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Investigation of the Reliability of Strength Training Intensity Determined on the Basis of One Repetition Maximum Strength Tests

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Abstract In sports practice and science, the intensity control of strength training is frequently based on maximum strength, which is usually determined by the one repetition maximum (1-RM) strength test. However, conducting a 1-RM strength test is somewhat critical because of the high stress on the musculoskeletal system and the high injury risk, especially for sportspersons involved in recreational sport. Furthermore, studies suggest that the 1-RM is inadequate for intensity control. The standard practice of applying percentages of the 1-RM for the deduction of the intensity of strength training may lead to an over- or under exertion of the respective sportsperson. The aim of the present study was to investigate the reliability of determining strength training intensity on the basis of 1-RM strength tests. Twenty-six participants (25.9 ± 3.4 years, 181.2 ± 5.1 cm, 79.4 ± 8.7 kg), with at least one year experience in strength training, completed two study sessions with the exercise long dumbbell bench press. In session one, the 1-RM was determined. In session two, the maximal possible repetitions at 90 % 1-RM were raised. The results showed a relatively high spread of the maximal possible repetitions (CV: 36.2 %), which corresponded with the findings of previous studies. The maximal possible repetitions at a defined training intensity, deduced from the 1-RM, varies not only among several sportspersons, but also between different strength training exercises. Consequently, the 1-RM should not be the basis for intensity control in strength training. Alternatively, multiple repetition maximum (M-RM) strength tests should be used.

Keywords Bench Press, Maximum Strength, Strength Diagnostic, Training Load

1. Introduction

In most intervention studies into strength training, the intensity control is based on the maximum strength of the respective sportsperson [1-3]. The one repetition maximum (1-RM) strength test is established as the gold standard method for determining maximum strength [4, 5]. The 1-RM is defined as the maximal weight, which a sportsperson can lift once with the correct lifting technique [7]. The 1-RM strength test is very reliable [8, 9] and relatively simple as well as a particularly cost-effective method [4, 7].

However, the 1-RM strength test is accompanied by side effects such as high stress for the musculoskeletal system [6] and a high risk for injury [10]. Another serious problem is the inappropriateness of 1-RM for intensity control in strength training as Berschin et al. [11] and Marschall and Fröhlich [12] suggest. Gail and Künzell [13] expect that the classic approach to deduce strength training intensity as a certain percentage of the 1-RM frequently leads to an over- or under exertion of the respective sportsperson.

The aim of the present study was to investigate the reliability of strength training intensity determined on the basis of 1-RM strength tests. A reliable determination of the training intensity is achieved if the number of maximal possible repetitions at a certain percentage of 1-RM is constant for different sportspersons. However, if the number of maximal possible repetitions at a certain percentage of the 1-RM should vary substantially, the reliability of the strength training intensity determined on the basis of 1-RM strength tests is doubtful. According to the consideration of Berschin et al. [11] as well as Marschall and Fröhlich [12], we assume that the use of 1-RM strength tests might result in an over- or under exertion of the individual sportsperson. To verify and confirm this, we consulted a comparatively high training intensity of 90% 1-RM and selected the upper body exercise bench press.

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2. Methods

2.1. Participants

Twenty-six healthy male recreational athletes, without any exercise contraindications, participated voluntarily in this study and gave their written informed consent. The participants had a mean (± standard deviation) age, body height, and body weight of 25.9 ± 3.4 years, 181.2 ± 5.1 cm, and 79.4 ± 8.7 kg, respectively. All participants experienced at least one year of strength training.

2.2. Procedures

All participants completed two study sessions. In the first session we determined the 1-RM. In the second session we collected the maximal possible repetitions at 90% 1-RM. Due to the conditions set by the test device Max Rack® IP-L8505 (Star Trac Inc., Irvine, CA, USA) as well as the available weights, in part slight rounds (on average 0.12 kg, which corresponded about 0.14% of the 1-RM) had be done in study session two. The chosen exercise was long dumbbell bench press. Each participant was tested separately and requested to achieve maximal performance. All tests were instructed and supervised by the same researcher. The warm-up program consisted of 5 minutes moderate cycling (1 watt per kilogram body weight at 60-80 revolutions per minute) and one submaximal set of the exercise with ten repetitions. Due to the negative effects on strength performance [14-16] and the lack of evidence for injury prevention [17], additional stretching was not included. The procedure to determine the 1-RM was based on the positively evaluated test protocol of Gail and Künzell [13]. The determination of the take-off weight was orientated on the individual assessment of the respective participant. The same was true for the extent of weight increase or weight decrease after each successful or unsuccessful test trial. The break duration between the test trials was 2 minutes.

