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SELF-SELECTED RESISTANCE EXERCISE LOAD:

IMPLICATIONS FOR RESEARCH AND PRESCRIPTION

Running head: Self-selected resistance exercise load

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ABSTRACT

Resistance training (RT) has been widely used for maintaining or improving quality of life and sports performance. It is not clear, however, whether the load commonly used in these exercises is equivalent to the number of repetitions determined for execution, that is, the level of effort applied to the self-selected load. Ergo, the aim of the present study was to identify the number of maximum repetitions that strength training practitioners can perform with the load commonly used (self-selected) to perform 10 repetitions in their training routines. The sample consisted of 160 healthy trained men (25.7 ± 4.5 years, 81.2 ± 10.4 kg, 177.9 ± 6.2 cm). Subjects answered the question "What weight do you usually lift for 10 repetitions on free-weight bench press exercise?". The answer was considered the self-selected 10 repetitions load (S10RL). After a brief warm-up, each individual was instructed to perform as many repetitions as possible at S10RL (RM_{S10RL}) at a single bout of free-weight bench press. The RM_{S10RL} was analyzed with the single sample t-test, adopting the reference value of 10 repetitions. Individuals performed 16 ± 5 RM_{S10RL} (median = 15), which represent a statistical difference for the 10-repetition reference value ($p < 0.001$). The most prevalent RM_{S10RL} range was from 13 to 15 repetitions (31%), and only 22% performed between 10 and 12 repetitions. It was concluded that most individuals can perform a number of repetitions well above the 10 repetitions predicted for the selected load. Therefore, the training routines are not compatible with maximum effort.

Key words: muscular strength; free-weight bench press; repetitions

INTRODUCTION

Resistance training (RT) has been widely used for maintaining or improving quality of life and sports performance. In this sense, both the identification and monitoring of muscle strength levels over time can provide important information for professionals and researchers working in the health area or with sports performance. This information can contribute to the evaluation of the functional capacity and effectiveness of training programs of different natures, favoring the establishment of training overload (31). One of the main reasons for the use of RT is the growing publications of the beneficial effects of training programs aimed at prevention, rehabilitation, health promotion, or improvement in sports performance (1, 5, 24). However, for these benefits to be achieved, training programs should consider some variables such as: frequency, type, duration and intensity of exercises (1).

It is worth mentioning that although some authors try to justify the use of the term "intensity" through its association with 1RM percentages (14, 40), this term seems to be unable to reconcile effort, load, repetition, genetic influences, and repetition duration (12). According to Fisher and Smith (12), within resistance training, "intensity" represents only the level of effort applied to a given load. In this sense, 1 RM percentages should be adopted only as reference values of the training load. In addition, it should be emphasized that the optimal level of load is exercise-dependent, i.e., the percentage ranges ideal for training may vary from one exercise to another, even though the training objective is the same (37, 38). Thus, it is understood that the correct identification of the exercise load magnitude would favor specific muscular adaptations (13).

Considering the strength evaluation, the 1 RM test has been used both to estimate the maximum force and to prescribe load percentages in training programs (18, 36). For the application of this procedure, the individual performs a specific warm-up in the exercise that the test will be performed, followed by several attempts at full load until failure to correctly perform the movement is observed by the evaluator (35). Usually, the 1 RM value is found between three and six attempts (27, 39), with recovery interval between three and five minutes (23, 27). Therefore, for a single exercise, this test requires approximately 30 minutes, compromising or disrupting the training routine of the individual being tested (39). Therefore, the test is barely used in gyms, clubs and fitness centers due to its difficulty of operationalization, since it depends on great human resource and high demand in terms of time (19). In addition, it needs to be repeated for each of the exercises that make up the training program.

Alternatively, another strategy used to prescribe the training load is the use of maximum repetition zones for a given load (1). However, Hoeger et al. (18) observed that, regardless of training status or gender, for the same relative load, there was a difference in the maximum number of repetitions performed in the different muscle groups tested. Their results showed mean variations between 12 and 22 repetitions in the leg press at 80% of 1 RM, for example. In order to solve this problem, some studies have investigated the exercise “intensity” through load self-selected by muscle grouping (11, 16, 29), since the adherence of individuals to training programs was a positive factor found in studies of this category (10). The best way to quantify 1 RM without requiring the application of the test itself seems to be by determining 1 RM predictive equations (21, 25).

