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Original research

Rating of perceived exertion is a stable and appropriate measure of workload in judo

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ABSTRACT

Objectives: Heart rate (HR), blood lactate concentration [La] and/or rating of perceived exertion (RPE) have been utilised to monitor judo training load in technical and randori (competition training) sessions, but are yet to be investigated in mixed sessions containing both elements. Therefore the purpose of this study was to: (1) determine the stability of these variables, and (2) to assess the efficacy of RPE as a load variable for mixed judo sessions.

Design: Cross-sectional study.

Methods: Twenty-nine athletes attended two mixed training sessions at an international training camp. Bout and session characteristics, including RPE, physical and mental effort, heart rate (HR) and post-session [La] were recorded. A two-way random-effects intra-class correlation assessed variable stability. Multilevel mixed-effects ordered logistic regression investigated relationships between RPE and other variables for bouts and sessions.

Results: Average and minimum HR across sessions correlated highly (ICC = 0.95 and 0.94, respectively). Good correlations existed between [La], session-RPE and mental effort, and fair correlation of max HR and physical effort. No relationships existed between [La]/HR and session-RPE. A unit increase in bout-RPE resulted in a 2.09 unit increase in physical, or a 1.36 unit increase in mental, effort holding all other bout variables constant. Gender and competitive level did not influence statistical models.

Conclusions: Results provide further evidence that RPE can be used across a range of competitive levels and genders to monitor workload of mixed sessions and individual randori in judo. Physical effort may play a larger role than mental effort when athletes reflect on exertion during training.

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1. Introduction

Physical and mental demand are measured across multiple sports to provide information which allows coaches and support staff to monitor athlete load.^{1–6} The early identification of periods of increased injury and illness risk is a primary outcome of load monitoring, and subsequently, strategies can be put in place to minimise the likelihood of injury/illness occurrence. A range of variables are utilised in sport to monitor load and the subsequent injury/illness risk. Load variables must be appropriate to each sport and have stability over time if they are to be worthwhile in collecting. Blood lactate and HR are two such variables, as they have a broad research base across both endurance^{7–9} and intermittent^{3,10,11} sports. Blood

lactate and heart rate of judo athletes have been investigated previously mainly in relation to competition load.^{12–14} It may not be feasible to collect such variables as part of daily training in Australian judo, and therefore a simpler, and more cost-effective approach must be investigated.

The training load of Australian elite Judo players is currently quantified using a the Borg Category Ratio-10 (CR-10) RPE scale multiplied by session duration, as detailed by Foster.¹⁵ One reliability study of the CR-10 scale exists in judo, however, reliability was investigated across distinct session types, for example, reliability across technical training, competition (randori) training, non-specific conditioning training.¹⁶ Australian combat training sessions and camps typically include a mix of technical training and randori (competition) training, therefore it is worthwhile investigating the stability of the CR-10 scale in these mixed sessions.

Results of studies utilising the CR-10 scale to determine workload in judo indicate that it correlates well to other workload

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variables. High correlations have been found between the CR-10 scale and the Desgorces work endurance recovery (WER) method,¹⁷ and athlete performance was shown to be related to both CR-10 ratings and training load (CR-10 × duration).¹⁶ The CR-10 scale has also been utilised as a measure of training load across periodised programs for national level judo athletes.¹⁸ In competition, the CR-10 scale has been shown to be related to maximum lactate concentration,¹⁴ and heart rate during bouts.¹⁹ There is no research which analyses whether these relationships hold in mixed training sessions containing both randori and technical training. Additionally, there is no information detailing whether competitive level and/or gender affect these relationships, possible due to small sample sizes in the published literature. This is a significant omission as results from previous literature may only apply to a sub-set of the judo population.

To date, no studies have investigated the separate physical and mental load of judo and how these may correlate to the CR-10, hereafter referred to as RPE. Previous literature has documented that judo athletes typically give a lower RPE rating for training than for randori training.¹⁶ There was not enough information to determine whether the intensity and duration of the technical training was matched that of the competition training. Judo training contains both low intensity technical training and maximal intensity matches, meaning that at times cognitive demand may be high and physical demand low. An assumption of utilising RPE is that athletes take physical and mental demand equally into account when providing a rating, however the literature indicates that this may not be the case. Previous research has attempted to understand how different demands affect CR-10 by utilising the NASATLX National Aeronautical and Space Administration Task Load Index (NASATLX).²⁰ The NASATLX contains six sub-scales: mental demand, physical demand, temporal (time) demand, performance, effort, and frustration. Results from these investigations conclude that RPE is more sensitive to changes in physical demand than mental demand.^{21–23} This deduction is further supported in a study showing that additional mental demand on an exercising participants do not change their final RPE rating.²³ The physical tasks in the aforementioned studies were static exertions (bicep flexion),²² lifting a box,²¹ and stationary cycling,²³ which were lab-based and very different to high-intensity demands of most sport. Therefore, physical and mental ratings should be correlated to RPE ratings in judo, as this may have implications for load monitoring.

