Comparison of Heart-Rate and Blood-Pressure Increases During Isokinetic Eccentric Versus Isometric Exercise in Older Adults


The authors compared heart-rate and blood-pressure responses to typical isometric (ISO) and isokinetic (90°/s) eccentric (ECC) resistance-training protocols in older adults. Twenty healthy older adults (74 ± 5 years old) performed randomly ordered ISO and isokinetic ECC exercise (3 sets of 10 repetitions) at a target intensity of 100% of their peak ISO torque value. Heart rate and systolic (SBP) and diastolic (DBP) blood pressures were recorded continuously, and mean arterial pressure (MAP) and rate-pressure product (RPP) were calculated. ECC peak torque (139 ± 33 N · m) was significantly greater than ISO peak torque (115 ± 26 N · m; p < .001). All variables increased significantly (p < .001) during both ISO and ECC exercise. Changes in SBP, DBP, MAP, and RPP were significantly greater during ISO exercise than during ECC exercise (p < .001). Clinically, an isokinetic ECC exercise program enables older adults to work at the same torque output with less cardiovascular stress than ISO exercise.

Key Words: aging, physical activity

Eccentric (ECC) exercise is recognized as a valuable tool in rehabilitation (Hortobagyi & De Vita, 2000; LaStayo, Reich, Urquhart, Hoppeler, & Lindstedt, 1999). This type of dynamic exercise is one in which an external force is applied to the muscle such that tension develops as the muscle lengthens (Dean, 1988). ECC muscle contractions occur in a variety of functional activities such as walking down stairs, decelerating a limb during ambulation, or moving from standing to sitting. In fact, in many activities, an ECC movement precedes a concentric (CON) contraction, a phenomenon known as the stretch-shortening cycle (Doan et al., 2002). Compared with other types of exercise (isometric [ISO] and CON), ECC exercise produces a greater maximum torque (Enoka, 1996; Horstmann et al., 1994; Westing, Cresswell, & Thorstenson, 1991). Furthermore, there are less neural activation and energy consumption required during ECC exercise than when
muscles perform equivalent ISO or CON contractions (Hortobagyi & De Vita; Tesch, Dudley, Duvoisin, Hather, & Harris, 1990).

There is potential for stress on the cardiovascular system during both ECC and ISO exercise because of the pressor response elicited during maximum effort (Dean, 1988; Smolander et al., 1998). Caution might be warranted in older adults, who have a higher incidence of hypertension and cardiovascular disease. In young adults, the magnitude of arterial blood-pressure increase is determined mainly by the relative effort applied during exercise, rather than the absolute amount of weight lifted (MacDougall et al., 1992; MacDougall, Tuxen, Sale, Moroz, & Sutton, 1985). Because ECC exercise requires less effort than ISO exercise at the same absolute torque, it might also elicit less cardiovascular stress, although this has yet to be shown in older adults.

Age-related declines in muscle strength and cardiovascular status can be altered by physical activity (Bortz, 1982; Elia, 1991; Fitzgerald, 1985). Isokinetic exercise is now a common form of training for individuals who cannot tolerate high levels of joint stress (McMeeken, Nall, McNicol, Goble, & Fleming, 1995). Isokinetic exercise involves velocity control throughout the movement range, which can reduce joint stress and is important in such everyday activities as going from standing to sitting and descending stairs. This form of resistance training might benefit older adults whose joints exhibit the effects of long-term use. A recent study (Gur, Cakin, Akova, Okay, & Kucukoglu, 2002) of 23 participants age 41–75 years investigated the effects of CON and CON-ECC isokinetic resistance training on functional capacity and pain of patients with osteoarthrosis of both knees. The results indicated that it is possible to improve functional capacity and decrease pain in these patients by using isokinetic resistance exercise. The extensive training protocol, composed of a high number of repetitions and ECC contractions, was safe, effective, and well tolerated. Maurer, Stern, Kinrossian, Cook, and Schumacher (2000) also indicated that isokinetic exercise is an effective and well-tolerated treatment for knee osteoarthritis.

