International Journal of Strength and Conditioning

Hanen, W., Hammami, R., Selmi, W., Selmi, M. A., Sekulic, D., Rebai, H., Granacher, U., Morna, J. (2022).Do Acute Bouts of Resistance Training Influence the Psychometric Status and Affective State of Prepubertal Weightlifters?
International Journal of Strength and Conditioning
https://doi.org/10.47206/ijsc.v2i1.111

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

Werfelli Hanen*[1,2], Raouf Hammami*[1,2], Walid Selmi[1,2], Mohamed Amine Selmi[3], Damir Sekulic[4], Haithem Rebai*[2], Urs Granacher*[5] & Jason Moran*[6]

[1]Higher Institute of Sport and Physical Education of Ksar-Said, University of La Manouba, Tunis, Tunisia, [2]Research Laboratory: Education, Motor Skills, Sports and Health (EM2S, UR15JS01), Higher Institute of Sport and Physical Education of Sfax, University of Sfax, Sfax, Tunisia, [3]Tunisian Research Laboratory "Sport Performance Optimisation" – National Centre of Medicine and Science in Sport (CNMSS) – El Menzah, Tunisia, [4]Faculty of Kinesiology, University of Split, Split, Croatia, [5]Division of Training and Movement Sciences, University of Potsdam, Potsdam, Germany, [6]School of Sport, Rehabilitation and Exercise Sciences, University of Essex, Colchester, United Kingdom.

**Denotes equal contribution*

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 diffulty 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 seperate 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 al., 2015). This can differ across individuals with the asscociated 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 perspecitves (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 weighlifters is currently lacking, meaning that further investgations 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 ourknowledge, 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, Durguerian 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 emanatesfrom the lack of knowledge about the acute effects of different RT types onp sychometric 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 standardised 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, Florhman 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 measure dusing 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, bipolarscale, which was isused 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).

STATISTICAL ANALYSES

Data are presented as means and standard deviations (SD) and normality was assessed and confirmed using the Shapiro-Wilk test. Equality of variances was determined by Levene's test. Differences between the varying conditions (condition: SSSC, FSSC, ISOM and DYN) were determined with a one-way ANOVA, and post hoc comparisons were calculated using the Tukey-HSD test for post-hoc analyses. Effect sizes were reported with Cohen's d. In accordance with Hopkins et al. (2002), ES were considered to be either 'trivial' (<0.2) 'small' (>0.2-0.6), 'moderate' (>0.6-1.2), 'large' (>1.2-2), or 'very large' (>2). Test re-test reliability of the variables was assessed using Cronbach's model of ICCs and SEMs according to the method of Hopkins (2002). The level of significance was set at $P < 0.05$. The statistical analysis was carried out using IBM SPSS (version 25) and R (R Core Team (2018).

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 an 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 2. Test-retest reliability of variables.

	ICC3.1 (95% CI)	SEM	CV (%)
RPE	0.92 (0.81-0.96)	2.17	1.52
FS	0.91 (0.85-0.94)	3.66	3.18

ICC = Intraclass correlation coefficient; SEM = standard error of measurements; CV (%) = coefficient of variation percent, RPE= rate of perceived exercion; FS: feeling scale.

The results of the analyses can beviewed 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 RPEs remained relatively low across the utililised

Table 3. Follow up rate of perceived excision (RPE) and feeling scale (FS) data, between-condition effect sizes and ANOVA (P).

	SSSC	DYN	ISOM	FSSC	Sum of Squares	Diff	Mean Squares	F	P
Performance Test	Follow-up (SD)	Follow-up (SD)	Follow-up (SD)	Follow-up (SD)					
RPE	2.25 (0.68)	3.63 (0.96)	4.19 (1.17)	2.31 (0.60)	44.813	3.000	14.938	19.223	< .001
FS	4.19 (0.83)	4.44 (0.71)	4.31 (0.73)	4.13 (0.81)	0.922	3.000	0.307	0.158	0.671

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 perceivedexertion, FS: Feeling scale.

Table 4. Acute effects of four different types of strength exercises (i.e., SSSC, DYN, FSSC and ISOM) on measures of rate of perceived exertion and feeling scale in youth weightlifters athletes.

Intervention	Mean Difference	SE	t	Cohen's d	p_{tukey}	
RPE						
SSSC	DYN	-1.37	0.31	-4.41	-1.65	< .001
	FSSC	-0.06	0.31	-0.20	-0.09	0.99
	ISOM	-1.93	0.31	-6.31	-2.02	< .001
DYN	FSSC	1.31	0.31	4.21	1.64	< .001
	ISOM	-0.56	0.31	-1.80	-0.52	0.28
FSSC	ISOM	-1.87	0.31	-6.01	-2.01	< .001
FS	Mean Difference	SE	t	Cohen's d	p_{tukey}	
SSSC	DYN	-0.25	0.27	0.91	-0.31	0.79
	FSSC	0.06	0.27	0.23	0.76	0.99
	ISOM	-0.12	0.27	-0.45	-0.16	0.96
DYN	FSSC	0.31	0.27	1.14	0.40	0.96
	ISOM	0.12	0.27	0.45	0.17	0.96
FSSC	ISOM	-0.18	0.27	-0.68	-0.24	0.90

Note. DYN = dynamic strength protocol; ISOM = isometric strength protocol; SSSC = slow stretch-shortening cycle; FSSC = fast stretch-shortening cycle, RPE: rate of perceive dexertion, FS: Feeling scale. SE : standard error.

10-point scale.

One way-ANOVA analysis

The results of the analyses can beviewed 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 RPEs remained relatively low across the utililised 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 notinduce 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 signficiant 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 charachteristic 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 percpetive point of view, could be prescribed to minimse 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 generalizabilty of the results of studies in sport-specific populations. On the contrary, the findings of Peñailillo 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-shrotening 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 currentwork, 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 efficiacy 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 contextualizing 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) noated 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 ovee 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.

FUNDING

The authors acknowledge the support of the Deutsche Forschungsgemeinschaft (DFG) and Open Access Publishing Fund of the University of Potsdam, Germany.

ACKNOWLEDGMENTS

We would like to thank the participants and the research assistants involved in the data collection.

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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