Do Acute Bouts of Resistance Training Influence the Psychometric Status and Affective State of Prepubertal Weightlifters?

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ABSTRACT

Resistance training (RT) can represent a challenging and stressful endeavour for those who participate in it. We aimed to investigate the acute effects of four common RT types, executed during a single training session, on psychological parameters (feeling scale [FS]) and perceived internal load [RPE]) in young weightlifters. Sixteen male and female young weightlifters, aged 11.3 ± 0.6 years, performed four different RT types undertaken in a randomized order. The RT included dynamic strength exercise (DYN; 3-sets of 3-repetitions of 10 RM), isometric strength exercise (ISOM; 3-sets of maintaining 3-seconds of 110% 1RM of back-squat), fast stretch shortening cycle exercise (FSSC; 3-sets of 3-repetitions of 20-cm drop-jumps) and slow stretch shortening cycle exercise (SSSC; 3-sets of 3 hurdle-jumps over a 20-cm obstacle) protocols. After executing the RT, participants reported scores for RPE and FS. The execution of different types of RT exercises did not induce changes in FS. On the contrary, differences in RPE were observed with the SSSC protocol being the least acutely strenuous, followed by the FSSC and DYN methods (F=19.22, P <0.0001). Of all four types used in this study, ISOM seemed to induce the highest RPE score (P<0.001, d=-2.01) though difficulty remained relatively low across the 10-point scale. Coaches can manipulate training activities based on the condition of the athlete and the potential physical strain that is associated with each exercise type.

Keywords: Plyometrics, strenghtening, psychometric status, affective prevalence.

INTRODUCTION

Weightlifting is an Olympic sport that is practiced worldwide. It is a dynamic strength- and power-based discipline in which two separate lifting movements (snatch and clean & jerk) are performed (Durguerian et al., 2015). Accordingly, weightlifting represents a challenging and stressful endeavor which coaches and sports scientists have previously conceptualized as a ‘psychophysiological complex’ (Durguerian et al., 2015, Faigenbaum et al., 1997). In this way, subtle changes in an athlete’s internal training load (TL) can exert a large effect on psychometric and physiological variables (Thorpe et
This can differ across individuals with the associated strain, stress, feelings towards training and impairment of psychophysiological processing varying according to the applied training methods (Hecksteden et al., 2015). In relation to this, multiple quantification systems have been developed to monitor internal TL and trainee status in team sport (Gaudino et al., 2015; Saw et al., 2016; Thorpe et al., 2015), and researchers have also recommended the use of different questionnaires to investigate TL and the wellness status of athletes (Buchheit et al., 2013; Coutts & Reaburn, 2008; Dias et al., 2014; Gaudino et al., 2015; Saw et al., 2016).

Because of the above described pattern of response to training across individuals, many athletes and coaches agree that it is important to systematically record their training efforts and to evaluate the nature of their effects from physiological and psychological perspectives (Kazakova, 2007). Using the Rating of Perceived Exertion (RPE) scale (Borg et al. 1981) is highly recommended for this purpose as the measure is highly valid and has become a standard method of measuring the level of intensity experienced during resistance training (RT) (Noble et al., 1996). In respect of this, Asadi et al. (2014) reported that the RPE method is effective in monitoring different plyometric exercises and training intensities and recommended that strength and conditioning professionals and athletes use the tool as a measure of the challenge associated with different modes and intensities of training. However, Peñailillo et al. (2017) found that perceived exertion was lower during fast stretch shortening cycle (FSSC), compared with slow stretch shortening cycle (SSSC) activity and this means that these exercises may exert different psychophysiological effects on the body. Published data on the efficacy of the RPE method as a mechanism to monitor the physiological and psychological state of youth weightlifters is currently lacking, meaning that further investigations are warranted in this population.

