r* range = .14 - .20) to large (*r* range = .55 - .90) correlation values. In particular, lower values emerged when RPE responses were collected at the end of the training session[9] with respect to those recoded at 30 minutes of the recovery phase.[8-10] Because these discrepancies could be ascribed also to the different training settings and age of the youth taekwondo athletes, a further study should clarify the effect of different data collection methods.

In the literature, the intensity of training sessions administered to youth male taekwondo athletes[8-10] resulted lower than that observed during official competitions.[19-20] Actually, taekwondo coaches differentiate the objectives of their training sessions with a focus on conditioning and development of fundamental technical skills (i.e., pre-competitive training, PC) or on technical and tactical skills to simulate combats (i.e., competitive training, C) of youth athletes. Furthermore, controversial results regarding combat intensities between male and female athletes emerged,[19-20] despite coaches tend to simultaneously train female and male taekwondo athletes. Therefore, it could be possible to hypothesize that gender-related athletic capability influences differently the ITL of taekwondo athletes. Unfortunately, no information is available regarding the relationship between session-RPE and HR responses with respect to the different training typology and gender-related differences.

Thus, taking into account the gender of athletes, the present study aimed to assess: 1) differences in ITL (i.e., session-RPE and Edwards' HR based method) between PC and C youth taekwondo training sessions; and 2) differences in the relationship between session-RPE and Edwards' HR based method with respect to the training typology (i.e., PC and C) and RPE data collection timing (i.e., at the end of the training session, RPE-1; and at 30 minutes of the recovery phase, RPE-30). It has been hypothesized that: i) gender would affect the ITL of youth athletes; ii) highest ITL values would emerge for C with respect to PC; iii) highest correlation values between session-RPE and Edwards' HR-based methods would emerge for PC with respect to C, and for the RPE-30 with respect to RPE-1.

Material and Methods

Design

According to the literature,[8-10,16] the Edwards' HR method[18] was used as reference criterion to test the validity of the session-RPE to quantify ITL in male and female youth taekwondo athletes during PC and C training sessions. In particular, the Edwards' HR method determines individual ITL by expressing the athletes' HR responses as percentages of their estimated maximal HR (i.e., HRmax; 220 – age), multiplying the accumulated time (i.e., minutes) in five HR zones of individual HRmax (i.e., 50–60% = 1; 60–70% = 2; 70–80% = 3; 80–90% = 4; 90–100% = 5), and summating the scores.

The Italian translation of the CR-10 scale[12] modified by Foster et al.[13,14] was used to assess the youth taekwondo athletes' RPE. The CR-10 RPE scale is a category-ratio scale characterized by scores and verbal links (i.e., from "rest" to "maximal"), referring to the athlete's perception of efforts into a numerical score between 0 (i.e., rest) and 10 (i.e., maximal). Although Foster and colleagues[13] recommended to administer the RPE-30 to assess the ITL of the entire training session, in youth male taekwondo athletes' RPE has been collected both at RPE-1[9] and RPE-30.[8,10] Therefore, to assess differences in session-RPE, if any, due to different data collections, in the present study both RPE-1 and RPE-30 scales were administered.

A total of 17 (100 individual) training sessions of the pre-season period were monitored (i.e., 2 months before the beginning of the *Italian Youth National Championships*). To favor ecological conditions, in this study no attempt was made to manipulate the training sessions, which included different combinations of technical and tactical skills, conditioning bouts, and simulated combats to meet the coach's PC (i.e., sport-specific skills) and C (i.e., combat skills) purposes of training.

Subjects

The institutional review board approved this study and an informed consent has been obtained from five females (age: 12.0 ± 0.7 y; height: 1.54 ± 0.08 m; body mass: 48.8 ± 7.3 kg) and four male (age: 12.0 ± 0.8 yrs; stature: 1.55 ± 0.07 m; body mass: 47.3 ± 5.3 kg) pre-adolescent taekwondo athletes, their coach, and parents, who declared the maturity stage of their sons (i.e., presence of

pubic hairs) and daughters (i.e., before the first menstruation). According to the rules of the Italian Taekwondo Federation,[21] the youth athletes were color belts, corresponding to 2-year (i.e., yellow) and 3-year (i.e., red) taekwondo experience ranging from 3 to 5·week^{-1} 90-minute training sessions.

