Physical performance and muscular status in sarcopenic elderly following exercise and dietary supplement

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Abstract. The aim of this study is to establish the effect of a functional and nutritional intervention on the physical performance and muscular state of elderly people with sarcopenia in Manizales, Colombia. 28 sarcopenic patients, aged between 60 and 85 years old, underwent evaluation before and after 12 weeks of nutritional intervention and aerobic and resistance exercises. The latter was gradually increased, with a frequency of 3 days per week and for 3 months. Muscle mass was estimated by bioelectrical impedance analysis (BIA) and corroborated by dual x-ray absorptiometry. The gait speed and the short battery of physical performance (SPPB) complemented the diagnosis. People with sarcopenia improved significantly with the intervention in their physical functionality, shown by physical performance tests (SPPB), and in the calf circumference, with no significant increases in grip strength or muscle size. A 12-week intervention with nutritional supplements and physical training improved physical performance without increasing skeletal muscle mass or grip strength. These results reinforce the findings of other researchers and suggest the need to continue investigating the most effective of supplements and exercises as well as the time required to impact the study variables.

1. Introduction
Sarcopenia has been defined as the gradual or generalized decrease or loss of skeletal muscle mass as well as the decrease in muscle strength or physical performance. It is a central element of frailty in the elderly, associated with an increased risk of falls, functional deterioration, disability, poor quality of life and higher mortality [1].

Worldwide, the prevalence for people aged 60-70 is estimated at 5 to 13% and increases with age [2]. In 2013, an investigation conducted for the first time in Colombia, with some of the elderly population, determined that prevalence is approximately 9.6% [3]. It has been estimated that sarcopenic elderly have 2-5 times more risk of disability than those who are not sarcopenic and predisposes them to a poorer quality of life [4,5, 6,7].

The document of the European working group on sarcopenia (EWGSOP) indicates that bioelectrical impedance analysis (BIA) and dual x-ray absorptiometry (DXA) are good techniques to estimate muscle mass and hand dynamometry and knee flexion are useful to evaluate muscle strength. Meanwhile, to determine physical performance, the short battery of physical performance (SPPB), the walking speed, the walking test for 6 minutes, the test time to get up and walk, or the power test of climbing stairs are appropriate options [8].
It has been shown that when protein intake decreases, muscle mass also reduces. However, this can also occur in the elderly who consume more than the daily protein nutritional requirements [9, 10]. Apparently, aging induces anabolic muscle resistance to use dietary proteins. The addition of leucine restores the response to the synthesis of muscle proteins, proving useful for the nutritional recovery of sarcopenic elderly [11]. Daily protein requirements in the elderly population are estimated at 0.8 g/kg/day, but it has been reported that a consumption of 1.2 to 1.5 g/kg/day can help these patients recover nutritionally if high quality proteins are given with each meal [9, 12, 13, 14-16].

Additionally, muscle strengthening at an intensity of 60 to 85% of the maximum voluntary strength in elderly people over 60 years old, increased muscle mass and strength [17,18] and walking speed up to 0.08 m/sec. [19-21]. The progressive resistance training, in 2 to 3 sessions per week, has shown improvements in functionality, reduction of muscle weakness and functional limitations such as balance, gait speed, walking time, test for getting up from the chair and walking, as well as climbing stairs [22].

Other treatment approaches are based on pharmacological therapy [23] that are being and researched have side effects. Therefore, the objective of this study was to determine the effect of a 12-week functional and nutritional intervention program on physical performance, grip strength and calf circumference in sarcopenic elderly in the city of Manizales-Colombia.

2. Methods

2.1. Study design and subjects
This is an analytical study of quasi-experimental intervention “before and after” with 38 elderly people aged between 60 and 85 with sarcopenia. Volunteers with a body mass index (BMI) < 18 kg/m², gait disability, intercurrent disease or decompensated chronic disease, dementia, immobility syndrome, edema or metallic osteosynthesis were excluded.

2.2. Techniques and methods
Elderly patients from a previous population study in Manizales who had already been diagnosed with sarcopenia were contacted [3]. All participants signed the consent form approved by the ethics committee of the Universidad de Caldas.

