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An investigation of eccentric versus concentric resistance training: the role of movement velocity and training type

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Abstract

It is known that high intensity dynamic resistance training which involves eccentric and concentric contractions is one of the effective method for maximizing strength. Although, it is postulated that eccentric and concentric contractions provide different physiological adaptations, previous studies comparing the short-term effects of these two contractions have reported contradictory findings, with some studies reporting greater strength development with eccentric, some with concentric and some with similar within both training (18). Methodological differences may be of critical importance to the reported different findings, when focusing on the underlying reasons for these effects are discussed. The majority of previous studies on this topic have used isokinetic equipment to compare eccentric with concentric training, however there are also several studies which used isotonic method which is the most common type of resistance training. Since the effects of these two methods can form different physiological adaptations (9), it may not be proper to review the studies related to eccentric and concentric comparisons without taking into account training method variable. In isokinetic, contraction velocity can be controlled by the dynamometer however it is hard to standardize the movement velocity of isotonic training. And also previous studies showed that movement velocity of resistance training may affect strength development (11). At this juncture, the aim of this paper was to review the studies investigating eccentric and concentric resistance training and discuss the reported findings by considering methodological differences (training type and movement velocity). Although it was difficult to present certain implications due to only few studies including same methods in terms of contraction types and training methods, some highlights from this paper can be very informative to further studies. One of them is that the effects of eccentric and concentric resistance training might be different according to training types. The effects of movement velocity of resistance training on strength may also be different in terms of isotonic or isokinetic training methods.

Key words: Strength, contraction type, isotonic, isokinetic

INTRODUCTION

Trainers, conditioners and coaches try to design appropriate resistance training program to enhance their player's strength because strength is one of the determinant components that affect athletic performance for almost all sports. It has been well documented that an effective way of improving muscular strength is through high intensity dynamic resistance training which involves eccentric and concentric actions. Concentric contractions involve the dynamic shortening of sarcomeres and eccentric contractions involve the active lengthening of sarcomeres (19). A number of studies aimed to examine the effects eccentric and concentric contractions on strength but they have not reached a consensus on which action is most effective for strength development even though some critical points have been attained. It is from this point in the literature that eccentric training can resulted in greater hypertrophy-typically refers to a strength development than concentric resistance training (7), and strength development due to increased muscle growth can be more after eccentric resistance training. Only few studies have reported similar hypertrophy increases within both training modes (3). However, it is known that strength development may result from neural activation of muscle as well as hypertrophy (6, 13). Furthermore, the short or long term effects of eccentric and concentric resistance training on inducing gains in neural activation is still a debatable issue, with some studies reporting greater neural activation of muscle with eccentric, some with concentric and some with similar within both training modes (5). In a similar vein, enhanced strength caused by neural adaptations after eccentric or concentric resistance

training could potentially different by different movement velocities (1).