Measures

Two weeks prior to the experimental sessions, the athletes were familiarized with the CR-10 scale. Before the training session, a HR transmitter belt (Team System, Polar, Kempele, Finland) was placed on the athlete's chest to record his/her HR responses every 1-second. Data were downloaded onto a computer using a specific software (Polar Precision software version 4, Kempele, Finland) to calculate the ITL according to the Edwards' method. Individual RPE-1 and RPE-30 scores were recorded and multiplied by the duration (minutes) of the training to quantify the ITL according to the session-RPE method.[13]

Statistical Analysis

Data are presented as mean values and standard deviations. The statistical analyses were performed by means of the SPSS package (version 21.0) with a $P < .05$ alpha level of significance. Before the study, the Kolmogorov test was applied to test the normal distribution of the data. When no difference between the Edwards' TL and RPEs of male and female emerged, the data were pooled. An analysis of variance (ANOVA) for repeated measures ascertained differences between standardized data of HR classes related to C and PC trainings. A one-way ANOVA was applied to duration, Edwards' TLs, RPE, and session-RPE (according to RPE-1 and RPE-30) data related to PC and C trainings. To provide meaningful analysis for significant comparisons from small groups, Cohen's effect sizes (ESs) were also calculated[22] for significant differences. For all significant findings, effect sizes were determined with values (negative or positive) of .2, .6, 1.2, and >1.2 indicating trivial, small, moderate, and large effect sizes, respectively.[23]

The relationships between Edwards' TL and session-RPE were estimated using the Pearson's product-moment correlation (i.e., r) as well as the coefficient of determination (i.e., R^2), in relation to type of training and different RPE data collections. In particular, coherently to

previous studies on session-RPE related to situational sports,[24] high correlations were identified with r ≥ .7. Furthermore, the 95% confidence intervals (95% C.I.) for the correlation coefficients were calculated.

Results

Because no statistically significant difference emerged for gender (Edwards, p = .50; session RPE-1, p = .70; session RPE-30, p = .42), the data were pooled. Therefore, the 100 individual youth taekwondo training sessions were analyzed only in relation to the training typology (PC = 33 sessions; range for individual athlete = 3-5 sessions; C = 67 sessions, range for individual athlete = 3-11 sessions).

Although no difference emerged for the HR classes (Figure 1) and duration of PC (1:13:58±0:05:26 h:min:s) and C (1:14:27±0:0:40 h:min:s), a main effect was found for Edwards' TL (Figure 2). In particular, higher values for C (228 ± 40 arbitrary units, AU) with respect to PC (192 ± 26 AU; p = .04, ES = .5) were observed. In addition, differences between training types emerged for session-RPE (1min: p < .01 , ES = .7; 30min: p = .029, ES = .5; Figure 2) with higher RPE values reported for C with respect to PC (1min: p < .01, ES =.7; 30min: p = .041, ES =.4; Figure 3).

Figure 1, 2, and 3 close to here

All training typologies and data collections achieved significant correlations between Edwards' and session-RPE methods. However, a large relationship (r = .71, P < .001) emerged only for PC sessions evaluated at 30 minutes of the recovery phases (Figure 4), whereas the other ones resulted less elevated (Table 1).

Figure 4, and Table 1 close to here

Discussion

The regular monitoring of young athletes' ITL resulted crucial to better plan training, and avoid unbalanced physiological stress potentially determining risks of an early specialization,[5] overreaching syndrome and burnout.[3] To our knowledge, this is the first study that has considered the validity of the Foster's RPE-based approach[13] to quantify the ITLs in male and female youth taekwondo athletes, during C and PC training sessions, as well as both with the RPE-1 and RPE-30 evaluations. In particular, this rationale arises from the fact that taekwondo coaches of youth athletes focus the objectives of their training sessions on fundamental technical skills (i.e., PC) or technical and tactical aspects of combats (i.e., C).

Although this is the first study highlighting divergences between female and male youth taekwondo athletes in terms of session-RPE, the absence of any gender-related effect related to ITL values constrained to pool data and reject the first hypothesis. Therefore, results are in line to previous studies on the distribution of heart rate[19] and technical and tactical aspects[25] of young female and male taekwondo athletes.

