Physical fitness in the elderly: a longitudinal study with individualized and supervised exercise programs[1]

Condicionamento físico em idosos: um estudo longitudinal com programas de exercícios individualizados e supervisionados.

Acondicionamiento físico en personas mayores: un estudio longitudinal con programas de ejercicio individualizados y supervisados.

[Research Article]

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Abstract:

This semi-experimental study aimed to investigate the impact of personalized and supervised exercise on the physical fitness of elderly people. Ninety people aged 60 or over took part in the study, in which significant improvements were observed in various dimensions of physical fitness. The data analyzed showed significant improvements in several dimensions of physical fitness. In particular, localized muscular strength and endurance showed substantial gains, highlighting the effectiveness of our exercise programs in improving functional capacity. When comparing the diagnostic and formative assessments, differences were observed, including improvements in body composition, localized muscular endurance, muscular strength and a positive evolution in the general fitness index ($\Delta\% = 7.89\%$, $p>0.0001$). This study emphasizes the possible benefits of individualized and supervised exercise programs to promote physical fitness and independence in the elderly population.
Key words: aged, physical conditioning, human, exercise.

Resumo:

Este estudo semi-experimental teve como objetivo investigar o impacto do exercício personalizado e supervisionado na aptidão física de pessoas idosas. Noventa pessoas com 60 anos ou mais participaram do estudo, no qual foram observadas melhorias significativas em várias dimensões da aptidão física. Os dados analisados mostraram melhorias significativas em várias dimensões da aptidão física. Em particular, a força muscular localizada e a resistência mostraram ganhos substanciais, destacando a eficácia de nossos programas de exercícios na melhoria da capacidade funcional. Ao comparar as avaliações diagnósticas e formativas, foram observadas diferenças, incluindo melhorias na composição corporal, resistência muscular localizada, força muscular e uma evolução positiva no índice de aptidão geral ($\Delta\% = 7,89\%$, $p>0,0001$). Este estudo destaca os possíveis benefícios de programas de exercícios individualizados e supervisionados para promover a aptidão física e a independência na população idosa.
Palavras-chave: idosos, condicionamento físico, exercício.

Resumen:

Este estudio semiexperimental pretendía investigar el impacto del ejercicio personalizado y supervisado en la forma física de las personas mayores. Noventa personas mayores de 60

años participaron en el estudio, en el que se observaron mejoras significativas en varias dimensiones de la forma física. Los datos analizados mostraron mejoras significativas en varias dimensiones de la forma física. En particular, la fuerza muscular localizada y la resistencia mostraron ganancias sustanciales, lo que pone de relieve la eficacia de nuestros programas de ejercicio para mejorar la capacidad funcional. Al comparar las evaluaciones diagnóstica y formativa, se observaron diferencias, incluyendo mejoras en la composición corporal, la resistencia muscular localizada, la fuerza muscular y una evolución positiva en el índice de aptitud física general ($\Delta\% = 7{,}89\%$, $p>0{,}0001$). Este estudio pone de relieve los posibles beneficios de los programas de ejercicio individualizados y supervisados para promover la forma física y la independencia en la población anciana.
Palabras Clave: acondicionamiento físico humano, anciano, ejercicio físico.

Introduction

Aging is a universal, physiological, morphological, and inevitable process that brings about various physiological and functional changes in the human body. As the elderly population grows worldwide, care for the elderly becomes an essential priority, necessitating the adoption of health policies aimed at reducing in every way the onset and worsening of comorbidities inherent to the age group itself.

In the World Report on Aging and Health, the WHO (2020) emphasized the need for public health actions and understands healthy ageing as the process of development and preservation of functional capacities that allows for well-being in old age.

In this context, physical exercise is positioned as an effective strategy to preserve functional capacity and improve frailty symptoms in the elderly. In addition to functional gains, exercise is considered essential for improving cognitive function in older individuals (Casas-Herrero et al, 2022).

Sarcopenia is one of the characteristics resulting from aging and is associated with functional decline, que to a decrease in muscle mass and, consequently, a decrease in strength. The first point of contact for patients in primary care, which plays an important role in health promotion and disease prevention (Kandayah et al., 2023). Decreased gait rhythm is one of the main limitations observed when carrying out daily activities, such as going up and down stairs, sitting down and getting up from a chair, which consequently increases the risk of falls and fractures.

Therefore, the exercise program and other forms of physical activity act as preventive strategies for the effects of sarcopenia and many chronic diseases, including various comorbidities, acting on mobility, mental health and quality of life, reducing mortality (Izquierdo et al, 2021).

