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Original Study

Four-Month Course of Soluble Milk Proteins Interacts With Exercise to Improve Muscle Strength and Delay Fatigue in Elderly Participants

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ABSTRACT

Background: The benefit of protein supplementation on the adaptive response of muscle to exercise training in older people is controversial.
Objective: To investigate the independent and combined effects of a multicomponent exercise program with and without a milk-based nutritional supplement on muscle strength and mass, lower-extremity fatigue, and metabolic markers.
Design: A sample of 48 healthy sedentary men aged 60.8 ± 0.4 years were randomly assigned to a 16-week multicomponent exercise training program with a milk-based supplement containing, besides proteins [total milk proteins 4 or 10 g/day or soluble milk proteins rich in leucine (PRO) 10 g/day], carbohydrates and fat. Body composition, muscle mass and strength, and time to task failure, an index of muscle fatigue, were measured. Blood lipid, fibrinogen, creatine phosphokinase, glucose, insulin, C-reactive protein, interleukin-6, tumor necrosis factor-α soluble receptors, and endothelial markers were assessed.
Results: Body fat mass was reduced after the 4-month training program in groups receiving 10 g/day of protein supplementation ($P < .01$). The training program sustained with the daily 10 g/day PRO was associated with a significant increase in dominant fat free mass (+5.4%, $P < .01$) and in appendicular muscle mass (+4.5%, $P < .01$). Blood cholesterol was decreased in the trained group receiving 10 g/day PRO. The index of insulin resistance (homeostasis model assessment–insulin resistance) and blood creatine phosphokinase were reduced in the groups receiving 10 g/day PRO, irrespective of exercise. The inflammatory and endothelial markers were not different between the groups. Training caused a significant improvement (+10.6% to 19.4%, $P < .01$) in the maximal oxygen uptake. Increased maximum voluntary contraction force was seen in the trained groups receiving 10 g/day of proteins (about 3%, $P < .05$). Time to task failure was improved in the trained participants receiving a 10 g/day supplementation with PRO ($P < .01$).
Conclusions: Soluble milk proteins rich in leucine improved time to muscle failure and increase in skeletal muscle mass and strength after prolonged multicomponent exercise training in healthy older men.

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The health benefits of exercise training in older persons is well-known,[1,2] but it is mainly the effect of progressive resistance training that has been shown to be effective in increasing both strength and muscle mass as a preventive therapy.[3] Few studies have evaluated training-induced changes in metabolic and fitness markers after a multicomponent exercise training program in elderly persons. Furthermore, although it is well-established that reduced muscle strength and muscle mass contribute to the diminished muscle function that heralds the onset of physical frailty,[4] data on age-related changes in skeletal muscle fatigue, defined as the acute decline in force-producing capacity in response to repeated or sustained contractions, are scant. However, balance and functional task performances are impaired with fatigue, and therefore, future studies should assess whether exercise intervention may also alleviate fatigue effects.[5] In addition, a multicomponent exercise training program has been found to be more effective than either form of training alone (aerobic exercise training or resistance exercise training) in counteracting the detrimental effect of a sedentary lifestyle on the health and functioning of the skeletal muscles.[6,7]

Most studies have reported considerable heterogeneity in skeletal muscle response to training. For muscle hypertrophy to occur, there must be a net increase in muscle protein balance (ie, muscle protein synthesis must exceed protein breakdown).[8,9] Although progressive resistance training alone stimulates muscle protein synthesis,[10] it has been suggested that the greatest gains in muscle mass will occur with an energy intake that exceeds requirements to meet the additional demands of training[11,12] and/or an increased intake of specific nutrients, particularly dietary protein.[13,14] To date, however, the findings from several intervention studies in older adults that have examined whether increased dietary protein or the ingestion of essential amino acids combined with progressive resistance training can promote muscle hypertrophy have produced contrasting results.[8,15–18] It was proposed that the differences in muscle hypertrophy response across these studies might be related to variations in the intensity, duration, and frequency of training and/or differences in the amount and in the source of protein consumed. It remained to be established whether exercise, especially a multicomponent exercise training program, and dietary intervention interact to maintain or enhance skeletal muscle mass and strength and reduce lower-extremity muscle fatigue in older people.