2.3. Data Analysis

All statistical analyses were carried out using the statistical software IBM® SPSS® Statistics version 22 (IBM® Corp., Armonk, NY, USA). Results are shown as mean and standard deviations as well as minima and maxima. Furthermore, the coefficient of variation (CV) was calculated to operationalize the relative spread of the maximal possible repetitions at 90% 1-RM [18].

3. Results

The mean (± standard deviation) 1-RM of the participants was 85.4 ± 15.0 kg (minimum: 55 kg, maximum: 110 kg). The maximal possible repetitions at 90% 1-RM were 5.3 ± 1.9 (minimum: 3, maximum: 10) (Figure 1). A relatively high CV of 36.2% was found for the maximal possible repetitions between the participants.

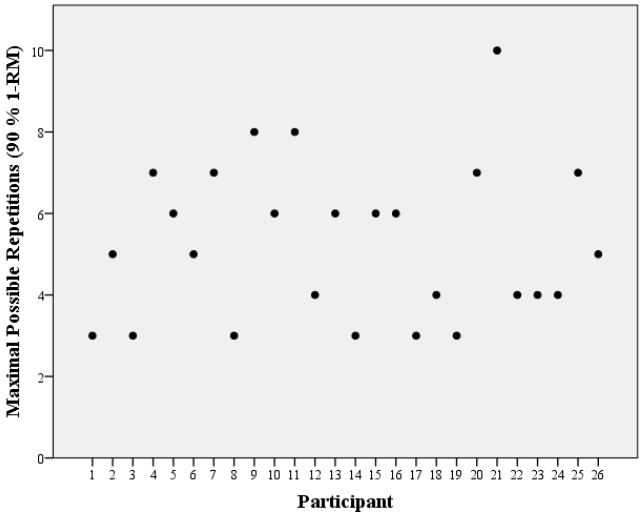

Figure 1. Maximal possible repetitions (90% 1-RM) of each single participant

4. Discussion

The aim of the present study was to investigate the reliability of strength training intensity determined on the basis of 1-RM strength tests. For this purpose, a relatively high training intensity of 90% 1-RM and the exemplary exercise bench press were applied.

The present results could affirm the findings of other studies, in which also a comparatively great spread of the maximal possible repetitions at various training intensities based on the 1-RM was found. The participants in the study of Berschin et al. [11] realized between three and six repetitions at 90% 1-RM and the same exercise as we used in our study. Consequently, the spread in our study with three up to ten repetitions was even higher than in the study of Berschin et al. [11]. In the study of Marschall and Fröhlich [12] the participants reached at 90% 1-RM 5.6 ± 1.2 repetitions during the exercise latissimus pull-down, respectively 10.4 ± 2.9 repetitions during the exercise leg press. This shows that besides the differences among various sportspersons also the maximal possible repetitions at a defined training intensity, deduced from the 1-RM, varies considerably between different strength training exercises.

Overall, our findings can be seen as further evidence for the unsuitability of the 1-RM as basis for the deduction of the intensity of strength training. The standard practice with the application of universal percentages of the 1-RM leads to an over- or under exertion of the corresponding sportsperson, which implies that for specific training goals essential strains cannot be achieved with this approach. Similar studies in future should include additional participant groups such as female recreational athletes or older adults.

5. Conclusions

The findings demonstrate that a strength training intensity control based on the 1-RM can result in an over- or under exertion of the respective sportsperson. Alternatively, the intensity control in strength training should be orientated on the foundation of so called multiple repetition maximum (M-RM) strength tests, as in the case of the individual lifting performance method (ILP), which was specially developed for sportspersons in recreational sport [19]. Test protocols to determine a certain M-RM were already provided by Gail and Künzell [13] for the 5-RM as well as Taylor and Fletcher [20] for the 8-RM.

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REFERENCES

[1] Beurskens, R., Gollhofer, A., Muehlbauer, T., Cardinale, M., and Granacher, U. (2015). Effects of heavy-resistance strength and balance training on unilateral and bilateral leg strength performance in old adults. *PLoS One* 10: e0118535.

[2] Conceição, M., Cadore, E. L., González-Izal, M., Izquierdo, M., Liedtke, G. V., Wilhelm, E. N., Pinto, R. S., Goltz, F. R., Schneider, C. D., Ferrari, R., Bottaro, M., and Kruel, L. F. M. (2014). Strength training prior to endurance exercise: impact on the neuromuscular system, endurance performance and cardiorespiratory responses. *J Hum Kinet* 44: 171-181.