According to the American College of Sports Medicine guidelines (2023), physical fitness encompasses a set of physical qualities that reflect the body's ability to perform motor actions effectively and healthily. Body composition refers to the proportion of muscle mass, adipose tissue, and other body components, playing a crucial role in metabolic health. Aerobic endurance is the body's capacity to perform moderate to high-intensity activities, involving the cardiovascular and pulmonary systems to provide sustainable energy over time. Localized muscular endurance relates to the muscles' ability to withstand repeated or sustained efforts, while muscular strength represents the ability to generate tension against resistance, being crucial for daily tasks and injury prevention. Lastly, flexibility is associated with mobility, specifically the range of motion of joints, playing a fundamental role in maintaining mobility and reducing the risk of musculoskeletal injuries.

It is common for elderly people not to practice physical activity adequately, not reaching the levels recommended by the World Health Organization to influence their health (Carballeira et al., 2021). For this reason, it is important to implement physical exercise programs adapted to the elderly, in a targeted way, minimizing the loss of muscle mass, giving better quality to the muscle, and consequently acting on functional capacity in a positive way. Physical exercise can be used to slow down and even mitigate the process of decline in organic functions that are observed as the years go by, promoting benefits in respiratory capacity, cardiac reserve, reaction time, muscular strength, recent memory, cognition, and social skills.

By promoting increased muscular strength, endurance, and flexibility, physical fitness has a significant effect on optimizing mobility, allowing older people to carry out their daily activities more easily and with reduced risk. In additionally, physical fitness also influences posture, balance, and motor coordination, essential aspects in prevention of falls and fractures. In view of this, regular physical activity becomes a comprehensive strategy for counteract the negative effects of aging, contributing to a longer and higher quality of life (La Greca et al, 2022).

It is clear that physical fitness plays a fundamental role in maintaining conditions for the overall well-being of this age group, influencing functional capacity, independence, and care against chronic diseases.

Despite the fundamental importance of fitness for the health of the elderly, there are significant challenges related to adherence to exercise programs and a lack of understanding of how fitness variables interact to promote well-being in this age group. Furthermore, physical training approaches may need to be adapted to take into account the physical and health limitations associated with aging.

Considering the above, this aim of this study was to analyze the influence of a 16-week supervised exercise program of the physical fitness of elderly individuals.

Method

The current investigation took the form of a quasi-experimental, quantitative, and cross-sectional descriptive study.

Population, Sampling, and Sample

The study was conducted among the elderly population receiving healthcare services from the Basic Health Units (BHU) in several neighborhoods of Aracaju, including Aeroporto, Atalaia, Castelo Branco, Coroa do Meio, Farolândia, Grageru, Inácio Barbosa, Jabotiana, and Ponto Novo. The BHUs included in the study were: BHU Antônio Alves, BHU Augusto Franco, BHU Augusto César Leite, BHU Ávila Nabuco, BHU Dona Sinhazinha, BHU Fernando Sampaio, BHU Geraldo Magela, BHU Hugo Gurgel, BHU Dr. Max de Carvalho, BHU Madre Tereza de Calcutá, and BHU Manoel de Souza Pereira.

Initially, all UBSs were visited. Elderly individuals who attend the UBSs were invited to attend a preliminary lecture held at the Farolândia Campus, during which the project, assessments, expected benefits, ethical aspects, and any existing doubts were explained. At the end of the lecture, an invitation to participate in the project was extended.

Volunteers from the UBSs were requested to bring a medical certificate authorizing them to engage in physical exercises, a referral from their respective UBS, identification, and CPF (Brazilian Tax ID) to the Laboratory of Biociences of Human Motility – LABIMH.

Upon arrival, they were screened based on inclusion criteria (being over 60 years old and committing to participate in a physical exercise program by signing the Informed

Consent Form) and exclusion criteria (having motor limitations or comorbidities that would prevent participation in the exercise programs).

All individuals selected for the study underwent a safety screening process to determine their eligibility for participation in a physical exercise program. This screening was carried out using the Revised Physical Activity Readiness Questionnaire (rPAR-Q).

Volunteers who met the eligibility criteria from the UBSs were randomly assigned to groups using a blinded selection process facilitated by the website www.random.org. Subsequently, participants were allocated to their respective classes, which were organized as follows: Class I (Mondays and Wednesdays, 2:00 PM to 3:00 PM), Class II (Tuesdays and Thursdays, 2:00 PM to 3:00 PM), Class III (Wednesdays, 3:00 PM to 4:00 PM), and Class IV (Tuesdays and Thursdays, 3:00 PM to 4:00 PM).