In order to respond to this need, some authors have conducted studies based on anthropometric variables (30, 32), maximum number of repetitions performed with 1RM percentages (19) and maximum number of repetitions in exercises with fixed loads (7, 39). In this sense, for a better professional follow-up about the prescription of training programs, the use of the ideal load must be correct and precise according to the goal of the individual to be trained.

It is important to emphasize that the scientific literature presents a very broad body of evidence about load quantification in resistance training exercises. This broad methodological scope, in addition to evidencing the lack of a standard protocol for the verification of an individual's muscular strength levels, has served as the basis for studies that evaluate, for example, the effects of stretching on strength performance (3, 20) and strength exercises on cardiovascular responses (5, 15). However, for the results obtained in studies of this nature to unequivocally represent the trends and magnitudes of the expected responses in professional practice, it is important to recognize whether in the daily life of gyms, clubs and fitness centers, training occurs based on maximal repetitions, as it is in studies. If the training load used in studies is different from that used in the daily training, its results should be analyzed with caution, since the effects identified in experiments may be overestimating their responses.

Considering the methodological difficulties mentioned above for assessing the maximum load for each exercise, even though it was possible at first to apply tests for the initial training prescription, it is unlikely that these procedures will be repeated throughout the program. This is even more evident in gyms and clubs due to the high number of people exercising simultaneously.

In this way, it could be inferred that load increases made throughout the training progression are subjectively determined and possibly self-selected, taking as reference the number of repetitions to be performed. It is not clear, however, whether this self-selected load matches the maximum number of repetitions proposed for each exercise, and if, as a result, subjects are underachieving training goals due to an underestimated training load.

In this sense, the aim of the present study was to identify the number of maximum repetitions that strength training practitioners can perform with the load commonly used (self-selected) to perform 10 repetitions in their training routines. The exercise chosen was bench press, since it is one of the most popular exercises used for upper limb strength training, especially involving chest, shoulders and arms (22). In addition, most studies in scientific literature use it as a tested exercise, providing reference values for the training load (18, 19, 26, 32).

METHODS

Experimental Approach to the Problem

A cross-section design was used to test the hypothesis that resistance training practitioners use to perform 10 repetitions on free-weight bench press exercise with loads much lower than that equivalent to 10RM. In a single visit, an RT group composed of experienced male young adults underwent standardized warm-up exercise followed by a single bout of maximum repetitions on free-weight bench press using self-selected 10 repetitions load (S10RL). Prior to beginning the procedure, participants answered questions about age, body mass, height, goal of strength training, order of execution of

the bench press exercise in the daily training program and S10RL. Maximal repetitions with self-selected load (RM_{S10RL}) were analyzed according to participants' goal of strength training, since individuals who aim at muscle hypertrophy are supposed to train with higher loads when compared to other goals. Likewise, the study analyzed RM_{S10RL} among individuals who adopted higher loads vs. those who adopted lower ones. All participants received instructions not to perform exercises before experimental procedures. Data collection took place between July and October (~four months length).

Subjects

One hundred and sixty healthy trained men (age 25.7 ± 4.5 years, body mass: 81.2 ± 10.4 kg, height: 177.9 ± 6.2 cm) volunteered to participate in this study. All participants had minimum of six months resistance training experience and have used free-weight bench press in their training routines. Inclusion criteria were: (a) individuals who have performed resistance training for at least six months with minimum frequency of three sessions per week; (b) those who could perform full range of the free-weight bench press exercise; (c) those who did not perform any other exercise or physical activity before the study procedures; and (d) those who did not present any medical conditions that could confound experimental procedures. All participants received information of the study procedures, as well as risks and benefits, and signed a written informed consent form in according to the Declaration of Helsinki. The experimental procedures were approved by the local Ethics Committee.