Until recently, there were very few studies that characterized the cardiovascular stress associated with isokinetic exercise (McMeeken et al., 1995; Scharf, Eckhardt, Maurus, & Puhl, 1994). A review of current literature suggests that the cardiovascular stress associated with isokinetic exercise is significantly less for ECC exercise than with CON exercise (Hortobagyi & De Vita, 2000; LaStayo et al., 1999; Thompson, Versteegh, Overend, Birmingham, & Vandervoort, 1999). There is little research available, however, on the comparison between the clinically measured cardiovascular effects of isokinetic ECC and ISO exercise in the older adult population. In addition, the cardiovascular stress elicited by resistance exercise is typically measured only at the end of such exercise; measurements taken after each repetition are rarely reported (Thompson et al.), although this would more accurately depict the real cardiovascular stress of the exercise.

Although ECC peak torque is higher than ISO peak torque, there are two main reasons that it is important to compare responses to ECC and ISO resistance exercise at the same absolute torque output (e.g., 100% ISO peak torque). First, high-threshold, fast-twitch motor-unit recruitment is important for inducing neural adaptations to resistance training, yet it is difficult for untrained participants to maximally activate these motor units (DeLuca, LeFever, McCue, & Xenakis, 1982). It has been reported, however, that submaximal ECC actions preferentially
recruit the high-threshold, fast-twitch motor units (Nardone, Romano, & Schieppati, 1989). Second, physical tasks frequently have fixed, rather than relative, metabolic demands. This puts older adults with lower maximal capacities at a disadvantage. Functionally, older adults are frequently faced with the challenge of producing an absolute torque output to accomplish a task. It is important that the cardiovascular stress associated with producing this absolute torque output be documented in the older adult population.

In order to provide resistance-training programs for older adults that incorporate functionally relevant movements and torque-output levels, do not stress the joints excessively, and are safe from a cardiovascular-stress perspective, it is important to determine the cardiovascular demands of isokinetic ECC exercise and ISO exercise at a given absolute torque output. The purpose of this study, therefore, was to examine heart-rate and blood-pressure responses, measured over each repetition, to typical ISO and isokinetic ECC resistance-exercise protocols at the same absolute torque output in older adults.

Methods

GENERAL OUTLINE

Peak torques for ISO and ECC knee-extension movements were measured on a Kinetic Communicator (Kin-Com® Model 500-H, Chattanooga Corp., Chattanooga, TN). Systolic and diastolic blood pressures and heart rate were recorded using an automated plethysmographic blood-pressure and heart-rate monitor (Finapres™, Ohmeda 2300, Englewood, CO) during sets of ISO and ECC knee-extension exercise at 100% of ISO peak torque.

PARTICIPANTS

Study participants included 20 healthy, recreationally active community-dwelling volunteers over 65 years of age (10 men and 10 women). Descriptive information on the participants is provided in Table 1. Participants were excluded if they had any orthopedic or neuromuscular problems that would limit knee-extension exercise, were taking any heart-rate or blood-pressure medications, or were master athletes

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<th>Table 1 Participant Characteristics, $M$ (SD)</th>
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(i.e., in formal training for a sport). The university’s ethics review board approved the study, and all participants provided informed written consent before participation.

PROCEDURES

Testing for each participant was completed in a single visit to a climate-controlled laboratory. After a brief orientation, descriptive information (age, height, body mass) was collected, and baseline data for blood pressure and heart rate (sitting position) were recorded after a minimum of 5 min seated rest. Participants were then led through a brief warm-up that included leg-stretching exercises and 3 min on an unloaded bicycle ergometer. Participants were then seated on the Kin-Com (back 80° from horizontal) and secured with belts across the chest and around the pelvis and thigh of the test leg. The dominant leg, defined as the leg with which the participant would kick a ball, was used for all tests. The non-test leg was supported with a stool. The Kin-Com was adjusted to ensure that the axis of rotation was coaxial with the lateral femoral epicondyle, and the resistance pad was fastened just above the ankle, thus permitting full dorsiflexion.

The left arm of the participant was comfortably supported on an adjustable table with the hand at the level of the heart. The appropriate-size finger cuff of the Finapres blood-pressure and heart-rate monitor was attached to the middle finger of the left hand, between the proximal and distal interphalangeal joints. The Finapres monitor provides a valid, noninvasive, continual measurement of blood pressure and heart rate (Langewouters, Settels, Roelandt, & Wesseling, 1998). Continual measurement was required for beat-by-beat collection; this level of precision is not possible with a standard arm cuff.

