Large and Small Muscles in Resistance Training: Is It Time for a Better Definition?

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Large and Small Muscles in Resistance Training: Is It Time for a Better Definition?

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ABSTRACT

MANY STUDIES HAVE MISAPPLIED THE DEFINITION OF MUSCLE VOLUME WITH RESPECT TO CLASSIFYING MUSCLES AS "SMALL" OR "LARGE." GIVEN FREQUENT MISAPPLICATION OF THE TERMS, WE PROPOSE THAT THEY SHOULD BE CLASSIFIED SIMPLY AS MULTI-JOINT OR SINGLE-JOINT EXERCISES. A VIABLE ALTERNATIVE CLASSIFICATION WOULD BE COMPOUND EXERCISES OR ISOLATION EXERCISES.

Resistance training (RT) is a type of physical exercise recommended to improve a wide range of health-related parameters including neuromuscular fitness, cognitive abilities, insulin sensitivity, bone density, and cardiovascular wellness (1,2,21), and is also practiced to enhance aesthetics and sports-performance. The benefits associated with RT are dependent on the proper manipulation of the variables that make up the RT program, which include magnitude of load, number of sets and repetitions, frequency, rest interval, exercise selection, time under tension, muscle action, velocity of movement, and exercise order (1,15). Regarding exercise order, there is evidence that this variable can acutely affect the volume and intensity of a RT session (1). However, the chronic effect of exercise order on muscular adaptations is still a matter of debate, especially because of the lack of longitudinal investigations on the topic.

Many studies focusing on exercise order have misapplied the definition of muscle volume (defined in this column as the total amount of muscular tissue, expressed in cubic units), with respect to classifying muscles as "small" or "large." These erroneous classifications persist both for muscles of the upper and lower body. The issue seems to exist based on visual perception of muscle size as opposed to the actual volume of a given muscle. For example, several studies have classified exercises for the triceps brachii as working a small muscle (3–9,16–19), but in fact, this muscle has one of the greatest volumes of all upper-body muscles; even larger than the latissimus dorsi and pectoralis major (11,12,20), which are typically considered as large muscles (3–9,16–19). It is noteworthy that values of muscle volume consider its 3-dimensional amount, not simply its length and width (surface area), and therefore these terms should not be confused with one another.

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Table
Volume of selected upper- and lower-body muscles

Muscle	Average volume, cm^3
Latissimus dorsi[a]	262.3 ± 147.2
Pectoralis major[a]	290.0 ± 169.0
Deltoid[a]	380.5 ± 157.5
Triceps brachii[a]	372.1 ± 177.3
Biceps brachii[a]	143.7 ± 68.7
Brachialis[a]	143.7 ± 63.7
Brachioradialis[a]	65.1 ± 36
Quadriceps femoris[b]	1,417.4 ± 440.8
Biceps femoris[b]	269.8 ± 87.1
Gluteus maximus[b]	764.1 ± 138.0
Iliopsoas[b]	353.0 ± 102.2
Sartorius[b]	126.7 ± 22.4

Data are presented as mean and standard deviation.

[a]Holzbaur et al. (11).

[b]Lube et al. (13).

Several studies have endeavored to quantify the volume of various human muscles. Holzbaur et al. (11) created 3-dimensional images from magnetic resonance imaging data to establish the volume of the upper limb muscles crossing the glenohumeral joint, elbow, forearm, and wrist in 10 young, healthy subjects. Results indicated that the deltoid (anterior, middle, and posterior heads combined) presents the largest muscle volume (380.5 ± 157.7 cm^3), followed by the triceps brachii (long, middle, and lateral heads combined) (372.1 ± 177.3 cm^3), pectoralis major (clavicular and sternocostal portions combined) (290.0 ± 169.0 cm^3), and latissimus dorsi (262.2 ± 147.2 cm^3).

Similarly, Vidt et al. (20) and Langerderfer et al. (12), analyzed the muscle volumes of older subjects and corpses, respectively. Both studies reported that the deltoid was the largest upper limb muscle followed by the triceps brachii and, contrary to popular belief, each of these muscles were larger than the pectoralis major and latissimus dorsi irrespective of sex. These results indicate that it is misguided to classify the triceps brachii or deltoids as a small muscle complex.

Moreover, misconceptions on nomenclature also occur in lower-body muscle groups, in which some studies categorize the knee extension as a small-muscle exercise (4,5,16,19). However, the quadriceps, the agonist in this exercise, is the largest lower limb muscle as noted by Lube et al. (13) and Handsfield et al. (10).

Therefore, we propose that the claims referring to knee extension and specific exercises for the triceps brachii (i.e., triceps pushdown) and deltoids (i.e., lateral raises) as working "small muscles" is a misapplication of terminology. Rather, given these exercises are single-joint movements, it would be more appropriate to say that the total amount of muscle mass worked is less than that during multijoint exercises. For example, the leg press works many muscles in addition to the quadriceps (i.e., gluteals, hamstrings, calves); the back squat works an even greater amount of muscle mass because of the contribution of stabilizer muscles (including the abdominals, erector spinae, trapezius, rhomboids, and many others) to carry out performance (14). Thus, these multijoint exercises necessarily involve the activation of more muscle tissue compared with a single-joint exercise such as the knee extension. The Table presents muscle volume values for a variety of upper and lower-body muscles.