2.3. Anthropometric measurements
Before the measurements were taken, the subjects removed their clothes and put on wore a hospital gown. After calibration; a trained person measured weight, height, arm and calf circumferences. The weight was measured with the electronic scale PP2000 (Icob-Detecto, A & D Co, Japan) with precision of 0.1 kg. The height was measured with a Heightronic-235 wall stadiometer (Seca, Hamburg, Germany) with a precision of 1 mm. The measurements were made in duplicate. When a difference greater than 0.1 kg or 0.5 mm was found, a third measurement was made and an average of all three was obtained.

2.4. Bioelectrical Impedance Analysis (BIA)
Subjects were instructed to arrive at the laboratory in a fasting state and to have avoided strenuous exercise, intake of caffeinated beverages or have taken diuretics the day before the test. After verifying stable laboratory environmental conditions, the test was carried out. The measurements were made in triplicate and most of the variables that can cause error were controlled. A BIA data acquisition system (Maltron BioScan 920-II), calibrated by ethnicity was used. A four-electrode arrangement of Ag/AgCL ECG (2228 3M®) was also used. The resistance at 50 kHz was used to estimate muscle mass (MM) with the Janssen formula [24].

2.5. Skeletal muscle mass index (SMMI)
This was calculated as the muscle mass estimated by BIA, divided by the height squared (MM (kg) / height in cm²). Considering the absence of Colombian data for SMMI, the NHANES III reference points from a Mexican-American population group were used [25].
2.6. Physical strength
The grip strength of the dominant hand was measured according to a well-known protocol [26] and using a digital dynamometer Baseline®. According to consensus, this is a good measure of physical strength [8].

2.7. Physical performance
The SPPB test adapted to Spain was used. It includes timed measures of walking speed, getting up repeatedly from a chair and the ability to maintain balance. A score of SPPB ≤ 10 indicated low physical performance and a score > 10 normal physical performance.

2.8. DXA
DXA was used to confirm muscle mass status. Results were interpreted independently by a radiologist and one of the medical researchers [8]. Any disparity was resolved by agreement. Only those subjects within the ranges referenced by the EWGSOP for sarcopenia were included in the study.

2.9. Interventions
Participants underwent supervised muscle training by specialists with resistance exercises and progressive increases according to their individual tolerance. Three weekly sessions were practiced at the gymnasium at the Universidad Autónoma de Manizales. The nutritional intervention consisted of the free supply of a nutritional supplement with a caloric product enriched with B hydroxy B methyl butyrate (HMB), as a precursor of leucine, and vitamin D, consumed twice a day, to ensure an intake of 3 g/d of HMB. Half of the daily dose was provided at the end of the physical exercise and the other dose in the afternoon, outside meal times. Participants were given two cans to consume daily mid-morning and mid-afternoon on days without scheduled exercise. The intake was monitored with a consumption record delivered to the participants and by collecting the empty bottles.

2.10. Post-intervention evaluation
After the 12-week intervention and with blinding of the initial results of the study, all measurements were repeated.

2.11. Statistical Analysis.
The results were presented as absolute and relative frequencies after an unvaried analysis was undertaken. The Shapiro Wilk normality test was carried out. Grip strength, gait speed, getting up from a chair 5 times, weight, height, BMI and calf circumference showed normality. Subsequently, a bivariate analysis of mean comparison was carried out using the student t-statistic for related samples. Variables that were not normal, were analyzed by the non-parametric Wilcoxon test, assuming a significance of p < 0.05.

3. Results
Ten out of the 38 cases included initially in the study were excluded for the following reasons: two cases were withdrawn due to an incidental disease and to the discovery of cancer; another had an old hernia that limited the execution of the exercises. Another two cases were removed from the study due to an absence of almost a month due to family issues and change of residence. Five other cases were excluded due to lack of social or family support. There were no cases of withdrawal due to exercise intolerance or intolerance to the dietary supplement. The remaining 28 fulfilled the criteria of the study for 12 weeks.