After positioning, the participant performed a standard warm-up on the Kin-Com, which included 12 repetitions at a self-judged perceived effort of 50% of maximum, eight repetitions at 75%, and, finally, three repetitions at 100% of perceived maximal effort each of ISO and ECC (90°/s) knee-extension movements. Rest intervals of at least 2 min, or until the participant felt rested, were permitted between warm-up sets and again before the actual trials to determine peak torque. Knee movements were performed over a 70° range of motion, from 10° to 80° of flexion. The minimum force required to activate the Kin-Com resistance arm was set at 10 N for the test contraction and 0 N to return the limb to the starting position. For the measurement of ISO peak torque, the stop angle for the resistance arm was set at 60°. The quadriceps muscles exert maximum force at angles between 50° and 70° of knee flexion (Knapik, Wright, Mawdsley, & Braun, 1983). Each ISO contraction was sustained for 5 s. Participants were not permitted to grasp the table or the restraining belts during testing. They were also instructed to exhale during the contractions to prevent performing a Valsalva maneuver (Linsenbardt, Thomas, & Madsen, 1992). The Valsalva maneuver increases intrathoracic pressure, thus decreasing the venous return to the heart and cardiac output (Langewouters et al., 1998).

ISO maximal trials were always performed before ECC trials in order to further familiarize these older participants with the Kin-Com. A 15-s rest interval was allowed between peak torque trials, and a 4-min rest was allowed between ISO and ECC tests. Peak torques for ISO and ECC movements were determined by averaging the best three of five maximal trials (Horstmann et al., 1994). After the
trials for maximal torque, participants were allowed a short stretch break (~5 min). Participants then performed, in random order, the ISO and ECC exercise protocols, each consisting of three sets of 10 repetitions at a target torque output of 100% of ISO peak torque. The ISO exercise protocol required a 3-s contraction with a rest interval of 15 s between repetitions (work-to-rest ratio 1:5) and a 2-min rest between sets. The ECC exercise protocol included a 1-s contraction with a 5-s rest interval between repetitions (work-to-rest ratio 1:5) and a 2-min rest interval between sets. Verbal encouragement was provided for both ISO and ECC exercise bouts. Participants were also provided with visual feedback in the form of a graphic display on the Kin-Com computer screen for the ECC portion of the exercise. Systolic blood pressure (SBP), diastolic blood pressure (DBP), and heart rate (HR) were continuously measured with the Finapres and recorded before each set of exercises and immediately after each repetition.

DATA ANALYSIS

The Finapres measured SBP, DBP, and HR. Mean arterial pressure (MAP) and the rate-pressure product (RPP) were then calculated, where MAP = DBP + \[1/3(SBP – DBP)\] and RPP = HR \times SBP/100. The RPP is an indirect measurement of the heart’s metabolic demands during exercise and has been used as an index of myocardial oxygen consumption or work of the heart (Nelson et al., 1974).

All statistical procedures were performed using a computer-based statistical package (SigmaStat for Windows®, release 2.03, StatSoft®, Inc., San Rafael, CA). A paired \(t\) test was used to compare ISO and ECC peak-torque values. Two-way repeated-measures analyses of variance (ANOVAs) were used to compare (a) baseline measurements of SBP, DBP, HR, MAP, and RPP across the three exercise sets for both ISO and ECC exercise; (b) initial baseline and peak values (end of the third set) for SBP, DBP, HR, MAP, and RPP for both ISO and ECC exercise; and (c) the change scores for SBP, DBP, HR, MAP, and RPP in each of the three sets (final-repetition value for each set minus baseline value for each set) in both exercise conditions. Tukey’s post hoc tests were used for pairwise comparisons if the omnibus \(F\) statistic was significant. The critical value for significance for all comparisons was set at \(p \leq .05\).

Results

All participants completed all procedures without incident. Isokinetic ECC peak torque (139 ± 33 N · m) was 21% greater than ISO peak torque (115 ± 26 N · m; \(p < .001\)). Baseline values for SBP (128 ± 11 mm Hg), DBP (73 ± 11 mm Hg), HR (70 ± 8 bpm), MAP (91 ± 10 mm Hg), and RPP (90 ± 14) were within normal limits for healthy older adults. The mean HR responses for the three sets of the ISO exercise protocol are provided in Figure 1 to illustrate the repetition-by-repetition measurements provided by the Finapres monitor.