On the other hand, the second hypothesis can be fully accepted because higher Edwards' TL emerged in C than PC. Although no difference emerged between the two types of training in terms of duration and single HR classes of intensity, the higher Edwards' C loads could be attributed to the absolute longer phases of sessions performed at the maximal (i.e., 91-100%HRmax) and high (i.e., 81-90%HRmax) classes of intensity (Edwards, 1993; Figure 2), which represent a coherent exercise scenario with respect to that of the adolescent taekwondo training.[10] In fact, according to previous studies on taekwondo,[9,15,16,19,20] the regular repetition of technical executions in simulated combat situations (i.e., highly represented in C) could determine the presence of a relevant portion of performance at high intensity, mainly referring to the anaerobic energy system. In addition, for C, the two most occurring portions of training were reported in not consecutive intensity categories (i.e., 61-70 %HRmax and 81-90 %HRmax), thus suggesting that this typology of training can be

fully recognized as a high intermittent exercise and could confirm the typical aspects of the elite[11,15,16,20] and youth[8-10,20] taekwondo performance.

The distribution of HR in PC training showed a different performance scenario where the highest duration of training are reported in the moderate and low intensity classes of intensity (i.e., 61-70 %HRmax and 71-80 %HRmax), which are principally related to the aerobic energy system. In line to this interpretation, data reported in previous studies on male youth taekwondo athletes showed that low session-RPE reliability emerged for the anaerobic[8] and high intermittent intensity[9] training sessions, whereas the opposite tendency emerged in correspondence of aerobic energy system.[8] In particular, the low intensity reported for PC could be determined by the main purpose of teaching techniques, which is usually characterized by individual executions and trainer explanations, which, differently from the pressure performed by opponent, tend to limit any HR increasing.[26]

Finally, the third hypothesis can be fully accepted because the relationship between session-RPE and Edwards' method reported higher values in PC with respect to C, and in the RPE-30 than RPE-1. In particular, although a general session-RPE reliability emerged, resulting in line[10,16] or higher[8,9] with respect to values reported in previous studies focused on session-RPE in taekwondo training, only PC sessions evaluated at RPE-30 showed a large correlation between the two adopted procedures. Therefore, according to the considered measurement of reference (i.e., the Edwards' method), it could represent the best condition to quantify the youth taekwondo athletes' ITL by means of the session-RPE method.

Although the ITL of PC resulted lower than that of C according to Edwards' as well as RPE and session-RPE (both at RPE-1 and RPE-30) values, it could be speculated that the first type of taekwondo training could be more appropriate in relation to the pre-pubescent ability to perform combats and to adapt to training load. In fact, according to previous studies, the elevated focus on the opponents' actions[11,15] or the high intermittent intensity occurring during youth taekwondo trainings,[8,9] mainly characterizing C training, can crucially alter the session-RPE reliability

similarly to other open skill sports.[24,25,27] Nevertheless, in our study, the satisfactory relationships with respect to the Edwards' method emerged both for C and PC suggest that the opponents' actions and the high intermittent intensity weakly influenced the validity of the session-RPE method, inferring that session-RPE can be effectively used in both types of training.

In addition, regarding RPE data collection, the lower session-RPE reliability emerged for the RPE-1 in both PC and C typologies (Table 1) corroborate the high validity of the RPE-30 to guarantee an ITL perception on the entire session.[13,14] Therefore, these results confirm previous studies on taekwondo, which reported high[8,10,15,16] and reduced[9] session-RPE reliability for RPE-30 and RPE-1 evaluations, respectively.

Conclusions

This study showed the effectiveness of the session-RPE to evaluate the ITL of PC (large) and C (not large) pre-pubescent taekwondo training. Therefore, taekwondo coaches could benefit by the use of this method, being very practical to monitor youth ITL and to avoid the necessity of expensive tools (i.e. telemetric HR systems, lactate analyzers). In addition, monitoring the ITL in pre-pubescent athletes is also crucial to plan future appropriate training proposes, which regularly tend to limit the occurrence of injuries, monotony, strain, overreaching conditions, and burnout. In particular, the results of the present study contributed to improve the coaches' awareness on the importance to monitor youth taekwondo training. Although PC sessions resulted more objectively perceived by pre-pubescent taekwondo athletes than C ones, both training typologies could be effectively perceived by this age category regardless of gender. In addition, RPE could be used also at the end of the training session, even though more reliable evaluations on the ITL of the entire session can be obtained at RPE-30. Therefore, coaches of prepubescent taekwondo athletes have the opportunity to propose and effectively monitor a high range of practices, which range from the development of fundamental technical skills to the technical and tactical skills to simulate competitive combats.

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Titles of tables and figures

Figure 1. Distribution of frequency, and effects ($p \leq .05$) of the heart rate data of pre-competitive (PC) and competitive (C) training sessions, in relation to classes of intensity. Abbreviations: HR_{max} indicates maximal heart rate.

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Session-RPE for quantifying load of different youth taekwondo training sessions.

