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Changes in anthropometric parameters and physical fitness in older adults after participating in a 16-week physical activity program

Cambios en los parámetros antropométricos y la condición física en adultos mayores luego de participar en un programa de actividad física de 16 semanas

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Abstract

Introduction: Physical activity is important for achieving healthy aging.
Objective: To analyze changes in anthropometric parameters and physical fitness among Chilean older adults after participating in a 16-week physical activity program and to evaluate whether there were differences in relation to their baseline nutritional status or not.
Materials and methods: Pre-experimental quantitative study. The study population consisted of 176 older adults (155 women and 21 men) distributed in three groups: normal weight (n=56), overweight (n=67) and obese (n=53). The following variables were evaluated: body mass index (BMI), waist circumference (WC), waist-to-height ratio (WHR) and physical fitness.
Results: Significant decreases between pre- and post-measurements were found for WC (p<0.001), BMI (p=0.015), and WHR (p<0.001). Improvements were observed in the following tests: chair stand (p<0.001), arm curl (p<0.001), 2-min step (p<0.001), chair sit-&-reach (p=0.018) and back scratch (p=0.014). Regarding BMI, significant changes were observed between normal weight vs. overweight participants (p=0.001) and between normal weight vs. obese participants (p=0.001).
Conclusion: Older adult participants that regularly attended the physical activity program were able to reduce their WC, BMI and WHR, and also improved their physical-functional performance on the chair stand, arm curl, 2-min step, chair sit-&-reach and back scratch tests. In addition, anthropometric parameters and physical fitness also improved regardless of their baseline nutritional status.
Keywords: Exercise; Anthropometry; Physical Fitness; Aging; Public Health (MeSH).

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Resumen

Introducción. La actividad física es de gran importancia para lograr un envejecimiento saludable.
Objetivos. Estudiar los cambios en los parámetros antropométricos y la condición física de adultos mayores (AM) chilenos después de 16 semanas de participación en un programa de actividad física, y evaluar las diferencias en relación con su estado nutricional inicial.
Materiales y métodos. Estudio pre-experimental cuantitativo. Población: 176 AM (155 mujeres y 21 hombres) distribuidos en 3 grupos: normopesos (n=56), sobrepesos (n=67) y obesos (n=53). Se evaluaron las siguientes variables: índice de masa corporal (IMC), perímetro de cintura (PC), índice cintura-estatura (ICE) y condición física.
Resultados. Se observaron reducciones significativas en PC (p<0.001), IMC (p=0.015) e ICE (p<0.001), y mejoras en las siguientes pruebas: sentarse y levantarse de una silla (p<0.001), flexiones del codo (p<0.001), dos minutos de marcha (p<0.001), flexión del tronco en silla (p=0.018) y juntar las manos tras la espalda (p=0.014). Se encontraron diferencias significativas respecto al IMC entre participantes normopesos y sobrepesos (p=0.001), y entre normopesos y obesos (p=0.001).
Conclusión. Los AM que participaron regularmente en el programa de actividad física lograron reducir su PC, IMC e ICE y mejorar su rendimiento físico-funcional en las pruebas de sentarse y levantarse de una silla, flexiones de codo, dos minutos de marcha, y flexibilidad del tren inferior y superior. Además, sus parámetros antropométricos y su condición física mejoraron independientemente de su estado nutricional inicial.
Palabras clave: Ejercicio físico; Antropometría; Condición física; Envejecimiento; Salud pública (DeCS).