Two-way repeated-measures ANOVAs indicated that both isokinetic ECC and ISO exercise protocols elicited significant (\(p < .001\)) increases for all variables (SBP, DBP, HR, MAP, RPP) from initial baseline (Rep. 0) to the end of exercise (Rep. 30). There were also a main effect of contraction type for DBP (ISO > ECC, \(p < .01\)) and significant interactions between contraction type (ISO > ECC) and
repetition number (Rep. 30 value > Rep. 0 value) for both DBP (p = .002) and MAP (p = .011). The increases (Rep. 30 value – Rep. 0 value) in DBP and MAP for ISO exercise were significantly greater than for isokinetic ECC exercise (p < .001). The baseline and end-exercise data are shown in Table 2.

There were no significant differences between baseline measurements of SBP, DBP, HR, MAP, or RPP for any of the three sets, for either ISO or ECC exercise. Similarly, no significant differences were detected in the magnitudes of change scores for each of the three exercise sets in either the ISO or isokinetic ECC exercise protocols. There was, however, a significant main effect of contraction type (ISO > ECC, p < .001) for SBP, DBP, MAP, and RPP change scores measured across the three exercise sets. The change-score data are provided in Table 2. Because neither baseline values nor peak scores for each of the three sets were different, a representative set (Set 2) was chosen to illustrate the MAP responses for both ISO and isokinetic ECC exercise (Figure 2). Absolute values and change scores for each variable in both exercise conditions in the representative set are provided in Table 3.

**Discussion**

This was the first study to compare cardiovascular responses across individual repetitions in typical training sessions of both ISO and isokinetic ECC resistance
exercise in older adults. Three main findings were noted. First, cardiovascular baseline measurements for each exercise set in the ISO and isokinetic ECC training protocols were not significantly different. This indicated that the training protocol provided sufficient rest between sets for participants to recover fully. Second, there was a significant difference for each exercise type between baseline measurements and the final repetition for each exercise set, indicating that the exercise regime was sufficiently intense to provoke a cardiovascular response. Finally, changes in SBP, DBP, MAP, and RPP elicited during ISO contractions were significantly greater than during isokinetic ECC contractions at the same absolute torque output, confirming the hypothesis that isokinetic ECC exercise is a less strenuous and thus potentially safer form of resistance exercise for the cardiovascular system of older adults.

The type of isokinetic exercise involved in this study provides a safe modality of strength testing (Horstmann et al., 1994; LaStayo et al., 1999), allowing a muscle group to be exercised to its maximum potential throughout a joint’s entire range of motion (Perrin, 1993). The ECC form of resistance training might have the most benefit for older adults because its consequences include inducing structural adaptations via an adaptive inflammatory response in muscle and modification of

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<th>ECC</th>
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<td>Baseline</td>
<td>Rep 30</td>
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<td>SBP, mm Hg</td>
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<td>Rep 30</td>
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<tr>
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<td>Rep 30</td>
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<td>Change score</td>
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<td>RPP</td>
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<td>Baseline</td>
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<tr>
<td>Rep 30</td>
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<td>Change score</td>
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Note. ISO = isometric exercise; Rep = repetition; ECC = eccentric exercise; SBP = systolic blood pressure; DBP = diastolic BP; HR = heart rate; MAP = mean arterial BP; RPP = rate-pressure product.

*Significant increase between baseline and Rep 30, p < .001. †ISO Rep 30 DBP significantly greater than ECC Rep 30, p < .01. ‡Significant difference in change scores (Rep 30 – baseline Rep) between contraction type (isometric > eccentric) in SBP, DBP, MAP, and RPP, p < .001.
Figure 2. Mean arterial blood pressure for 10 repetitions during representative sets of both isometric and isokinetic eccentric exercise (Set 2). The data reflect the values for MAP in Table 3. *Significant difference between ECC and ISO contraction types for both the peak MAP score (124 vs. 109 mm Hg) and change in MAP (29 vs. 13) for the exercise set (isometric > eccentric). *p < .001.