Eccentric versus concentric resistance training

It has been well documented that physiological responses after eccentric and concentric HRT period can be different; however the studies investigating the short term effects of eccentric and concentric resistance training on strength have contradictory findings. Chronic exposure to HRT produces marked increases in muscular strength, which are attributed to neurological and morphological adaptations(8,20). The primary morphological adaptations involve an increase in the cross sectional area of the whole muscle and individual muscle fibres, which is due to an increase in myofibrillar size and number (8). On the other hand, Sale (20) stated that strength training may cause adaptive changes within the nervous system that allow a trainee to more fully activate prime movers in specific movements and to better coordinate the activation of all relevant muscles, thereby effecting a greater net force in the intended direction of movement(20). In the light of this information, the contradictory findings in previous studies which related to short term effects of eccentric or concentric training can be attributed to different effects of neural factors and hypertrophy. Gür et al. (11) revealed that concentric-eccentric training improves functional capacity more compared to the isokinetic strength training with only concentric contraction. Vikne et al. (24) revealed that both eccentric and concentric training increased concentric strength to a similar extent (14 vs 18%), whereas eccentric training led to greater increases in eccentric strength than concentric training did (26 vs 9%). Roig et al. (19) revealed that high intensity eccentric resistance training is more effective than high intensity concentric resistance training in increasing muscle strength and hypertrophy. Roig et al. (19) have also concluded in their systematic review with meta-analysis that adaptations after resistance training are highly specific to the contraction type and velocity. In an another recent systematic review Schoenfeld, Ogborn and Krieger (21) highlighted that it seems highly difficult to identify the effects of concentric and eccentric resistance training on hypertrophy or muscle development without taking the contraction velocity under control as a variable while this variable has an impact on strength development. Eccentric and concentric resistance training did not reach statistical significance, however eccentric training resulted in a greater effect size compared to concentric training in their meta-analysis (21). When examining the effects of contraction velocity of resistance training on strength it can also be distinguished that these effects may be different according to training methods (isotonic and isokinetic) (10, 14). The majority of previous studies have not considered contraction velocity issue, and several of them have used different training types (isotonic and isokinetic).

The different effects of movement velocity: with respect to training type

Isotonic resistance training is the most common type of resistance training (generally more feasible when compared with isokinetic equipment) which uses free weights such as dumbbells and barbells. In this method, training load stays constant during the action and the muscle length changes concentrically and eccentrically.

Pereira and Gomes (17) emphasized that movement velocity for resistance training with isotonic equipment needs to be further investigated. Since then, there has been insufficient number of studies related to the effects of movement velocity in isotonic resistance training. Hackett et al. (12) maintained that the relevant literature is inclined to show that resistance training at high and low speed may lead to similar strength improvement. However, Pereira et al.'s study (18) which is one of the current studies on this topic employed an isotonic training method and keeping the concentric contraction velocity constant, it evaluated the effect of keeping eccentric contraction at 1 sc and 4 sc as fast and slow training. The findings of their study (18) revealed that slow training has more effect on hypertrophy compared to fast training. In this study, they interpreted their findings such that "a longer time under tension also increases acute mitochondrial, sarcoplasmic and myofibrillar protein synthesis after resistance exercise, stimulating hypertrophy response." From a mechanical perspective, it is previously stated that muscles are capable of achieving higher absolute forces when contracting eccentrically as compared with concentrically (19). In order to understand these different effects after different velocities of isotonic resistance training, examining the acute physiological responses after these trainings also may be elucidated. Burd et al. (4) found that compared to fast resistance training, slow resistance training leads to more acute amplitude of mitochondrial and sarcoplasmic protein synthesis

and that slow resistance training may be more effective for hypertrophy. Even though slow isotonic resistance training appears to be more effective at increasing strength than fast isotonic resistance training, these few findings are not adequate to assert that.

On the other hand, previous studies investigating the effect of movement velocity in resistance training have reported contradictory findings when muscular strength is measuredisokinetically. Roig et al. (19) reviewed the studies on this topic and discussed the findings separately with isotonic and isokinetic methods. Since only few studies regarding the effects of movement velocity of isotonic resistance training on strength had been conducted by that time, the factor of movement velocity in isokinetic resistance training was considered comprehensively. This review revealed that the effect of eccentric and concentric does not seem to be affected by movement velocity. Farthing and Chilibeck (7) compared eccentric and concentric training at two velocities simultaneously and found that fast eccentric training (180^0 sc^{-1}) resulted in greater hypertrophy than both slow (30^0 sc^{-1}) and fast concentric training, but not slow eccentric training (7). Moreau et al. (16), who conducted a study on the youth with cerebral palsy, found an increase in rectus femoris fascicle length following fast-velocity training, while they observed a decrease in the length after slow-velocity training. However, rectus femoris cross-sectional area increased in both groups. The same study also revealed that only fast-velocity training leads to an improvement in the velocity of movement, muscle power, and walking speed (16). Schoenfeld et al. (22) suggested in the most recent review study that training at volitionally very slow durations (>10s per repetition) is inferior from a hypertrophy standpoint, although a lack of controlled studies on the topic makes it difficult to draw definitive conclusions.