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Introduction

Physical activity (PA) plays a fundamental role in achieving healthy aging.[1-4] All over the world, public and private institutions have implemented programs fostering the regular practice of PA in older adults.[1,2,5-7] However, in Chile, and despite the fact that the link between PA and health condition has been recently pointed out,[8,9] PA programs for older adults are limited.[10] The Older Adults in Motion program (*Adulto Mayor en Movimiento* in Spanish), created by the National Sports Institute, is one of the most important PA programs in the country and aims at promoting active aging.[11]

There is another older adults-oriented PA program, the More Independent Older Adults Program (*Programa Más Adultos Mayores Autovalentes* in Spanish), which has been implemented by the Chilean Ministry of Health to improve quality of life among older adults through health and self-care training and functional stimulation activities.[12] These governmental efforts are of great importance for the Chilean population, provided that, according to the most recent National Health Survey, 76.8% and 94% of the population over the age of 65 years are overweight and have sedentary lifestyles, respectively,[13] while only 15.8% are physically active.[14]

These government initiatives have scarce follow-up, measurement and socialization of results among the community.[15] Without a doubt, this relates to the difficulty of developing a research protocol that follows rigorous technical and methodological principles that could add value to the scientific community[1] and could show the effects of initiatives in real practice contexts.[16,17]

Evaluating older adults participating in government-designed PA programs is necessary considering the high levels of sedentarism and obesity in this population, as well as the lack of information on the impact that these programs have on their health status.[15] With this in mind, the present study was designed to examine possible changes in anthropometric parameters and physical fitness among Chilean older adults after participating in a 16-week PA program. Moreover, we evaluated whether differences varied by baseline nutritional status. Based on the literature,[1,7] it was hypothesized that participating regularly in a PA program may be associated with the decrease in waist circumference (WC), body mass index (BMI) and waist-to-height ratio (WHR), and in the improvement of physical fitness in older adults, regardless of their baseline nutritional status.

Material and methods

A pre-experimental (one-group pretest–posttest design) study with a quantitative approach was conducted.

Participants

Participants were selected using convenience sampling. The initial sample consisted of 312 people of both sexes aged between 60 and 85 years (mean=71.03 years) that attended the National Sports Institute's Older Adults in Motion Program in the Araucanía region, Chile. The inclusion criteria were: a) being a program participant for >6 months; b) being >60 years of age; c) ability to understand and follow instructions in context through simple commands; d) being independent according the Ministry of Health;[18] and e) attending at least 80% of the program sessions during the second measurement. Exclusion criteria were a) having a disabling disease; b) having musculoskeletal injuries that hindered normal physical performance; or c) having permanent or temporary contraindications for PA. A total of 176 older adults (mean height=1.52m) met the inclusion criteria. Participants were classified as normal weight, overweight or obese before the intervention based on their body mass index (BMI).

All participants were informed of the aim of the investigation and signed an informed consent authorizing the use of their data for scientific purposes. The research protocol was reviewed and approved by the Scientific Ethics Committee of the Universidad Autónoma de Chile (Minutes No. 06-2016 - 14/04/2016) and the principles of the Declaration of Helsinki were followed for its development.[19]

Anthropometric parameters

Anthropometric assessments were made by measuring standing height using a stadiometer (Seca model 220, USA, 0.1cm accuracy). Bodyweight was measured with a digital scale (Scale-tronix, USA; 0.1kg accuracy), while WC was obtained using a measuring tape (Sanny, Brazil, 0.1cm accuracy). BMI was calculated by dividing body weight by squared standing height (kg/m^2), and participants were classified according to their nutritional status as normal weight (<27.9 kg/m^2); overweight (28-31.9 kg/m^2) and obese (>32 kg/m^2), according to the recommendations of the Pan American Health Organization[20] and the Ministry of Health[18] for classification of older adults. The waist-to-hip ratio (WHR) was measured by dividing WC by standing height.[21]

All measurements were performed according to the International Society for the Advancement of Kinanthropometry (ISAK)[22] by a level II (technical error of measurement: 0.8%) and a level III (technical error of measurement: 0.7%) ISAK anthropometrists. Test-retest reliability was assessed using the interclass correlation coefficient (ICC), with values between 0.93 and 0.98 for all measurements.