Given this information, we propose that rather than categorizing exercises as pertaining to either large or small muscle groups, they instead should be classified simply as multijoint or single-joint exercises. A viable alternative classification would be compound exercises (squat, deadlift, bench press, lat-pulldown, rows, etc.) or isolation exercises (knee extension, leg curl, lateral raises, arm curl, pec deck, triceps pushdown, etc.). Both definitions would more accurately reflect the total amount of muscle mass involved in an exercise without making reference to the volume of the individual muscles worked; this avoids potentially misleading statements on the matter.

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REFERENCES

1. American College of Sports Medicine. American College of Sports Medicine position stand. Progression models in resistance training for healthy adults. *Med Sci Sports Exerc* 41: 687–708, 2009.
2. American College of Sports Medicine. American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. *Med Sci Sports Exerc* 43: 1334–1359, 2011.
3. Assumpção CO, Tibana RA, Viana LC, Willardson JM, and Prestes J. Influence of exercise order on upper body maximum and submaximal strength gains in trained men. *Clin Physiol Funct Imaging* 33: 359–363, 2013.
4. Bellezza PA, Hall EE, Miller PC, and Bixby WR. The influence of exercise order on blood lactate, perceptual, and affective responses. *J Strength Cond Res* 23: 203–208, 2009.
5. Chaves CP, Simão R, Miranda H, Ribeiro J, Soares J, Salles B, Silva A, and Mota MP. Influence of exercise order on muscle damage during moderate-intensity resistance exercise and recovery. *Res Sport Med* 21: 176–186, 2013.
6. da Conceição RR, Simão R, Silveira AL, Silva GC, Nobre M, Salerno VP, and Novaes J. Acute endocrine responses to different strength exercise order in men. *J Hum Kinet* 44: 111–120, 2014.
7. Dias I, Salles BF, Novaes J, Costa PB, and Simão R. Influence of exercise order on maximum strength in untrained young men. *J Sci Med Sport* 13: 65–69, 2010.
8. Farinatti PT, da Silva NS, and Monteiro WD. Influence of exercise order on the number of repetitions, oxygen uptake, and rate of perceived exertion during strength training in younger and older women. *J Strength Cond Res* 27: 776–785, 2013.
9. Figueiredo T, Rhea M, Bunker D, Dias I, de Salles BF, Fleck SJ, and Simão R. The influence of exercise order on local muscular endurance during resistance training in women. *Hum Mov* 12: 237–241, 2011.
10. Handsfield GG, Meyer CH, Hart JM, Abel MF, and Blemker SS. Relationships of 35 lower limb muscles to height and body mass quantified using MRI. *J Biomech* 47: 631–638, 2014.
11. Holzbaur KR, Murray WM, Gold GE, and Delp SL. Upper limb muscle volumes in adult subjects. *J Biomech* 40: 742–749, 2007.
12. Langenderfer J, Jerabek SA, Thangamani VB, Kuhn JE, and Hughes RE. Musculoskeletal parameters of muscles crossing the shoulder and elbow and the effect of sarcomere length sample size on estimation of optimal muscle length. *Clin Biomech* 19: 664–670, 2004.
13. Lube J, Cotofana S, Bechmann I, Milani TL, Ozkurtul O, Sakai T, Steinke H, and Hammer N. Reference data on muscle volumes of healthy human pelvis and lower extremity muscles: An in vivo magnetic resonance imaging feasibility study. *Surg Radiol Anat* 38: 97–106, 2016.
14. Schoenfeld BJ. Squatting kinematics and kinetics and their application to exercise performance. *J Strength Cond Res* 24: 3497–3506, 2010.
15. Schoenfeld BJ. The mechanisms of muscle hypertrophy and their application to resistance training. *J Strength Cond Res* 24: 2857–2872, 2010.
16. Sforzo GA and Touey PR. Manipulating exercise order affects muscular performance during a resistance exercise training session. *J Strength Cond Res* 10: 20–24, 1996.
17. Simão R, Spineti J, de Salles BF, Oliveira LF, Matta T, Miranda F, Miranda H, and Costa PB. Influence of exercise order on maximum strength and muscle thickness in untrained men. *J Strength Cond Res* 24: 2962–2969, 2010.
18. Spineti J, de Salles BF, Rhea MR, Lavigne D, Matta T, Miranda F, Fernandes L, and Simão R. Influence of exercise order on maximum strength and muscle volume in nonlinear periodized resistance training. *J Strength Cond Res* 24: 2962–2969, 2010.
19. Spreuwenberg LP, Kraemer WJ, Spiering BA, Volek JS, Hatfield DL, Silvestre R, Vingren JL, Fragala MS, Häkkinen K, Newton RU, Maresh CM, and Fleck SJ. Influence of exercise order in a resistance-training exercise session. *J Strength Cond Res* 20: 141–144, 2006.
20. Vidt ME, Daly M, Miller ME, Davis CC, Marsh AP, and Saul KR. Characterizing upper limb muscle volume and strength in older adults: A comparison with young adults. *J Biomech* 45: 334–341, 2012.
21. Westcott WL. Resistance training is medicine: Effects of strength training on health. *Curr Sports Med Rep* 11: 209–216, 2012.