Diagnostic Assessment (DA)

After conducting preliminary procedures (participant recruitment, ethical and safety precautions, group stratification), all study participants underwent a diagnostic assessment in which the Physical Fitness variable was measured during the initial two weeks of the project.

Physical Fitness Assessment

In the pursuit of acquiring data related to the physical fitness of research participants, we implemented the protocol recommended by the Latin American Development Group for Aging (GDLAM). This protocol evaluates physical fitness by means of a comprehensive set of tests, which encompass the following: Body Composition (BC): Comprising measurements such as Body Mass Index (BMI) and Calf Circumference (CC); Aerobic Endurance (AE): Evaluated through the Six-Minute Test (VO2Max); Localized Muscular Endurance (LME): Assessed using tests for elbow flexion and extension, as well as sit and stand tests; Strength (ST): Measured by means of elbow flexion and extension tests, as well as sit and stand tests while carrying a load (7 kg for women and 11 kg for men) and Flexibility (FL): Evaluated with the Normalflex test.

Based on the results obtained in the tests, the Elderly Individual's Physical Fitness Index (PFI) is established using a geometric mean that compensates for the raw value of each variable. PFI is calculated as follows:

$$CC = (BMI/1.86) + (CC/1.08) / 2$$

AE = test result / 1.21

LME = (Elbow flexion/1.08) + (Sit and stand/0.76) / 2

ST = (Elbow flexion/0.76) + (Sit and stand/0.85) / 2

FL = (Sum of scores) / 1.04A

$$PFI = \frac{CC + AE + LME + ST + FL}{5}$$

The protocol for assessing the Physical Fitness of the Elderly includes a qualitative classification according to table 1:

Table 1: Classification of the Elderly Physical Fitness Index

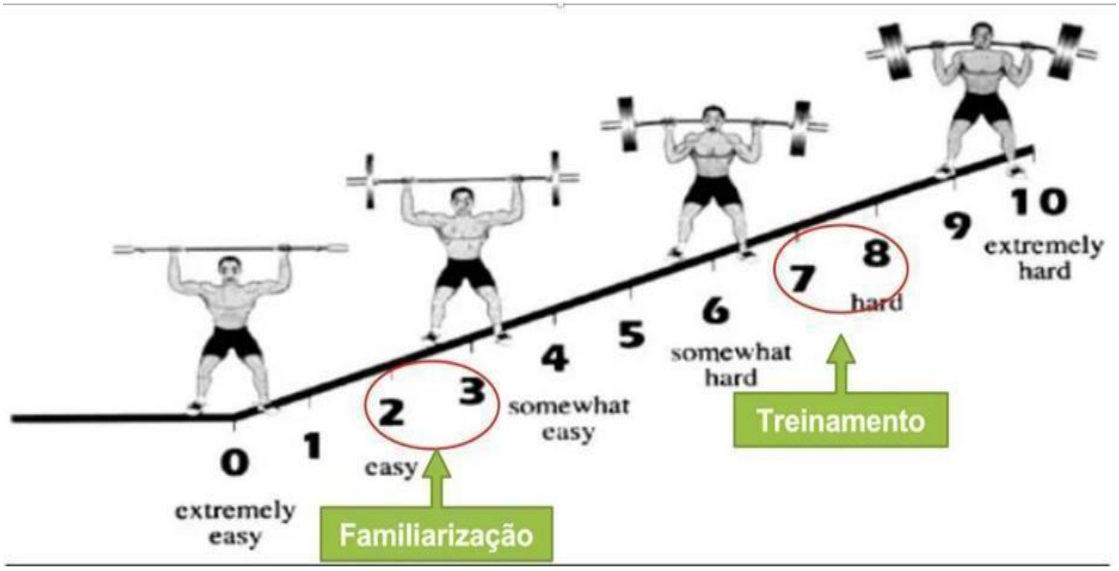
VARIABLE	LOW	MODERATE	HIGH
Body composition	BC ≤ 30.325	30.325 > BC ≤ 35.200	BC > 35.200
Aerobic resistance	AR ≤ 15.410	15.410 > AR ≤ 18.570	AR > 18.570
Muscle endurance	LME ≤ 23.160	23.160 > LME ≤ 32.810	LME > 32.810
Muscle strength	MS ≤ 16.760	16.760 > MS ≤ 28.700	MS > 28.700
Flexibility	FL ≤ 8.500	8.500 > FL ≤ 14.510	FL > 14.510
ICFI	ICFI ≤ 20.720	20.720 > ICFI ≤ 24.880	ICFI > 24.880

Comparisons between mean values of intragroup variables CC, AE, LME, ST, FL for Sig. $p < 0.0001$.