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<tr>
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<th>SBP (mm Hg)</th>
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<td><strong>Isometric</strong></td>
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<tr>
<td>peak</td>
<td>172.8 (25.5)</td>
<td>101.1 (29.7)*</td>
<td>79.5 (8.6)</td>
<td>123.9 (22.9)*</td>
<td>136.1 (26.1)</td>
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<td>change</td>
<td>37.6 (21.7)*</td>
<td>26.8 (21.0)*</td>
<td>10.8 (5.7)</td>
<td>29.4 (16.3)*</td>
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<td><strong>Eccentric</strong></td>
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<td>peak</td>
<td>163.7 (34.6)</td>
<td>82.9 (15.4)</td>
<td>79.0 (8.7)</td>
<td>109.5 (21.3)</td>
<td>129.9 (36.7)</td>
</tr>
<tr>
<td>change</td>
<td>26.6 (21.0)</td>
<td>8.1 (15.1)</td>
<td>10.1 (5.5)</td>
<td>13.5 (17.6)</td>
<td>35.0 (21.6)</td>
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*Note. Rep = repetition; SBP = systolic blood pressure; DBP = diastolic BP; HR = heart rate; MAP = mean arterial BP; RPP = rate-pressure product.
*Significant difference between contraction types (isometric > eccentric), *p < .001.
the neural commands used to control the movement (Perrin; Dudley, Tesch, Miller, & Buchanan, 1991) while at the same time being well tolerated and requiring lower energy cost than traditional (free weight) training (LaStayo, Ewy, Pierotti, Johns, & Lindstedt, 2003). Although other types of contractions can also induce these adaptations, they seem to be maximized by ECC exercise (Enoka, 1996). In a recent study involving 21 frail elderly participants (mean age 80 years) who completed 11 weeks of lower extremity resistance training in either an ECC group or a traditional lower extremity weight-training group, LaStayo et al. (2003) reported that high-force ECC exercise is a well-tolerated intervention, perceived as only "somewhat hard," that provides a potent stimulus to muscle growth and strength. The greater strength increase found after negative (eccentric) work training resulted in improved balance, stair descent, and falls risk only in the ECC group. The authors suggested that ECC exercise might be useful for individuals that are otherwise unable to achieve high muscle forces with traditional resistance exercise because of the low energy cost coupled with high force production characteristic of ECC exercise. Cardiovascular stress was not investigated in that study.

It has been reported in young adults that ISO, CON, and ECC contractions at the same relative intensity elicited a pressor response of the same magnitude, despite different absolute forces (MacDougall et al., 1992). Furthermore, the same relative (different absolute) muscle force produces not only the same subjective sense of force (Cafarelli & Bigland-Ritchie, 1979) but also the same blood-pressure response (Ng, Agre, Hanson, Harrington, & Nagle, 1994). This might explain why differences between ISO and ECC exercise were found in the present study, in which the pressor response was measured when comparing exercises of the same absolute intensity. Because ISO contractions were performed at a higher relative torque level, the pressor response was greater than for isokinetic ECC contractions. This had not been previously determined in older adults. Activities that induce a greater pressor response are more stressful on the cardiovascular system (Dean, 1988; Smolander et al., 1998) and thus potentially more dangerous for older adults with or without a cardiac condition.

Many studies of maximal human strength have demonstrated that ECC peak torque is greater than ISO or CON peak torque (Enoka, 1996; Horstmann et al., 1994; Jensen, Neickarz, Overend, & Vandervoort, 1999; Thompson et al., 1999; Westing et al., 1991). The neural input required to produce a given force is much lower during ECC than during CON exercise (Tesch et al., 1990). Likewise, when neural input is the same for ECC and CON muscle actions, force is much greater for the ECC condition. In the present study, therefore, because the force was held constant between exercise conditions (at 100% of peak ISO torque), it was likely that the isokinetic ECC contractions required less voluntary activation by the nervous system. The ability to perform the same work rate with less neural input (i.e. greater efficiency) is a result of the inherent capacity of skeletal muscle to develop greater force during ECC actions (Colliander & Tesch, 1989; Tesch et al.). Thus, skeletal muscle should experience less metabolic demand during, and more rapid recovery from, ECC exercise than with ISO exercise (Tesch et al.), a hypothesis that needs further investigation for our exercise protocols with older adults.