Physical fitness measurements

Physical fitness measurements followed the Senior Fitness Test (SFT) protocol, previously described and validated for independent-living adults without health problems between 60 and 94 years of age.[23] The following tests were included: a) chair stand test to assess the strength of the lower body, counting the number of repetitions made in 30s; b) arm curl test to assess the strength on the upper body, using a 3lb (women) and 5lb (men) dumbbell, counting the number of repetitions made in 30s; c) 2-minute step to assess aerobic fitness, recording the number of knee elevations; d) chair sit-&-reach test to assess the flexibility of the lower-body, measured in cm; e) back scratch test to assess flexibility on the upper-body, measured in cm; and f) timed up-and-go test to assess agility and dynamic balance, surrounding a cone at 8ft (2.44m) and recording time in seconds.

An experienced researcher conducted each test after a 15min warm-up, which included joint mobility drills and aerobic exercises. ICC was between 0.72 and 0.94 for all physical fitness test measurements.

Physical activity workshops description

The Older Adults in Motion Program was implemented in the Araucanía region in March 2015.[11] The program

was free for participants, was offered two or three times per week (180min weekly) in different social venues, and targeted independent-living persons aged 60 years or older.[10,11]

The program had a training load progression in terms of intensity and number of repetitions for muscle strength and muscle endurance exercises. The duration of the sessions was between 60min (three times per week) and 90min (two times per week). A typical session included a 10-to-15min warm-up, consisting of joint mobility exercises and low intensity aerobic exercises. It was followed by 10 to 15min of muscle strength and muscle endurance exercises for biceps, triceps, deltoids, latissimus dorsi, quadriceps, hamstrings, buttocks and gastrocnemius muscles, in combination with 10 to 15min of aerobic exercise, agility and dynamic balance, using elastic bands, canes, 2kg medicine-balls and chairs. Then, participants performed 20 to 30min of healthy dance using music with a beat rate no higher than 120 beats per minute. Finally, the sessions ended with a 10 to 15min cool down with dynamic and static flexibility exercises. Each workshop was led by a physical education teacher, responsible for carrying out and designing the activities of the PA sessions.

Statistical Analysis

The Statistical Package for Social Science (SPSS) version 23.0 was used for all analyses. The means and standard deviations were calculated for anthropometric and physical fitness measurements. Furthermore, the distribution of normality and homogeneity of variance were calculated using the Kolmogorov-Smirnov and Levene's tests, respectively. To compare anthropometric parameters and physical fitness before (pre) and after (post) the 16-week PA program, the paired student's t-test was used when the variables had a normal distribution, and the Wilcoxon test when they did not have a normal distribution. To compare pre- and post-change according to nutritional status (normal weight, overweight and obese), the Kruskal-Wallis test with Dunn's post hoc (not parametric) was applied. Effect size (ES) was calculated with Cohen's *d*,[24] considering a small (0.20-0.49), moderate (0.50-0.79), or large (>0.80) effect. In all cases, a value of $p<0.05$ was considered statistically significant.

Standard errors of measurement (SEM) and minimal detectable change (MDC) were calculated for all anthropometric parameters and physical fitness tests. The SEM were calculated using the following equation: $SEM = SD \times (\sqrt{1} - ICC)$. In this equation, SD is the standard deviation of the measure, and ICC is the interclass correlation coefficient (test-retest reliability). MDC were calculated for the body weight, WC, BMI, WHR, chair stand test, arm curl test, 2-minute step test, chair sit-&-reach test, back scratch test and up-and-go test using the 95% confidence interval. The formula used for calculating MDC was $MDC = 1.96 \times \sqrt{2} \times SEM$. In this equation, SEM was calculated as described previously. The 1.96 in the MDC equation represents the z-score at the 95% confidence level.

Results

Table 1 shows the pre- and post-program anthropometric parameters. Significant decreases with a small effect size were observed in men, women and overall sample for WC ($p=0.022$ in men; $p<0.001$ in women and overall sample; $ES<0.30$ in men, women and overall sample), BMI ($p<0.05$ in men, women and overall sample; $ES=0.20$ in men) and WHR ($p=0.004$ in men, $p<0.001$ in women and overall sample; $ES=0.35$ in men, $ES=0.28$ in overall sample). No significant changes in body weight were observed. On the other hand, WC showed a higher change than the MDC in men, compared to women and overall sample (men and women together), while, for BMI, the change was greater than the MDC in men only.

