**Título**: La Aptitud Física se Relaciona con la Grasa Corporal y la Respuesta Autonómica Cardíaca al Ejercicio Físico en Personas Mayores

**Title**: Physical Fitness is Related to Body Fat and Cardiac Autonomic Response to Exercise in Older People

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## Abstract

**Objective**: […]. **Material and methods**: […]. **Results**: […]. **Conclusion**: […].

**Keywords**: […].

# Introduction

The process of aging is accompanied by a multitude of physiological changes that have the potential to significantly impact people’s overall health and well-being(1), (2). Body composition and cardiovascular function are particularly relevant, as they are closely associated with the aging process (3–7). In recent times, there has been a growing interest in comprehending the interplay between physical fitness, body composition, and cardiac autonomic response to exercise in older individuals, as these factors play pivotal roles in determining health outcomes within this age group.

Physical fitness is defined as the ability to perform daily tasks with vigor and without undue fatigue. It is a crucial component of healthy aging. The term encompasses a multitude of aspects, including cardiovascular endurance, muscular strength, flexibility, and balance. Numerous studies have demonstrated the positive impact of physical fitness on overall health and longevity, highlighting its role in reducing the risk of chronic diseases, improving quality of life, and improving functional independence in older adults.

Moreover, the alteration of body composition, specifically the proportion of body fat, is accompanied by significant changes with age, resulting in a tendency towards an increase in adiposity and a decrease in lean muscle mass. Excessive body fat accumulation, particularly visceral adiposity, has been associated with a higher risk of cardiovascular disease, metabolic disorders, and functional limitations in older individuals.

Autonomic nervous system (ANS) plays a critical role in regulating cardiovascular function, with sympathetic and parasympathetic branches exerting opposing effects on heart rate and vascular tone. Furthermore, during stressful situations, such as physical exercise, the ANS ensures a sufficient cardiac response to higher metabolic demands. The measurement of heart rate variability (HRV), serves as a non-invasive indicator of ANS activity and cardiovascular health. A reduction in HRV has been linked to various adverse outcomes, including cardiovascular events, mortality, and impaired exercise tolerance.

However, despite extensive research into physical fitness, body composition, and cardiovascular health in older adults, gaps persist in understanding of their interrelationships and underlying mechanisms. One area of interest is the relationship between physical fitness, body fat percentage, and cardiac autonomic response to exercise in older individuals. Although previous studies have explored these factors independently, few have examined their collective influence on cardiovascular function during exercise in the aging population.

The conceptualization of this study is based on the recognition of the interplay between physical fitness, body composition, and autonomic cardiovascular regulation in aging. We aim to answer the following research question: How does physical fitness relate to body fat percentage and cardiac autonomic response to exercise in older people? By elucidating these correlations, our objective is to gain valuable insights into the physiological mechanisms that underlie age-related modifications in cardiovascular function and identify potential interventions to enhance health outcomes in older adults.

We hypothesize that physical fitness will be inversely related to body fat percentage and positively associated with cardiac autonomic response to exercise in older individuals, based on existing literature and theoretical frameworks. In our opinion, it will be essential for this population to have an optimal cardiac autonomic response, characterized by balanced sympathetic and parasympathetic modulation.

The primary objective of this study is to investigate the relationship between physical fitness, body fat percentage, and cardiac autonomic response to exercise in older people. We aimed to assess how variations in physical fitness and body composition influence autonomic cardiovascular regulation during low to moderate-intensity exercise, with implications for cardiovascular health and functional capacity in aging.

# Material and methods

## Study design

A prospective, cross-sectional and correlational study was conducted on older people in one data collection session, to determine the associations between physical fitness, body composition and cardiac autonomic response to moderate-intensity exercise.

## Participants

XX older adults community-dwelling older adults were recruited and selected by non-probabilistic sampling. They were included if: 60 years age or older; residents of the Region of Magallanes and Chilean Antartica, Chile; and being able to understand the study aims and instructions. But they were excluded in case of: diagnosis of congenital heart disease; consumption of beta-blocker drugs, taking stimulant substances within 24 h before assessments session; motor or cognitive disability; or presence of pain during cardiac or physical assessments.

