Original article

Control of the velocity loss through the scale of perceived effort in bench press

Daniel Varela-Olalla[1], Juan del Campo-Vecino[1], José M García-García[2]

[1]Universidad Autónoma de Madrid. [2]Universidad de Castilla-La Mancha. Grupo de Investigación Akanthos.

Received: 17.04.2018
Accepted: 12.09.2018

Summary

Controlling the training variables is vital to ensure the desired adaptations in resistance training; intensity is the most important variable to improve maximum strength and rate of force development (RFD). The movement velocity has shown to be the best variable to monitor the intensity of resistance training, in particular the velocity loss related to fatigue. However, there are material impediments to use this variable. Therefore, the aim of this paper is to analyze the relationship between RPE and velocity losses as an alternative to control training. Sample included 5 subjects (4 men and 1 woman) from the Spanish Olympic Wrestling team who performed a total of 15 sets of bench press (3 set/subject), of which only 14 were included in the statistical analysis for breaching one of them the protocol, with 3 different relative loads (5 set/load) and a velocity loss between 20%-32%. The dependent variables were: RPE, the velocity loss, the number of repetitions performed in each set and the velocity of the best repetition of each set. The correlations between the RPE-velocity loss; RPE-number of repetitions; and RPE-velocity best repetition variables were analyzed, obtaining only significant correlation (r Pearson 0.843, P <0.001) between the RPE and the velocity loss; correlations between RPE-number of repetitions; and RPE-velocity best repetition did not show statistical significance . The results of the present work could indicate the possibility of managing fatigue and controlling training intensity using the RPE-velocity loss relationship, although it is necessary to carry out similar studies with larger sample sizes that reinforce the results of this study.

Key words:
Resistance training.
Bench press. RPE.
Monitoring. Movement velocity.

Control de la pérdida de velocidad a través de la escala de esfuerzo percibido en *press* de banca

Resumen

Controlar las variables de entrenamiento es vital para garantizar las adaptaciones deseadas en el entrenamiento de fuerza, siendo la intensidad especialmente importante para mejorar la fuerza máxima y el RFD. La velocidad de ejecución ha resultado ser la mejor variable para monitorizar la intensidad del entrenamiento de fuerza, en particular las pérdidas de velocidad relacionadas con la fatiga. Sin embargo, existen impedimentos materiales para poder utilizar esta variable. Por tanto, el objetivo de este trabajo es analizar la relación entre el RPE y las pérdidas de velocidad como alternativa para controlar el entrenamiento. Se midió a 5 sujetos (4 hombres y 1 mujer) pertenecientes a la selección española de lucha libre olímpica un total de 15 series de *press* de banca (3 series/sujeto), de las cuales solo 14 se incluyeron en el análisis estadístico por incumplir una de ellas el protocolo, con 3 cargas relativas distintas (5 series/carga) y una pérdida de velocidad entre 20%-32%. Las variables dependientes fueron: RPE, la pérdida de velocidad, el número de repeticiones realizadas en cada serie y velocidad de la mejor repetición de cada serie. Se analizaron las correlaciones entre las variables RPE-pérdida de velocidad; RPE-número de repeticiones; RPE-velocidad mejor repetición, obteniéndose solamente correlación significativa (r Pearson 0,843; P <0,001) entre el RPE y la pérdida de velocidad; la correlaciones entre el RPE-número de repeticiones y RPE-velocidad mejor repetición no mostraron significación estadística. Estos resultados podrían indicar la posibilidad de gestionar la fatiga y la intensidad del entrenamiento utilizando la relación RPE-pérdida de velocidad, aunque es necesario llevar a cabo estudios similares con tamaños muestrales mayores que refuercen los resultados obtenidos en este estudio.

Palabras clave:
Entrenamiento de fuerza.
Press de banca. RPE. Monitorización.
Velocidad de ejecución.