Table 1. Anthropometric parameters in older adults after 16 weeks of participation in a physical activity program.

Anthropometric parameters Mean (σ)		Pre-test Mean (σ)	Post-test	p-value	Change %	SEM	MCD	Effect Size
Body weight (kg)	Overall (n=176)	70.19 (12.56)	70.02 (12.35)	0.473 *	-0.24	0.25	1.39	0.01
	Women (n=155)	68.93 (12.39)	68.76 (12.27)	0.538 *	-0.29	0.25	1.38	0.01
	Men (n=21)	79.51 (9.73)	79.26 (8.58)	0.625 *	-0.31	0.19	1.22	0.64 **
Waist circumference (cm)	Overall (n=176)	93.75 (11.10)	90.96 (11.47)	<0.001 *	-2.98	0.78	2.44	0.25 ‡
	Women (n=155)	92.83 (11.00)	89.97 (11.40)	<0.001 *	-3.08	0.88	2.60	0.26 ‡
	Men (n=21)	100.59 (9.52)	98.24 (9.31)	0.022 *	-2.34	0.57	2.09	0.25 ‡
Body mass index (kg/m2)	Overall (n=176)	30.18 (4.62)	29.91 (4.47)	0.015 *	-0.89	0.23	1.33	0.08
	Women (n=155)	30.22 (4.76)	29.98 (4.65)	0.022 *	-0.79	0.14	1.05	0.07
	Men (n=21)	29.87 (3.42)	28.44 (2.70)	0.039 *	-4.78	0.21	1.26	0.20 ‡
Waist-to-height ratio	Overall (n=176)	0.62 (0.07)	0.59 (0.07)	<0.001 †	-4.84	0.00	0.19	0.28 ‡
	Women (n=155)	0.62 (0.06)	0.59 (0.07)	<0.001 †	-4.84	0.00	0.19	<0.001
	Men (n=21)	0.61 (0.06)	0.59 (0.06)	0.004 †	-3.28	0.00	0.17	0.35 ‡

σ: standard deviation; SEM: standard error of measurement; MCD: minimal detectable change.
* Student's t-test for related samples.
† Wilcoxon test.
‡ small.
** moderate.
Source: Own elaboration.

Table 2 shows the pre- and post-program SFT parameters. Significant improvements between the pre-and-post measurements were observed in men, women and overall sample for the chair stand ($p<0.001$ in women and overall sample; ES=0.35 in men, ES>0.80 in women and overall sample), arm curl ($p=0.001$ in men, $p<0.001$ in women and overall sample; ES=1.16 in men, ES<0.80 in women and overall sample), 2-minute step ($p=0.003$ in men, $p<0.001$ in women and overall sample; ES=0.71 in men, ES>0.80 in women and overall sample), chair sit-&-reach ($p<0.05$ in women and overall sample), and back scratch ($p<0.05$ in women and overall sample) tests. No significant changes in the timed up-and-go test were observed. In addition, the arm curl and the 2-minute step tests showed a higher change than the MDC in men, women and the overall sample. The chair stand test showed a higher change than the MDC in women and overall sample, while the chair sit-&-reach test showed a decrease in men with higher change than the MDC.

Table 2. Physical fitness of older adults after 16 weeks of participation in a physical activity program.