CONCLUSION, IMPLICATIONS & RECOMMENDATIONS

It is difficult to say one of contractions has more effect on strength development due to the lack of controlled studies; however there is general consensus that eccentric resistance training can be better for hypertrophy. Another important point is that adaptations after eccentric or concentric training can be highly specific to the contraction velocity and training types (isotonic, isometric, isokinetic etc.) (18, 20,21).

For individuals desiring increased dynamic muscular strength [i.e., 1 repetition maximum (1 RM)], the American College of Sports Medicine (ACSM) provides resistance-training recommendations for novice (no resistance-training experience) to advanced ([12 months' resistance-training experience) trainers (9). Therefore, it can say that the effects of eccentric and concentric trainings most likely to specific to training experience. Pereira et al.'s study which reported that slow resistance training is more effective than fast resistance training for increasing strength included well-trained subjects and it is an important point. If they could apply same interventions in sedanteries or less trained subjects, they might obtain different results. Training experience can form different physiological adaptations after short or long term (20). Early adaptations can be attributed to neural factors, after the neural adaptations reach a plateau muscular adaptations (hypertrophy) dominates. Assume that neural adaptations of the subjects were already high before the study, some kind of training such as eccentric training which has more effects on hypertrophy can cause more increases.

Apart from training experience, a great number of training variables such as training intensity and volume, frequency, rest periods, gender, physical activity, disability or heredity etc. can be covariate in enhancing athletic performance (2, 15, 23). Even though, it is hard to control all these internal or external factors when designing a research, further studies should be considered these when discussing their findings with their others.

As practical applications, it can say that eccentric and concentric resistance trainings should be preferred by depending on the goals. If the goal is to increase the muscle size, eccentric training seems to be more effective. On the other hand, in order to enhance maximum strength, the situation is somewhat complicated. Concentric resistance training can enhance muscular strength as much as eccentric resistance training can. Since the neurological factors may make their greatest contribution in the early stages of a training programme (8), concentric resistance training may be good choice for novice level individuals. High intensity eccentric training may be one of the most effective exercises forwell-trained athletes who aim to increase muscle size. Bot resistance training

methods (eccentric and concentric) may have similar effects in maximizing strength.