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Abstract

BACKGROUND: The session rating of perceived exertion (session-RPE) proved to be a valuable method to quantify the internal training load (ITL) in taekwondo. However, no study validated this method in youth taekwondo athletes performing different training sessions. Thus this study aimed at evaluating the reliability of the session-RPE to monitor the ITL of prepubescent taekwondo athletes during pre-competitive (PC) and competitive (C) training sessions. METHODS: Five female (age: 12.0 ± 0.7 y; height: 1.54 ± 0.08 m; body mass: 48.8 ± 7.3 kg) and four male (age: 12.0 ± 0.8 yrs; height: 1.55 ± 0.07 m; body mass: 47.3 ± 5.3 kg) taekwondo athletes were monitored during 100 individual sessions (PC: n = 33; C: n = 67). The Edwards' HR method was used as reference measure of ITL; the CR-10 RPE scale was administered at 1- and 30-minutes from the end of each session. RESULTS: No difference for gender emerged. The ITLs of C (Edwards: 228 ± 40 arbitrary units, AU) resulted higher than that of PC (192 ± 26 AU; $P = .04$). Although all training typologies and data collections achieved significant correlations between Edwards' and session-RPE methods, a large relationship ($r = .71$, $P < .001$) emerged only for PC sessions evaluated at 30 minutes of the recovery phases. CONCLUSION: Findings support coaches of prepubescent taekwondo athletes to successfully use session-RPE to monitor the ITL of different training typologies. However, PC training evaluated at 30 minutes of the recovery phase represents the best condition for a highly reliable ITL perception.

Key Words: rating of perceived exertion, heart rate, internal training load, situational sports, training monitoring.

Introduction

Olympic taekwondo is a combat sport officially included in the Youth Olympic Games[1]. In considering that youth taekwondo athletes start training and competing around 10 years of age, coaches are urged to structure sound training sessions aimed to assist them in acquiring and mastering technical-tactical skills, meantime avoiding potential risks due to a skill level not fully developed prior to exposing them to competitions.[2-7] In this respect, training monitoring is a precious tool to inform coaches on the internal load (ITL) of youth taekwondo training sessions.[8,10]

Based on the relationship between heart rate (HR) and maximal oxygen consumption, several methods have been proposed to assist coaches in systematically monitoring ITL. In considering that HR monitoring presents some limitations during combats, subjective ratings of perceived exertion (RPE) have been used to evaluate the training load posed on taekwondo athletes during training[8-10] and competition.[11] In fact, RPE category-ratio scale[12] summarizes the psychological and physiological load experienced by athletes, is inexpensive, could be easily administered, and could assist coaches in monitoring the ITL of their training plan when taking into account also the total duration of the training sessions (i.e., session-RPE).[13,14] In particular, session-RPE has been promoted as a valuable tool to quantify the ITL of both elite[11,15,16] and youth[8-10] taekwondo athletes. Actually, intensity of taekwondo competition ascertained by means of RPE tends to be lower with respect to that calculated by means of HR-based methods,[17,18] which might not fully represent the effects of variations in period of efforts and rest in intermittent taekwondo activities.[16] In fact, the high cognitive and technical and tactical demands to effectively interact with the opponents might reduce the athletes' perception of their efforts.[11] Conversely, in taekwondo trainings, the athletes' RPE tends to correspond to their HR responses.[15,16] This discrepancy could be due to different conditions between the closed-skill-specific taekwondo circuit training and the open-skill of fighting, which requires high levels of attentional focus on the opponent's actions.[15]

Investigating the relationship between session-RPE and HR-based methods in youth male taekwondo athletes (ranging in age from 10 to 18 yrs of age) during training sessions, Haddad and

colleagues[8-10] reported low (*r* range = .14 - .20) to large (*r* range = .55 - .90) correlation values. In particular, lower values emerged when RPE responses were collected at the end of the training session[9] with respect to those recoded at 30 minutes of the recovery phase.[8-10] Because these discrepancies could be ascribed also to the different training settings and age of the youth taekwondo athletes, a further study should clarify the effect of different data collection methods.

In the literature, the intensity of training sessions administered to youth male taekwondo athletes[8-10] resulted lower than that observed during official competitions.[19-20] Actually, taekwondo coaches differentiate the objectives of their training sessions with a focus on conditioning and development of fundamental technical skills (i.e., pre-competitive training, PC) or on technical and tactical skills to simulate combats (i.e., competitive training, C) of youth athletes. Furthermore, controversial results regarding combat intensities between male and female athletes emerged,[19-20] despite coaches tend to simultaneously train female and male taekwondo athletes. Therefore, it could be possible to hypothesize that gender-related athletic capability influences differently the ITL of taekwondo athletes. Unfortunately, no information is available regarding the relationship between session-RPE and HR responses with respect to the different training typology and gender-related differences.