All participating subjects gave their permission and provided informed consent before participation. The Ethics Committee of the University of Magallanes (N°XXX/YY/YEAR) approved this study following the regulations established by the Declaration of Helsinki on ethical principles in human beings.

## Procedures

During recruitment,the participants were instructed to avoid the use of psychoactive substances for the 24 hours prior to the assessment, and to sleep for at least 7 hours during the previous night. Upon arrival, participants were informed about the study aims and risks associated with their participation, and the socio-demographic and medical information was collected during the initial interview. Then, Body composition parameters were measured using bioimpedance analysis.

Cardiac autonomic response to physical exercise was measured as previously validated for this age group (8). The protocol is briefly described below:

HRV was recorded through a non-invasive chest band, immediately before, during, and immediately after the execution of the two-minutes step test (TMST). Vital signs, including blood pressure, were monitored throughout the test, and participants’ well-being was visually checked to ensure they were comfortable and mentally prepared. For resting HRV measurements (prior and posterior to TMST), the volunteers remained seated in a chair, while proper support of the feet and back, and avoiding talking during the recording was ensured. RR intervals were recorded continuously during the last 10 min of rest, and were subsequently analyzed for 5 min in each occasion. The breathing rate was spontaneous. As part of the protocol, it was ensured that the participant had a blood pressure less than 140/90 mmHg to start the HRV measurements.

Finally, after 15 minutes of resting from the TMST, the Short Physical Performance Battery (SPPB) was applied to the participants. Blood pressure, heart rate and general aspect of the subjects was verified before ending the session.

All the assessments were made between 09:00 and 11:00 hours of the morning. Measurements and tests were carried out by professional physiotherapists, ensuring the privacy and comfort of the subjects. The room temperature was set at 20°C and a white artificial lighting was used.

## Instruments

### Short Physical Performance Battery

SPPB consists of a physical test used to measure three components of physical fitness, described below (9):

Balance: to achieve the maximal score (4 points), the subject should be able to stay balanced for at least 10 seconds in side-by-side stand (feet together), semi-tandem stand and tandem stand.

Usual gait speed: the subjects are asked to walk normally a 4 meters distance. Two chances are given and the best of both is registered. To achieve the maximal score (4 points),they should obtain 4.82 sec. or less.

Lower body fitness: The subjects are asked to perform 5 chair stands without using their arms and time upon complete is registered. A time lower or equal 11.19 sec. gives the maximal score (4 points).

To obtain the final score, the summing of the three components is calculated, with a maximal total score of 12 points.

### Body Composition

Body mass (kg) and total body fat (%) were assessed by bioimpedance using the Tanita BC-558 Ironman Segmental Body Composition Monitor (Tanita Ironman, Arlington Heights, IL 60005, USA), with a concordance of 89.3% compared to the Dual X-ray Absorption test using standard measurement protocols (10).

### Cardiac Autonomic Activity

Cardiac autonomic activity was assessed using RR interval recordings obtained through the Polar Team2 system (Polar®) application. Artifacts and ectopic heartbeats, which did not exceed 3% of the recorded data, were excluded [32]. Time-domain parameters considered for analysis included the square root of the mean squared differences of successive RR intervals (RMSSD, expressed in ms) as an index of parasympathetic activity [33], and the standard deviation of RR intervals (SDNN), reflecting total variability encompassing both sympathetic and parasympathetic contributions to cardiac autonomic function [34,35]. Additionally, the Stress Index (SI) and Parasympathetic and Sympathetic Nervous System Index (PNS and SNS, respectively) were calculated. The PNS Index, indicative of total vagal stimulation, was derived from mean R-R intervals, RMSSD, and Poincaré Plot Index SD1 in normalized units (linked to RMSSD), representing deviations from normal population averages [34,39]. The SNS Index, reflecting total sympathetic stimulation, was derived from mean R-R intervals, Baevsky’s Stress Index (positively related to cardiovascular system stress and cardiac sympathetic activity), and the Poincaré Plot Index SD2 in normalized units (related to SDNN) with interpretation similar to the PNS Index [34,39]. The SI serves as an indicator representing the ANS control system’s workload [40], normalized by the square root of Baevsky’s SI [41]. All analyses were conducted using Kubios HRV® software (Kuopio, Finland).