While participating in training, it is common to experience changes in mood (Voss et al. 2011). For example, some individuals find exercise pleasurable, whereas others find it to be decidedly unpleasant (Hardy and Rejeski, 1989). Sheppard et al. (2008) previously demonstrated that during exercise, affective state, assessed by the Feeling Scale (FS), remained positive in self-selected and low-intensity training conditions but declined in a high-intensity condition in adolescent boys and girls. In addition, psychophysiological parameters such as perceived internal TL and affective valence may change throughout RT regimens in youth weightlifters. To monitor such changes, the FS (Hardy and Rejeski, 1989), is a validated tool used to assess affective responses during exercise. Considering that RT can induce feelings of pleasure after a single bout (Alves et al., 2017), it is therefore important to study the responses to different types of RT modalities (plyometrics, dynamic and isometric strength) that are used in youth trainees. To the best of our knowledge, there is no study drawing a comparison between acute bouts of different RT modalities in youth weightlifters. Therefore, the aim of this investigation was to determine the acute effects of different types of RT (FSSC, SSSC, dynamic [DYN] and isometric [ISOM] exercises), performed during a single session, on subsequent RPE and FS in young weightlifters. With reference to the relevant literature (Alves et al., 2017, Durgerian et al., 2015, Faigenbaum et al., 1997, Peñailillo et al., 2017), we hypothesized that the implementation of these exercises would lead to acute changes in measures of psychometric and effective state in youth weightlifters. Considering that RT can induce feelings of pleasure (Alves et al., 2017) and due to the increased metabolic demand associated with greater time under tension (Lee et al., 2015), we speculated that the ISOM protocol would elicit the greatest change in subsequent RPE and FS scores.

METHODS

Study Design

The rationale for this study emanates from the lack of knowledge about the acute effects of different RT types on psychometric parameters and affective state in youth weightlifting. A between-group post test study design was applied to evaluate the acute effects of four different interventions on RPE and FS. The chosen RT protocols were differentiated according to the contractile characteristics of the involved muscles and comprised: (i) SSSC: 3 sets of 3 hurdle jumps; (ii) FSSC: 3 sets of 3 repetitions of 20 cm drop jumps; (iii) ISOM: 3 sets of 3-second maximal isometric back squat (110% 1RM); (iv) DYN: 3 sets of 10 repetitions of maximal back squats (10 RM). Each session began with the athletes performing a standardized warm-up consisting of five minutes of jogging followed by ten minutes of dynamic stretching. The RT protocols were conducted in a randomized order. Thereafter, participants reported the RPE and FS for each RT bout.
Participants

This study was conducted in 16 athletes (five girls and eleven boys) who were members of the local weightlifting club (Table 1). They were involved in systematic weightlifting training for at least 2.44 years, training 2-3 times per week for 90 minutes per session. All participants had routinely performed back squats as part of their regular RT regimen for a minimum of one year before the study and, therefore, were highly familiarized with the exercise. The study was conducted according to the latest version of the Declaration of Helsinki and the protocol was fully approved by the Local Ethics Committee of the National Centre of Medicine and Science of Sports of Tunis (CNMSS-LR09SEP01) before the commencement of the assessments. None of the participating athletes had a history of musculoskeletal, neurological or orthopaedic disorders that might have impaired their ability to execute the prescribed RT protocols.

Procedures

Testing was performed in an indoor weightlifting gymnasium. One week before the commencement of the study, all subjects participated in an orientation session to become familiar with the testing procedures. Each participant’s stature and mass were collected using a wall-mounted stadiometer (i.e., OHAUS, Florham Park, NJ, USA) and an electronic scale (i.e., Baty International, West Sussex, England), respectively. The sum of skinfolds was assessed using a Harpenden skinfold calipers. Body measurements were conducted according to Deurenberg et al. (1990) who reported similar prediction errors between adults and adolescents. Pubertal timing was estimated according to the biological age of maturity for each sex, as described by Moore et al. (2015). Thereafter, the athletes performed in randomized order the four strength exercise protocols (SSSC, FSSC, ISOM and DYN) on consecutive days with at least 48 hours in between the different experimental conditions. After the strength exercise protocol, all weightlifters participated in post-intervention psychometric (RPE) and affective (FS) tests.