Procedures

To minimize measurement error, the following strategies were adopted: (a) standard instructions concerning the experimental procedure were given to

participants before the test; (b) participants received standardized instructions on exercise technique (6); (c) body position was held constant; and (d) verbal encouragement was provided during the free-weight bench press in order to elicit maximum effort from each participant.

The procedure consisted of performing a single bout of free-weight bench press. At first, the following question was performed: "What weight do you usually lift for 10 repetitions on free-weight bench press exercise?" The answer was considered the S10RL. After the answer, the individual performed a specific warm-up with the same free-weight bar and bench, which consisted of a 10-repetition bout with 50% of S10RL and one minute later, a second 5-repetition bout with 70% of S10RL (35). After a 2-minute recovery interval, the individual was instructed to perform as many repetitions as possible at S10RL (Figure 1). One repetition was considered if the subject lowers the bar to touch his chest, and then press it upward by fully extending his forearms. Barbell velocity was not controlled in order to simulate daily strength practice routines. All procedures were monitored by a single and experienced examiner.

Place figure 1 About Here.

Statistical Analysis

All sample characteristic variables presented normal distribution (Shapiro-Wilk test, $p > 0.05$). The RM_{S10RL} was analyzed with the single sample t-test, adopting the reference value of 10 repetitions. Data were also analyzed by splitting the sample into two groups according to RT personal goals and absolute load lifted. RT personal goals were defined as hypertrophy vs. other objectives (health promotion, weight loss, etc.). The sample was stratified

according to the median load lifted, as groups below (BM) and above (AM) median. These groups were also compared in terms of relative training load. Student's t-test for independent samples was used for all comparisons between groups.

Data were descriptively analyzed to determine RM_{S10RL} ranges and free-weight bench press execution rank order during training. In order to estimate the load corresponding to 1 RM, we first used the equation proposed by Guedes and Guedes,(17) based on statistical regression models that suggest that the 1 RM load decreases at about 2 to 2.5% for each repetition. Therefore, the equation used was: 1 RM = submaximal load / [100% - (2% x reps)]. Subsequently, we adopted the simple rule of three in order to determine the relative loads for 1 RM and 10 RM. Statistical analyses were performed using SPSS software statistical package version 20.0 (SPSS Inc., Chicago, IL, USA), and statistical significance was set at $p < 0.05$.

RESULTS

Individuals performed 16 ± 5 RM_{S10RL} (median = 15; IC95% = 15.6 to 17.3 reps), which represent a statistical difference for the 10-repetition reference value ($p < 0.001$). The most prevalent RM_{S10RL} range was from 13 to 15 repetitions, representing a relative load between 67% and 77% (Table 1). The average relative load for 1 RM and 10RM was 67% ± 10% and 65% ± 16%, respectively.

Place table 1 About Here

Most individuals (76%; n = 122) aimed at hypertrophy as personal RT goals, while 24% (n = 38) reported other targets. There is no difference according to RT personal goals (16 ± 5 vs. 17 ± 6 RM_{S10RL}, for hypertrophy and other objectives; IC95% = -2.8 to 1.0; p = 0.338, figure 2).

Place figure 2 About Here

The median load lifted was 54 kg. The BM group (load ≤ 54 kg) represented 51% of the sample. The BM group performed more maximum repetitions compared to AM (IC95% = 2.8 to 5.7; *p* <0.001; figure 3).

Place figure 3 About Here

In terms of relative load, there was a significant difference between groups, as the AM group trained at higher loads both on the load for 1 RM as for 10 RM (figure 4).

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Ultimately, about 82% of participants reported that free-weight bench press is the first exercise for the chest muscle group in their daily training routine.

DISCUSSION

The aim of this study was to identify the number of maximal repetitions that RT practitioners can perform with the load commonly used for 10 repetitions in their training routines in the free-weight bench press exercise. The main finding of this study was that RT practitioners do not usually train with

maximum loads. Most individuals can perform a number of repetitions well above the 10 repetitions expected for the self-selected load. They usually finish the exercise in the number fixed by teachers / coaches, not reaching maximum voluntary muscular actions (maximum repetitions).

