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Evidence of muscular adaptations within four weeks of barbell training in women

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ABSTRACT

We investigated the time course of neuromuscular and hypertrophic adaptations associated with only four weeks of barbell squat and deadlift training. Forty-seven previously untrained women (mean ± SD, age = 21 ± 3 years) were randomly assigned to low volume training ($n = 15$), moderate volume training ($n = 16$), and control ($n = 16$) groups. The low and moderate volume training groups performed two and four sets, respectively, of five repetitions per exercise, twice a week. Testing was performed weekly, and included dual X-ray absorptiometry and vastus lateralis and rectus femoris B-mode ultrasonography. Bipolar surface electromyographic (EMG) signals were detected from the vastus lateralis and biceps femoris during isometric maximal voluntary contractions of the leg extensors. Significant increases in lean mass for the combined gynoid and leg regions for the low (+0.68 kg) and moderate volume (+0.47 kg) groups were demonstrated within three weeks. Small-to-moderate effect sizes were shown for leg lean mass, vastus lateralis thickness and pennation angle, and peak torque, but EMG amplitude was unaffected. These findings demonstrated rapid muscular adaptations in response to only eight sessions of back squat and deadlift training in women despite the absence of changes in agonist–antagonist EMG amplitude.

1. Introduction

Historically, investigators have considered skeletal muscle growth to be a slow process. Publications endorsed by both the National Strength and Conditioning Association (Baechle & Earle, 2008) and the American College of Sports Medicine (2009) state that the initial adaptations associated with resistance training in novices are controlled by neuromuscular factors. Neuromuscular adaptations associated with short-term training interventions have been relatively well documented (Aagaard, Simonsen, Andersen, Magnusson, & Dyhre-Poulsen, 2002; Carolan & Cafarelli, 1992; Moritani & deVries, 1979; Stock & Thompson, 2014; Vila-Cha, Falla, & Farina, 2010). Perhaps the most influential investigation was carried out by Moritani and deVries (1979), who were the first to examine the time course associated with neuromuscular and hypertrophic adaptations during resistance training, and did so with the use of monopolar surface electromyography (EMG), skinfolds, and circumference measurements. What was novel about their experimental approach was the sophisticated analysis of the linear

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slope coefficient for the EMG amplitude versus isometric force relationship over time. Moritani and deVries (1979) concluded that the initial improvement in muscular strength was due to neuromuscular factors, and that hypertrophy did not become evident until the latter stages of the investigation. While the novelty of their techniques was admirable, one might contend that expressing neuromuscular and hypertrophic changes into mutually exclusive categories is simplistic and creates the impression that small-to-moderate changes in muscle size do not occur.

In contrast to the concept that the rapid improvement in muscular strength is governed solely by neuromuscular adaptations, some authors have reported evidence of muscle hypertrophy in response to short-term training (Baroni et al., 2013; Boone, Stout, Beyer, Fukuda, & Hoffman, 2015; DeFreitas, Beck, Stock, Dillon, & Kasishke, 2011; Seynnes, de Boer, & Narici, 2007; Staron et al., 1994). However, making direct comparisons among these studies is complicated by the fact that each of them assessed dissimilar time courses, distinct training programs, and different methods for measuring muscle growth. Using muscle biopsy sampling, Staron et al. (1994) reported that short-term resistance training resulted in a gradual shift for the type IIx muscle fibers to the more oxidative type IIa, and this alteration occurred in the absence of increases in both fat-free mass and fiber cross-sectional area. Three investigations have utilized B-mode ultrasonography to examine hypertrophy of the superficial quadriceps femoris muscles in response to short-term training (Baroni et al., 2013; Boone et al., 2015; Seynnes et al., 2007). In general, these studies have demonstrated that within four weeks of training, the vastus lateralis and/or rectus femoris showed altered muscle architecture, as evidenced by increased thickness, pennation angle, or fascicle length (Baroni et al., 2013; Boone et al., 2015; Seynnes et al., 2007). Perhaps the most intriguing findings were reported by DeFreitas et al. (2011), who performed testing on a weekly basis using peripheral quantitative computed tomography. In that study, the training program involved three sessions per week of leg press and leg extension exercises. The subjects performed three sets for each exercise with external loads that allowed for muscular failure between 8 and 12 repetitions. These authors showed statistically significant increases in thigh muscle cross-sectional area after only two training sessions, with further increases each week. It is worth noting that none of the previously described short-term investigations have studied multiple training groups and compared responses among differing types of training programs (e.g., high volume versus high load training). If meaningful increases in muscle hypertrophy are attainable within only a few training sessions (as shown by DeFreitas et al. (2011)), it is unclear how this response may be optimized by manipulating various acute training program variables.

The purpose of this investigation was to examine weekly neuromuscular and hypertrophic adaptations associated with only four weeks (two sessions per week) of barbell back squat and deadlift training in previously untrained women. The barbell squat and deadlift were of interest because they involve dozens of muscles and multiple joints through a large range of motion. A secondary purpose was to compare these responses between subjects exposed to low versus moderate volume training. We hypothesized that four weeks of barbell squat and deadlift training would result in increased isometric peak torque and surface EMG amplitude, as well as decreases in agonist–antagonist coactivation. In agreement with two recent studies (Baroni et al., 2013; DeFreitas et al., 2011), we further hypothesized that significant increases in lean mass, muscle thickness, and pennation angle would be evident within four weeks. We also postulated that moderate volume training would bring about better improvements than those demonstrated for low volume training.

2. Methods

2.1. Subjects

Forty-seven women (mean ± SD age = 21 ± 3 years; body mass = 63.3 ± 11.0 kg; height = 162.1 ± 9.6 cm) who were not engaged in resistance training during the previous six months completed this study. Prior to participation, potential subjects were screened for health-related illness. Women were not able to participate if they were affected by neuromuscular or metabolic disease. Furthermore, women with recent musculoskeletal discomfort, pain, or injury were not able to participate. Contraceptive use was permitted as long as its usage had remained consistent over the previous three months, since a previous training study showed minimal influence on strength-related outcomes (Nichols, Hetzler, Villanueva, Stickley, & Kimura, 2008). This study and its procedures were approved by the university's Human Research Protection Program. All subjects read, understood, and signed an informed consent form prior to participation. Each subject was randomly assigned to one of three groups: (1) low volume training (n = 15), (2) moderate volume training (n = 16), and (3) control (n = 16). The subjects were asked to refrain from resistance training outside of the study, but up to two hours physical activity (e.g., walking, light jogging, and cycling) per week were permitted.

2.2. Testing and training schedules

The subjects participated in six separate testing sessions, the first of which served as a familiarization trial. The pretest occurred 48 h following the familiarization session. Testing commenced at the conclusion of each of the four training weeks. For the subjects assigned to one of the two training groups, each testing session occurred 72 h following the final training session of the week. In addition, the subjects in the training groups performed testing and training on the same day (testing followed by training). A concerted effort was made to test each subject at the same time of day for the six testing sessions (±one hour). Most of the subjects in the training groups visited the laboratory on Monday (training only) and Thursday