Intervention

The strength training protocol implemented with the participants included a two-week familiarization period, followed by 16 weeks of training consisting of two weekly sessions, conducted in the afternoon and divided into class schedules, as previously specified. Strength training routines, modeled after the resistance exercise circuit involving weightlifting machinery depicted in Figure 4, will be recommended. These routines will be tailored to individuals' perceived exertion levels, as assessed by the OMNI-Res scale (Robertson et al., 2003), akin to the approach employed in the research conducted by Kukkonen-Harjula et al. (2007), illustrated in Figure 1.

Figure 1: OMNI- Res Perceived Exertion scale



In relation to the cardiovascular component of the circuit, we assessed its intensity by utilizing the Borg Rating of Perceived Exertion scale (1982), as detailed in the following citation (Figure 2).

Figure 2: Borg's Cardiopulmonary Effort Perception Scale

In both perceived exertion scales, levels 2 and 3 were used during the familiarization phase. During the 16 weeks of the training period, the load was adjusted to ensure that participants perceived the effort at levels 7 to 8 (Strong). This criterion also served as feedback for load readjustment every two weeks.

The neuromuscular training consisted of a series of exercises performed in the following sequence: barbell curls, leg extension machine, triceps with high cable crossover, leg curl machine, shoulder exercises with dumbbells, bench squats with a weight plate on

the chest, pec deck, leg press, front pull, plank, and concluding with pelvic elevation. A two-minute rest interval was observed between sets (Figure 4).

Strength exercises were performed at a moderate speed in both the eccentric and concentric phases, lasting approximately 2 seconds. The rest intervals between sets and between exercises should always be at least 2 minutes. The elderly participants in the project performed the proposed physical exercises in a circuit format, which emphasized strength training while respecting the individuality of the participants.

Flexibility training, which was conducted during warm-up and at the end of the training, will also have its intensity assessed using the PERFLEX Rating of Perceived Exertion scale (Dantas et al., 2008), with submaximal intensity (stretching - levels 31 to 60 of PERFLEX) used during warm-up and maximal intensity (flexion - levels 61 to 80 of PERFLEX) at the end, as shown in Figure 3.

Figure 3: PERFLEX Rating of Perceived Exertion scale

Level	Description of sensation	Effect	Specification
0 - 30	normality	mobility	does not occur any change in relation to the mechanical components, plastic components and inextensible components.
31 - 60	forcing	stretching	causes deformation of plastic components and elastic components are stretched at submaximal.
61 - 80	discomfort	overstretching	causes durable adaptations in plastic, elastic and inextensible components.
81 - 90	bearable pain	lesion possibility	the involved muscle-conjunctiva structures are subjected to an extreme stretch, causing pain.
91 + 110	strong pain	lesion	overpass the extreme stretching of the involved structures, focusing mainly on the skeletal structures.

Physical Education and Physiotherapy professionals were responsible for training the elderly participants in the study, ensuring that intensity levels and volumes were respected. Before the start of the training, all participants had to perform a general warm-up consisting of exercises and stretching (levels 31 to 60 of PERFLEX) and elevating heart rate for ten minutes.

After completing the training, participants engaged in a cool-down, which included stretching exercises (levels 61 to 80 of PERFLEX) for approximately 10 minutes. Daily, the following data were collected from study participants: heart rate (before training); blood pressure; perceived exertion related to cardiovascular, neuromuscular, and flexibility training (all after training). The neuromuscular training was conducted with the exercise sequence presented in Figure 4.

Figure 4 - Order of Exercise Execution.

Summative Assessment (SA)

At the end of the intervention phase (16 weeks), all research participants underwent a new round of assessments, using the same procedures as those employed in the diagnostic evaluation.

Statistical Analysis

Data organization and analysis were carried out using Microsoft Office Excel® 2016. Descriptive statistics were employed to characterize the surveyed sample population. Measures of central tendency and dispersion were utilized to depict the collected data, aligning with the referenced literature (Costa Neto, 1995; Thomas; Nelson; Silverman, 2007; Triola, 2017).