Fleck and Kraemer (13) reported that the performance of maximal voluntary muscular actions in RT is described by muscle overload and that the level of muscular requirement must be increased in order for physiological changes to occur (hypertrophy and / or strength gains). The concept of maximal voluntary muscular actions seems to be overlooked in RT routines, given the high number of repetitions performed by participants in the present study. During procedure, the individuals in our sample achieved maximal voluntary muscle actions because they were stimulated to achieve them, unlike what seems to occur in the daily life of gyms.

Our results suggest that individuals do not actually train at their limit of maximal repetitions. In fact, almost half of the sample (about 47%) trained with load equivalent to less than 67% of 1 RM. Nonetheless, it is noteworthy that the use of 1 RM percentages to determine the training load has long been disputed. In this sense, Hoeger et al. (18) performed 1 RM tests in seven exercises on untrained and trained men and women. They then established loading percentages (40%, 60% and 80%) for 1 RM and asked participants to perform the maximum number of repetitions. There was a wide variability in the number of maximal repetitions, regardless of exercise, training status or gender. Men trained in 80% bench press exercise performed an average of 12 RM. Despite emphasizing the limitations of prescription based on 1 RM percentages, the authors suggest using load equivalent to or greater than 80% of 1 RM for large

muscle groups for the execution of 10 RM. In our study, only one out of five subjects appeared to be training with loads above this recommendation (10-12 RM).

In the following two decades, strength trained men undergoing a similar training protocol performed 9 RM with 80% of 1 RM (n = 8) (36), and 8-9 RM with 85 % of 1 RM (n = 9) (2) in the bench press exercise, showed results conflicting to Hoeger et al. (18) study. In these studies, individuals were unable to reach 10 RM with loads equal or higher than 80% of 1 RM. All this information, associated with the results of the present study, ratifies the argument that the training loads observed in scientific literature do not represent the natural conditions of daily practice, which is based on self-selected loads.

Another point observed in the present study refers to the participants' RT goal. When questioned, three out of four individuals answered that hypertrophy was the main goal when performing RT. Surprisingly, there was no difference in RMS10RL for each reported objective (hypertrophy vs. others). The expectation was that workouts aimed at hypertrophy should use loads closer to the expected 10 repetitions, which in fact did not occur.

In this sense, Campos et al. (4) found greater muscular hypertrophy in groups that trained 3 to 5 RM and 9 to 11 RM in the leg press, squatting and leg extension. In our sample, individuals performed a much higher number of repetitions. In fact, although the majority aimed at hypertrophy, almost half of our sample adopted loads that fit local muscular endurance training (above 15 repetitions) (1). However, although a little more than half of the sample complied with ACSM recommendations for muscle hypertrophy gains (≥70% of 1 RM) (1), only one out of five individuals trained in the optimum load zone

suggested by Campos et al. (4) (up to 11 RM). In addition, only 4.4% (seven individuals) achieved the recommendations of Fry (14) for training load (80-95% of 1 RM).

Some authors present metabolic stress as one of the factors for muscular hypertrophy (9, 28, 34). Hereupon, Schoenfeld (33) published a very careful literature review regarding metabolic stress and observed that it is possible to obtain muscular hypertrophy with lower loads. However, most studies advise individuals to train up to maximal voluntary fatigue (28, 34). Nevertheless, it is noteworthy that in our study, individuals who sought hypertrophy, although being able to perform an average of RMS10RL, in their daily routine, would have stopped exercising shortly after the tenth repetition. Thus, although Da Silva-Grigoletto et al. (8) suggest that the use of repetitions up to movement failure is usually applied in sports training, our results show that individuals did not reach this point and, possibly, did not generate metabolic stress enough to optimize muscular hypertrophy (33).

As expected, participants who lifted more weight (AM group) performed fewer repetitions than the BM group (14 ± 6 and 19 ± 3 RMS10RL, respectively). Considering that an absolute load may represent different effort levels among individuals, the comparison of relative loads for the same groups was timely. Thus, it was observed that the AM group trained with relatively higher loads compared to the BM group, remaining within limits lower than ACSM recommendations (1) for hypertrophy. However, none of the groups approached the optimal zone of maximal repetitions for hypertrophy training proposed by Fry (14).

