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ORIGINAL RESEARCH

Effects of a Physical Exercise Program on the Physical Capacities of Older Adults: A Quasi-Experimental Study

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Purpose: To measure the effects of an exercise program on the physical capacities of older adults such as strength, flexibility, balance, and aerobic capacity.

Patients and Methods: This was a quasi-experimental study on a population of 5550 older adults and a sample of 4830 participants in an active aging program designed by the Municipal Health Secretary. The exercise program lasted 12 months, and pre-and post-program intervention measures were recorded using the senior fitness test.

Results: Most participants were women (92.4%) and their mean age was 70.7 years (standard deviation, 7.3 years; range, 60–97 years). All areas showed significant differences before and after the program in terms of the participants' physical capabilities ($p < 0.05$), muscular strength and flexibility had a more significant mean difference and a large effect (>0.80), except for aerobic capacity, which had a small effect.

Conclusion: The present study revealed that a supervised physical exercise program at the community level has positive effects on the physical capacities of coordination, balance, flexibility, strength, and aerobic capacity, which are essential components for a better functional capacity at this stage of life, with improvements that encompassed the improved self-perception of their health status, a reduction of overweight and obesity. The reinforcement of these programs is recommended, consequently, promoting pre-sport games and sports championships among the elderly population, as a public health strategy.

Keywords: aging, physical exercise, postural balance, public health

Introduction

Physical exercise programs in healthy older adults or those with preexisting health conditions have been studied by different entities and research groups at an international level, in an attempt to determine its impact on their physical capacities such as strength, resistance, aerobic capacity, flexibility, and other features. Physical activity, besides bringing positive benefits to the health of the elderly people, is an effective strategy to treat and prevent frailty, helping to improve physical and mental functions, as well as reversing some of the effects of chronic diseases and maintaining mobility and functional independence.[1] In this sense, studies have examined community-dwelling older adults and focused mainly on the following parameters: cognitive and nutritional interventions and their relationship with frailty;[2] the effects on their functional capacities after supervised vigorous exercise interventions;[3] the performance of comprehensive physical exercise programs on the physical fitness and its psychosocial role;[4] multicomponent interventions comprising aerobic fitness, cardiovascular function, and insulin resistance after high-intensity interval training[5] along with progressive resistance, balance, and functional and aerobic training;[6] among other physical exercise programs with the aim to attain the improvements at the level of the aforementioned capacities.[7–12] In groups of older adults of the same population ages and with a pre-existing health condition such as obesity and/or sarcopenia, the effects on physical qualities were studied,

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as the impact on body composition, physical capacity,[13] the functional aptitude,[14,15] growth and gains in the muscle function,[16] and fat oxidation through high-intensity interval training[17] was measured, as well in patients with coronary heart disease, the intervention with exercise improved the quality of life.[18]

Different tests have been considered as measurement tools in research projects aimed at determining the efficacy of interventions based on physical exercise programs for older adults, including the Senior Fitness Test (SFT),[19,20] such as exercise protocols ranging from 12 weeks to 8 months, in programs including vigorous exercise[3] and comprehensive physical exercise,[4] also in PRIME (Peripheral Remodeling Training through Intermittent Muscular Exercise),[8] in community-based exercise,[9] home-based tele-exercise programs,[13] or multicomponent physical activities.[21]

Several studies in Latin America, most were published in Brazil, have assessed the impact of training programs on physical functions and capacities of institutionalized older adults with frailty syndromes[22] and older adults in the community with a history of falls.[21] Furthermore, these studies evaluated the positive effects on the strength, aerobic capacity, functional fitness, and lipid profile of healthy older adults,[23] the impact on the functionality of healthy women through aerobic and muscle strength training,[24] and the community-based physical exercise programs with repercussions on their mental health and well-being.[25] In Colombia, there are few studies that have recorded pre- and postintervention measurements using physical exercise in older adults who aimed to work on their physical capacities. However, one of the previously published studies establishes significant results concerning anthropometric parameters, strength, flexibility, aerobic resistance and balance, and decreased risk of falls in a group of older adults in the city of Barranquilla.[26]

