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Beyond Handgrip—Trunk Strength, Gait Speed, Resting Metabolic Rate, and Muscle Mass as Integrated Predictors of Sarcopenia in Brazilian Older Women: A Pilot Observational Study

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Abstract

Sarcopenia is a complex condition marked by reductions in muscle strength, mass, and overall physical performance, which has significant consequences for functional autonomy and metabolic health in elderly women. This study sought to examine the correlations between lower limb strength, functional capabilities, and metabolic indicators in community-dwelling older women categorized according to the EWGSOP2 criteria. A total of thirty-eight women aged ≥ 60 years underwent assessments, including anthropometric, hemodynamic, and metabolic evaluations, along with functional tests such as handgrip strength, chair-rise test, gait speed, Timed Up-and-Go, and maximal isometric hip extension strength (MIHE). The criteria for probable sarcopenia were established using the handgrip thresholds set by the EWGSOP2. Women identified as having probable sarcopenia displayed markedly lower MIHE, diminished gait speed, inferior performance in chair-rise and Timed Up-and-Go tests, decreased muscle mass, and a lower resting metabolic rate than their non-sarcopenic counterparts. MIHE exhibited robust correlations with muscle mass, resting metabolic rate, and functional performance metrics. These results suggest that assessments of lower limb and trunk strength yield pertinent insights beyond handgrip strength alone. Function-oriented evaluations may improve sarcopenia screening and facilitate the identification of older women at risk of functional and metabolic deficiencies in community-based environments.

Keywords: sarcopenia; muscle strength; physical performance; gait speed; functional mobility; aging; older women; sarcopenic obesity

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1. Introduction

Sarcopenia is a progressively advancing and broadly generalized disorder affecting skeletal muscle, which is fundamentally characterized by notable and significant reductions in muscle mass, muscle strength, and overall physical performance, ultimately culminating in various forms of functional impairment, a loss of independence, and an increased risk of mortality, particularly among the aging population of older adults [1]. As the phenomenon of global population aging continues to accelerate at an unprecedented pace, the imperative to enhance both early detection methods and the accuracy of diagnostic protocols has become increasingly crucial, as this improvement is essential for the formulation and implementation of preventive and therapeutic strategies aimed specifically at preserving mobility and promoting autonomy in older individuals.

In 2019, the European Working Group on Sarcopenia in Older People (EWGSOP2) undertook a comprehensive revision of its diagnostic framework, placing significant emphasis on the assessment of low muscle strength as the primary criterion for diagnosing sarcopenia, with this condition being mostly evaluated through the measurement of handgrip strength [2]. Although handgrip testing is recognized for its practicality, cost-effectiveness, and extensive validation within clinical settings, it may not adequately represent the functional status of the various muscle groups responsible for essential activities such as postural control and locomotion, particularly those located in the trunk and lower extremities [3,4]. A growing body of evidence suggests that deficits in strength within these specific anatomical regions are more closely correlated with limitations in mobility and heightened dependence on assistance for activities of daily living than isolated weaknesses observed in the upper limbs [3,4].

Functional performance assessments serve as a comprehensive evaluation of essential aspects, such as neuromuscular coordination, balance, and overall mobility. The Timed Up and Go (TUG) test, for instance, effectively captures dynamic postural control and locomotor capacity and has been consistently associated with both sarcopenia and an increased risk of falls among older adults [7,9]. Similarly, gait speed has been aptly described as a “functional vital sign” because of its robust predictive capabilities regarding disability and overall survival rates [5,10]. Although gait speed is recognized by the EWGSOP2 as a pertinent marker of physical performance [2], it simultaneously reflects the coordinated function of multiple physiological systems, including trunk stability and cardiovascular fitness, thereby reinforcing its potential as a highly sensitive indicator of sarcopenia severity [5,8,10].

From a musculoskeletal standpoint, the strength of the trunk extensor muscles plays a pivotal role in maintaining center-of-mass control. Trunk muscle strength deficiency has been systematically linked to impaired balance and subsequent reduction in functional performance among older adults [4]. Concurrently, functional assessments, such as the 30-second chair-stand test, provide reliable indicators of lower body strength in older adults residing in community settings [6], while evaluations of hip musculature have demonstrated commendable test–retest reliability and clinical feasibility [11]. Importantly, the effectiveness of the diagnostic criteria for sarcopenia may vary across different populations, and models that integrate both muscle mass and functional measures have shown enhanced predictive capabilities regarding mortality within specific clinical contexts [12].