A possible limitation of this study is the fact that we did not reassess RMS10RL performed by participants, submitting them to another evaluation day (retest). However, we believe that the large sample size may have attenuated possible intraindividual variations. The choice of bench press exercise for these analyses proved to be correct, since four out of five individuals performed it as the first exercise of the training session. To our knowledge, there are studies investigating the order of execution of this exercise in training routines. Thus, the ecological validity of the study was maintained, as in the daily routine, subjects would not perform other exercises before bench press, excluding variable previous fatigue in the transfer of information from the laboratory to the practical application.

It was concluded that most individuals can perform a number of repetitions well above the 10 repetitions predicted for the selected load. Therefore, the training routines are not compatible with maximum effort nor with their most prevalent goal, muscle hypertrophy.

PRACTICAL APPLICATIONS

For researchers, the present data elucidates that loads applied on studies based on 1RM percentage loads may be overestimating the effects related to resistance exercises, such as stretching or cardiovascular responses, for instance. Therefore, the interpretation of published data must consider this scenario, ensuring a proper decision making process.

Based on the present results, it seems beyond a shadow of doubt that training loads have been receiving poor attention, thus, coaches and trainers must address this issue more carefully to allow a more objective and reliable

exercise prescription and control. Since subjects do not use maximum load nor repetitions on daily basis, coaches and trainers should be aware of situation and adjust training loads to match evidence based recommendations (14), to enhance training results. When prescribing RT programs, especially if the goal is hypertrophy, trainers must make sure that subjects fulfil maximum repetitions, with loads compatible to this level of effort and objectives.

REFERENCES:

1. American College of Sports Medicine. Progression models in resistance training for healthy adults. *Med Sci Sports Exerc* 41: 687-708, 2009.
2. Arazi H and Asadi A. The relationship between the selected percentages of one repetition maximum and the number of repetitions in trained and untrained males. *Facta Universitatis* 9: 25-33, 2011.
3. Behm DG, Blazevich AJ, Kay AD, and McHugh M. Acute effects of muscle stretching on physical performance, range of motion, and injury incidence in healthy active individuals: a systematic review. *Appl Physiol Nutr Metab* 41: 1-11, 2016.
4. Campos GE, Luecke TJ, Wendeln HK, and al. e. Muscular adaptations in response to three different resistance-training regimens: specificity of repetition maximum training zones. *Eur J Apply Physiol* 88: 50-60, 2002.
5. Casonatto J, Goessler KF, Cornelissen VA, Cardoso JR, and Polito MD. The blood pressure-lowering effect of a single bout of resistance exercise: A systematic review and meta-analysis of randomised controlled trials. *Eur J Prev Cardiol* 23: 1700-1714, 2016.

6. Caulfield S and Berninger D. Exercise Technique for Free Weight and Machine Training, in: *Essentials of Strength Training and Conditioning*. GG Haff, NT Triplett, eds. Champaign, IL: Human Kinetics, 2016, p 735.

7. Chapman PP, Whitehead JR, and Binkert RH. The 225-lb reps-to-fatigue test as a submaximal estimate of 1RM bench press performance in college football players. *J Strength Cond Res* 12: 258-261, 1998.

8. Da Silva-Grigoletto ME, Valverde-Esteve T, Brito CJ, and García-Manso JM. Ability to repeat strength: effects of recovery between repetitions. *Rev Bras Educ Fís Esporte* 27: 689-705, 2013.

9. Dankel SJ, Jessee MB, Mattocks KT, Mouser JG, Counts BR, Buckner SL, and Loenneke JP. Training to Fatigue: The Answer for Standardization When Assessing Muscle Hypertrophy? *Sports Med* 47: 1021-1027, 2017.

10. Dishman RK, Farqyhar RP, and Cureton KJ. Responses to preferred intensity of exercise in men differing in activity level. *Med Sci Sports Exerc* 26: 783-790, 1994.