However, the different departments and municipalities have organized physical exercise programs and activities that promote healthy lifestyles in older adults. Such guided and supervised programs and activities are regularly conducted in the municipality of Santiago de Cali. The purpose of the present study involved using a municipality strategy[27] and measuring the impact of an exercise program on the physical capacities of older adults such as strength, flexibility, balance, and aerobic capacity. The selected sample comprised 4830 older adults living in a community, who are engaged in a program from the Municipal Secretary for Sport. The research adopts the hypothesis that applying a community intervention program based on physical exercise significantly improves the physical qualities of the study.

Materials and Methods

A quasi-experimental research was performed on a study group according to the guidelines proposed in the TREND statement. Checklist for quasi-experimental studies and the criteria described by the *CERT* for interventions based on physical exercise.

Participants

The population under study corresponded to 5550 community-dwelling older adults, engaged in a program from the Municipal Health Secretariat for active aging. A total of 4830 subjects, who agreed to participate in the intervention, were selected using non-probabilistic convenience sampling. All of the participants voluntarily signed the informed consent. The following exclusion criteria were considered: age of <60 years; the presence of cognitive impairment (minimal test greater than 24 points in schooled individuals, 1 point less if not schooled or of rural origin), uncontrolled chronic disease (hypertension and diabetes, the participants had to be under medical management), uncorrected vestibular disorders, or seizures; and individuals with acute traumatic injuries and movement disorders that limited the practice of physical exercise. Participants who attended <70% of the physical exercise sessions were not considered for the study, this value has been established in previously generated interventions with exercise in a community setting.[28]

Procedure

Assessments

A pilot test for the data collection process was performed to help improve the validity and reliability of the procedures, train the team, and reduce possible biases and errors in the data collection. Initially, a sociodemographic data collection form was applied that included the variables of age, sex, health insurance, leisure activities, support network, type of housing and the identification of deficiencies or clinical history.

