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## **A Single Session of Testing for One Repetition Maximum (1RM) with Eight Exercises is Trustworthy**

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### **ABSTRACT**

**Campanholi Neto J, Cedin L, Dato CC, Bertucci DR, Perez SEA, Baldissera V.** A Single Session of Testing for One Repetition Maximum (1RM) with Eight Exercises is Trustworthy. **JEPonline** 2015;18(3):74-80. Although the 1RM test is used as the gold standard for assessing muscle strength in non-laboratory situations, the question is this: "Are the 1RM values performed in a single exercise session with 8 exercises trustworthy?" Sixteen male subjects (mean  $\pm$  SEM: age  $27.3 \pm 1.0$  yrs; height,  $179.1 \pm 1.8$  cm; body mass,  $89.3 \pm 2.9$  kg; body mass index  $27.8 \pm 0.6$  kg·m<sup>-2</sup>; and fat percentage  $18.7 \pm 1.5\%$ ) participated in this study. They completed two 1RM test sessions with 8 exercises. Session one (T-1RM): leg press, bench press, squat, front pulldown, leg curl machine, pushdown on a cable machine, leg extension machine, biceps barbell curl. Session two (RT-1RM) inverse order of the exercises was used, starting with the weight of 1RM found on the first test (T-1RM). Six blood samples were collected to analyze blood lactate concentration. The results of this study demonstrated the reliability of 1RM test in a single session with 8 exercises. A high intraclass correlation coefficient was also found (ranging from 0.911 to 0.993). The findings indicate that a single 1RM test session with 8 exercises is a reliable test without the need for a second session to confirm the previous values.

**Key Words:** Resistance Training, Lactic Acid, Training Intensity

## INTRODUCTION

Among the modalities of physical exercise, resistance training (RT) is an integral component of an exercise program. Whether it is the resistance generated by one's own body weight or equipment such as dumbbells and/or specific machines, there is an inverse relationship between the amount of weight lifted and the number of repetitions (9). The strength training literature is often based on a percentage of one repetition maximum (1RM) in order to define the intensity of training by exercise physiologists, rehabilitation specialists, and strength coaches (1,16). Changes in the RT intensity of exercise can be used to improve muscular endurance, hypertrophy, strength, and muscle power (1,20). Moreover, it is considered the gold standard for assessing muscle strength in non-laboratory situations (8,15).

Nevertheless, the practice of one repetition maximum test (T-1RM) is still of little use by fitness professionals, athletic trainers, and strength coaches. Protocols consist of only one exercise per day or made in different times and intervals higher than 24 hrs in order to avoid a possible neural fatigue (4,10). Thus, the practice of T-1RM can be an unviable strategy for strength coaches and other fitness professionals. However, the values found in T-1RM are of fundamental importance to determining the zones of intensity in RT (1,2).

Other forms of obtaining 1RM using prediction equations aimed at estimating maximal strength were utilized in other works, but to determine, with efficiency, the intensity of the exercise it is necessary to use T-1RM instead of prediction equations (12,17). However, the question is this: "Are the 1RM values realized in only one session with 8 exercises trustworthy?" For reliability purposes, the current study tested the validity of 1RM Test while also analyzing the subjects' Blood Lactate Concentration (BLC) during a single session with 8 exercises.

## METHODS

### Subjects

Sixteen healthy, male subjects (mean  $\pm$  SEM: age  $26.9 \pm 1.0$  yrs; height,  $179.1 \pm 1.9$  cm; body mass,  $89.0 \pm 3.1$  kg; body mass index  $27.7 \pm 0.6$  kg·m<sup>-2</sup>; body fat percentage  $18.7 \pm 1.7\%$ ) provided informed consent to take part in the study. Exclusion criteria were: (a) not practicing RT in the last 3 months at a minimum frequency of 3 d·wk<sup>-1</sup>; and (b) use of any nutritional and/or pharmacological ergogenic aids. All subjects were considered able in the Physical Activity Readiness Questionnaire PAR-Q (18). The study was conducted according to the declaration of Helsinki, and ethical approval was granted by the ethics committee of the Federal University of São Carlos, São Paulo, Brazil (CEP/UFSCar n° 434.096 - 15/10/2013).

### Procedures

The study was performed in three separate days, with minimum 72 hrs and maximum 120 hrs rest between them. On the first day the subjects were assessed for height, weight, and body fat percent based on skinfold (14). Also, for food intake supervision, three 24-hr recordatories (R24hs) were made (5). Food control was performed to maintain a feeding pattern during the study. T-1RM (second day): each subject was tested in the following order: leg press 45°, smith machine bench press, smith machine half-squat, front pulldown, leg curl, elbow extension, leg extension, and biceps barbell curl.