### Two-Minutes Step Test

The TMST is a sub-test from the Senior Fitness Test, demanding a low to moderate intensity (8,11). The test consists of a two-minute assessment designed to evaluate cardiorrespiratory fitness. Participants are instructed to raise their right knee to a marked point on a wall as many times as possible within the given time frame, ensuring that each raise reaches at least a 70° angle at the thigh-femoral joint.

## Statistical analysis

[…], using the *R* programming language for statistical computing, (12).

# Results

## Sample characteristics

The sample assessed consisted on 81 adults (age: 71.1 ± 6.2 years old, BMI: 31 ± 6.2 kg/m2), of whom 67 (82.7%) were females. Sociodemographic and anthropometric characteristics of the sample can be seen in table 1.

|  | | **Sex** | |  | |
| --- | --- | --- | --- | --- | --- |
| **Characteristic** | **Overall**, N = 811 | **Female**, N = 671 | **Male**, N = 141 | **Difference**2 | **95% CI**23 |
| Age (years) | 71.1 ± 6.2 | 71.0 ± 6.4 | 71.9 ± 5.5 | -0.15 | -0.73, 0.43 |
| Hypertension | 33 (41%) | 26 (39%) | 7 (50%) |  |  |
| Diabetes | 12 (15%) | 9 (13%) | 3 (21%) |  |  |
| Body weight (kg) | 74.6 ± 13.2 | 72.8 ± 12.6 | 85.0 ± 12.7 | -0.98 | -1.6, -0.33 |
| Height (cm) | 155.8 ± 9.2 | 153.3 ± 7.6 | 167.8 ± 6.3 | -2.1 | -2.8, -1.4 |
| BMI (kg/m2) | 31.0 ± 6.2 | 31.2 ± 6.5 | 29.7 ± 3.2 | 0.28 | -0.36, 0.92 |
| BMI category |  |  |  |  |  |
| Normal | 7 (9%) | 6 (9%) | 1 (9%) |  |  |
| Overweight | 35 (45%) | 29 (43%) | 6 (55%) |  |  |
| Obese | 36 (46%) | 32 (48%) | 4 (36%) |  |  |
| Muscle mass (kg) | 43.9 ± 8.2 | 41.0 ± 4.3 | 59.9 ± 6.5 | -3.5 | -4.4, -2.7 |
| Fat mass (%) | 37.5 ± 9.3 | 39.5 ± 8.3 | 26.2 ± 6.4 | 1.8 | 1.2, 2.5 |
| Bone mass (%) | 2.3 ± 0.4 | 2.2 ± 0.2 | 3.1 ± 0.3 | -3.6 | -4.5, -2.8 |
| Water (%) | 47.0 ± 6.7 | 45.4 ± 5.6 | 55.8 ± 5.0 | -2.0 | -2.7, -1.3 |

## Body composition and autonomic response

We observed that body fat percentage was linked to a lower SNS (r = -0.252, p = 0.030) and Stress index (r = 0.258, p = 0.027) response during the intervention. However, body fat percentage was positively correlated with time domain HRV during exercise, more specifically RMSSD (r = 0.253, p = 0.029) and SDNN (r = 0.269, p = 0.020).

## Body composition and physical fitness

In addition, a greater body fat percentage was negatively correlated with physical fitness (r = -0.273, p = 0.015).

## Physical fitness and cardiac autonomic response to exercise

Physical fitness was positively correlated with a greater simpathetic activity during exercise, which was reflected by SNS index (r = 0.313, p = 0.006), mean HR (r = 0.355, p = 0.002) and its inverse counterpart mean R-R (r = -0.35, p = 0.002).

However, this appears to be accompanied by an proportional decrease in parasympathetic drive during exercise with increasing levels of physical fitness, which was denoted by the inverse correlation of the later with PNS index during (r = -0.375, p = 0.001) and after exercise (r = -0.229, p = 0.049), in addition to RMSSD during exercise (r = -0.294, p = 0.010)

# Discussion

[…].

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[…].

# Conclusion

[…].

# Author Contributions

All authors listed have made a substantial, direct and intellectual contribution to the work and approved it for publication.

# Funding

[…].

# Institutional Review Board Statement

[…].

# Informed Consent Statement

[…]

# Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors without undue reservation.

# Conflicts of interests

The authors declare that the research was conducted without any commercial or financial relationships construed as a potential conflict of interest.

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