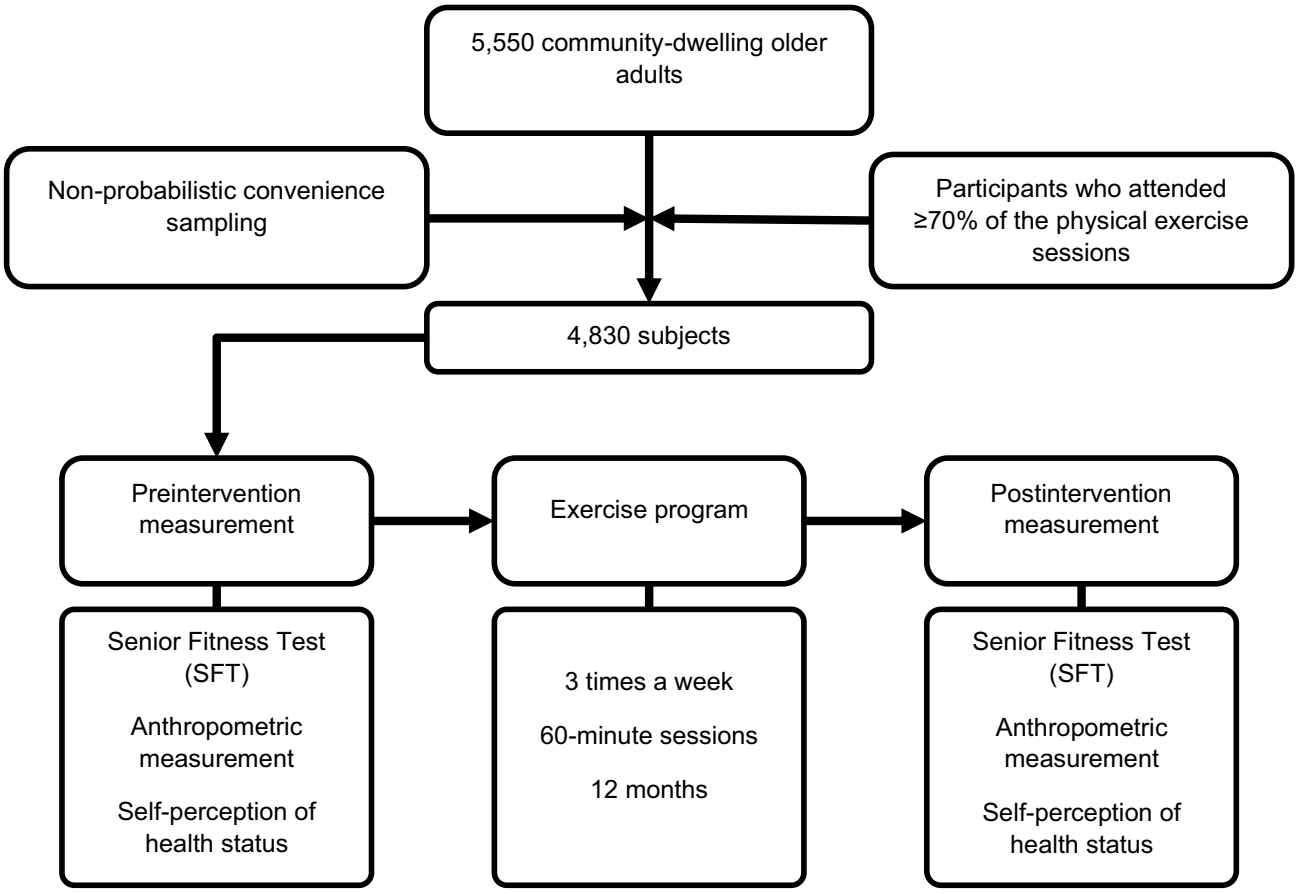

Figure 1 Study flow chart.

Measurements were recorded at the following two representative stages: First, a preintervention measurement was conducted, followed by the application of a 12-month exercise program, following which the second postintervention measurement was performed (Figure 1). Both the measurements and the exercise program focused on a series of physical capacities such as strength, flexibility, balance, and aerobic capacity. The study was performed pursuant to the institutional and governmental regulatory frameworks that regulate research with human beings, such as the World Medical Association Declaration of Helsinki (ethical principles for medical research involving human subjects)[29] and resolution 08430 of 1993 of the Ministry of Health (establishing the scientific, technical, and administrative standards for health research).[30] Furthermore, this study was endorsed by the scientific ethics and bioethics committee of the institution.

The pre-and postintervention measurements were recorded while taking into account a series of tests and measurements that are included in the SFT, including the lower limb strength test,[31] which requires participants to sit at the front edge of a chair, bringing one leg straight in front of the hip, with the heel flat on the floor and the ankle dorsiflexed (approximately 90°), while the other leg remains slightly bent to the side, in order to obtain a measurement of the hamstrings flexibility in older adults this presents good intraclass test-retest reliability (r =0.92 for men and r =0.96 for women), and the chest lift test,[32] in which each participant had to perform the greatest number of correctly executed trunk flexion exercises, to obtain a measurement of muscular performance of the upper limbs the correlation index between the revised scores was 80 for women and 87 for men.

The squat test[33] was also performed, wherein each participant started the test by sitting in the middle of the chair, moving to a body upright position, and then returning to the initial position without completely sitting on the chair. The aim of this test was to obtain a measurement of the muscle performance of the lower limbs that had reported values in validation studies (men r =0.78 and women r =0.71). The balance test, where participants had to sit in the middle of the chair, with their back straight, their feet flat on the ground, and, at the "go" signal, participants had to rise from the chair

and walk as quickly as possible until they went around the cone and sat back down.[20] The 2-minute walk test,[20] where participants had to walk according to their aerobic capacity for 2 minutes. Lastly, the shoulder external rotation test, where each subject was instructed to stand with the hand of his or her preference on the same shoulder, the palm facing downwards and his or her fingers extended. From this position, the participant will bring his or her hand toward the middle of the back as far as possible, keeping the elbow up. The other arm is placed behind the back, surrounding the waist with the palm of the hand facing upwards and taking it as far as possible, trying to make the middle fingers of both hands touch each other.[20]