Physical fitness test		Pre-test	Post-test	p-value	Change %	SEM	MCD	Effect Size
		Mean (σ)	Mean (σ)					
Chair stand test (repetitions)	Overall (n=176)	15.54 (3.44)	18.74 (4.13)	<0.001 †	20.59	0.69	2.30	0.84 ††
	Women (n=155)	15.33 (3.38)	18.79 (4.18)	<0.001 †	22.57	0.48	1.93	0.91 ††
	Men (n=21)	17.09 (3.57)	18.38 (3.89)	0.081 *	7.55	1.01	2.78	0.35 ‡
Arm curl test (repetitions)	Overall (n=176)	21.84 (4.42)	25.65 (5.76)	<0.001 †	17.44	0.84	2.54	0.74 **
	Women (n=155)	21.81 (4.64)	25.52 (5.86)	<0.001 †	17.01	0.65	2.24	0.70 **
	Men (n=21)	22.04 (2.29)	26.57 (5.02)	0.001 *	20.55	0.54	2.04	1.16 ††
2-minute step test (repetitions)	Overall (n=176)	94.05 (23.36)	115.18 (22.95)	<0.001 †	22.47	4.91	6.14	0.91 ††
	Women (n=155)	92.34 (23.77)	114.36 (22.66)	<0.001 †	23.85	4.40	5.81	0.95 ††
	Men (n=21)	106.66 (15.23)	121.19 (24.72)	0.003 †	13.62	3.78	5.39	0.71 **
Chair sit-&-reach test (cm)	Overall (n=176)	3.17 (7.81)	4.07 (7.81)	0.018 †	28.39	0.94	2.68	0.11
	Women (n=155)	3.15 (7.58)	4.61 (7.89)	<0.001 †	46.35	0.48	1.92	0.19
	Men (n=21)	3.38 (9.55)	0.05 (5.94)	0.083 †	-52.07	1.74	3.65	0.42 ‡
Back scratch test (cm)	Overall (n=176)	-8.28 (9.04)	-6.95 (9.60)	0.014 †	16.06	0.90	2.64	0.14
	Women (n=155)	-7.63 (8.75)	-6.27 (9.16)	0.017 †	17.82	0.56	2.07	0.15
	Men (n=21)	-13.00 (9.92)	-11.98 (11.43)	0.512 *	8.55	1.53	3.43	0.10
Up-and-go test (s)	Overall (n=176)	5.32 (1.07)	5.25 (0.85)	0.261 †	-1.13	0.16	1.11	0.06
	Women (n=155)	5.38 (1.10)	5.30 (0.86)	0.122 †	-1.48	0.15	1.07	0.08
	Men (n=21)	4.81 (0.70)	4.91 (0.70)	0.401 *	2.08	0.12	0.96	0.14

σ: standard deviation; SEM: standard error of measurement; MCD: minimal detectable change.
* Student´s t-test for related samples.
† Wilcoxon test.
‡ small.
** moderate.
†† large.
Source: Own elaboration.

Figure 1 shows a significant decrease among normal weight participants in WC ($p=0.039$) and WHR ($p=0.022$), and a significant decrease in WC ($p<0.001$), BMI ($p<0.001$) and WHR ($p<0.001$) in the overweight and obese participants. Multiple comparisons of pre-post program changes between groups according to their baseline nutritional status showed a significant difference ($p<0.001$) for BMI only. The post-hoc test showed differences between normal weight versus overweight ($p=0.001$) and between normal weight versus obese ($p=0.001$) groups.

