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ORIGINAL INVESTIGATION

Validity of the Online Athlete Management System to Assess Training Load

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Purpose: To validate the quantification of training load (session rating of perceived exertion [s-RPE]) in an Australian Olympic squad (women's water polo), assessed with the use of a modified RPE scale collected via a newly developed online system (athlete management system). ***Methods:*** Sixteen elite women water polo players (age = 26 [3] y, height = 1.78 [0.05] m, and body mass = 75.5 [7.1] kg) participated in the study. Thirty training sessions were monitored for a total of 303 individual sessions. Heart rate was recorded during training sessions using continuous heart-rate telemetry. Participants were asked to rate the intensity of the training sessions on the athlete management system RPE scale, using an online application within 30 min of completion of the sessions. Individual relationships between s-RPE and both Banister training impulse (TRIMP) and Edwards' method were analyzed. ***Results:*** Individual correlations with s-RPE ranged between $r = .51$ and .79 (Banister TRIMP) and $r = .54$ and .83 (Edwards' method). The percentages of moderate and large correlation were 81% and 19% between s-RPE method and Banister TRIMP, and 56% and 44% between s-RPE and Edwards' method. ***Conclusions:*** The online athlete management system for assessing s-RPE was shown to be a valid indicator of internal training load and can be used in elite sport.

Keywords: water polo, quantification, mobile, application, team sport

The session rating of perceived exertion (s-RPE)[1] has been validated in individual and team sports[2–4] and has been used in training load monitoring[5] and injury prevention.[6,7]

Different perceptual scales have been proposed, validated, and used in several sports to measure exercise intensity and calculate s-RPE.[8–10] Psychophysical ratio-scaling methods have been used to create scales where the position of the numbers and verbal anchors (ie, the words next to the scale numbers) is crucial for their psychometric properties such as reliability, validity, responsiveness, and interpretability.[11–13]

Small variations in verbal anchors or in the actual question (eg, rating of exertion, effort, or fatigue) could result in different ratings.[14–16] In addition, in order to collect reliable data, it is fundamental that athletes read and follow scale instructions and are familiar with the scale.[17,18]

The most commonly used valid scales for s-RPE are Borg category ratio (CR) 10[18] and Foster,[1] both ranging from 0 to 10. Recently, the use of the Borg CR100 has been suggested and its interchangeability with the CR10 validated.[10] According to the Borg's range model, the CR scales have been built to reflect an equal subjective range of intensity between individuals (minimal to maximal, 0–10 or 0–100) allowing intersubject comparisons.[19] However, it is not rare to see teams and practitioners using modified versions of these scales.[18] An example of this is a 1–10 rating scale mentioned, without citing validation studies, in a recent review.[7] It is important to highlight that using modified scales (even if the difference appears small) may lead to collection of inconsistent data,[14,18] and inconsistency in literature means studies are not able to be combined (eg, meta-analysis) and therefore are unable to contribute to knowledge growth; also, using flawed data in research may result in dissemination of unreliable or erroneous results.[20]

The RPE is assessed by asking athletes to report their perceived intensity of the exercise, and it can be considered a response process. The question-and-answer model derived from cognitive psychology is commonly used in survey research to explain the theory underpinning the response process.[21] A response process has been suggested to be based on the following points: (1) the comprehension of the question, (2) the retrieval of the necessary information from long-term memory, and (3) the use of the information to make a decision and respond to the question.[21] Similarly, in the RPE assessment, the players have to understand the question; to retrieve information on the previously experienced RPE; to make decision on the actual RPE; and finally, to report their rating.

The RPE data have been generally collected with face-to-face interviews by researchers and/or team staff members.[2,4,10] However, some sports' specific requirements (ie, noncentralized teams/sports, with athletes training in different parts of the world) in association with the increasing availability of new technologies (ie, smartphones and tablets), require and promote the use of online methods to collect training load data.[22,23] For example, the Australian Institute of Sport has adopted an online platform called athlete management system (AMS) to record and monitor, among other variables, training data and performances of Australian athletes. It is estimated that more than 30 national sporting organizations and about 6000 athletes log their training data into this online system.

Interestingly, research on the response process has demonstrated that data collection modality (eg, verbal face-to-face, verbal by telephone, self-administered with paper and pencil or

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self-administered with computer/tablet) can significantly influence accuracy and quality of the responses.[24] Although data collected with mobile applications have been suggested to be equivalent to data collected with the paper method, there is to date not enough evidence to recommend the use of mobile applications in survey studies.[25] Therefore, when switching from face-to-face to self-administered and online data collection, a scientific validation of the new method is due to ensure the quality of the data.