Correspondence: Daniel Varela Olalla
E-mail: dvarel23@gmail.com

Introduction

Strength training has been shown to be a key factor in improving health, physical appearance and sport performance[1-4]. It is essential to control the training variables in order to optimise the results[5] and, more specifically, training intensity appears to be the most important factor in improving maximum strength[6-9] and the RFD[7,8,10,11], considered to be the most determining factor in sport performance[4,12,13]. Although strength training intensity was traditionally prescribed according to the repetition maximum (RM) percentage or the maximum number of repetitions that a subject is able to perform with a load[5,14,15], over the last few years velocity of execution has been proposed as a more precise, reliable and safe alternative for the control of intensity[16-18]. A specific load (%RM)-velocity relationship has been demonstrated for different exercises, according to which each load is closely related to the maximum velocity at which it can be lifted[16-21]. On the other hand, it has been demonstrated that training up to muscle failure is unnecessary and is less beneficial than training at a far lower capacity than muscle failure for sport performance[22-25], having a particularly negative effect on the RFD[12]. A loss of velocity pattern was observed in relation to the maximum possible velocity during a set to failure in which the last repetition coincided with the RM velocity[26]. On the other hand, a linear relationship was described between the loss of velocity and lactate concentrations, as well as a non-linear relationship with ammonium concentrations, regardless of the number of repetitions made[27]. Recently it has been shown how, when comparing the effects of training protocols that differed in the total amount of work performed based on the velocity loss % during the set, the following was obtained: 1) improvements of more than $_1$RM and in execution velocity in trained subjects when compared to velocity losses of 20% in relation to training to muscle failure[28]; and 2) greater improvements in CMJ and smaller decreases in the percentage of myosin heavy chains (MHC-IIX), with similar improvements in maximum strength when comparing velocity losses of 20% in relation to 40%[29].

In view of the above, the velocity of execution was considered to be the most suitable variable to prescribe the intensity and monitor fatigue during strength training.

A number of devices are available to precisely and reliably control the velocity of execution, such as linear transducers, accelerometers or video analysis systems[30-32]. However these are relatively expensive and are still not accessible to all users. As an alternative, a mobile iPhone application (more affordable) was recently validated as a reliable and valid tool for measuring the velocity of execution[33]. Despite the fact that the means of monitoring the velocity of execution are becoming increasingly more accessible and affordable, other disadvantages still exist. For example, in order to monitor large groups of athletes in a number of different exercises, various devices would be necessary. All this means that we need to continue to seek reliable, valid alternatives to monitor strength training.

Another method to assess and monitor the strength training load are the subjective rating of perceived exertion scales (RPE)[34-37], based on the psychophysiological response of the body, whereby the information on physiological or environmental changes comes from the sensory perception of the individual, causing a subjective perception for a specific stimulus[38]. The scales commonly used to rate the perception of exertion are the Borg 6 to 20 scales and the 0 to 10 scale[38] , these were followed by the OMNI-RES scale from 0 to 10 which is accompanied by pictograms to make it easier for the subject to interpret exertion[39]. The RPE has been shown to be useful to predict the %RM or the 1RM[35-37], a number of studies have also found correlations between the RPE, the %RM, the velocity of execution[34,40-43], and mechanical power[44]. Finally, a speed perception scale has been developed, which has demonstrated its validity for the bench press and for the squat[44,45].

Therefore, the RPE has been shown to be a useful alternative to the traditional methods to control the intensity of strength training when more precise means cannot be used to measure of the velocity of execution.

Hypothesis

To the best of our knowledge, there are no investigations that have related RPE with loss of velocity during strength training. Based on the aforementioned existing evidence on the relationship between the RPE values and the velocity of execution; the relationship existing between metabolic markers for internal load (lactate and ammonium concentrations) and the losses of velocity during strength training[27]; and the validity of the RPE as a psychophysiological indicator[38] to relate the external load and internal load, we could think that there is a relationship between the losses of velocity and the RPE which would allow us to monitor fatigue when no suitable technological resources are available to do so.

Objective

The objective of this work is to analyse the relationship between the velocity losses and the RPE perceived by subjects during the bench press exercise.

Material and method

Sample

The sample comprised 5 subjects (23.2±5.3 years; 169.2±6.9 cm; 72.2±17.8 kg) (4 male (23±6 years; 171.3±6 cm; 75.3±19 kg) and 1 female (24 years; 161 cm; 60 kg) who are part of the Spanish Olympic wrestling team, selected incidentally. The subjects had at least 1 year's experience in strength training and they had been involved in a training routine that included 2 strength training sessions a week at least for the last 6 months. Table 1 provides a description of the characteristics of the total sample. Prior to the investigation, the participants signed an informed consent form, informing them of the procedures, risks and benefits of the investigation. The study protocol complies with the provisions of the Declaration of Helsinki for research involving human subjects.

Table 1. Characteristics of the sample expressed as a mean ± standard deviation.

Age	Height (years) (cm)	Weight (kg)	Prior RM (kg)	Estimated RM (kg)
23.2 ± 5.3	169.2 ± 6.9	72.2 ± 17.8	101.5 ± 31.8	106.7 ± 35.4

RM: repetition maximum.