A final issue with the published literature on the investigation of RPE in judo is that the RPE scale is often treated as a continuous variable during statistical analyses. The descriptors of effort within the CR-10 RPE scale (for example, 4 = “somewhat hard”), indicates that the scale ordinal categorical.¹⁵ Therefore, an investigation into the appropriateness of CR-10 as a measure of competitive bout effort in an elite population is warranted, alongside analysis of the usefulness of RPE to monitor overall judo session load.

Therefore the aims of this study were to: (1) determine the stability of the CR-10 RPE scale and other session workload variables across two training sessions, and (2) to assess the efficacy of RPE as a training load measure in judo, by investigating relationships between this and the following variables:

- Other measures of workload, specifically blood lactate, HR (minimum/maximum/average) and NASATLX physical and mental effort scales.
- The number of previous bouts an athlete has completed that session.
- Athlete gender and competitive level.

2. Methods

Ethical approval for this investigation was obtained from the University Human Research Ethics Committee (A16-023 & B15-143). Approval to utilise heart rate measures was also obtained from the National Institute of Sport as this data is routinely collected as part of national level Judo training camps.

Thirty-two athletes attending an international training camp in September 2015 at the Australian Institute of Sport (AIS) Combat Centre were invited to participate in this study. All athletes attending this camp who were able to participate in all training sessions without limitation were included. The exclusion criteria was any invited athlete who was not able to participate unrestricted in all training sessions due to injury, illness or any other reason. An observational research study performed at a national judo camp, with visiting Japanese opponents. Twelve elite, internationally competitive Japanese athletes attended the camp as training partners to the Australian athletes (females $n=3$, males, $n=9$, age, range 15–17 years). Data were not collected on the Japanese athletes due to ethics approval barriers. Two training sessions, spaced 48 h apart on day 1 and 3 of the 5 day camp, were developed in consultation with the Australian head judo coach. The first hour of each session contained technique training, including throwing practice and grappling on the ground, the second hour was simulated competition with repetitive judo bouts (see Fig. 1). Prior to warm up, athletes were assigned a HR strap and a number was taped on the back of their judo suit for identification.

During the first hour of each session, the Australian head coach and/or visiting Japanese head coach explained various techniques and athletes were given time to practice them. There were no restrictions placed on the types of techniques or the intensity of practice in this part of the training session. Athletes worked in pairs and self-selected the number of repetitions and effort of practice. Before the repetitive judo bouts began, coaches divided athletes into two groups: heavyweight (≥ 70 kg for women, ≥ 80 kg for men) and lightweight (< 70 kg for women, < 80 kg for men). While one group was fighting, the other group was passively resting on the side of the mat. Each bout lasted for 4 min and there was a 60 s transition between groups. Immediately after each bout, athletes reported to one of four staffed tables along the mat side to record their bout details (bout ID, opponent number, RPE, NASATLX). A CR-10 RPE scale was utilised, which ranged from 1 (really easy) to 10 (maximal).²⁴ The NASATLX sub-scales utilised related to physical and mental effort, and ranged from 1 to 20 with 1 being least effort and 20 being maximal effort. All scales were paper-based. Seven athletes were on the cut-off between the heavyweight and lightweight groups, therefore these athletes performed bouts against opponents in both groups. Across the hour, athletes completed a minimum of five, four minute bouts, followed by a ten minute of cool down after all bouts had finished.

Blood lactate concentration (Lactate Pro™ 2 Arkray, Japan) was collected using an ear lobe prick sample after each athlete's final bout, and session scores for RPE and NASATLX, and the number of Japanese and Australian opponents were collected from each athlete immediately after the cool down. All blood lactate measurements were completed within 3 min of an athlete finishing their final bout, and all session scores were taken within 15 min of the session finishing. Heart rate traces, including minimum, maximum and average HR, were collected across both two hour training sessions by staff as part of routine camp practices, via a Firstbeat system (Firstbeat Technologies Oy, Finland).

Variables were tested against the assumptions of normality (see Supplement 1). To assess the stability of variables, a two-way random-effects intra-class correlation (ICC) model, with the athlete as a fixed effect was employed. This ICC measured the absolute agreement of variables on day one and three of the

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