In elite sport, it may happen that the 2 previously mentioned situations occur at the same time: use of a modified RPE scale and use of a new method for data collection. For the previously mentioned reasons, it is the best practice to ensure validity of the collected data. Therefore, the aim of this study was to validate the quantification of training load (s-RPE) in an Australian Olympic squad (women's water polo), assessed with the use of a modified RPE scale collected via a newly developed mobile application (AMS-s-RPE).

Methods

Subjects

Sixteen elite women water polo players (age = 26 [3] y, height = 1.78 [0.05] m, and body mass = 75.5 [7.1] kg) participated in the study. A total of 303 sessions were recorded (19 [4] sessions for each participant).

Design

To examine the validity of the AMS-RPE scale (Table 1) and mobile application (SMARTABASE Athlete Data Management; Fusion Sport, Sumner Park, Australia) for training load monitoring, 30 training sessions were monitored during a senior national water polo training camp, for a total of 303 individual sessions. To guarantee ecological validity, data were collected during regular training sessions (as per coach's training plan) without any attempt at manipulation by the researchers. Instructions on the use of the scale and AMS application were provided to the participants at the start of the water polo domestic competitive season. The participants were highly familiar with both the scale and the application, having used the system daily for more than 6 consecutive months before the study data collection began.

Table 1 The AMS-RPE Scale Used by the Australian Water Polo National Team in Preparation for the Rio Olympic Games

Rating	Verbal anchor
1	
2	Light
3	
4	Moderate
5	
6	Hard
7	
8	Very hard
9	
10	Maximal

Abbreviations: AMS, athlete management system; RPE, rating of perceived exertion.

In order to examine the construct validity of the AMS system, the individual relationships between s-RPE and both Banister training impulse (TRIMP) and Edwards' method were analyzed.[1,26,27]

Written informed consent was collected from each participant. The study conformed to the Declaration of Helsinki, and it was approved by the ethics committee of the Australian Institute of Sport.

Methodology

Participants were asked to rate the intensity of the training sessions on the AMS-RPE scale (Table 1), using the mobile application within 30 minutes of the completion of the sessions. Despite this recommendation, in order to mimic the noncentralized daily training environment, during the camp, no specific extra reminders were provided to the athletes regarding data input compliance. The AMS-s-RPE was calculated as arbitrary units (a.u.) by multiplying duration of the training session (in minutes) and intensity (AMS-RPE scale).

Heart rate was recorded during training sessions using continuous heart rate telemetry (TM200; Hosand Technologies, Verbania, Italy); each individual player wore a transmitter chest belt (T31 Transmitter; Polar, Alexandria, Australia) during every training session.

Resting heart rate was recorded by each athlete during the training camp, in the morning before the player got out of bed on a day in which they were able to wake up naturally (ie, not by an alarm) by counting pulse. Athletes were educated on how to do so prior to data collection. Peak heart rate was individually determined at the end of a maximal incremental swimming test[28] and confirmed during game play.

Statistical Analysis

Data are presented as mean (SD). Assumption of normality was examined using the Shapiro–Wilk test. Data were analyzed after log transformation to reduce bias due to nonuniformity error. The individual relationships between s-RPE and both Banister TRIMP and Edwards' method were analyzed using Pearson's product moment correlation and 90% confidence intervals. The magnitude of the correlations was determined using the modified scale by Hopkins (http://www.sportsci.org/resource/stats/2002): $r < .1$, trivial; .1 to .3, small; .3 to .5, moderate; .5 to .7, large; .7 to .9, very large; >.9, nearly perfect; and 1, perfect.

Statistical analyses were performed using the software package SPSS (SPSS Statistics 17.0; SPSS Inc, Chicago, IL) and the spreadsheet provided by Hopkins (www.sportsci.org, http://www.sportsci.org/resource/stats/relycalc.html).