Protocol

The subjects performed 3 bench press sets, each with a different load based on the average velocity (load 1→ ≈1-1.1 m/s; load 2→ ≈0.75-0.85 m/s; load 3→ ≈0.53-0.61 m/s) based on the data previously presented in the literature[21] in order to adapt the relative load between 40-45%RM for $load_1$, between 55-60%RM for $load_2$, and between 70-75%RM for $load_3$. In the first set (1-1.1 m/s) the subjects made repetitions until, in two repetitions, they reached a velocity of 8 m/s (velocity loss of 20%-27.3%) or less; in the second set (0.75-0.85 m/s) until, in two repetitions, they reached a velocity of 0.6 (velocity loss 22.1%-29.4%); and in the third set (0.53-0.61 m/s) until, in two repetitions, they reached a velocity of 0.42 m/s (velocity loss 20.7%-31.1%) or until a repetition achieved a velocity of 0.37 m/s (velocity loss 30.1%-39.3%) or less. After each set, the subjects rated the RPE with a value of between 0-10 using the OMNI-RES scale. Prior to the data collection, all subjects performed at least 4 bench press training sessions to become familiar with the OMNI-RES scale (Figure 1), giving their subjective perception of effort (0-10) after each set.

Material

The bench press exercise was conducted on a free weight bench. The bar weighed 20 kg without plates. To determine the average velocity, a linear transducer (EV PRO Dynamic Isocontrol 5.2 Quasar Control S.L. Madrid) with a sampling frequency of 1000Hz connected to the bar by a cable and by USB to a laptop, which recorded the data in real time (Figure 2).

Figure 1. OMNI-RES scale developed by Robertson et al. (2003).

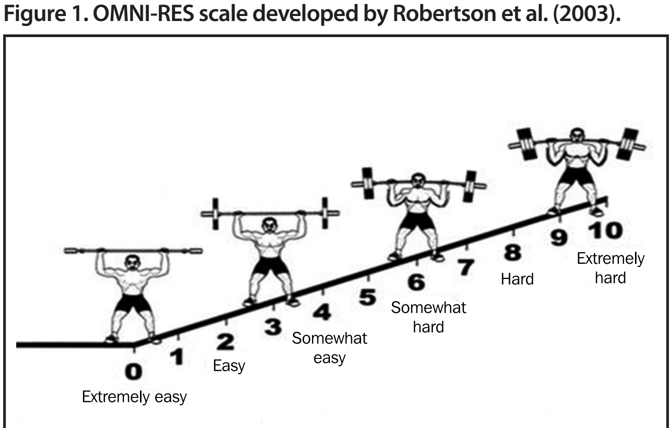


Figure 2. A. Connection between the bar and the linear transducer; B. Linear transducer; C. Laptop.

Statistical analysis

Firstly, the Shapiro-Wilk test was performed in order to determine the distribution normality of the values of the variables. The next step was to study the degree of correlation of the variables (RPE-loss of velocity; RPE-number of repetitions; RPE-best repetition velocity) through Pearson' correlation test and, more specifically, we studied the relationship of RPE-loss of velocity through a quadratic regression. For the data processing, statistical analysis software was used (SPSS v.23, SPSS Inc., Chicago, Illinois, USA). The statistical significance cutoff was set at $p < 0.05$.

Results

The data analysis was made on 14 bench press sets, given that one of the sets did not comply with the established protocol. The kinematic variables ("loss of velocity" and "best repetition velocity") in relation to the repetitions analysed, showed a normal distribution.

Correlations between variables

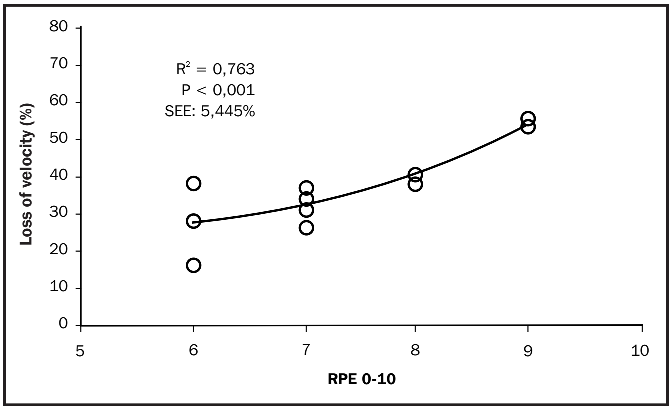
Table 2 shows the results for the relationships RPE-loss of velocity, RPE-number of repetitions, and RPE-best repetition velocity, analysed through Pearson's correlation.

