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ORIGINAL ARTICLE

Effects of Fitness and Vibration Training on Muscle Quality: A 1-Year Postintervention Follow-Up in Older Men

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Abstract

Objective: To evaluate the residual effects of fitness and whole-body vibration (WBV) training in older men 1 year after completion of the interventions.

Design: A 1-year follow-up of a randomized controlled trial comparing the effects of 1 year of fitness training, including combined resistance and aerobic (R+A) training and WBV training, with a control (CON) group.

Setting: University training center.

Participants: Adult men (N=72) between 60 and 80 years of age. Response rate was 80%, 92%, and 90% in the R+A training (n=20), WBV training (n=23), and CON (n=29) groups, respectively.

Interventions: The intervention groups exercised 3 times weekly during 1 year. The R+A training group performed a standard training program, combining resistance exercises and aerobic training, following the American College of Sports Medicine guidelines. The WBV training group performed unloaded static and dynamic leg exercises on a vibration platform. The CON group did not participate in any training program.

Main Outcome Measures: Muscle volume, isometric and concentric muscle strength, muscle quality, and muscle power.

Results: Both interventions had resulted in comparable increases in muscle quality characteristics. No significant changes had been found in the CON group. During the 1-year follow-up period, the R+A (−4.05%, P=.006) and WBV (−2.45%, P<.0001) training groups had lost most of their gains in muscle volume. However, isometric muscle strength was preserved in the R+A training group (+1.65%, P=.745), resulting in an increase in muscle quality (+7.97%, P=.034). In the WBV training group, muscle power decreased (−6.10%, P<.0001) but remained significantly higher than at baseline (P=.038). Except for a strong decrease in muscle power, no significant changes were found in the CON group.

Conclusions: One year of R+A and/or WBV training can equally reverse the adverse effects of aging on muscle quality in older men, but their residual impact after follow-up is different.

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Human aging is characterized by a progressive decline in the ability to perform basic mobility tasks, such as walking, rising from a chair, or climbing a flight of stairs, eventually resulting in functional dependence and disability. This impaired physical performance in older adults is related to sarcopenia, the age-related loss of muscle mass.[1] However, several studies have shown that physical performance is more determined by muscle strength and muscle power than by muscle mass.[2,3] Particularly, power of the lower extremities seems to be crucial to a variety of activities of daily living.[4] Therefore, greater attention should be paid in determining the role of dynapenia, the age-related loss of muscle strength or power.

Previous research in older adults has provided evidence for a proportionally larger age-related loss of muscle strength compared with the loss of muscle mass.[5,6] Furthermore, maintenance or gain in

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muscle mass does not necessarily prevent a reduction in muscle strength in the elderly.[6,7] Muscle power, defined as the ability to generate force quickly, declines even earlier and more precipitously than muscle strength during the aging process.[8,9] When considering functional status at older age, it is therefore important to highlight the interaction between muscle mass and muscle strength. In this context, expressing muscle strength per unit muscle mass is a particularly relevant indicator of muscle quality, providing a noninvasive estimate of the relative contribution of muscle quantity and neural factors to the changes in muscle performance.[10,11] In addition, muscle power may provide a good assessment of muscle quality because changes in muscle power are influenced by both morphologic and neural factors.[10]

If and to what extent age-related changes in muscle quality will ultimately develop into a clinically significant problem depends on several factors, including the individual's physical activity level.[12,13] Various studies have shown that exercise interventions can counteract the age-related losses of muscle mass, muscle strength, and muscle power.[14,15] In addition, owing to the specificity of training effects, high-intensity resistance training (60%−80% of 1 repetition maximum) is considered the most effective countermeasure against the effects of aging on muscle quality characteristics.[16,17] However, clinicians are still hesitant to subject the musculoskeletal system of old and frail individuals to high mechanical loadings. In the context of this discussion, whole-body vibration (WBV) training has been shown to be an efficient, low-impact alternative for conventional resistance training in a population of unfit older adults.[18,19]