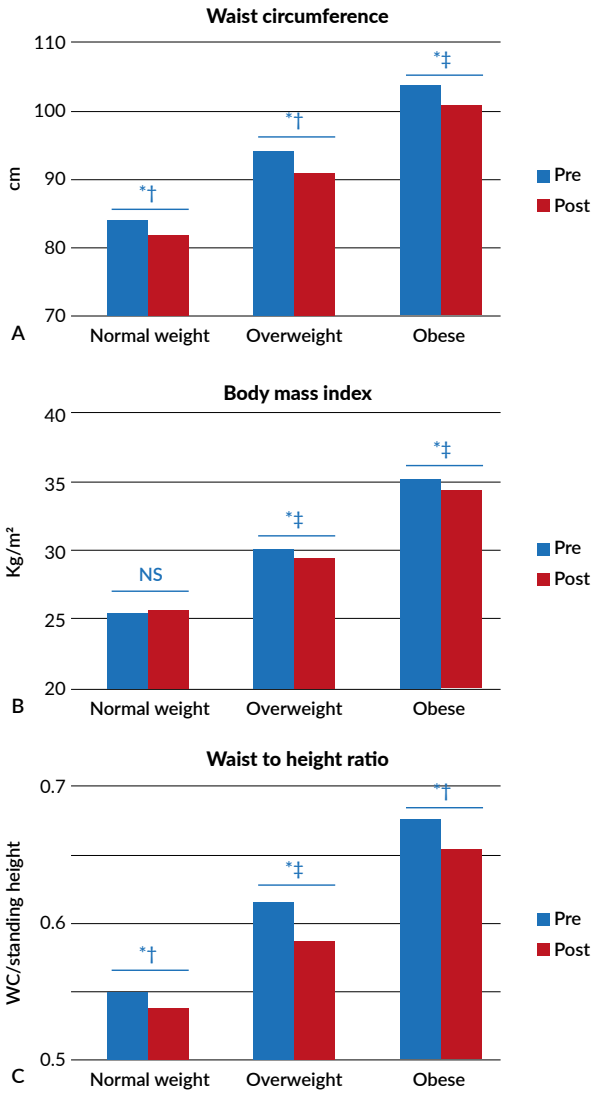

Figure 1. Changes in anthropometric parameters of older adults after 16 weeks of participation in a physical activity program by baseline nutritional status. A: Waist circumference; B: Body mass index; C: Waist-to-height ratio.
WC: waist circumference; NS: not significant.
* Significant differences between pre-and-post measurements ($p<0.05$).
† Paired Student's t-test.
‡ Wilcoxon test.
Source: Own elaboration.

Figure 2 shows a significant improvement among the normal weight and obese groups for the chair stand ($p<0.001$), arm curl ($p<0.001$) and 2-minute step ($p<0.001$) tests. In the case of the overweight group, significant improvements were seen for the chair stand ($p<0.001$), arm curl ($p<0.001$), 2-minute step and chair sit-&-reach ($p=0.036$) tests. When comparing the pre-post program changes between the normal weight, overweight and obese groups, no significant differences were observed for the SFT measurements.

Discussion

In this study, changes in anthropometric parameters and physical fitness in a group of Chilean older adult participants was assessed after 16 weeks of participation in a PA program. Differences based on participants' baseline nutritional status were also determined. Results obtained here show that, regardless of baseline nutritional status and sex, there was an improvement in the anthropometric parameters and physical fitness of all participants. However, greater improvement was observed in women and in the overweight and obese groups. The findings reported here are in agreement with those described in a study conducted in a Chilean primary healthcare center with a sample of healthy older women who participated in a 12-week training intervention involving combined exercises, in which improvements in WC, muscle strength, flexibility, and balance were reported.[25]

BMI decreased significantly among women, men, the overall sample and in the overweight and obese groups after completing the program, although most of older adults maintained their basal nutritional status classification. A similar work among Argentinian older adults has shown decreases in the prevalence of overweight/obesity after a 12-month intervention from 49.3% to 31%.[26] Similarly, the WC and the WHR decreased significantly post-program in all groups (women, men, overall sample, normal weight, overweight and obese). Similar findings were shown in a study of Colombian older adults.[27]

WHR has been used to a lesser extent among older adults even though relevant scientific evidence has positioned it as a better risk marker compared to other measurement indexes such as WC and BMI.[28] As stated in other works,[10] using only nutritional status and cardiometabolic risk classification, without considering the continuous values of BMI, WC, and WHR, could underestimate the specific modifications among participants. Therefore, all of them should be used jointly to minimize possible errors.

The SFT performance improved in all groups with no differences by nutritional status. In particular, the chair stand (except for men) and arm curl tests showed significant changes in all older adult groups, similar to what was reported among Chilean older adults in the central[25] and northern[29] regions. Our findings are important given that strength in older adults relates to higher independence for performing daily activities,[10,30] and its increase may improve the quality of life of older women.[31-34]

The 2-minute step test improved significantly in all groups from 94 to 115 repetitions, and differences were greater than those shown in a study conducted with Colombian older adults that improved steps from 70 to 83 repetitions.[27] The relevance of this finding is that a recent review by Witard *et al.*[2] emphasized aerobic resistance as a key component, not only of cardiovascular health but also of muscle strengthening and sarcopenia protection in older adults. Similarly, in Chilean older women,[35] cardiorespiratory fitness was shown to be related to improved cardiovascular health.