Results

The mean resting heart rate was 57 (8) beats·min^{-1}. The mean peak heart rate was 189 (7) beats·min^{-1}. The mean Banister TRIMP, Edwards', and s-RPE methods values for all the players were 122 (34), 243 (61), and 661 (177) a.u., respectively. The correlations between each heart-rate-based method and s-RPE are presented in Figures 1 and 2. Individual correlations were determined from a minimum of 13 to a maximum of 27 individual sessions and presented in Table 2 (s-RPE vs Banister TRIMP, $r = .51–.79$ and s-RPE vs Edwards' method, $r = .54–.83$). The percentages of moderate and large correlation were 81%, 19%, and 56%, 44% between s-RPE method versus Banister TRIMP and versus Edwards' method, respectively.

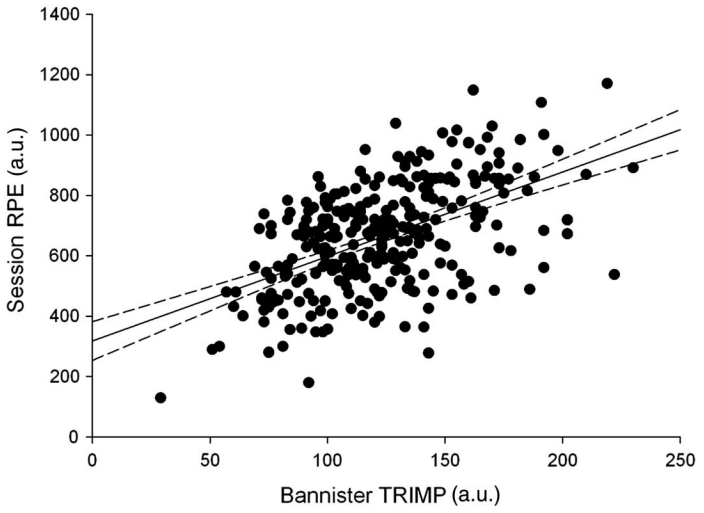

Figure 1 — Correlation between Banister TRIMP and AMS-s-RPE values for all data. AMS indicates athlete management system; s-RPE, session-rating of perceived exertion.

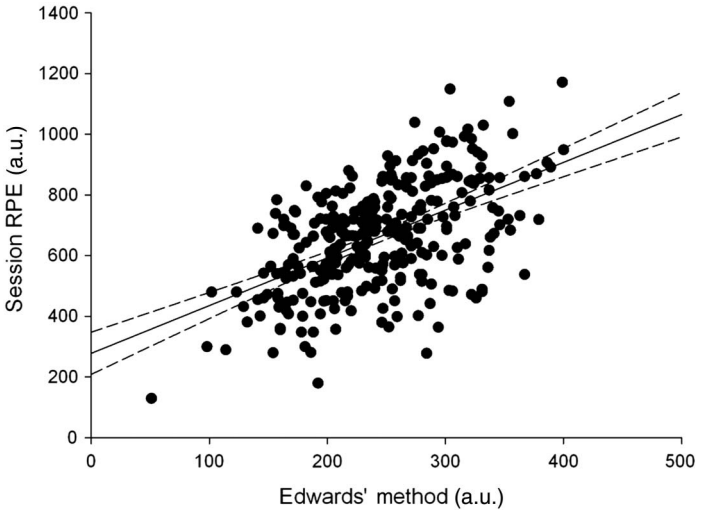

Figure 2 — Correlation between Edwards' method and AMS-s-RPE values for all data. AMS indicates athlete management system; s-RPE, session-rating of perceived exertion.

Discussion

The results of the present study showed that the AMS-s-RPE can be considered a valid measure of training load in elite women's water polo. In addition, the use of a mobile application to collect AMS-RPE is promising.

The validity of the AMS-s-RPE, when assessed against different heart-rate-based methods, was comparable with outcomes of previous studies in team sport disciplines. For example, the s-RPE has been shown to be a valid method to assess training load in basketball (range = .70–.82),[29] Australian football (.83),[3] youth soccer (range = .50–.78),[4] elite soccer (range = .52–.85),[10] team-gym (range = .77–.85),[30] and Canadian football (range = .69–.91).[31] However, studies examining sport disciplines with different pattern of activity can provide different RPE values and results; therefore, the s-RPE validity should be checked in each different sport discipline before use as an indicator of internal load. In the present study, the individual correlations between AMS-s-RPE and Banister TRIMP (range = .50–.79) provided similar values compared with what was found in well-trained (range =.55–.92)[31] and elite (.70)[32] swimmers. Likewise, the individual correlations calculated with the Edwards' method (range =.54–.83) showed similar or slightly lower values compared with what was found in well-trained swimmers (range = .56–.91)[31] and male water polo players (range = .76–.99).[2]