In total, there were 18 women and 10 men with an average age between of 62 (±5.9) and 69.9 (±4.0) respectively. With regards to occupation, 88.9% of the women were housewives, but only 10% had a similar occupation. 72.2% of the women had incomplete or complete primary education, while 70% of the men only had incomplete primary education. Women had a support network in 94.4% of cases and men in 10%. In relation to the socioeconomic status, approximately half of the population was
middle class. 100% of women and only 10% of men reported regular physical activity. Finally, 94.4% of the women and 90% of the men did not smoke.

Regarding the study participants’ co-morbidities, all of them were stable. The arterial hypertension was the predominant pathology in both sexes. Coronary heart disease, incipient prostate cancer, skin cancer, nervous system disorder and diabetes were other pathologies reported by men. Hiatal hernia, gastric ulcer, hypothyroidism and diabetes mellitus were those reported by women. When comparing the physiological variables at the end of the intervention, the women statistically showed significant favorable changes in the body mass index, calf circumference, SPPB equilibrium and SPPB total score. The men had a favorable increase in balance, getting up from the chair, total score of the SPPB, BMI and calf circumference. In no participants were significant increases in grip strength or in gait speed observed (Table 1).

BMI increased by 0.78 points in women (p: < 0.00) and by 0.81 in men (p: < 0.00). The calf circumference showed a significant increase of 0.53 cm in men and 0.47 cm in women.

Even though there were no statistically significant changes in the subtest of the SPPB “gait speed”, it should be noted that this test does not measure the best possible performance. In fact, the test evaluated the person’s usual step, whose changes are difficult to see in a short time.

In the SPPB equilibrium test, women had an improvement of 0.72 points (p˂ 0.01) and men of 0.8 (p< 0.01). These results could represent better mobility and lower risk of falls for sarcopenic patients.

In the subtest “incorporate from a chair”, women showed a slight non-significant improvement with a decrease in the performance time of 0.14 sec. (p: < 0.74). On the contrary, men had a better performance with a decrease in 3.65 sec (p: < 0.03), which implies a favorable reduction in the execution time in seconds of 22.61%. After the intervention, the total score of the SPPB increased by 0.72 points in women, (p< 0.01). In men, the result was higher, with an increase of 2.2 points (p < 0.00). The grip strength showed a slight tendency to increase without statistical significance.

Table 1. Comparative results before and after intervention by sex (Student t test).

| Sex   | Variables        | Sex     | Variables        | Sex     | Variables        | Sex     | Variables        | Sex     | Variables        | Sex     | Variables        |
|-------|------------------|---------|------------------|---------|------------------|---------|------------------|---------|------------------|---------|------------------|
|       |                  | Mean(Deviation) |         | 95%CI          | t       |                  |         |                  |         |                  |         |                  |
|       |                  | Inferior  | Superior         |         |                  | Inferior  | Superior         |         |                  | Inferior  | Superior         |         |                  |
| Women |                  | Before   | After            |         |                  | Before   | After            |         |                  | Before   | After            |         |                  |
|       | Gait speed(sec)  | 5.30     | 1.06             | 0.98    | 1.02             | 0.34      | -1.1             | 0.30    |                  | 5.64     | 0.98             | 1.02      | 0.34             | -1.1     | 0.30             |
|       | Balance (points) | 2.17     | 1.06             | 0.98    | -1.31            | -0.14     | -2.6             | 0.01    |                  | 2.89     | 0.98             | -1.31     | -0.14            | -2.6     | 0.01             |
|       | Incorporate from | 15.40    | 2.65             | 2.65    | -0.77            | 1.05      | 0.3              | 0.74    |                  | 15.26    | 2.31             | -0.77     | 1.05             | 0.3      | 0.74             |
|       | a chair (sec)    |          |                  |         |                  |          |                  |         |                  |          |                  |          |                  |         |                  |
|       | SPPB total score | 8.11     | 1.32             | 1.24    | -1.28            | -0.16     | -2.7             | 0.01    |                  | 8.83     | 1.24             | -1.28     | -0.16            | -2.7     | 0.01             |
|       | Weight (kg)      | 51.83    | 7.80             | 7.80    | -2.38            | -1.03     | -5.3             | 0.00    |                  | 53.54    | 7.80             | -2.38     | -1.03            | -5.3     | 0.00             |
|       | Height (m)       | 1.52     | 0.04             | 0.04    | 0                | 0         | -0.4             | 0.67    |                  | 1.53     | 0.04             | 0         | 0                | -0.4     | 0.67             |
|       | BMI (kg/m²)      | 22.18    | 3.00             | 3.00    | -1.06            | -0.48     | -5.7             | 0.00    |                  | 22.96    | 3.07             | -1.06     | -0.48            | -5.7     | 0.00             |
|       | Calf circumference| 31.82    | 2.63             | 2.63    | -0.92            | -0.14     | -2.9             | 0.01    |                  | 32.29    | 2.57             | -0.92     | -0.14            | -2.9     | 0.01             |
|       | Grip force (kg/f)| 19.83    | 3.29             | 3.29    | -0.92            | 0.58      | -0.5             | 0.64    |                  | 20.00    | 3.58             | -0.92     | 0.58             | -0.5     | 0.64             |
Gait speed (sec) | Before | 4.96 | 1.04 | -1.40 | 0.38 | -1.3 | 0.23
| After | 5.47 | 0.87 |