Thus, taking into account the gender of athletes, the present study aimed to assess: 1) differences in ITL (i.e., session-RPE and Edwards' HR based method) between PC and C youth taekwondo training sessions; and 2) differences in the relationship between session-RPE and Edwards' HR based method with respect to the training typology (i.e., PC and C) and RPE data collection timing (i.e., at the end of the training session, RPE-1; and at 30 minutes of the recovery phase, RPE-30). It has been hypothesized that: i) gender would affect the ITL of youth athletes; ii) highest ITL values would emerge for C with respect to PC; iii) highest correlation values between session-RPE and Edwards' HR-based methods would emerge for PC with respect to C, and for the RPE-30 with respect to RPE-1.

Material and Methods

Design

According to the literature,[8-10,16] the Edwards' HR method[18] was used as reference criterion to test the validity of the session-RPE to quantify ITL in male and female youth taekwondo athletes during PC and C training sessions. In particular, the Edwards' HR method determines individual ITL by expressing the athletes' HR responses as percentages of their estimated maximal HR (i.e., HRmax; 220 – age), multiplying the accumulated time (i.e., minutes) in five HR zones of individual HRmax (i.e., 50–60% = 1; 60–70% = 2; 70–80% = 3; 80–90% = 4; 90–100% = 5), and summating the scores.

The Italian translation of the CR-10 scale[12] modified by Foster et al.[13,14] was used to assess the youth taekwondo athletes' RPE. The CR-10 RPE scale is a category-ratio scale characterized by scores and verbal links (i.e., from "rest" to "maximal"), referring to the athlete's perception of efforts into a numerical score between 0 (i.e., rest) and 10 (i.e., maximal). Although Foster and colleagues[13] recommended to administer the RPE-30 to assess the ITL of the entire training session, in youth male taekwondo athletes' RPE has been collected both at RPE-1[9] and RPE-30.[8,10] Therefore, to assess differences in session-RPE, if any, due to different data collections, in the present study both RPE-1 and RPE-30 scales were administered.

A total of 17 (100 individual) training sessions of the pre-season period were monitored (i.e., 2 months before the beginning of the *Italian Youth National Championships*). To favor ecological conditions, in this study no attempt was made to manipulate the training sessions, which included different combinations of technical and tactical skills, conditioning bouts, and simulated combats to meet the coach's PC (i.e., sport-specific skills) and C (i.e., combat skills) purposes of training.

Subjects

The institutional review board approved this study and an informed consent has been obtained from five females (age: 12.0 ± 0.7 y; height: 1.54 ± 0.08 m; body mass: 48.8 ± 7.3 kg) and four male (age: 12.0 ± 0.8 yrs; stature: 1.55 ± 0.07 m; body mass: 47.3 ± 5.3 kg) pre-adolescent taekwondo athletes, their coach, and parents, who declared the maturity stage of their sons (i.e., presence of

pubic hairs) and daughters (i.e., before the first menstruation). According to the rules of the Italian Taekwondo Federation,[21] the youth athletes were color belts, corresponding to 2-year (i.e., yellow) and 3-year (i.e., red) taekwondo experience ranging from 3 to 5·week^{-1} 90-minute training sessions.

Measures

Two weeks prior to the experimental sessions, the athletes were familiarized with the CR-10 scale. Before the training session, a HR transmitter belt (Team System, Polar, Kempele, Finland) was placed on the athlete's chest to record his/her HR responses every 1-second. Data were downloaded onto a computer using a specific software (Polar Precision software version 4, Kempele, Finland) to calculate the ITL according to the Edwards' method. Individual RPE-1 and RPE-30 scores were recorded and multiplied by the duration (minutes) of the training to quantify the ITL according to the session-RPE method.[13]