Several previous studies (Haennel et al., 1992; MacDougall et al., 1992; Negus, Rippe, Freedson, & Michaels, 1987) have failed to detect significant differences in SBP and DBP responses between isokinetic and static contractions.
In submaximal isokinetic exercise, however, Iellamo et al. (1997) reported greater increases in SBP and DBP than in ISO exercise. The discrepancy between these studies and the present study might be related to differences in the exercise protocols employed, such as differences in contraction duration, active muscles, participant population, rest periods, number of repetitions, and contraction intensity. It is important to note that although the current study compared ISO and isokinetic ECC exercise protocols using the same torque outputs (and hence the intensity of force in the muscle for stimulating a training effect), there was a difference in the total amount of muscle activity performed (measured by the Force × Time integral), because ISO contraction time was longer than ECC contraction time. Eccentric repetitions were separated by shorter rest periods (5 s vs. 15 s between ISO repetitions) in an attempt to make the bouts of ISO and ECC exercise more comparable in work-to-rest ratios. Further studies should attempt to equalize the total amount of muscle activity by shortening the ISO contraction time or lengthening the ECC contraction time.

In future studies, it would also be beneficial to incorporate a rating of perceived exertion to compare the subjective responses to ISO and ECC exercise. This could be important in determining whether perceived effort of exercise correlates with differences in blood pressures for older adults. In young adults, MacDougall et al. (1992, 1985) found that the magnitude of increase in arterial blood pressure was determined mainly by the effort applied during the exercise, rather than the absolute amount of weight lifted. The concept of relative versus absolute effort with respect to blood-pressure increases has yet to be investigated in older adults. Because ECC contractions were performed at only 83% of isokinetic ECC maximum voluntary contraction in the present study, perceived effort might have been less for the ECC exercise. LaStayo et al. (2003) recently reported the successful use of the 10-point Borg scale of perceived exertion to monitor training intensity in older participants performing negative lower extremity work.

Useful clinical implications arise from the present study. High-intensity strengthening exercise yielded a substantial increase in functional stress on the cardiovascular system, despite a significant rest interval between repetitions of both ISO and ECC exercise. If an exercise participant is suffering from known or unrecognized cardiovascular disease (e.g., hypertension, silent myocardial ischemia, arrhythmia), he or she might be at risk for significant complications. Because ECC exercise produces less stress on the cardiovascular system than does ISO exercise at the same absolute torque output, isokinetic ECC exercise might be, overall, a safer form of exercise for older adults who are at higher risk of cardiovascular disease. In addition, because isokinetic exercise has been shown to be effective for individuals suffering from osteoarthritis (Gur et al., 2002), a common condition in older adults, the isokinetic mode of ECC exercise might well further enhance the tolerance of resistance training by older adults. There is accumulating evidence indicating that low-intensity exercise produces substantial changes in muscle strength, muscle-fiber size, mobility, and bone-mineral density in older adults (Brown & Holloszy, 1991; Hortobagyi, Tunnel, Moody, Beam, & De Vita, 2001; Krebs, Jette, & Assmann, 1998; Taaffe, Pruitt, Pyka, Guido, & Marcus, 1996). Hortobagyi and DeVita (2000), in their study comparing CON and ECC exercise bouts over 7 days in older women, found that exercising at approximately
60% of maximum intensity resulted in marked and rapid strength gains. Nichols, Hitzelberger, Sherman, and Patterson (1995) were able to demonstrate significant improvements in one-repetition-maximum strength with exercise intensity as low as 45%. The present study used exercise intensities of 100% of ISO peak torque and 83% of ECC peak torque, and thus significant increases in cardiovascular stress were evident in both training regimens. Because exercise intensity in the older adult population with cardiovascular disease is often severely limited by the inability of the cardiovascular system to supply working muscles with sufficient oxygen, submaximal ECC exercise might be the only form of exercise that these individuals are capable of performing (LaStayo et al., 2003, 1999).

Habitual exercise has many benefits for the older population, including reducing the age-related rate of decline in maximum aerobic capacity, decreasing mean blood pressure and systemic vascular resistance, preserving lean body mass, decreasing fat deposits, and increasing bone-mineral content, cognitive functioning, and muscle strength (Bortz, 1982; Elia, 1991; Krishnathasan & Vandervoort, 2000). It is now evident that, in addition to endurance exercise, older adults need to be involved in some type of strengthening regimen, and isokinetic ECC exercise protocols appear particularly advantageous. The results of the present study also suggest both the need for a careful cardiovascular examination before older adults initiate a high-intensity strength-training program and the importance of monitoring the cardiovascular responses of clients with cardiovascular disease during strength-training activities, particularly if ISO exercises are included.

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References