Regarding chair sit-&-reach and back scratch tests, only significant improvements in the pre-and-post measurements were found in women, the overall sample, and among the overweight group in the chair sit-&-reach test; on the other hand, improvements were observed in women and the overall sample for the back scratch test. Other publications have reported significant improvements on the chair sit-&-reach test[25] and back scratch test[25,27] among older

adults after 12 weeks of intervention. It is probable that the low scoring in the chair sit-&-reach and back scratch tests demonstrated by older adults relates to the increase in rigidity of the cartilage and tissues, a phenomenon typical of the aging process, which decreases the articular movement range, and therefore, reduces flexibility.[10,27]

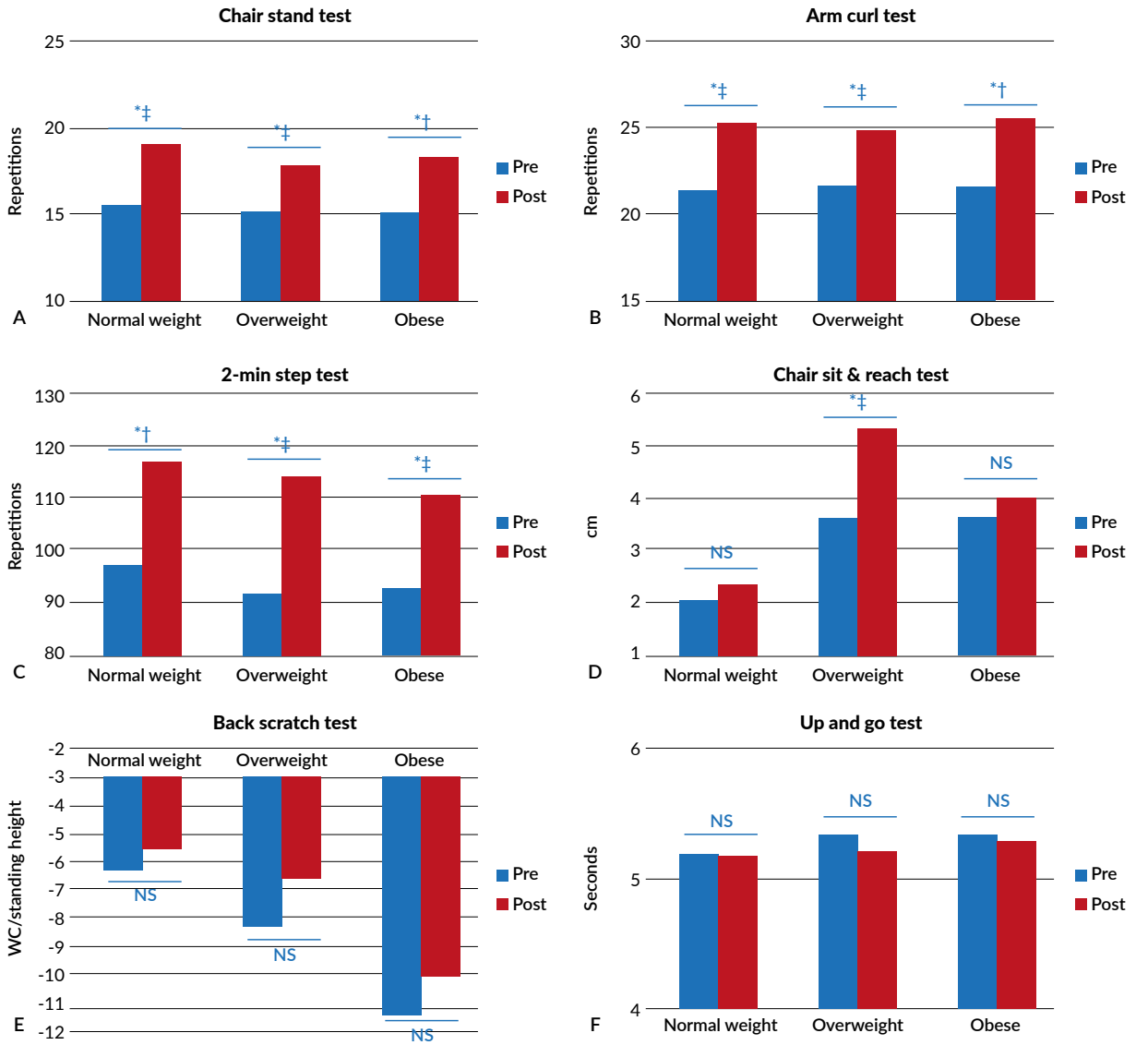

Figure 2. Changes in physical fitness in older adults after 16 weeks participation in a physical activity program by baseline nutritional status. A: Chair stand test; B: Arm curl test; C: 2min step test; D: Chair sit-&-reach test; E: Back scratch test; F: Up-and-go test.
NS: not significant.
* Significant differences between pre-and-post measurements ($p<0.05$).
† Paired Student's t-test.
‡ Wilcoxon test.
Source: Own elaboration.

The up-and-go test showed no significant improvement in any group after the program. Contradictory results are reported among older adults following a 12-week program of combined exercises.[25] However, the reaction time of all groups evaluated (except for men) improved after the program, which was equal to or higher than the one expected for their age and sex. This could be auspicious since this capacity is related to a lower risk of falling in older adults.[5,6]

Although this study shows how beneficial PA programs are for improving anthropometric parameters and physical fitness in all groups of older adults, the poor adherence to the program (56.4%) and the lack of technical orientations that guide teachers to develop their program[11] are concerning. Despite this, the activities planned for the program seem to stimulate physical-functional capacities successfully and improve anthropometric measures of older adults regardless of their nutritional status. In this sense, the public institutions in charge of PA programs oriented towards older adults should reinforce strategies to retain the beneficiaries of these initiatives and develop techni-