Balance (points) | Before | 2.40 | 1.07 |
| After | 3.20 | 1.13 | -1.36 | -0.24 | -3.2 | 0.01

Incorporate from a chair (sec) | Before | 16.14 | 3.10 |
| After | 12.49 | 2.95 | 0.40 | 6.88 | 2.5 | 0.03

SPPB total score | Before | 7.90 | 1.37 |
| After | 10.10 | 1.10 | -3.01 | -1.39 | -6.1 | 0.00

Weight (kg) | Before | 60.18 | 5.56 |
| After | 62.37 | 4.99 | -2.97 | -1.40 | -6.3 | 0.00

Height (m) | Before | 1.64 | 0.04 |
| After | 1.65 | 0.05 | -0.02 | 0 | -1.3 | 0.23

BMI (kg/m²) | Before | 22.13 | 2.26 |
| After | 22.94 | 2.11 | -1.11 | -0.50 | -6.0 | 0.00

Calf circumference (cm) | Before | 32.97 | 2.03 |
| After | 33.50 | 1.73 | -1.09 | 0.03 | -2.1 | 0.05

Grip strength (kg/f) | Before | 32.20 | 5.37 |
| After | 33.40 | 3.89 | -2.95 | 0.55 | -1.6 | 0.15

4. Discussion

Similar to other studies carried out with populations aged between 60 and 79, the current study was undertaken with subjects with an average age of 73 [27]. Our results showed a favorable and significant increase in different parameters [28] although the mechanisms by which the decrease in muscle strength occurs in the elderly are not yet complete, there is a significant increase in different parameters [28]. Although the mechanisms by which the decrease in muscle strength occurs in the elderly are not yet completely clarified, there are several variables affecting this function: decrease in muscle size, sedentary life style and low protein intake among others. Therefore, studies suggest that a combined strategy of exercise, supplementation of essential amino acids (leucine), and vitamin D improve functional performance in older adults [29-33]. It is also known that endurance exercises are effective not only to increase skeletal muscle mass and strength, but also functional capacity in the elderly [34, 35]. Strategies that improve endurance can produce improvement in functional performance [36-38]. It has been observed that the effects of high intensity resistance training lead to an increase in strength of 107 to 227% and of 11% in the muscular area [39].