The physical fitness variables were rated on a numerical scale according to their response options: Balance was measured as the time in seconds when traveling 2.44 meters; muscle strength as the number of repetitions in 30 seconds; Wells flexibility as the distance in centimeters from the tips of the fingers of the hands to the upper part of the shoe; flexibility of the shoulder external rotation as the distance in centimeters between the tips of the middle fingers of both hands; and aerobic capacity as the total number of steps completed, these latest tests have reliability values of 0.80 to 0.98.[34]

The anthropometric measurement of the waist/hip ratio (WHR) was recorded, which relates the waist perimeter to that of the hip (in centimeters), and according to the provisions of the World Health Organization, levels of 0.8 in women and 1.0 in men were considered normal, while higher values indicated an increased cardiovascular risk, this was taken with a tape measure (SECA 201). Regarding the body mass index (BMI) corresponding to the ratio between the body weight and height (Weight/Height^2: kg/m^2), values<18.5 kg/m^2 were classified as low weight, 18.5–24.9 kg/ m^2 as normal, 25–29.9 kg/m^2 as overweight, and $\geq$ 30 kg/m^2 as obesity, to take this measurement, a scale (Meter 800KL) and a portable stadiometer (SECA 217) were used.

Physical Activity Program

The program was conducted at recreational community centers. The intervention scheme was 3 times a week, in 60-minute sessions, divided into a warm-up phase, a central phase, and a cool-down phase, for 12 months. The intervention was conducted by a methodological team made up of physiotherapists, graduates, and sports professionals linked to the Municipal Sports Secretariat. All the professionals who taught the sessions had experience in exercise planning for the elderly and had received training from two of the team's researchers.

At the beginning of the sessions, we started with an effort monitoring using the Borg scale to measure the perception reported during the activities, taking the participants up to a perception of 6 (hard). If the participant reported a greater effort, he/she was instructed to decrease the pace of work.

Strength training was developed through exercises with free weights, focused on 12 muscle groups as follows: shoulder flexors, shoulder abductors, shoulder extensors, elbow flexors, elbow extensors, hip flexors, hip abductors, hip extensors, hip, knee flexors, knee extensors, ankle plantar and dorsi flexors, these contemplated variabilities in positioning, they were worked in a seated position, initiating the processes to guarantee safety while the exercise was understood. As the sessions passed, changes were made, such as execution from the biped or changes in the base of support to increase the load.

The flexibility capacity was worked through directed static stretching, along with joint mobility exercises in all body segments. The aerobic capacity was trained through continuous or discontinuous physical activities lasting approximately 15–60 minutes.

Dynamic and static balance exercises included changes in the base of support, speed, and attention change exercises, as well as specific accessories for this type of exercise. The activities and physical exercises were adapted to each subject's circumstances. Breaks of 60–90 seconds were provided between each series of exercises.

The progression was given according to the response capacity of the groups, generating an increase in the series of repetitions every two months, which allowed the variability of the exercise.

Statistical Methods

Concordance was evaluated and statistical validation of the database was performed. The unit corresponded to the participants subjected to the intervention. A descriptive analysis of the study variables was performed in the general population, as well as according to age ranges. This description was developed for categorical data using frequency distribution, relative frequencies,

and proportions. For the quantitative data, a numerical analysis of measures of central tendency and dispersion was conducted, including the estimation of the respective confidence interval (95% CI) for the proportions.

The qualitative variables were sex, the general system of social security in health, recreational activities, main support network, type of household, type of deficiency or clinical history, and medication intake. These were assumed as independent variables, the Chi-square test (χ^2) was used to establish the differences in proportions. Regarding the quantitative variables the Kolmogorov–Smirnov normality test was carried out to consider the distribution of the data, for the comparison of the hypotheses of differences between the sample means, a Student's *t*-test was used for paired data. The differences in proportions and means were measured with a significance level of 0.05 and a CI of 95%. The magnitude of the effect of the physical exercise intervention was estimated using Cohen's d, interpreting the cut-off value as small effect (0.20), medium effect (0.50), and large effect (0.80). Data analysis was conducted with the statistical programs RStudio® and JASP.