REFERENCES

1. Aagaard P, Simonsen EB, Andersen JL, Magnusson SP, Halkjaer-Kristensen J, Dyhre-Poulsen P. Neural inhibition during maximal eccentric and concentric quadriceps contraction: effects of resistance training. Journal of Applied Physiology, 2000: 89(6), 2249–2257.
2. Aslan AK, Erkmen N, Aktaş S, Güven F. Postural control and functional performance after core training in young soccer players. Malaysian Journal of Movement, Health & Exercise, 2018:7(2).
3. Blazevich AJ, Cannavan D, Coleman DR, Horne S. Influence of concentric and eccentric resistance training on architectural adaptation in human quadriceps muscles. Journal of Applied Physiology, 2007:103(5), 1565–1575.
4. Burd NA, Andrews RJ, West DW. D, Little JP, Cochran AJR, Hector AJ. Baker SK. Muscle time under tension during resistance exercise stimulates differential muscle protein sub-fractional synthetic responses in men. The Journal of Physiology, 2012:590(2), 351–362.
5. Cadore EL, González-Izal M, Pallarés JG, Rodriguez-Falces J, Häkkinen K, Kraemer WJ, Izquierdo M. Muscle conduction velocity, strength, neural activity, and morphological changes after eccentric and concentric training. Scandinavian Journal of Medicine & Science in Sports, 2014: 24(5), e343–e352.
6. Colliander EB, Tesch PA. Effects of eccentric and concentric muscle actions in resistance training. Acta Physiologica, 1990: 140(1), 31–39.
7. Farthing JP, Chilibeck PD. The effects of eccentric and concentric training at different velocities on muscle hypertrophy. European Journal of Applied Physiology, 2003: 89(6), 578–586.
8. Folland JP, Williams AG. Morphological and neurological contributions to increased strength. Sports medicine, 2007: 37(2), 145-168.
9. Fleck SJ, Kraemer W. Designing Resistance Training Programs, 4E. Human Kinetics.2014.
10. Golik-Peric D, Drapsin M, Obradovic B, Drid P. Short-term isokinetic training versus isotonic training: effects on asymmetry in strength of thigh muscles. Journal of Human Kinetics, 2011:30, 29–35.
11. Gür H, Cakın N, Akova B, Okay E, Küçükoğlu S. Concentric versus combined concentric-eccentric isokinetic training: effects on functional capacity and symptoms in patients with osteoarthrosis of the knee. Archives of Physical Medicine and Rehabilitation, 2002:83(3), 308–316.
12. Hackett DA, Davies TB, Orr R, Kuang K, Halaki M. Effect of movement velocity during resistance training on muscle-specific hypertrophy: A systematic review. European Journal of Sport Science, 2018: 18(4), 473–482.
13. Higbie EJ, Cureton KJ, Warren III GL, Prior BM. Effects of concentric and eccentric training on muscle strength, cross-sectional area, and neural activation. Journal of Applied Physiology, 1996:81(5), 2173–2181.
14. Kim MK, Yoo KT. Effect of isotonic and isokinetic exercise on muscle activity and balance of the ankle joint. Journal of Physical Therapy Science, 2015: 27(2), 415–420.
15. McArdle WD, Katch FI, Katch VL. Exercise physiology: nutrition, energy, and human performance (seventh). Lippincott Williams & Wilkins. 2010.
16. Moreau NG, Holthaus K, Marlow N. Differential adaptations of muscle architecture to high-velocity versus traditional strength training in cerebral palsy. Neurorehabilitation and Neural Repair, 2013:27(4), 325–334.
17. Pereira MIR, Gomes PSC. Movement velocity in resistance training. Sports Medicine, 2003: 33(6), 427–438.
18. Pereira PEA, Motoyama YL, Esteves GJ, Quinelato WC, Botter L, Tanaka KH, Azevedo P. Resistance training with slow speed of movement is better for hypertrophy and muscle strength gains than fast speed of movement. International Journal of Applied Exercise Physiology, 2016:5(2), 37-43.
19. Roig M, O'Brien K, Kirk G, Murray R, McKinnon P, Shadgan B, Reid WD. The effects of eccentric versus concentric resistance training on muscle strength and mass in healthy adults: a systematic review with meta-analysis. British Journal of Sports Medicine, 2009: 43(8), 556–568.
20. Sale Digby G. "Neural adaptation to strength training." Strength and power in sport 2003: 281-314.
21. Schoenfeld BJ, Ogborn DI, Krieger JW. Effect of repetition duration during resistance training on muscle hypertrophy: a systematic review and meta-analysis. Sports Medicine, 2015:45(4), 577–585.
22. Schoenfeld BJ, Ogborn DI, Vigotsky AD, Franchi MV, Krieger JW. Hypertrophic effects of concentric vs. eccentric muscle actions: a systematic review and meta-analysis. The Journal of Strength & Conditioning Research, 2017:31(9), 2599–2608.
23. Tatlıcı A, Çakmakçı E, Yılmaz S, Arslan F. Comparison of visual reaction values of elite deaf wrestlers and elite normally hearing wrestlers. 2018.
24. Vikne H, Refsnes PE, Ekmark M, MedbØ J., Gundersen, V., & Gundersen, K. Muscular performance after concentric and eccentric exercise in trained men. Medicin*e and Science in Sports and Exercise*, 2006:*38*(10), 1770–1781.