cal/methodological manuals for the professionals that carry out the sessions, since PA is a key element for the promotion of healthy aging.

It should be noted that, according to these results, an overweight/obese status would not limit the improvement of the physical fitness of older adults since they responded equally to similar PA stimuli compared to normal weight participants. Physical inactivity has been described as a greater risk for mortality than excess weight.[36] On the other hand, physical fitness is a protective factor for several diseases.[37] Therefore, older adults that are physically active, regardless of their nutritional status, could decrease their mortality risk even more if they improve their physical fitness.[36,37]

Some of the main strengths of this study are the relatively large sample size of older adults that participated in the PA program; the fact that older adults participants were evaluated in a community-based setting; and, the simplicity of the measurements, which means that the methodology could be replicated and implemented in other PA initiatives for older adults. Likewise, the costs required for conducting this type of intervention are very low, and it could be used in large population groups such as those found in community centers, preventive health units, back-to-school events, among others).

The limitations to this study include the non-probabilistic selection of the sample, which restrains the external validity of the results, and the reduction of the sample size, which went from 312 at the beginning of the study, to 176 in the end. Despite of these limitations, this study provides input that supports government actions that encourage healthy aging.

Conclusion

Older adults that took part regularly in a PA program decreased their WC, BMI and WHR, and improved their physical-functional performance on the chair stand, arm curl, 2-minute step, chair sit-&-reach, and back scratch tests. Anthropometric parameters and physical fitness improved regardless of their baseline nutritional status. We recommend that governmental and non-governmental institutions encourage the practice of PA in older adults, as well as in middle-aged adults, to provide longevity with health and quality of life for this portion of the population.

Conflicts of interest

None stated by the authors.

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