Eccentric Exercise in Rehab

During many movements, an eccentric muscle action occurs as a braking, or opposition, force in response to a concentric (shortening) action, in order to protect joint structures from damage. In an eccentric action, the muscle *elongates* under the tension caused when an opposing force (such as a weight) is greater than the force generated by the muscle.

Most of the classical muscle load studies in exercise physiology have focused on isometric (same length) and isotonic (shortening) contractions. One of the first research observations on eccentric muscle actions took place in 1882, when Adolf Fick discovered that a contracting muscle under stretch could produce a greater force than a shortening muscle contraction (Lindstedt, LaStayo & Reich 2001). About 50 years later, A.V. Hill (who became a Nobel laureate) ascertained that the body had a lower energy demand during an eccentric muscle action than during a concentric muscle action (Lindstedt, LaStayo & Reich 2001).

Lindstedt, LaStayo and Reich note that in 1953 researcher Erling Asmussen introduced eccentric exercise as “excentric,” with ex meaning “away from” and *centric* referring to “center,” thus giving the meaning of moving away from center. Lindstedt and colleagues further explain that when weight exceeds the force developed by the muscle, as in an eccentric muscle action, the exercise is referred to as negative work because the muscle is absorbing energy in this loaded motion.

Clinical applications of eccentric contractions have been studied (Hoppeler, 2016). The high forces and low energy cost associated with eccentric contraction make eccentric exercise uniquely suited for a variety of applications. Eccentric training regimes range from low-to-moderate intensity exercises that are safe for exercise-intolerant and elderly persons to high-intensity exercises that enhance athletic performance (Vogt and Hoppeler, 2014), prevent injury, and improve rehabilitation (LaStayo et al., 2003b; Roig et al., 2009).

Many reviews in the literature focus on eccentric exercise as a rehabilitation strategy for persons with exercise intolerance (e.g., cardiovascular or other conditions that limit training intensity; LaStayo et al., 2000; Reeves et al., 2009). For healthy subjects, exercise strategies—such as blood flow restriction with low force (Pope et al., 2013; Dankel et al., 2016)—may be just as effective as low to moderate eccentric exercises. However, the high-forces produced by muscles during eccentric contractions, and the high forces consequently exerted on muscles, bones and tendons, stimulate not only unique muscle hypertrophy and architectural adaptations (Franchi et al., 2014, 2015, 2016; Wisdom et al., 2015; Narici et al., 2016), but also bone mineralization and tendon remodeling (Reeves et al., 2009; Franchi et al., 2014; Wisdom et al., 2015).

DOMS. All types of muscle contractions, especially in untrained individuals, can cause exercise-induced delayed-onset muscle soreness (DOMS), but it is especially noticed after a bout of eccentric exercise. DOMS is typically characterized as the muscle soreness and swelling that become evident 8–10 hours after exercise and peak 24–48 hours after the activity (Balnave & Thompson 1993).

One area of research that has much promise in relation to DOMS and eccentric exercise is the repeated-bout effect (RBE). One of the only ways, it seems, to prevent or lessen DOMS from eccentric exercise (or to hasten recovery from it) is to eccentrically stimulate the muscles about 1 week (or more) prior to the eccentric training bout (Pettitt et al. 2005). The reduced DOMS response to eccentric resistance, after the prior eccentric exposure, is referred to as the RBE.

Several studies have shown that performing a bout of exercise leading to DOMS and then repeating the eccentric bout of exercise several days (and/or up to 6 months) later results in significantly lower levels of DOMS; reduced levels of circulating creatine kinase (a marker of muscle damage); increased range-of-motion recovery; and enhanced strength recovery after the repeated eccentric workout (Pettitt et al. 2005; Balnave & Thompson 1993).

Age and DOMS. Older men are not as susceptible as their younger counterparts to the muscle damage caused by eccentric exercise (Lavender and Nosaka 2006). Lavender and Nosaka hypothesize that the older adults may instinctively have developed neural inhibitory mechanisms to avoid exercise-induced muscle damage. With females, Ploutz-Snyder et al. (2001) found no difference in DOMS between older women (66 years) and younger women (23 years) in either concentric or eccentric strength training in a 12-week study evaluating knee extension strength.

Low Level Clients. Findings indicated that in untrained subjects performing eccentric exercise, muscle damage was significantly less and muscles recovered significantly faster after submaximal (50%) loading than after maximal loading. The finding is meaningful to wellness practitioners in that it shows that too much intensity can cause greater DOMS, which may lead to a drop-off in exercise adherence among these clients.

Rehab. Anterior cruciate ligament reconstruction (ACL-R) rehabilitation continues to be a challenging area of research. Safe and effective methods are constantly being researched. Careful, progressive overloading of the muscle early after surgery is essential to an effective recovery.