Following this, we assessed the normality of the collected data using the Shapiro-Wilk test. This assessment guided the choice of using the T-Test: Two Independent Samples.

Significance Level and Experiment Power

The present study, in order to maintain the scientific rigor of the research, adopted a significance level of $p < 0.05$, meaning a 95% probability that the statements made during

the investigations are correct (Type I error α), allowing for a 5% probability of obtaining results by chance. The experiment's power (Type II error β) was assessed with an acceptance level set at 80%. All statements were limited to the scope of this study, depending on the acceptance level for the population, as indicated by the experiment's power.

Results

Analyzed were the data of 90 individuals whose attributes align with those outlined in Table 1.

Table 1: Provides an overview of the study sample's characteristics.

DATA	**Nº**	**%**
GENDER		
Female	75	83.33%
Male	15	16.67%
ETHNICITY		
White	35	38.89%
Indigenous	1	1.11%
Black	25	27.78%
Mixed race	28	31.11%
(Empty)	1	1.11%
SMOKER		
Up to 10 cigarettes	4	4.44%
11 to 20	1	1.11%
More than 30	1	1.11%
I do not smoke	82	91.11%
(Empty)	2	2.22%
AGE		
60-64	25	27.75%
65-69	34	37.74%
70-74	17	18.87%
75-79	9	9.9%
80+	5	5.5%
MONTHLY INCOME		
Up to 2 minimum wages	52	57.78%
From 02 a 04 MW	2	2.22%
From 02 a 04 MW	20	22.22%
From 04 a 10 MW	15	16.67%
(Empty)	1	1.11%
DAILY ACTIVITIES		
Studies and cares for family members	4	4.44%
Studies and works	4	4.44%
Studies, cares for family members, and works	1	1.11%
Only studies	5	5.56%
Works and cares for family members	51	56.67%
(Empty)	25	27.78%

DRINKS PER WEEK		
More than 15	1	1.11%
Less than 5	27	30.00%
I do not drink	62	68.89%
DISEASES		
Has some illness	65	72.15%
Does not have any diseases	6	6.66%
Not specified	19	21.09%

In the sample of the present study, there was a prevalence of female individuals (83.33%), white ethnicity (38.89%), non-smokers (91.11%), aged between 65 and 69 years (37.74%), with a monthly income of up to 2 minimum wages (57.78%), engaged in physical activity related to work and family care (56.67%), who do not drink alcohol (68.89%), but have some pre-existing medical condition (72.15%).

The outcomes derived from the physical fitness assessment tests will be showcased in Table 2, which is dedicated to the analysis of the Elderly Physical Fitness Index (ICFI) results.

Table 2: Analysis of the Results of the Elderly Physical Fitness Index (ICFI)

	Diagnostic		**Summative**	
	Mean	**SD**	**Mean**	**SD**
Body Composition	24.13	2.64	23.80	3.07
Aerobic Endurance	16.40	1.88	16.51	1.77
Localized Muscular Endurance	16.59	2.96	20.45	4.16
Strength	17.08	4.02	20.79	5.06
Flexibility	16.42	3.00	16.25	3.09
ICFI	18.13	1.70	19.56	2.12
Median	18.11		19.39	
Coefficient of Variation %	2.78		4.61	
Maximum Value	22.59		25.28	
Minimum Value	12.73		14.54	
p-value	6.437E-05			
Variation %	7.79			

a. Body Composition (CC): Includes Body Mass Index (BMI) and Calf Circumference (PP). b. Aerobic Endurance (RA): Comprises the Six-Minute Test (VO2Max). c. Localized Muscular Endurance (RL): Encompasses assessments for elbow flexion and extension, as well as sit and stand tests. d. Strength (FM): Involves tests for elbow flexion and extension, as well as sit and stand exercises, with added resistance (7kg for women and 11kg for men). e. Flexibility (FL): Covers the Normalflex assessment.

In the comparison between the diagnostic and formative assessment (as show at table 2), differences can be observed in: body composition (Δ% = -1.37%); aerobic endurance (Δ% = 0.67%); localized muscular endurance (Δ% = 23.27%); muscular strength (Δ% = 21.72%); and flexibility (Δ% = -1.04%), resulting in a positive evolution in the overall physical fitness index (Δ% = 7.89%, p>0.0001).

Discussion

In light of the obtained results from the comprehensive analysis of physical fitness in 90 elderly individuals, assessing physical characteristics such as aerobic endurance, localized muscular endurance, strength, flexibility, and body composition, we observed a positive response rate when analyzing diagnostic and formative outcomes, with an increase in the ICFI value towards the end (p-value = 6.437E-05 and a variation of 7.79). These results indicate an effective intervention that leads to an improvement in the physical fitness index, thereby promoting aging with a higher quality of life.