Results

The present study corresponded to a quasi-experimental design, with a significant sample size of 4830 older adults from the community, which included the evaluation of tests and measures for physical qualities with a highly reliable instrument, before and after an intervention based on physical exercise.

The study population consisted mainly of older female adults (92.4%) and members of the contributory regime of the general social security health system (68.2%). Among their leisure activities, spending time with family, friends, and neighbors was predominant (45.6%), the majority of them reporting their family as the main support network (89.1%), the consumption of medicines (73.2%), and residing in their own home (68.0%) (Table 1).

In the comparison of proportions by age groups <75 and ≥75 years, female adults and those with their own home predominated in the younger group; however, in the older group, adults who take medications, and with a clinical history of deficiencies in the cardiorespiratory system and in the movement of the body, hands, arms, and legs were predominant, all with statistically significant differences ($p < 0.05$).

The age of the total study population presented an average of 70.7 years, a standard deviation of 7.3, and an age range between 60 and 97 years. When comparing the statistics of the age variable by sex, it can be observed that the average is

Table 1 Sociodemographic Characteristics

Characteristics	OA ≥ 75 Years (n = 3400)		OA ≥ 75 Years (n = 1430)		Total OA (n = 4830)			*p* value
	n	%	n	%	n	%	CI 95%	
Sex:								0.000
Female	3195	94.0	1267	88.6	4462	92.4	91.5–93.1	
Male	205	6.0	163	11.4	368	7.6	6.8–8.4	
SGSSS affiliation scheme:								0.922
Contributory	2320	68.2	973	68.0	3293	68.2	66.8–69.4	
Special	81	2.4	28	2.0	109	2.3	1.8–2.7	
Subsidized	999	29.4	429	30.0	1428	29.6	28.2–30.8	
Recreational activities:								0.442
Spending time with family, Friends, and neighbors	1562	45.9	639	44.7	2201	45.6	44.1–46.9	
Listening to music	698	20.5	290	20.3	988	20.5	19.3–21.6	
Board games	552	16.2	259	18.1	811	16.8	15.7–17.8	
Reading	588	17.3	242	16.9	830	17.2	16.1–18.2	
Main support network:								0.547
Community:	53	1.6	27	1.9	80	1.7	1.3–2.0	
State	323	9.5	122	8.5	445	9.2	8.4–10.0	
Family	3024	88.9	1281	89.6	4305	89.1	88.2–89.9	

(*Continued*)

Table 1 (Continued).

Characteristics	OA ≥ 75 Years (n = 3400)		OA ≥ 75 Years (n = 1430)		Total OA (n = 4830)			*p* value
	n	%	n	%	n	%	CI 95%	
Type of household:								0.000
Rental	512	15.1	257	18.0	769	15.9	14.8–16.9	
Family	510	15.0	265	18.5	775	16.0	15.0–17.1	
Own	2378	69.9	908	63.5	3286	68.0	66.6–69.3	
Type of deficiency or clinical history:								
Movement of body, hands, arms, legs	170	5.0	82	5.7	252	5.2	4.6–5.8	0.328
Nervous system	42	1.2	27	1.8	69	1.4	1.1–1.8	0.106
Eyes	22	0.6	2	0.1	4	0.08	0.02–0.2	0.039
Cardiorespiratory system and Immune system	2200	64.7	1039	72.6	3239	67.0	65.7–68.3	0.000
Ears	4	0.1	3	0.2	7	0.1	0.05–0.2	0.723
Voice and speech	7	0.2	5	0.3	12	0.2	0.1–0.4	0.548
Digestion, metabolism, hormones	186	5.4	56	3.9	242	5.0	4.4–5.6	0.028
Mental and behavioral disorders	8	0.2	16	1.1	24	0.4	0.3–0.7	0.000
Medication intake:								0.000
No	993	29.2	301	21.0	1294	26.8	25.5–28.0	
Yes	2407	70.8	1129	79.0	3536	73.2	71.9–74.4	

Abbreviations: OA, Older adults; SGSSS, General System of Social Security in Health; CI 95%, 95% confidence interval.

higher in men compared to women (73 vs 70), as well as a wider age range for the female gender, since it is within this group that the extreme values exceeding the cut-off point of 90 years could be found (Figure 2).