There is emerging evidence that the ingestion of dairy foods, particularly whole or fat-free milk, may represent an ideal food source to enhance muscle protein synthesis and thereby skeletal muscle hypertrophy.[19] Previous findings in young adults have demonstrated that the consumption of whole milk after resistance training can promote muscle protein synthesis and/or inhibit protein breakdown, leading to an improved net muscle protein balance.[20–22] However, there are differences in the capabilities of anabolic stimulation muscle between young and elderly persons, especially with exercise.[23] In addition, previous work has demonstrated that pulse and specific fast-digested dairy proteins (ie, soluble milk proteins rich in leucine) improve postprandial muscle protein synthesis in older men.[24] The aim of this study was to investigate the independent and combined effects of a multicomponent resistance and aerobic exercise program[25] with and without a milk-based nutritional supplement, on skeletal muscle strength and mass, lower-extremity fatigue and metabolic markers. This milk-based product contains, besides proteins, carbohydrates and fat, in contrast to previous studies in which only intact protein or free amino acids were supplied. We hypothesized that exercise combined with nutritional supplement with soluble milk proteins would elicit a greater skeletal muscle response than exercise alone or consumption of the nutritional supplement with soluble milk proteins alone, and even exercise combined with nutritional supplementation with total milk proteins.

Methods

Participants

Forty-eight older men aged 60.8 ± 0.4 years were initially recruited to take part in the present study. All the men had medical clearance to participate in the testing and/or training sessions. This population was selected because it is acknowledged that a decline in physiological function is observed after age 60.[26] The participants were recruited from our internal database and from advertisements in local newspapers and radio. All participants met one of the investigators who explained the scientific rationale, the procedures, and the potential risks of the study. During recruitment, screening included medical history, physical examination and testing, and blood sampling for laboratory tests. Each participant had a normal blood biochemical profile and physical condition with no medical history of renal, cardiovascular, endocrine, digestive, hepatic, inflammatory or currently evolving disease. Persons were excluded from the study if they had undergone surgery in the 3 months before the study. Participants were not taking any medications liable to disturb glucose control (eg, metformin), or affect inflammation (eg, statins) or cardiovascular responses to exercise (eg, beta-blockers or blood pressure medication), or modify intestinal protein absorption. Participants did not follow vegetarian diet, and did not take any nutritional supplements (vitamins, minerals, polyols, fiber, etc.) during the 3 months before the study and during the study. Participants were excluded if they were lactose-intolerant, consumed >4 standard alcoholic drinks per day, or were current smokers. They were sedentary (less than 2 hours exercise per week), and none of them were involved in any competitive training program. They were requested not to change their level of physical exercise before or during the study. The ethical committee of Auvergne University approved the study protocol, and written informed consent to partake in the study was signed by each participant.

Study Design

The study was performed in the General Clinical Research Center of the Centre de Recherche en Nutrition Humaine Auvergne. This was a blinded study (ie, participants, care providers, and those assessing outcomes have no information about the products). The design study was a 16-week randomized controlled trial. The 2 factors were exercise and diet (fortified milk). A total of 45 participants were randomly allocated to 1 of the 5 groups. In a first putative step, we decided to study the dose effect of total milk proteins in enhancing the efficacy of training on muscle mass and function and metabolic markers. For this purpose, 3 groups were formed: (1) untrained group with placebo drink containing 4 g of total milk protein (TMP) ($n = 9$, TMP4), (2) trained group with placebo drink containing 4 g of total milk protein ($n = 9$, TMP4t), and (3) trained group with fortified drink containing 10 g of total milk protein ($n = 9$, TMP10t). In a second step, we planned to evaluate the supplemental effect of using fast milk proteins on the potential of training to improve muscle mass and function, and also metabolic markers during aging. Two additional groups were therefore studied: (4) untrained group with fortified drink containing 10 g soluble milk proteins rich in leucine (PRO) ($n = 10$, PRO10), and (5) trained group with fortified drink containing 10 g soluble milk proteins rich in leucine ($n = 8$, PRO10t). However, no statistical difference was found when the 2 evaluations were made separately. Therefore, for greater clarity, we pooled the results in a single statistical analysis over the whole population. A drink containing 4 g of proteins was chosen because it corresponds to an average milk intake for breakfast or to 1 yogurt (125 mL milk). The products were consumed at breakfast on the day without training, and after the exercise session on training days.