Statistical Analysis

Data are presented as mean values and standard deviations. The statistical analyses were performed by means of the SPSS package (version 21.0) with a $P < .05$ alpha level of significance. Before the study, the Kolmogorov test was applied to test the normal distribution of the data. When no difference between the Edwards' TL and RPEs of male and female emerged, the data were pooled. An analysis of variance (ANOVA) for repeated measures ascertained differences between standardized data of HR classes related to C and PC trainings. A one-way ANOVA was applied to duration, Edwards' TLs, RPE, and session-RPE (according to RPE-1 and RPE-30) data related to PC and C trainings. To provide meaningful analysis for significant comparisons from small groups, Cohen's effect sizes (ESs) were also calculated[22] for significant differences. For all significant findings, effect sizes were determined with values (negative or positive) of .2, .6, 1.2, and >1.2 indicating trivial, small, moderate, and large effect sizes, respectively.[23]

The relationships between Edwards' TL and session-RPE were estimated using the Pearson's product-moment correlation (i.e., r) as well as the coefficient of determination (i.e., R^2), in relation to type of training and different RPE data collections. In particular, coherently to

previous studies on session-RPE related to situational sports,[24] high correlations were identified with r ≥ .7. Furthermore, the 95% confidence intervals (95% C.I.) for the correlation coefficients were calculated.

Results

Because no statistically significant difference emerged for gender (Edwards, p = .50; session RPE-1, p = .70; session RPE-30, p = .42), the data were pooled. Therefore, the 100 individual youth taekwondo training sessions were analyzed only in relation to the training typology (PC = 33 sessions; range for individual athlete = 3-5 sessions; C = 67 sessions, range for individual athlete = 3-11 sessions).

Although no difference emerged for the HR classes (Figure 1) and duration of PC (1:13:58±0:05:26 h:min:s) and C (1:14:27±0:0:40 h:min:s), a main effect was found for Edwards' TL (Figure 2). In particular, higher values for C (228 ± 40 arbitrary units, AU) with respect to PC (192 ± 26 AU; p = .04, ES = .5) were observed. In addition, differences between training types emerged for session-RPE (1min: p < .01 , ES = .7; 30min: p = .029, ES = .5; Figure 2) with higher RPE values reported for C with respect to PC (1min: p < .01, ES =.7; 30min: p = .041, ES =.4; Figure 3).

Figure 1, 2, and 3 close to here

All training typologies and data collections achieved significant correlations between Edwards' and session-RPE methods. However, a large relationship (r = .71, P < .001) emerged only for PC sessions evaluated at 30 minutes of the recovery phases (Figure 4), whereas the other ones resulted less elevated (Table 1).

Figure 4, and Table 1 close to here

Discussion

The regular monitoring of young athletes' ITL resulted crucial to better plan training, and avoid unbalanced physiological stress potentially determining risks of an early specialization,[5] overreaching syndrome and burnout.[3] To our knowledge, this is the first study that has considered the validity of the Foster's RPE-based approach[13] to quantify the ITLs in male and female youth taekwondo athletes, during C and PC training sessions, as well as both with the RPE-1 and RPE-30 evaluations. In particular, this rationale arises from the fact that taekwondo coaches of youth athletes focus the objectives of their training sessions on fundamental technical skills (i.e., PC) or technical and tactical aspects of combats (i.e., C).

Although this is the first study highlighting divergences between female and male youth taekwondo athletes in terms of session-RPE, the absence of any gender-related effect related to ITL values constrained to pool data and reject the first hypothesis. Therefore, results are in line to previous studies on the distribution of heart rate[19] and technical and tactical aspects[25] of young female and male taekwondo athletes.

On the other hand, the second hypothesis can be fully accepted because higher Edwards' TL emerged in C than PC. Although no difference emerged between the two types of training in terms of duration and single HR classes of intensity, the higher Edwards' C loads could be attributed to the absolute longer phases of sessions performed at the maximal (i.e., 91-100%HRmax) and high (i.e., 81-90%HRmax) classes of intensity (Edwards, 1993; Figure 2), which represent a coherent exercise scenario with respect to that of the adolescent taekwondo training.[10] In fact, according to previous studies on taekwondo,[9,15,16,19,20] the regular repetition of technical executions in simulated combat situations (i.e., highly represented in C) could determine the presence of a relevant portion of performance at high intensity, mainly referring to the anaerobic energy system. In addition, for C, the two most occurring portions of training were reported in not consecutive intensity categories (i.e., 61-70 %HRmax and 81-90 %HRmax), thus suggesting that this typology of training can be

fully recognized as a high intermittent exercise and could confirm the typical aspects of the elite[11,15,16,20] and youth[8-10,20] taekwondo performance.