Regarding changes in the physical capacities after the physical exercise intervention in older adults, it could be found that generally speaking, although all areas benefited from the exercise, the area with the greatest mean difference was muscle strength in the lower limbs, followed by flexibility and muscle strength in the upper limbs. This can be seen in the statistically significant differences between the two measurement moments ($p < 0.05$).

It can also be observed that flexibility shows the largest effect magnitude (Cohen's d), followed by muscle strength of the lower limbs. However, the intervention with physical exercise reveals a large effect (>0.80) in all variables, except in the aerobic capacity where the effect is small (Table 2).

In addition, the variables self-perception of health status, BMI, and WHR showed a tendency to benefit, showing an increase in the number of people who perceive their health status as "good", while the frequency of older adults with overweight and WHR in the cardiovascular risk category decreased (Figure 3).

Discussion

According to the results reported in the literature, there is evidence of acceptance of the hypothesis proposed in the present study, which is focused on the possible benefits for the physical capacities of older adults after completing a physical exercise program. Additionally, a substantial percentage of studies establish similarities when reporting the SFT set as an assessment and measurement instrument. For example, Ramalho et al worked with two study groups, both with physical exercise intervention, and found significant improvements in all the physical capacities measured by the SFT.[9]

In a study applying for a vigorous exercise program in healthy older adults, significant improvements could be measured in the capacities of strength, flexibility, balance, and agility. However, in the 8-foot Up and Go test (of the SFT), no statistically significant results ($p > 0.05$)[3] could be observed. Sbardelotto et al after evaluating three groups with different exercise protocols, found that those protocols directly related to the combination of exercises focused on developing physical strength and aerobic capacity within the same session proved to be more efficient than when performed separately.[23] On the other hand, Martínez et al assessed the degree of functional decline in older adults after a 5-month non-intervention period, finding that the capacities of mobility, strength, resistance, and balance presented a significant worsening.[12]

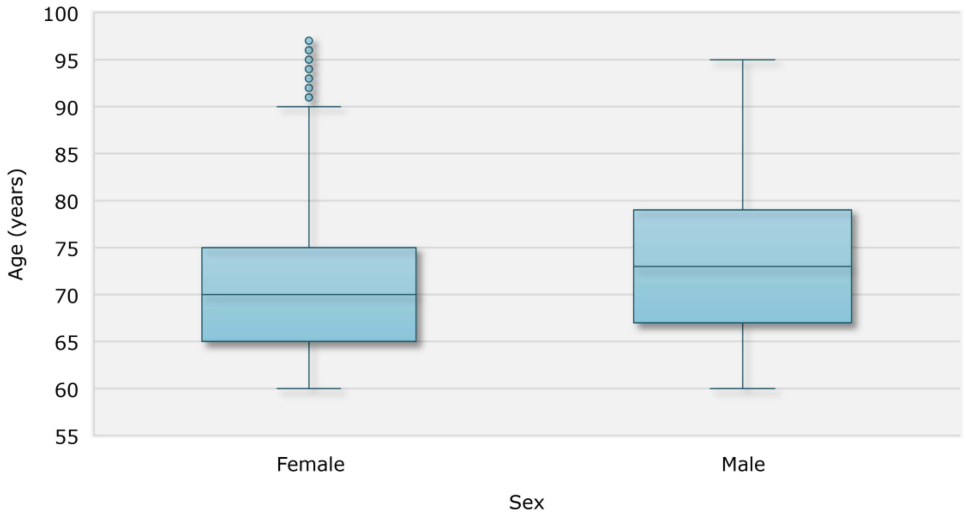

Figure 2 Box-and-whisker plot for age by sex.