Upon analyzing the data, we noticed an increase in the ICFI even with a slight decrease in some specific variables such as flexibility and body composition. This result suggests that even with more limiting criteria, aerobic, muscular, and strength conditions contribute to an ICFI growth. As shown in other studies, the strength variable indicates that physical adaptations following resistance training lead to satisfactory responses in terms of functional autonomy levels in the elderly (de Souza et al., 2021). Furthermore, as a physical exercise program is formulated, muscular strength is enhanced, aiding in the prevention of cardiovascular risks and serious illness (Castro et al., 2013), and is assessed using the subjective perception of effort scale, which is cost-effective and easily applicable for monitoring physical training (Bustos-Viviescas et al., 2019).

Another aspect of the results involves the analysis of parameters that may influence the physical fitness of the elderly, including: gender; ethnicity; smoking; age; marital status; monthly income; educational level; training days; daily activities; self-control; alcoholism; and previous illnesses. These influences have a positive impact when examining the project's results due to the variation in conditioning. Daily activities such as work and household chores should be complemented with physical exercise, as failing to do so may lead to a disadvantage in career development, causing a decline in health conditions, as discussed in another study (Castro-Jiménez et al., 2018).

Over the course of the 16-week study period, a notable enhancement in physical fitness was observed. A study, which served as a reference, described a 12-week program for elderly individuals conducted at moderate intensity. This program assessed its impact on physical functions and blood pressure parameters, with positive effects documented (Choi et al., 2020). As a result, participants experienced improvements in various physical variables as they engaged in a phase of physical exercises, ultimately leading to enhanced functional fitness and the promotion of overall health and well-being.

This present study aimed to demonstrate through the physical fitness index that its enhancement supports the healthy aging process by developing physical variables through exercise. Therefore, by implementing appropriate physical activity programs, it is possible to ensure an improvement in various aspects of the physical health of the elderly, mitigating the physiological process of senescence.

Conclusion

In conclusion, our comprehensive longitudinal study, entitled "Physical Fitness in the Elderly: A Longitudinal Investigation with Customized and Supervised Exercise Regimens," has provided valuable insights into the repercussions of such programs on the physical fitness of elderly individuals. Throughout the study's duration, we observed significant improvements across various dimensions of physical fitness. These findings underscore the potential benefits inherent in tailored and closely monitored exercise interventions for this demographic.

Notably, our findings revealed substantial gains in localized muscular endurance and strength. Localized muscular endurance increased from a mean score of 16.59 to an impressive 20.45, while strength exhibited a remarkable rise from 17.08 to 20.79. These substantial enhancements in muscular performance highlight the efficacy of our exercise programs in promoting greater physical strength and endurance among elderly participants. These outcomes are particularly noteworthy as they signify improvements in functional capacity, which can significantly impact the daily lives and independence of older individuals.

Furthermore, while some parameters such as body composition, aerobic endurance, flexibility, and the ICFI (Index of Cardiovascular Fitness and Independence) showed more modest variations, these changes remain relevant. They indicate that our exercise programs

can positively influence multiple facets of physical fitness in elderly individuals, contributing to their overall well-being.

Of particular significance is the improvement in the ICFI, which serves as a comprehensive measure of cardiovascular fitness and overall physical independence. The increase in ICFI scores from a mean of 18.13 to 19.56 highlights the substantial enhancement in the cardiovascular health and functional independence of our study participants. This finding demonstrates that our intervention strategies effectively enhance the general conditioning of elderly individuals, promoting their ability to engage in daily activities and maintain an independent lifestyle.

The statistical analysis, supported by the p-value of 6.437E-05, reaffirms the statistical significance of these observed improvements. Additionally, the low coefficient of variation (2.78% for median ICFI) underscores the consistency of these changes across the study population, minimizing the influence of outliers.

In brief, our study presents strong evidence affirming that individually tailored and closely supervised exercise programs yield significant improvements across various aspects of physical fitness in elderly individuals. These enhancements encompass not only heightened muscular performance but also the promotion of cardiovascular health and increased functional independence. As the aging population continues to expand, our findings underscore the vital role of such interventions in ensuring a healthier and more active aging process. Further research and the implementation of customized exercise programs hold promising potential for enhancing the overall well-being of older adults.

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