Table 2. Pearson's correlations between RPE-velocity loss, RPE-number repetitions, RPE-best repetition velocity.

	Velocity loss		Number repetitions		Velocity best repetition	
	r	P	r	P	r	P
RPE	0.843	<0.001	-0.317	0.27	-0.463	0.096

RPE: rating of perceived exertions.

Figure 3. Relationship between the RPE and the loss of velocity derived from the 14 set measured on the bench press.



RPE-loss of velocity

Figure 3 shows the quadratic regression for the relationship RPE-loss of velocity. This regression has given the following predictive equation for the loss of velocity through RPE: loss of velocity (%) = $2.294RPE^2$ - 25.68RPE + 99.29.

Discussion

To the best of our knowledge, this is the first study to analyse the relationship between velocity losses during a strength training set and the RPE. The objective of this work was, therefore, to analyse the relationship between the velocity loss and the RPE during the bench press exercise. The principal results of the study show how, considering all the variables analysed, only the relationship between loss of velocity-RPE was significant (Table 2). Moreover, it should be emphasised that this relationship shows a non-linear trend (Figure 3).

The results obtained can be related to prior studies which demonstrated the validity of the RPE based on the RIR of the subjects[43]; and, on the other hand, the relationship between the loss of velocity and the number of repetitions made in relation to the maximum possible number (muscle failure)[26,27]. Taking account of the fact that the RIR concept refers to the number of repetitions that subjects perceive that they could do until failure, these investigations show the relationship of the RIR with both the RPE and also with the loss of velocity. It therefore seems logical to think that there is also a relationship between RPE-loss of velocity, as shown by the results of this study.

The fact that no significant relationships were found between the RPE and the total number of repetitions, nor between the RPE and the velocity of the best repetition in the set (relative load marker), is in line with the results of Lodo *et al.*[46] who demonstrated that, when training with different relative intensities (%RM), but with the same total volume load, similar RPE values are obtained. However, our results are not in line with prior studies that have found higher RPE values when making fewer repetitions with high intensities than for more repetitions with low intensities[35]; and, on the other hand, when comparing strength training in circuits with high loads to strength training in a circuit directed at power training with light, moderate loads, it has been seen how the RPE is higher for strength training with high loads[47]. However, in these two studies, no comparison was made with the total load volume, nor the number of repetitions to muscle failure among the protocols analysed. This may explain the differences with our results, where the total load was controlled through the loss of velocity, which is related to metabolic markers and fatigue mechanics[27].

Of particular interest is the fact that velocity losses of between 30-35% have been found almost systematically at an RPE value of 7 (Figure 3). Sánchez-Medina and González-Badillo[27] found how velocity losses close to 35% on the bench press were reached after doing half the repetitions plus two, in relation to the maximum possible number, and at this point the ammonium concentrations started to rise above baseline levels. These authors recommend not to exceed the said velocity losses and even to stop the set before reaching this point, finding in subsequent studies that velocity losses of 20% are greater than velocity losses of 40% or training to failure[28,29]. Therefore, the limit could be established in RPE 7 to cut off the sets when this bench press fatigue management method is used.

Conclusions

In conclusion, the results of our study show a relatively high correlation between velocity losses and RPE, independently of the number of repetitions or relative load used. This appears to indicate that bench press fatigue can be monitored by RPE when it is not possible to directly measure the velocity of execution. Moreover, the trend observed in the results, according to which REP 7 is associated with velocity losses of 30-35%, could prove useful for marking the perceived effort limit when making more or less repetitions during a bench press set. Nevertheless, these results must be interpreted with caution, given that they are an initial approximation to the validity of the RPE to control velocity losses. There is a need to continue along this line of investigation, with more robust methodologies and larger samples in order to be in a position to more accurately establish the validity of our proposal.

Study limitations

The principal limitations of this study are as follows:

- The results were obtained with a very small sample.
- The results of the experimental verification have not been replicated with a second data collection.
- The results are only applicable to the bench press exercise. It would be necessary to check the validity of the relationship between loss of velocity-RPE in different exercises.
- Due to the small size of the sample, no analysis was made of possible differences between subjects for the RPE values associated with loss of velocity.

Future lines of investigation

This work shows signs of the possible validity of RPE as a useful tool to control velocity losses during strength training. Due to the limitations of this work, our analysis should be replicated with larger samples, for different exercises and analysing the possible differences between subjects for the same exercise.

Conflict of interest

The authors have no conflict of interest whatsoever.

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