A 2020 study on the effects of a balance and resistance exercise program on physical fitness, quality of life, and fear of falls found that two weeks of intervention with multi-component interventions targeting physical activity generated significant results in these capacities.[35] The starting point for the present study was the little evidence found about studies that measured physical capacities before and after intervention in older adults in Colombia. In 2012, Vidarte et al reported the effects of physical exercise on functional physical condition and the risk of falls in older adults, finding significant changes in body composition, strength, flexibility, aerobic resistance, and balance.[26] Unlike the previous investigation, our study included a longer intervention period that reached 12 months of the supervised physical exercise program, which significantly contributes to local and regional knowledge about the effects of this type of community strategies in the context of public health policies for the elderly population.

On the other hand, Chabeene et al in a systematic review, postulated that physical training of >3 weekly sessions in healthy older adults generates a series of significant improvements in muscle strength, balance, and physical fitness in general.[36] Mendes et al measured the impact of a community-based exercise program for middle-aged and older adults, finding significant improvements in aerobic fitness, muscle strength, agility, balance, and flexibility.[37]

Therefore, similarities become evident in the research report, which sustains and support the hypothesis of the present investigation, endorsing the results found in this study, which show significant differences for all the physical capacities evaluated such as strength, flexibility, proprioception, balance, and aerobic capacity.

Additionally, and in line with the Colombian policy on human aging and old age (2015–2024), where active aging is considered based on definitions of the World Health Organization (2002), which defines it as "Active aging is the process of optimizing opportunities for health, participation, and security in order to enhance the

Table 2 Changes in the Physical Capacities

Physical Qualities	Preintervention		Postintervention		Diff. $\bar{x}$	Est. t	Cohen's d	*p* value
	$\bar{x}$	SD	$\bar{x}$	SD				
Balance (seconds)	5.971	1.608	5.010	1.481	0.961	116.757	1.680	<0.001
Flexibility test by Wells and Dillon (cm)	1.073	3.440	1.751	3.123	−2.824	−138.835	−1.998	<0.001
ER shoulder flexibility (cm)	7.285	2.458	3.709	2.847	−3.577	−246.824	−3.552	<0.001
ULs strength (repetitions)	19.157	4.323	22.691	4.901	−3.534	−129.105	−1.858	<0.001
LLs strength (repetitions)	17.163	3.735	21.194	4.682	−4.031	−147.315	−2.120	<0.001
Aerobic capacity (number of steps)	87.000	11.061	89.000	10.553	−2.811	−18.718	−0.270	<0.001

Abbreviations: ER, external rotation; ULs, Upper limbs; LLs, Lower limbs; Cm, centimeters; $\bar{x}$, Average; Diff, Difference; Est., Statistical.