Gerber and colleagues (2009) found that patients performing a 12-week eccentric training program (along with functional rehabilitation exercises) beginning 3 weeks after surgery showed greater improvements in quadriceps femoris and gluteus maximus muscle volume and overall function than patients performing a standard rehabilitation protocol of weight-bearing exercise, resistance exercise and functional training. At a 1-year follow-up, the eccentric exercise group had a 50% greater improvement in quadriceps femoris and gluteus maximus muscle volume. Additionally, improvement in overall function was significantly greater in this group than in the standard rehabilitation control group.

Metabolism. Research has found that doing exercise with an eccentric emphasis can acutely and meaningfully raise the resting energy expenditure (REE) of both trained and untrained individuals after a total-body workout (Hackney, Engels & Gretebeck 2008).

Key Findings About Eccentric Training

1. Eccentric exercise creates greater force during the eccentric bout, owing to the decreased rate of actin-myosin cross-bridge detachments (Herzog et al. 2008). Clients are therefore capable of working with greater weight during an eccentric exercise.

2. Eccentric contractions use less energy, even though they create more force than concentric actions. This is because during a concentric muscle action one molecule of ATP is used to detach each actin-myosin cross-bridge. However, during an eccentric action some cross-bridges are forcibly detached as a result of the stretching of the muscle fiber, thus using less ATP (McHugh et al. 1999).

3. Some clients feel more muscle “tenderness,” as opposed to muscle soreness, from DOMS (Proske & Allen 2005).

4. The only scientific method of using eccentric exercise with clients to markedly reduce DOMS is the repeated bout effect. Completing a bout of eccentric exercises and then repeating the workout 1 week (or more) later will result in less DOMS after the second workout (Pettitt et al. 2005).

5. For injured clients, eccentric exercise of the “healthy” limb is a viable cross-training option for the immobilized limb (that has been injured or recently had surgery) (Housh et al. 1998).

6. Older clients are less susceptible to muscle injury from eccentric exercise than their younger counterparts, owing to several inhibiting and physiological mechanisms (Lavender & Nosaka 2006). Thus, eccentric training is an efficacious strategy to use with older clients.

7. Near-maximal or maximal eccentric muscular contractions should be avoided with “entry-level” clients (Nosaka & Newton 2002). Submaximal loads have been shown to produce much less DOMS and thus may also improve exercise compliance.

8. Resistance exercise programs should include periods of eccentric exercise, as this type of training will provide protection from injury or re-injury (Proske & Allen 2005).

9. For optimal development of muscle strength and size, programs should include both concentric and eccentric training (Proske & Allen 2005).

10. An enhanced submaximal training volume is possible if supramaximal eccentric loading (i.e., > 100% of 1-RM) is integrated into the resistance training program (Doan et al. 2002).

11. Supramaximal eccentric training (i.e., > 100% of 1-RM) is an excellent tool for athletes and clients who wish to break through training plateaus (Doan et al. 2002).

12. Eccentric training has proved to be a successful postrehabilitation intervention for lower-body injuries (Bahr et al. 2006).

13. In some research, subjects report less fatigue from eccentric training than from concentric training. These findings support the importance of integrating eccentric training into personal training settings (Hortobágyi et al. 1996).

14. Total-body eccentric emphasis training (i.e., 1-second concentric and 3-second eccentric contractions) can elevate resting metabolic rate about 9% (greatest magnitude in first 2 hours) (Hackney, Engels & Gretebeck 2008).

15. The energy cost of eccentric training is very low, while the magnitude of the force produced is unusually high. Therefore, muscles respond to eccentric training with meaningful changes in strength, size and power (Lindstedt, LaStayo & Reich 2001).

Aquatic Exercises

Here are two eccentric exercises that can be used with most basic exercises:

Eccentric Emphasis with Weights (imagine a simple bicep curl)

- Start with the weight the client normally uses for the particular muscular goal being worked on (i.e., if the client normally does 8 repetitions using a specific weight use that).
- Have the client do the concentric contraction, lifting the load in a 1-second “up.”
- Have the client do the eccentric contraction, lowering the load in 3–5 seconds (thus emphasizing the eccentric phase of the exercise).
- Have the client complete 8 repetitions if possible.
- Progress with increased time during the lowering, eccentric emphasis phase.
- Individualize the number of sets according to the client’s goals.

Eccentric Emphasis with Buoyancy (again, imagine a simple bicep curl)

- Start with the buoyant handbar the client normally uses for the particular muscular goal being worked on.
- Have the client do the eccentric contraction, lifting (flexing the elbow) the handbar in 3–5 seconds (thus emphasizing the eccentric phase of the exercise).
- Have the client do the concentric contraction, lowering the load in 1-second (if possible).
- Have the client complete 8 repetitions if possible.

- Progress with increased time during the lifting, eccentric emphasis phase.
- Individualize the number of sets according to the client's goals.

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