Retest session (RT-1RM) took place on the third day. An inverse order of the exercises was used, starting with the weight of 1RM found on the first test (T-1RM). The reverse order was chosen to minimize the possible fatigue in the last exercises performed during T-1RM.

### One-Repetition Maximum Test

Each 1RM test session was preceded by a dynamic warm-up of 3 min of light cycling on a stationary bike at 75 W with 65 to 70 rev·min<sup>-1</sup> (Ergo Fit 167, Version 1.27, Ergo Fit, Partner Ihrer Gesundheit®). The starting weight loads were according to the training records of each subject. During each exercise test, if the subject successfully completed the weight loads more than two repetitions, the load was increase. 1RM was defined as the weight load that the subject could successfully raise before the last weight load that he could not raise. Five minutes of rest between each attempt and 2 min between exercise were allowed, as this has been shown to be adequate for phosphocreatine replenishment (4).

### Blood Lactate Concentration (BLC)

During both sessions of 1RM test, six blood samples (25 µL) were collected from the moments: 1 – 5 min before the sessions; 2 – after the second exercise; 3 – after the fourth exercise; 4 – after the sixth exercise; 5 – after the eighth (last) exercise; and 6 – 10 min after the end of the session, using heparinized previously calibrated capillaries (11). BLC was determined by electroenzymatic method with a lactate analyzer (1500 Sport; Yellow Springs Instruments Inc., Yellow Springs, OH), Figures 1 and 2 show the scheme.

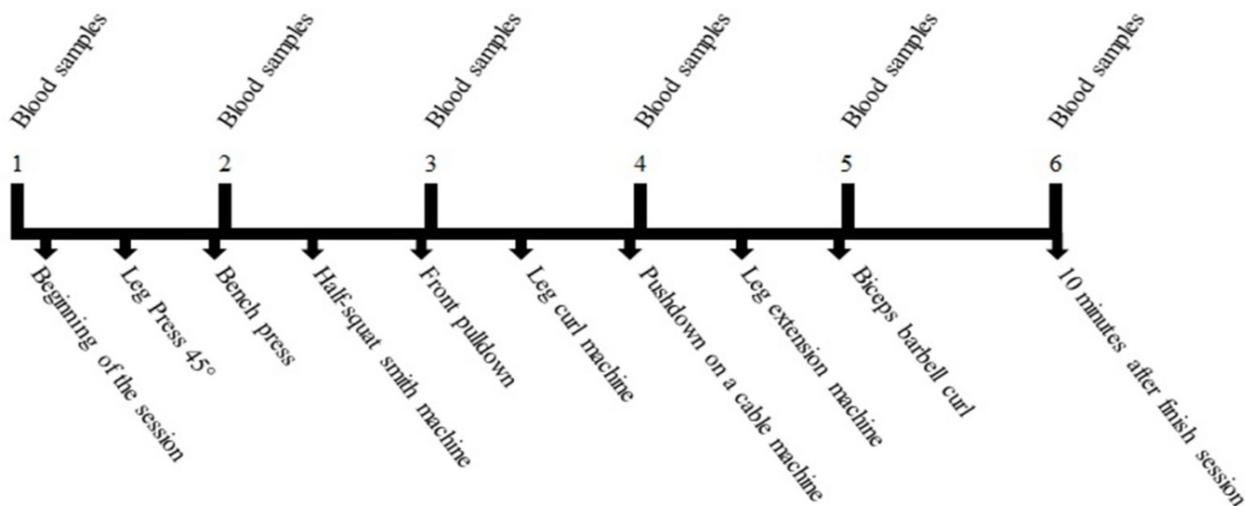


Figure 1. Moments 1 to 6 of Blood Samples in T-1RM and Exercise and Order of Exercises.