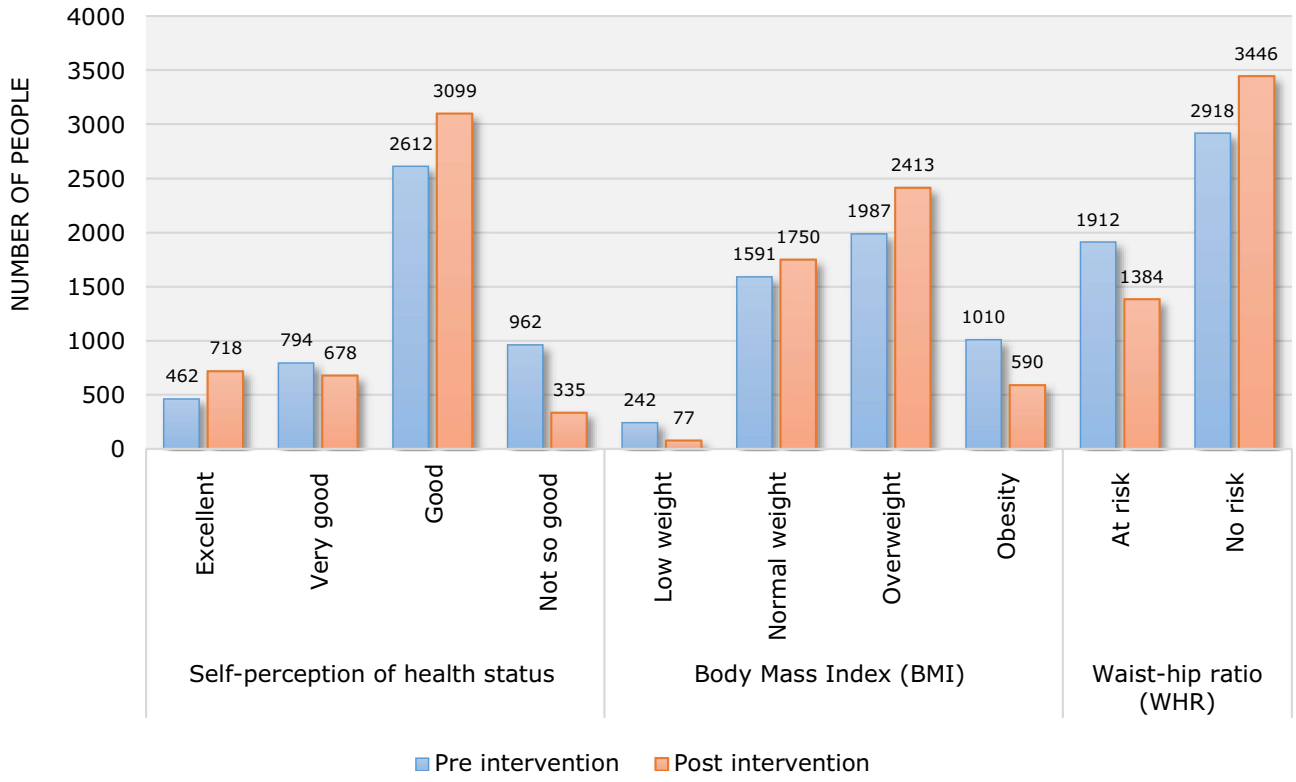

Figure 3 Pre- and postintervention changes in the self-perception of health status, body mass index, and waist-hip ratio.

quality of life as people age",[38] the present study contributes to this insight of aging, highlighting the benefits in physical development (as part of the physical, mental, and social components), thus favoring an optimal level of performance with the potential to impact other components of the life of the older adult. This point was evidenced in our study with the positive change in the perception of the state of health, which went from being perceived as "excellent" from 9.5% (462) to 21% (718) after the intervention.

This impact is highlighted based on the fact that the population under study was made up of 4830 older adults living in the community, who were engaged in a program of the Municipal Health Secretary for active aging. The measurements and strategies were based on a 12-month intervention, in which the respective measurements were made before and after the intervention, the results of which have been presented above.

The limitations of this research correspond to those of quasi-experimental studies, related to the limitation to control other associated factors that may influence the intervention and the lack of a control group, however, we sought to reduce these situations with a sample size important and representative of the total population and that had good adherence to the exercise-based intervention, which allows the changes found in the physical qualities of older adults to be related with greater strength of association.

Conclusion

The present study revealed that a supervised physical exercise program at the community level has positive effects on the physical capacities of coordination, balance, flexibility, strength, and aerobic capacity, therefore such programs with a specific intensity have physical benefits.

Similarly, there was evidence of an improvement in the self-perception of health status and the reduction of overweight and obesity. In addition, the majority of the population that attends this type of intervention is female, so the programs that respond to public health policies must establish strategies that allow greater adherence and participation of older adults of both sexes.

Ethics Approval and Informed Consent

Approval of the ethics committee Universidad Santiago de Cali on September 21, 2018 according to Minutes No. 04.

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Disclosure

The authors report no conflicts of interest in this work.

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