Different scales have been used to assess RPE in previous studies, and the most commonly used are the CR10 scale modified by Foster, the Borg CR10, and the Borg CR100. It is worthwhile to note that, if not interchangeable, different scales can provide different values of training load; therefore, caution should be used when comparing results from studies using different scales. The AMS-RPE scale used in the present study differs compared with the more frequently used and validated Foster and Borg CR10 scales. The main difference between the scales concerns their properties. The AMS-RPE and Foster scales are both interval scales with equidistant space between the ratings and a linear increase; however, the Borg CR10 and CR100 are category ratio scales with nonlinear growth function in respect to the Borg range model. The lowest value of the scale is 1 in the AMS-RPE scale, whereas the other scales start from 0 (ie, "rest") representing no exertion. The position of the verbal anchors is different too, for example, "moderate," "hard," and "very hard" are positioned at numbers 4, 6, and 8, respectively, in the AMS-RPE scale, whereas at numbers 3, 5, and 7 in the Foster scale.

The increased use of smartphones and tablets in daily life have influenced the modality of various data collection allowing sports scientists and practitioners to monitor sessional training loads even when athletes are training remotely. Recently, a systematic review examined the differences between survey studies performed with online technologies (ie, applications and SMS)

Table 2 Individual Correlations and 90% CIs Between s-RPE and Banister TRIMP and Between s-RPE and Edwards' Method for the Players Involved in the Study

Player ID (no. of sessions)	Banister TRIMP (90% CI)	Edwards' method (90% CI)
1 (22)	.70 (.46–.85)	.74 (.51–.87)
2 (27)	.79 (0.63–.89)	.83 (.70–.91)
3 (19)	.66 (.36–.83)	.75 (.50–.88)
4 (20)	.59 (.28–.79)	.63 (.34–.82)
5 (20)	.66 (.37–.83)	.67 (.39–.84)
6 (25)	.73 (.51–.85)	.77 (.59–.88)
7 (15)	.59 (.20–.82)	.59 (.21–.82)
8 (22)	.58 (.28–.78)	.63 (.35–.81)
9 (18)	.53 (.16–.77)	.56 (.20–.78)
10 (18)	.69 (.40–.86)	.70 (.41–.86)
11 (18)	.51 (.13–.75)	.54 (.17–.77)
12 (13)	.73 (.39–.90)	.77 (.46–.91)
13 (20)	.58 (.26–.79)	.66 (.37–.83)
14 (15)	.69 (.36–.87)	.76 (.48–.90)
15 (13)	.70 (.33–.88)	.74 (.40–.90)
16 (18)	.61 (.27–.81)	.66 (.35–.84)

Abbreviations: CI, confidence interval; TRIMP, training impulse; s-RPE, session rating of perceived exertion.

versus paper. The authors not only found an equivalence between all modalities, but also highlight that online methods may have a specific effect on the response process, when compared with paper mode.[25] Therefore, the psychometric properties of the online methods should be further investigated. In the present study, the association with heart-rate-based methods supported the use of the online AMS application as a valid method of data collection.

Practical Applications

Results of this investigation are of particular use for professionals, coaches, and support staff working in sports characterized by a decentralized training environment. In fact, the use of online applications can allow valid quantification of training loads to ensure training goals are met and injury risks monitored.

In order to increase individual correlations between s-RPE and training load assessed with heart-rate-based methods, proper education and familiarization with the scale should be promoted. In addition, the use of a previously validated scale, and/or an interchangeable scale should be encouraged, rather than creating new scales. However, given the fact that in sport it is not uncommon for teams to be using modified scales, the methods adopted in this study could be used as a template for situations in which a retrospective evaluation of the training load quantification is warranted.

The main limitation of the present study was that it did not control for the single effect of the AMS-RPE scale or the online AMS application on the association with heart-rate-based methods. However, the main aim of the present study was to analyze the validity of the overall system as used by elite Australian sporting teams. Future studies could examine the mobile application mode of data collection with an experimental design.

Conclusions

The results of the present study suggest that before using a new system to assess training load, its validity should be controlled. In addition, the Borg category ratio scales have been constructed with several psychophysical properties; therefore, sport scientists and practitioners should avoid changes of the validated scales. The use of the online AMS application for assessing s-RPE was shown to be a valid indicator of internal training load and can be used in elite sport.

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