In the current study, we evaluated the impact on calf circumference, which is more related to lean muscle mass than BMI. The increase of 0.47 cm in women (p< 0.01) and 0.53 cm in men (p= 0.05) would indicate higher skeletal muscle mass. However, it is now known that more than the increase in muscle mass, the more important impact is on strength, power and endurance [40, 41]. This seems to coincide with the best results of this study in the performance of the SPPB sub-tests "incorporate from a chair" and "balance", and in the SPPB's overall score. This is also concordant with a study of 24 weeks on fragile subjects aged 62 and above, using a dietary supplement of 30 g of protein/day divided into two doses. The subjects improved the muscle strength of their legs, and the performance of the SPPB changed from 8.9 to 10 points in comparison with the placebo group (p = 0.02) [42]. These results are similar to those of the present study despite the fact that the intervention was shorter. The grip strength did not increase in this study. This could be explained by the lack of specific strengthening exercises for hand grip. Previous studies showed more significant increase in muscle strength with exercise and protein supplements (20 g/d) in frail elderly after 12 weeks of intervention [43, 44]. Likewise, this study
showed improvement in two subtests of the SPPB and in the total score [45-47]. Another study showed that a low performance in the SPPB had a predictive value of disability [48].

Unlike this research, which did not reveal a significant increase in walking speed, a previous study of 32 frail elderly with resistance exercises at home for 12 weeks, increased the speed of gait from 0.06 to 0.07 m/s [49]. However, it is necessary to bear in mind that an increase in the total score SPPB, would mean better physical fitness, mobility and lower risk of falls [50].

The result of the intervention in the SPPB timed subtest “incorporate from a chair” only showed improvement in men. These results are consistent with those from a systematic review showing that even in the elderly, strengthening training increases muscle mass and strength, improving this parameter [51]. Although a non-significant average gain of 0.34 kg in skeletal muscle was identified, no improvement in muscle strength was found [52]. In addition to protein supplements, a meta-analysis revealed a small significant effect on overall muscle strength with vitamin D intervention [53]. The results were more significant in people who had 25-hydroxyvitamin D < 30 nmol/l. It has also been shown that the nutritional therapy in people with sarcopenia is better when it contains vitamin D, as in the current study.

Thus, in general, nutritional supplements combined with physical exercise, particularly resistance, have shown favorable results in body composition, strength and physical function in the elderly. Most of these studies, however, have been focused on healthy elderly people, being more limited in sarcopenic patients, in whom the nutritional part but not specifically the supplement of proteins and amino acids were measured. Moreover, what make comparisons difficult are the wide variation in the doses of protein supplement and the length of the intervention [54-57].

A dietetic intervention or progressive exercise in frail 72-year-old elderly showed that exercise as a single intervention did not improve muscle strength. However, it improved functional tests (p = 0.01). BMI increased with nutritional supplements, not with placebo. Although that study separated the nutritional intervention from the exercise and was longer than ours, the results were similar in terms of better physical performance [16].

The results of our nutritional intervention cannot be separated from those shown from physical training. This is how the experts recommend combining both interventions for the greater benefit of the persons being [58]. In another study, a combination of both interventions improved skeletal muscle mass, favoring mobility and autonomy [59].

A similar intervention to this one in terms of diet, intensity, type and duration of exercise, in fragile elderly aged 87, an increase in muscle strength and size, mobility and level of spontaneous physical activity were demonstrated. The weakest had the best benefits with exercises, with greater gain in strength, (113 ± 8% (p < 0.001), gait speed (11.8 ± 3.8% (p = 0.02) and climbing stairs (28.4 ± 6.6% (p < 0.01). In another study, two groups had progressive resistance exercises at high or low speed 3 times a week for 12 weeks. Both groups showed significant improvement in getting up from the chair and SPPB score, but the former obtained better results (p < 0.05), meaning that type and intensity of the exercise are important [60].

5. Conclusions and recommendations
A combined functional and nutritional intervention in sarcopenic elderly for 12 weeks had a favorable impact, mainly on functional performance. Unlike other studies, results showed that there was limited improvement in grip strength, and it did not have an impact on gait speed. Future studies will need to expand the sample size and do a longer-term follow-up to estimate muscle behavior and functionality in cohorts of patients with different conditions of skeletal muscle mass and functionality. Bioimpedance is a helpful tool to determine the decrease in muscle mass, but physical tests seem to be more useful to determine the impact of interventions.

Conflict of interest
The nutritional supplement was sponsored by the company Abbot Nutrition®, which did not intervene in any stage of the study and did not have, at any time, contractual links to the research interest.
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