Internal Training load and Affective valence

Rating of Perceived Exertion (RPE) assessment

The RPE data were collected immediately after each intervention using the modified 10-point Borg Scale (Borg et al., 1987). To collect subjective estimations of the physiological loads during each RT condition, each athlete was asked: “How did you perceive exertion during execution?”. They provided this information alone such that they were not in close proximity to any of their peers, meaning that no one individual could influence another. Responses to training were also measured using the FS (Hardy & Rejeski, 1989). After each intervention, the participant was asked to respond subjectively to the affective valence pleasure. This is an 11-point, single-item, bipolar scale, which was is used to assess affective responses during exercise, ranging from −5 (i.e. very bad) to +5 (i.e. very good). Data from the FS was gathered alongside the RPE data.

Protocols of the applied resistance training exercises

Each RT exercise protocol lasted 20 minutes and consisted of four exercises, namely: SSSC, FSSC, ISOM and DYN. The SSSC consisted of 3 sets of 3 hurdle jumps over 20 cm hurdles. The FSSC consisted

| Table 1. Participants’ anthropometric and dynamic strength characteristics in the whole sample, males and female young weightlifters. |
|---------------------------------|-----------------|-----------------|
| Whole Sample (N=16)             | Males (N=11)    | Females (N=5)   |
| Age (yrs)                       | 11.33 ± 0.66    | 11.44 ± 0.83    | 11.50 ± 0.51 |
| TE (yrs)                        | 2.44 ± 0.81     | 2.30 ± 0.82     | 3 ± 1        |
| Body height (cm)                | 148.19 ± 6.48   | 147.30 ± 7.90   | 152.40 ± 5.50 |
| Body mass (kg)                  | 36.51 ± 6.95    | 36.53 ± 9.43    | 38.72 ± 7.53 |
| Sitting height (cm)             | 62 ± 20.50      | 66.60 ± 21.19   | 63.80 ± 31.36 |
| Leg length (cm)                 | 86.19 ± 18.93   | 80.70 ± 18.63   | 88.60 ± 33.81 |
| Body fat (%)                    | 6.69 ± 1.35     | 6.30 ± 1.21     | 7.62 ± 2.13  |
| PHV                             | -1.98 ± 1.07    | -2.58 ± 0.64    | -0.40 ± 0.30 |
| APHV                            | 13.31 ± 0.89    | 14.02 ± 0.62    | 11.90 ± 0.61 |

Notes: Values are means and standard deviations (SD); TE: training experience; PHV: peak height velocity; APHV: age at peak height velocity.
of 3 sets of 3 repetitions of drop jumps from a height of 20 cm. The ISOM consisted of 3 sets of 3-second maximal voluntary contractions while performing the back squat with a load corresponding to 110% 1RM. Finally, the DYN protocol comprised back squats with 3 sets of 3 repetitions at a 10 RM load. Each session began with a standardized 15-minute warm-up, including submaximal intensity running, dynamic stretching, calisthenics, and preparatory exercises (i.e. squatting and jumping exercises at a progressively increased intensity). To minimize the risk of injury, session familiarization was performed and progressed from low to moderate to high intensity drills, thus gradually imposing a greater stress on the musculotendinous unit (Lloyd et al., 2015).

RESULTS

All 16 weightlifters completed the study according to the described design and methods. Participants attended all testing sessions and none reported any exercise- or test-related injury. Table 2 displays the test-retest reliability analyses for the RPE and FS. Intraclass correlation coefficients showed good reliability for all psychological parameters. ICC-values ranged from 0.91 to 0.92, with a standard error of measurement (SEM) from 2.17 to 3.66 and a coefficient of variation from 1.52 to 3.18. Furthermore, a paired t-test showed no significant differences between the scores recorded during the two trials for all measured variables.