[3] Gatta, G., Leban, B., Paderi, M., Padulo, J., Migliaccio, G. M., and Pau, M. (2014). The development of swimming power. *Muscles Ligaments Tendons J* 4: 438-445.

[4] Kraemer, W. J., Ratamess, N. A., Fry, A. C., and French, D. N. (2006). Strength testing: development and evaluation of methodology. In: Maud, P. J., and Foster, C. (Eds.), *Physiological assessment of human fitness* (2nd ed., pp. 119-150). Champaign, IL: Human Kinetics.

[5] Levinger I., Goodman, C., Hare, D. L., Jerums, G., Toia, D., and Selig, S. (2009). The reliability of the 1-RM strength test for untrained middle-aged individuals. *J Sci Med Sport* 12: 310-316.

[6] Baechle, T. R., Earle, R. W., and Wathen, D. (2008). Resistance training. In: Baechle, T. R., and Earle, R. W. (Eds.), *Essentials of strength training and conditioning* (3rd ed., pp. 381-412). Champaign, IL: Human Kinetics.

[7] Schlumberger, A., and Schmidtbleicher, D. (2000). Grundlagen der Kraftdiagnostik in Prävention und Rehabilitation. *Manuelle Med* 38: 223-231.

[8] Abdul-Hameed, U., Rangra, P., Shareef, M. Y., and Hussain, M. E. (2012). Reliability of 1-repetition maximum estimation for upper and lower body muscular strength measurement in untrained middle aged type 2 diabetic patients *Asian J Sports Med* 3: 267-273.

[9] Seo, D. I., Kim, E., Fahs, C. A., Rossow, L., Young, K., Ferguson, S. L., Thiebaud, R., Sherk, V. D., Loenneke, J. P., Kim, D., Lee, M. K., Choi, K. H., Bemben, D. A., and So, W. Y. (2012). Reliability of the one-repetition maximum test based on muscle group and gender. *J Sports Sci Med* 11: 221-225.

[10] Dohoney, P., Chromiak, J. A., Lemire, D., Abadie, B. R., and Kovacs, C. (2002). Prediction of one repetition maximum (1-RM) strength from a 4-6 RM and a 7-10 RM submaximal strength test in healthy young adult males. *J Exerc Physiol Online* 5: 54-59.

[11] Marschall, F., and Fröhlich, M. (1999). Überprüfung des Zusammenhangs von Maximalkraft und maximaler Wiederholungszahl bei deduzierten submaximalen Intensitäten. *Dtsch Z Sportmed* 50: 311-315.

[12] Berschin, G., Günther, J., and Sommer, H.-M. (2010). Zum Zusammenhang zwischen der Belastungsintensität und der Zahl der Wiederholungen beim Krafttraining. *Leistungssport* 40: 20-23.

[13] Gail, S., and Künzell, S. (2014). Reliability of a 5-repetition maximum strength test in recreational athletes. *Dtsch Z Sportmed* 65: 314-317.

[14] Behm, D. G., Button, D. C., and Butt, J. C. (2001). Factors affecting force loss with prolonged stretching. *Can J Appl Physiol* 26: 262-272.

[15] Fowles, J. R., Sale, D. G., and MacDougall, J. D. (2000). Reduced strength after passive stretch of the human plantarflexors. *J Appl Physiol* 89: 1179-1188.

[16] Power, K., Behm, D., Cahill, F., Carroll, M., and Young, W. (2004). An acute bout of static stretching: effects on force and jumping performance. *Med Sci Sports Exerc* 36: 1389-1396.

[17] Marschall, F., and Ruckelshausen, B. (2004). Dient Dehnen der Verletzungsprophylaxe? Eine qualitative Metaanalyse. *Spectrum Sportwiss* 16: 31-47.

[18] Sachs, L., and Hedderich, J. (2006). *Angewandte Statistik* (12th ed.). Berlin: Springer.

[19] Strack, A., and Eifler, C. (2005). The individual lifting performance method (ILP). A practical method for fitness- and recreational strength training. In: Gießing, J., Fröhlich, M., and Preuss, P. (Eds.), *Current results of strength training research* (pp. 153-163). Göttingen: Cuvillier.

[20] Taylor, A., and Fletcher, J. P. (2012). Reliability of the 8-repetition maximum test in men and women. *J Sci Med Sport* 15: 69-73.