The ability of these exercise interventions to counteract muscle deterioration has been widely established. Even sedentary or previously "inactive" older adults can be motivated to participate in and adhere to these exercise programs.[20] However, most of these individuals do not continue exercising as soon as the programs are no longer supervised and guided.[21,22] Consequently, the long-term preventive value of these interventions remains uncertain. Because studies typically focus on immediate postintervention effects only, few data exist on the sustainability of training-induced improvements in muscle characteristics in older adults. In this context, follow-up studies of the residual effects of resistance training and WBV training are warranted. Therefore, the aim of the present study was to evaluate the effects of high-intensity fitness training, including resistance training and aerobic training, and the effects of WBV training in older men 1 year after the intervention had ended. Both interventions lasted 1 year, with 3 training sessions weekly. The postintervention effects have been reported previously,[23] with both interventions resulting in similar increases in muscle volume, muscle strength, and countermovement jump (CMJ) height.

In line with these findings, it was hypothesized that 1 year after the end of the interventions, subjects might still benefit from increased muscle volume, muscle strength, and muscle power compared with control (CON) subjects who had not participated in any form of training. In addition, as the postintervention adaptations in muscle quality characteristics were identical in both intervention groups, no differential changes in muscle parameters between the intervention groups were expected 1 year after the intervention stopped.

List of abbreviations:

CMJ	**countermovement jump**
CON	**control**
MQ_{con}	**muscle quality based on concentric muscle strength**
MQ_{iso}	**muscle quality based on isometric muscle strength**
R+A	**combined resistance and aerobic**
WBV	**whole-body vibration**

Methods

Procedure

The present study was designed as a 1-year follow-up of a randomized controlled trial comparing the effects of high- and low-intensity training in older men. In the initial intervention phase, participants were randomly assigned to 1 of the 3 following groups: a combined resistance and aerobic (R+A) training group, a whole-body vibration (WBV) training group, or a control (CON) group.[23] The training programs are described in the Interventions section. Both the R+A and WBV training groups exercised 3 times weekly on nonconsecutive days over a period of 1 year. All sessions were held at the University Training Center and were guided and supervised by qualified health and fitness instructors. One year after the intervention had ended, all men who had complied with the 1-year training period were invited to participate in the follow-up measurements. The study was approved by the University's Human Ethics Committee in accordance with the Declaration of Helsinki. All subjects gave written informed consent.

Participants

In the initial intervention study, 114 noninstitutionalized older men between 60 and 80 years old volunteered to participate. They were recruited from the local community in the city of Leuven and its surrounding area. Exclusion criteria were previously described in more detail. Briefly, the key objective was to exclude older adults who had musculoskeletal disorders or any recent training experience. The current follow-up focused on the changes in muscle quality in the sample of 72 men (R+A: n=20, WBV: n=23, and CON: n=29, respectively) who completed both measurements at baseline, postintervention (1y), and follow-up (2y after baseline).

Interventions

The R+A training group

The fitness training program was constructed following the American College of Sports Medicine guidelines for exercise prescription in older adults and included aerobic, resistance, balance, and flexibility exercises. The duration of each session increased from 60 minutes at the beginning toward 90 minutes at the end of the study. Aerobic training consisted of walking or running on a treadmill,[a] cycling on a cycle ergometer, or stepping. Training intensity varied between 75% and 85% of the individual heart rate reserve (Karvonen formula). Subsequently, total-body resistance exercises,[a] including leg press and leg extension for lower body, were performed. A moderate to high loading between 8 and 15 repetition maximum for 1 to 2 sets was used. Thereafter, balance was trained by standing on 1 or both legs with the eyes open or closed, on a firm or unstable surface. Finally, all participants performed stretching exercises.

The WBV training group

The WBV group performed unloaded static and dynamic leg exercises on a vibration platform[b]: squat, deep squat (knee angle 90°, hip angle 80°), wide stance squat (feet apart, toes pointed