The distribution of HR in PC training showed a different performance scenario where the highest duration of training are reported in the moderate and low intensity classes of intensity (i.e., 61-70 %HRmax and 71-80 %HRmax), which are principally related to the aerobic energy system. In line to this interpretation, data reported in previous studies on male youth taekwondo athletes showed that low session-RPE reliability emerged for the anaerobic[8] and high intermittent intensity[9] training sessions, whereas the opposite tendency emerged in correspondence of aerobic energy system.[8] In particular, the low intensity reported for PC could be determined by the main purpose of teaching techniques, which is usually characterized by individual executions and trainer explanations, which, differently from the pressure performed by opponent, tend to limit any HR increasing.[26]

Finally, the third hypothesis can be fully accepted because the relationship between session-RPE and Edwards' method reported higher values in PC with respect to C, and in the RPE-30 than RPE-1. In particular, although a general session-RPE reliability emerged, resulting in line[10,16] or higher[8,9] with respect to values reported in previous studies focused on session-RPE in taekwondo training, only PC sessions evaluated at RPE-30 showed a large correlation between the two adopted procedures. Therefore, according to the considered measurement of reference (i.e., the Edwards' method), it could represent the best condition to quantify the youth taekwondo athletes' ITL by means of the session-RPE method.

Although the ITL of PC resulted lower than that of C according to Edwards' as well as RPE and session-RPE (both at RPE-1 and RPE-30) values, it could be speculated that the first type of taekwondo training could be more appropriate in relation to the pre-pubescent ability to perform combats and to adapt to training load. In fact, according to previous studies, the elevated focus on the opponents' actions[11,15] or the high intermittent intensity occurring during youth taekwondo trainings,[8,9] mainly characterizing C training, can crucially alter the session-RPE reliability

similarly to other open skill sports.[24,25,27] Nevertheless, in our study, the satisfactory relationships with respect to the Edwards' method emerged both for C and PC suggest that the opponents' actions and the high intermittent intensity weakly influenced the validity of the session-RPE method, inferring that session-RPE can be effectively used in both types of training.

In addition, regarding RPE data collection, the lower session-RPE reliability emerged for the RPE-1 in both PC and C typologies (Table 1) corroborate the high validity of the RPE-30 to guarantee an ITL perception on the entire session.[13,14] Therefore, these results confirm previous studies on taekwondo, which reported high[8,10,15,16] and reduced[9] session-RPE reliability for RPE-30 and RPE-1 evaluations, respectively.

Conclusions

This study showed the effectiveness of the session-RPE to evaluate the ITL of PC (large) and C (not large) pre-pubescent taekwondo training. Therefore, taekwondo coaches could benefit by the use of this method, being very practical to monitor youth ITL and to avoid the necessity of expensive tools (i.e. telemetric HR systems, lactate analyzers). In addition, monitoring the ITL in pre-pubescent athletes is also crucial to plan future appropriate training proposes, which regularly tend to limit the occurrence of injuries, monotony, strain, overreaching conditions, and burnout. In particular, the results of the present study contributed to improve the coaches' awareness on the importance to monitor youth taekwondo training. Although PC sessions resulted more objectively perceived by pre-pubescent taekwondo athletes than C ones, both training typologies could be effectively perceived by this age category regardless of gender. In addition, RPE could be used also at the end of the training session, even though more reliable evaluations on the ITL of the entire session can be obtained at RPE-30. Therefore, coaches of prepubescent taekwondo athletes have the opportunity to propose and effectively monitor a high range of practices, which range from the development of fundamental technical skills to the technical and tactical skills to simulate competitive combats.

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Sample	Edwards	RPE-1					RPE-30				
	Arbitrary unit (AU)	RPE	Session-*RPE*	*R*	95% C.I.	R^2	RPE	Session-*RPE*	*r*	95% C.I.	R^2
ALL (n=100)	210±38	6±1	446±74	.55*	.40 - .67	.30	6±1	446±81	.57*	.42 - .69	.33
PC (n=33)	192±26	5±1	391±56	.57*	.28 - .76	.33	5±1	406±82	.71*	48 - .85	.51
C (n=67)	228±40	7±1	501±42	.48*	.27 - .65	.23	6±1	487±60	.50*	.29 - .66	.25

Table 1. Correlation coefficients (*r*), 95% confidence intervals (95% C.I.), and coefficients of determination (R^2) between Edwards's HR and session-RPE methods for all individual training sessions (ALL), and pre-competitive (PC) and competitive (C) youth taekwondo athletes, in relation to the RPE data collection at the end of the training session (RPE-1) and 30 minutes of the recovery phase (RPE-30). *Significant correlation (p < .001).