11. Elsangedy HM, Krause MP, Krinski K, Alves RC, Hsin Nery Chao C, and da Silva SG. Is the self-selected resistance exercise intensity by older women consistent with the American College of Sports Medicine guidelines to improve muscular fitness? *J Strength Cond Res* 27: 1877-1884, 2013.

12. Fisher J and Smith D. Attempting to better define "intensity" for muscular performance: is it all wasted effort? *Eur J Appl Physiol* 112: 4183-4185; author reply 4187-4188, 2012.

13. Fleck SJ and Kraemer WJ. *Designing Resistance Training Programs* Champaign, IL: Human Kinetics, 2014.

14. Fry AC. The role of resistance exercise intensity on muscle fibre adaptations. *Sports Med* 34: 663-679, 2004.

15. Gjovaag T, Hjelmeland AK, Oygard JB, Vikne H, and Mirtaheri P. Acute hemodynamic and cardiovascular responses following resistance exercise to voluntary exhaustion. Effects of different loadings and exercise durations. *J Sports Med Phys Fitness* 56: 616-623, 2016.

16. Glass SC and Stanton DR. Self-selected resistance training intensity in novice weightlifters. *J Strength Cond Res* 18: 324-327, 2004.

17. Guedes DP and Guedes JERP. *Manual prático para avaliação em educação física.* Barueri, SP: Manole, 2006.

18. Hoeger W, Hopkins DR, Barette SL, and Hale DF. Relationship between repetitions and selected percentages of one repetition maximum. *J Appl Sport Sci Res* 4: 47-54, 1990.

19. Julio UF, Panissa VLG, and Franchini E. Prediction of one repetition maximum from the maximum number of repetitions with submaximal loads in recreationally strength-trained men. *Sci Sports* 27: e69-e76, 2012.

20. Kay AD and Blazevich AJ. Effect of acute static stretch on maximal muscle performance: a systematic review. *Med Sci Sports Exerc* 44: 154-164, 2012.

21. Kim PS, Mayhew JL, and Peterson DF. A modified YMCA bench press test as a predictor of 1 repetition maximum bench press strength. *J Strength Cond Res* 16: 440-445, 2002.

22. Kompf J and Arandjelovic O. The Sticking Point in the Bench Press, the Squat, and the Deadlift: Similarities and Differences, and Their Significance for Research and Practice. *Sports Med* 47: 631-640, 2017.

23. Kravitz L, Akalan C, Nowicki K, and Kinzey SJ. Prediction of 1 repetition maximum in high-school power lifters. *J Strength Cond Res* 17: 167-172, 2003.

24. Larsson A, Palstam A, Lofgren M, Ernberg M, Bjersing J, Bileviciute-Ljungar I, Gerdle B, Kosek E, and Mannerkorpi K. Resistance exercise improves muscle strength, health status and pain intensity in fibromyalgia--a randomized controlled trial. *Arthritis Res Ther* 17: 161, 2015.

25. Macht JW, Abel MG, Mullineaux DR, and Yates JW. Development of 1RM Prediction Equations for Bench Press in Moderately Trained Men. *J Strength Cond Res* 30: 2901-2906, 2016.

26. Mayhew JL, Ball TE, Arnold MD, and Bowen JC. Relative muscular endurance performance as a predictor of bench press strength in college men and women. *J App Sport Sci Res* 6: 200-206, 1992.

27. Mayhew JL, Ware JS, Bemben MG, Wilt B, Ward TE, Farris B, Juraszek J, and Slovak JP. The NFL-225 test as a measure of bench press strength in college football players. *J Strength Cond Res* 13: 130-134, 1999.

28. Ogasawara R, Loenneke JP, Thiebaud RS, and Abe T. Low-load bench press training to fatigue results in muscle hypertrophy similar to high-load bench press training. *Int J Clin Med* 4: 114-121, 2013.

29. Ratamess NA, Faigenbaum AD, Hoffman JR, and Kang J. Self-selected resistance training intensity in healthy women: the influence of a personal trainer. *J Strength Cond Res* 22: 103-111, 2008.