<table>
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<tr>
<th>Table 2. Test-retest reliability of variables.</th>
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<tr>
<td>ICC (95% CI)</td>
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<tr>
<td>RPE 0.92 (0.81-0.96)</td>
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<tr>
<td>FS 0.91 (0.85-0.94)</td>
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The results of the analyses can be viewed in Tables 3 and 4. The execution of different types of RT exercises did not induce any changes in FS. On the contrary, differences in RPE were observed with the SSSC protocol being the least acutely strenuous, followed by the FSSC and DYN methods (F=19.22, P < .0001). Of all four types used in this study, ISOM seemed to induce the highest RPE score, though RPEs remained relatively low across the utilised

<table>
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<th>Table 3. Follow up rate of perceived excision (RPE) and feeling scale (FS) data, between-condition effect sizes and ANOVA (P).</th>
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<tr>
<td>SSSC</td>
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<td>Performance Test</td>
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<td>RPE</td>
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Notes: Values are expressed as means and standard deviations (SD); DYN = dynamic strength protocol; ISOM = isometric strength protocol; SSSC = slow stretch-shortening cycle; FSSC = fast stretch-shortening cycle, Diff: difference, RPE: Rate of perceived exertion, FS: Feeling scale.
The results of the analyses can be viewed in Tables 3 and 4. The execution of different types of RT exercises did not induce any changes in FS. On the contrary, differences in RPE were observed with the SSSC protocol being the least acutely strenuous, followed by the FSSC and DYN methods (F=19.22, P <0.0001). Of all four types used in this study, ISOM seemed to induce the highest RPE score, though these still remained relatively low across the utilised 10-point scale.

**Post hoc analysis**

Specific to post hoc analysis, results are detailed in Table 4. The execution of different types of RT exercises did not induce changes in FS. Of all four types used in this study, ISOM seemed to induce the highest RPE score (P<0.001, d = -2.01), though these remained relatively low across the 10-point scale.

**DISCUSSION**

To the best of our knowledge, this is the first study to investigate the acute effects of different types of RT exercise on psychometric status (RPE) and affective state (FS) in prepubertal weightlifters. The main findings indicate no significant differences between any of the applied conditions on FS. On the contrary, of the significant differences between conditions, higher RPE score were noted for DYN over SSSC, ISOM over SSSC and ISOM over FSSC interventions. In the case of each of these comparisons, large to very large effect sizes were observed, with ISOM being the most strenuous, followed by DYN, FSSC and SSSC in that order. Of all four types used in this study, ISOM induced the highest RPE score, though these still remained relatively low across the 10-point scale.

The significant differences in RPE seen in the current study indicate that variable levels of strain are seen across the four exercise types with ISOM being the most strenuous, potentially due to the increased metabolic demand associated with a greater time under tension; a common characteristic of isometric training (Lee et al., 2015). Our results indicate that the least strenuous exercise, from a psychometric perspective, seemed to be SSSC.
with that exercise type yielding the lowest RPE score. This is an interesting finding for coaches who may want to manipulate the desired intensity of a RT session to meet the needs of an athlete on a given day or, indeed, to address the demands imposed by an athlete’s sport of choice. In terms of preserving an athlete’s condition, it could be argued that SSSC could be a suitable exercise to undertake during times of increased training stress when lower intensity exercises, from an athlete’s perceptive point of view, could be prescribed to minimise fatigue and overtraining. The same could be argued of FSSC which was less strenuous than both ISOM and DYN.

Despite our results, these findings contrast with those of Abbes et al. (2018) who found that RPE values did not differ between SSSC conditions, suggesting that one’s perception of exercise difficulty was not dependent on the applied condition and did not seem to exert an impact on post-effort RPE in adolescent swimmers. Similar 50-m HR values were observed for the different conditions in that study indicating that differences between athletic populations could affect how RPE can be interpreted, thus reducing the generalizability of the results of studies in sport-specific populations. On the contrary, the findings of Peñaillillo et al. (2017) are in agreement with our own in that these authors found that perceived exertion was lower during FSSC, compared with SSSC activity. Similarly, we found FSSC to be less strenuous than DYN, a result that could be explained by the potential of the young weightlifters in our study to have a well-developed stretch-shortening cycle capability, indicating a higher tolerance to the rigours associated with rapid FSSC exercise (Briedgeman et al., 2017). Such a development could be attributed to the nature of the training effect that is yielded from regular engagement in weightlifting activity with adaptations being specific to the type of applied training stimulus (Behm and Colado, 2012; Vissing et al., 2008).