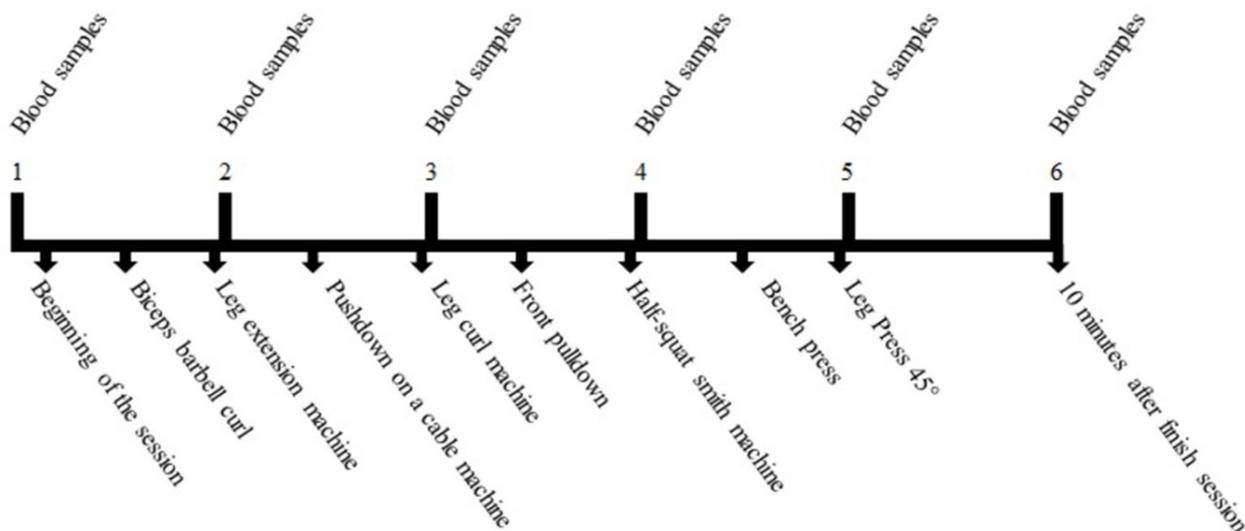


Figure 2. Moments 1 to 6 Blood Samples in RT-1RM and Exercise and Order of Exercises.

## Statistical Analyses

Results are expressed as mean  $\pm$  SEM and confidence interval (CI). Initially, the Kolmogorov-Smirnov ( $P > 0.05$ ) test was used to analyze variable normality. Normality test failed, thus the Mann-Whitney test was performed (22). Intraclass correlation coefficient (ICC; two-way random model, consistency option, single measures) was calculated to analyze the reliability (19). ICC values of 0.80 and higher were interpreted as large reliability (6). In all cases, a probability level of 95% ( $P \leq 0.05$ ) was used for statistical significance. ICC was analyzed using Statistical Package for the Social Sciences (SPSS) version 17, Chicago, USA, 2008 (www.ibm.com) (13). Other tests were analyzed using GraphPad Prism 5.00 for Windows, GraphPad Software, San Diego, CA.

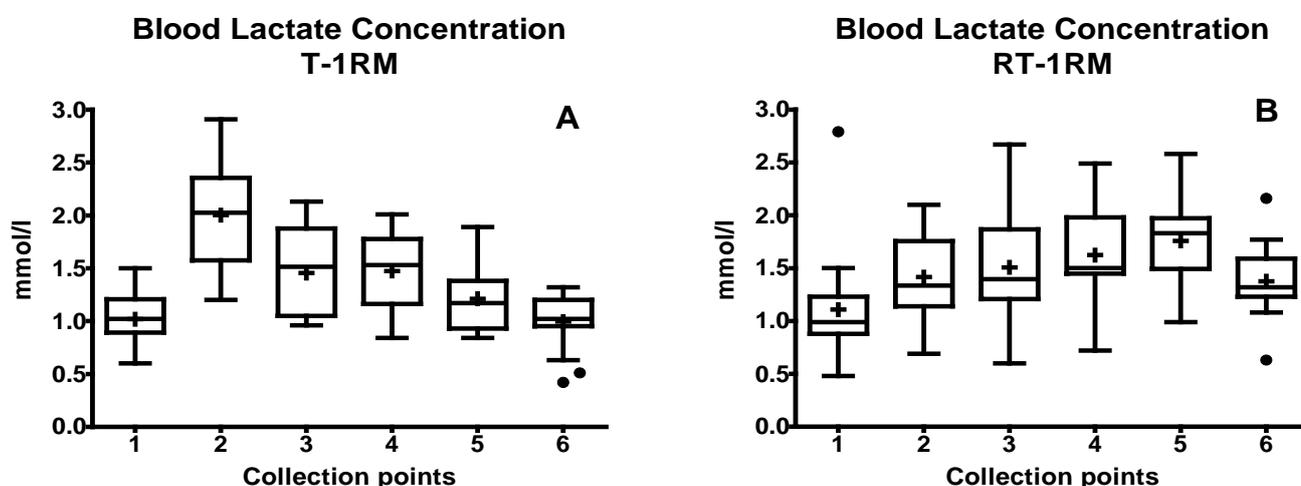
## RESULTS

The 1RM load (kg) for the 8 exercises and the ICC between T-1RM and RT-1RM sessions are presented in Table 1. No statistically significant differences were found for any of the exercises between T-1RM and RT-1RM. The lower ICC presented in the study was 0.9111 for half-squat exercise, demonstrated a large reliability between tests. Figure 3 show low levels in BLC and variation during Sessions T-1RM and RT-1RM.