30. Reynolds JM, Gordon TJ, and Robergs RA. Prediction of one repetition maximum strength from multiple repetition maximum testing and anthropometry. *J Strength Cond Res* 20: 584-592, 2006.

31. Ritti-Dias RM, Avelar A, Menêses AL, Salvador EP, Silva DRP, and Cyrino ES. Safety, reliability, intervenient factors and applicability of 1-RM tests. *Motriz* 19: 231-242, 2013.

32. Scanlan JM, Ballmann KL, Mayhew JL, and Lantz CD. Anthropometric dimensions to predict 1-RM bench press in untrained females. *J Sports Med Phys Fitness* 39: 54-60, 1999.

33. Schoenfeld BJ. Is there a minimum intensity threshold for resistance training-induced hypertrophic adaptations? *Sports Med* 43: 1279-1288, 2013.

34. Schoenfeld BJ, Peterson MD, Ogborn D, Contreras B, and Sonmez GT. Effects of Low- Versus High-Load Resistance Training on Muscle Strength and Hypertrophy in Well-Trained Men. *J Strength Cond Res* 29: 2954-2963, 2015.

35. Sheppard JM and Triplett NT. Program Design for Resistance Training, in: *Essentials of Strength Training and Conditioning*. G Haff, NT Triplett, eds. Champaign, IL: Human Kinetics, 2016, p 735.

36. Shimano T, Kraemer WJ, Spiering BA, Volek JS, Hatfield DL, Silvestre R, Vingren JL, Fragala MS, Maresh CM, Fleck SJ, Newton RU, Spreuwenberg LP, and Hakkinen K. Relationship between the number of

repetitions and selected percentages of one repetition maximum in free weight exercises in trained and untrained men. *J Strength Cond Res* 20: 819-823, 2006.

37. Soriano MA, Jimenez-Reyes P, Rhea MR, and Marin PJ. The Optimal Load for Maximal Power Production During Lower-Body Resistance Exercises: A Meta-Analysis. *Sports Med* 45: 1191-1205, 2015.
38. Soriano MA, Suchomel TJ, and Marin PJ. The Optimal Load for Maximal Power Production During Upper-Body Resistance Exercises: A Meta-Analysis. *Sports Med* 47: 757-768, 2017.
39. Ware JS, Clemens CT, Mayhew JL, and Johnston TJ. Muscular endurance repetitions to predict bench press and squat strength in college football players. *J Strength Cond Res* 9: 99-103, 1995.
40. Willardson JM and Burkett LN. The effect of different rest intervals between sets on volume components and strength gains. *J Strength Cond Res* 22: 146-152, 2008.

Figure legends

Figure 1. Experimental design.

Figure 2. Maximal repetitions with self-selected load (RM_{S10RL}) depending on the goals of the training program.

Figure 3. Maximal repetitions with self-selected load (RM_{S10RL}) according to the median load adopted for 10 repetitions. * means $p < 0.001$.

Figure 4. Relative loads considering the maximal repetitions with self-selected load (RM_{S10RL}). * means $p < 0.001$ compared with group BM.

Table 1. Distribution of the sample to RM_{S10RL}, percentage of ranges of RM_{S10RL} and relative intensities of the 1RM and 10RM.

RM_{S10RL}	**n (%)**	**% range of RM_{S10RL}**	**Relative Intensities of the 10RM**	**Relative Intensities of the 1RM**
10	7 (4.4)			
11	6 (3.8)	22%	83% to 100%	76% to 80%
12	22 (13.8)			
13	13 (8.1)			
14	18 (11.3)	31%	67% to 77%	70% to 74%
15	18 (11.3)			
16	11 (6.9)			
17	10 (6.3)	21%	56% to 62%	64% to 68%
18	13 (8.1)			
19	5 (3.1)			
20	15 (9.4)	26%	<53%	<62%
>20	22 (13.8)			

RM_{S10RL} = maximum repetitions on free-weight bench press using self-selected 10 repetitions load.