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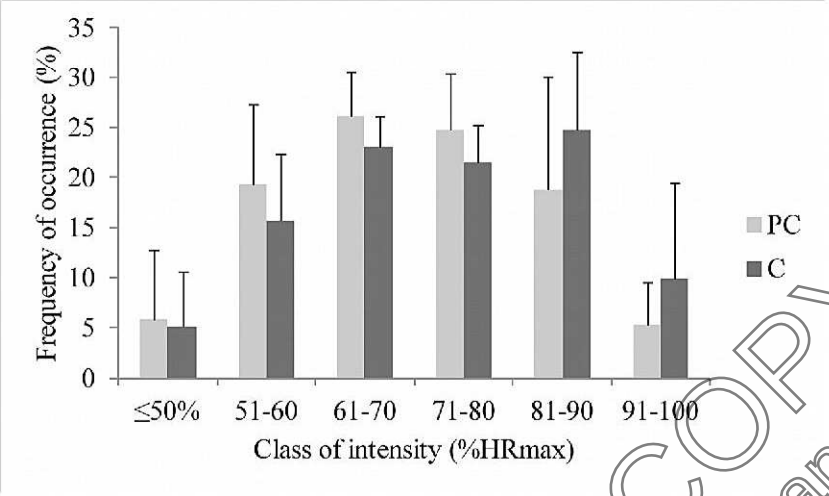

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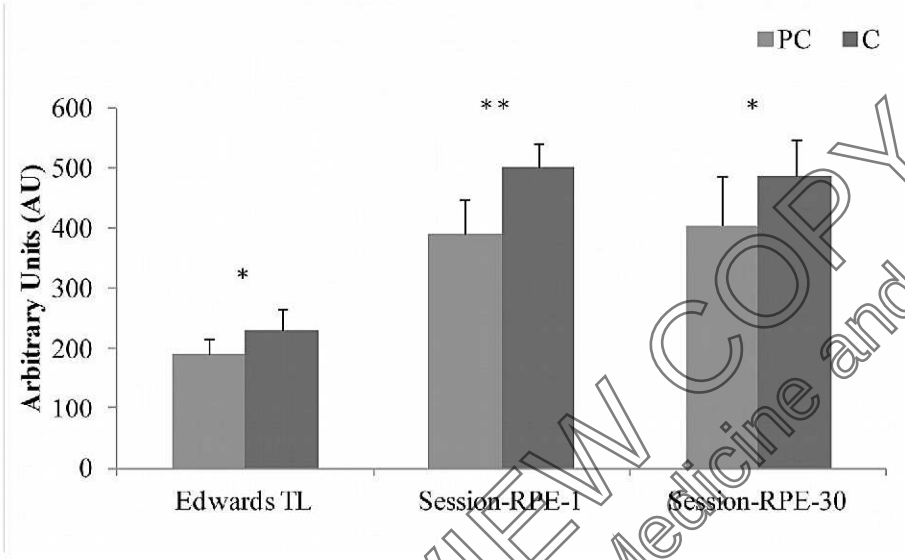

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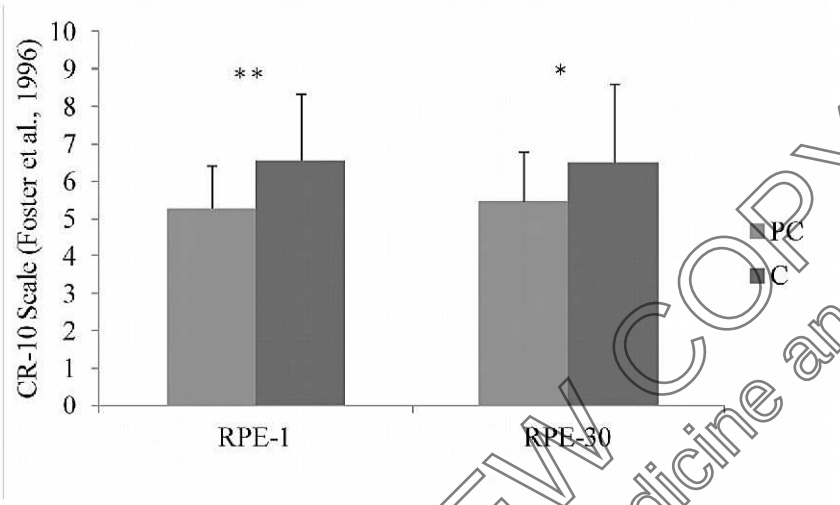

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