**Table 1. 1RM Results in T-1RM and RT-1RM.**

Exercises	T-1RM (kg)		RT-1RM (kg)		P	ICC
	$\bar{x} \pm \text{SEM}$	CI	$\bar{x} \pm \text{SEM}$	CI		
Leg Press 45°	416.3 $\pm$ 13.2 <sup>1st</sup>	388.2 to 444.4	418.5 $\pm$ 11.9 <sup>8th</sup>	393.1 to 443.9	0.9698	0.963
Bench Press	109.3 $\pm$ 4.3 <sup>2nd</sup>	100.2 to 118.4	107.7 $\pm$ 3.9 <sup>7th</sup>	99.3 to 116.0	0.8026	0.967
Half-Squat	141.8 $\pm$ 4.1 <sup>3rd</sup>	132.9 to 150.6	143.3 $\pm$ 4.2 <sup>6th</sup>	134.4 to 152.2	0.7894	0.911
Front Pulldown	94.1 $\pm$ 1.9 <sup>4th</sup>	90.0 to 98.1	94.4 $\pm$ 2.0 <sup>5th</sup>	90.0 to 98.7	0.8603	0.933
Leg Curl	76.4 $\pm$ 2.7 <sup>5th</sup>	70.6 to 82.3	76.8 $\pm$ 2.6 <sup>4th</sup>	71.2 to 82.3	0.9697	0.993
Pushdown	44.7 $\pm$ 2.0 <sup>6th</sup>	40.5 to 48.9	46.8 $\pm$ 2.2 <sup>3rd</sup>	42.1 to 51.4	0.4806	0.956
Leg Extension	102.2 $\pm$ 3.5 <sup>7th</sup>	94.8 to 109.6	104.8 $\pm$ 3.8 <sup>2nd</sup>	96.7 to 112.9	0.5433	0.924
Biceps Barbell Curl	53.4 $\pm$ 1.7 <sup>8th</sup>	49.8 to 57.0	55.4 $\pm$ 1.7 <sup>1st</sup>	51.8 to 58.9	0.4597	0.943

n = 16;  $\bar{x}$ : Mean; SEM: Standard Error of the Mean; CI: Confidence Interval; ICC: Intraclass Correlation Coefficient; Superscripts 1<sup>st</sup> to 8<sup>th</sup> Show the Execution Order of Exercises in Both Test Sessions.



**Figure 3. Blood Lactate Concentration during Sessions T-1RM and RT-1RM.** Blood Collection Points (1 to 6, Figures 1 and 2); **A:** T-1RM and **B:** RT-1RM; n = 16; + = mean; • = outliers.

## DISCUSSION

### 1RM Values

One repetition maximum is the object of considerable research, but it is more often than not designed with few exercises (i.e., 2 to 4 per session and, in some cases, the exercises are done on different days (3,12,21). Levinger et al. (15) demonstrated high reliability of 1RM testing on chest press, leg press, lat pull down, triceps push down, knee extension, seated row, and biceps curl in 53 untrained males ( $n = 25$ ) and females ( $n = 28$ ) aged  $51.2 \pm 0.9$  yrs, but all sessions were conducted in the same order of exercises. The results of this study demonstrated high reliability of the 1RM Test in a single session with 8 exercises, (ICC ranged from 0.911 to 0.993). The reverse order of the exercises in RT-1RM allowed for the evaluation of the effect of a possible fatigue (that did not occur) during the last exercises of the T-1RM protocol and during the last exercises during the RT-1RM.

### Blood lactate concentration

Highest BLC was found at Point 2 in T-1RM ( $\bar{x} \pm \text{SEM } 2.0 \pm 0.1 \text{ mmol}\cdot\text{L}^{-1}$ ) and at Point 5 in RT-1RM ( $\bar{x} \pm \text{SEM } 1.8 \pm 0.1 \text{ mmol}\cdot\text{L}^{-1}$ ). Both values are below what is typically found at the lactate threshold (i.e., moment where anaerobic lactic becomes metabolically relevant) in RT in other studies (7,16). Oliveira et al. (16) found BLC at the lactate threshold of  $2.7 \pm 0.3 \text{ mmol}\cdot\text{L}^{-1}$  in the bench press and  $3.8 \pm 0.5 \text{ mmol}\cdot\text{L}^{-1}$  in the leg press at  $45^\circ$ . These data show the possibility of applying T-1RM in a single session without requiring action of glycolytic metabolism during the execution. Also, the test allows for calculating the intensity of RT, which is very important for the participants of a very engaging exercise program.

## CONCLUSIONS

The findings indicate that a single 1RM test session with eight exercises is a reliable test without the need for a second session to confirm the previous values. Thus, it is reasonable to conclude the predominance of ATP-phosphocreatine (PC) energy system during the sessions. This finding should prove helpful in the encouragement of exercise physiologists and others (e.g., athletic trainers, rehabilitation specialists, and strength coaches) to use the 1RM test.

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