Further to the results with regard to RPE, irrespective of the type of RT modality, our findings showed no significant differences in affective prevalence (FS) between any of the applied conditions. To the authors’ knowledge, this is the first study that has examined the acute effects of different plyometric and strength exercise modalities on FS. The present data demonstrate that feelings of pleasure were not significantly different after any of the exercise conditions. This seems to indicate that whilst these training types may exert a physical cost on the athlete, the effect on emotional state, at least after isolated acute bouts of activity, is minimal. This is an interesting finding given that RT has been previously shown to have value over traditional exercise, such as standard physical education classes, as it can enhance self-concept in adolescents (Velez et al., 2010). In this way, a long-term study that moves beyond the restraints of mere acute measurements, as in the current work, could shed more light on this particular issue. It is also interesting to note that a recent meta-analysis indicated that RT seems to be more beneficial for those with a mental illness than it is for those without one (Gordon et al., 2018). As the current cohort did not suffer from mental health difficulties, the efficacy of RT in improving affective state could be undermined. The absence of any significant differences in FS, means that use of plyometric and strength exercise during weightlifting training could be an effective stimulus for valence, regardless of exercise type. Unfortunately, very little information has been published on this topic in youth, preventing us from contextualising our results against the bulk of the literature on RT. Relatedly, in a recent meta-analysis, Gordon et al. (2018) outlined some concerning gaps in the body of literature that prevent RT being used to its full potential by coaches. For example, the meta-analysis included only two studies in youths under the age of 18 years (Lau et al., 2004, Goldfield et al., 2015), demonstrating the lack of investigations carried out in this population.

Though there is a lack of studies with which to compare our results, Fessi and al. (2016) noted the absence of any significant differences in FS in relation to physical, technical and tactical training during an in-season period in professional soccer players. Another investigation, by Ekkekakis et al. (2011), reported a negative relationship between exercise intensity and feelings of pleasure, suggesting that exercise intensities above the ventilatory threshold (close to respiratory compensation point) generated feelings of displeasure. Together, these findings could indicate that training, of any type, above a certain intensity, could result in negative outcomes in terms of preventing the trainee leveraging the endorphins associated with exercise (Theron et al., 1990).

This study is not without limitations. First, we are conscious that the findings reported in this study are based on a relatively small sample size. Therefore, future studies are needed with a larger cohort of youth athletes. Also, the cross-sectional, short-term nature of the study does not reveal how the reported metrics could change over time in a study that spanned the duration of an entire training programme or sport season. In this way, readers are encouraged to
differentiate between the acute and chronic effects of different forms of RT. Despite these limitations, the inclusion of trained, prepubertal weightlifters can be considered a strength of this study and we consider this work a valuable addition to the very small body of literature on this specific topic.

CONCLUSION

The execution of different types of RT exercises did not induce changes on subsequent affective state (FS) in prepubertal weightlifters. On the contrary, differences in RPE score were observed with the SSSC protocol being the least acutely strenuous, followed by the FSSC and DYN methods. Of all four types used in this study, ISOM seemed to induce the highest RPE score, though these remained relatively low across the 10-point scale. Accordingly, coaches and strength and conditioning professional, can manipulate training activities based on the status of the athlete and the potential physical strain that is associated with each exercise type. Further longitudinal research is needed to assess more advanced RT types (i.e. elastic bands and surface instability) to reveal further relationships between training and affective prevalence and psychometric status in youth weightlifters.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The study was conducted according to the latest version of the Declaration of Helsinki and the protocol was fully approved by the Local Ethics Committee of the National Centre of Medicine and Science of Sports of Tunis (CNMSS) before the commencement of the assessments. Written informed consent to participate in this study was provided by the participants’ legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

HW, RH, HR, MS participated in the conception and design of the study. HW, RH, MS, WS, and HR were responsible for testing. DS, JM, and RH were responsible for data collection and statistical analysis. HW, RH, MS, JM, WS, DS, UG, and HR were responsible for the writing and finalization of the manuscript. All authors contributed to the manuscript and approved the submitted version.

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CONFLICT OF INTEREST

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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