This observation underscores the necessity of validation tailored to specific populations, particularly among older Brazilian women, who are known to experience high rates of functional decline [13]. Furthermore, metabolic impairments frequently coexist with the deterioration of muscle mass, contributing to alterations in the resting metabolic rate and further exacerbating the progression of sarcopenia [1]. Nevertheless, relatively few studies have directly compared the predictive capabilities of trunk strength, gait speed, and TUG performance with handgrip strength for the identification of sarcopenia within this demographic. Consequently, the primary aim of the present study was to meticulously evaluate the predictive capacity of trunk extensor strength, gait speed, and TUG performance in identifying sarcopenia among older Brazilian women, while also comparing their diagnostic accuracy with that of handgrip strength, as recommended by the guidelines established by the EWGSOP2 [2].

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2. Materials and Methods

2.1. Study Design and Setting

This cross-sectional investigation was conducted by the Faculty of Medicine at the University of the State of Rio de Janeiro (UERJ), Cabo Frio Campus, as an integral component of a social initiative within a university extension program aimed at older women. The research was conducted at the facilities of the Secretariat for the Elderly (*Secretaria da Melhor Idade*), which operates under the Municipal Health Department of Cabo Frio, Rio de Janeiro, Brazil. This study was part of a more extensive study examining the functional capacity and metabolic factors associated with sarcopenia in elderly women.

A total of 38 community-dwelling women aged ≥ 60 years were recruited through local health programs and university extension initiatives. The eligibility criteria included physical independence, the ability to walk without assistive devices, and voluntary participation after receiving detailed information about the study procedures. The exclusion criteria comprised diagnosed neuromuscular or severe osteoarticular disorders, decompensated cardiovascular disease, cognitive impairment affecting task execution, and any condition contraindicating physical testing.

2.2. Participants

All participants underwent an initial health screening that included medical history, anthropometric assessment, and evaluation of hemodynamic and metabolic parameters. Information on comorbidities such as hypertension, diabetes mellitus, dyslipidemia, and hypothyroidism was obtained through self-report and confirmed, when available, through clinical documentation. Resting blood glucose and blood pressure were measured under standardized conditions after a 10 min seated rest, in accordance with the guidelines of the Brazilian Society of Cardiology.

Frailty and sarcopenia were assessed according to the EWGSOP2 framework [2], which integrates measures of muscle strength, quantity, and physical performance. Functional assessments included handgrip strength (HG), chair rise test (CRT), gait speed (GS), maximal isometric hip extension (MIHE), and timed up-and-go (TUG) test, as detailed below. The study was conducted in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee (CEP) of the Pedro Ernesto University Hospital of the University of the State of Rio de Janeiro (HUPE/UERJ) (CAAE: 94655325.0.0000.5259). All participants provided written informed consent prior to the study.

2.3. Sarcopenia Classification

Sarcopenia was operationally defined and classified according to the EWGSOP2 criteria [2], which follow a stepwise diagnostic approach summarized as Find–Assess–Confirm–Severity (F–A–C–S) classification. Initial case finding was performed using the SARC-F questionnaire, which comprises five self-reported items related to strength, walking assistance, rising from a chair, stair climbing, and falls. Each item is scored from 0 to 2, yielding a total score of 0–10, with scores ≥4 indicating an increased risk of sarcopenia. The questionnaire was administered verbally by trained researchers using a standardized interview protocol.

Muscle strength was assessed as the primary diagnostic criterion using the handgrip strength and chair rise tests. Probable sarcopenia was defined by reduced handgrip strength (<16 kg for women) or prolonged chair rise time (>15 s), in accordance with the EWGSOP2 thresholds [2]. Confirmation of sarcopenia required evidence of low muscle quantity, assessed by bioelectrical impedance analysis (BIA) (InBody 120, Seoul, Korea), with appendicular skeletal muscle mass indexed to height (ASM/height² ≤ 6.0 kg/m²) in women. Severe sarcopenia was defined as the coexistence of low muscle strength and low muscle mass, combined with poor physical performance, characterized by a gait speed of <0.8 m/s or a TUG time of >12 s. This classification strategy is consistent with the EWGSOP2 recommendations and previous validation studies [2,8].

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2.4. Functional Tests

All functional and strength assessments were conducted in a temperature-controlled laboratory environment (22–24 °C) by trained evaluators with experience in exercise physiology and geriatric assessment. Prior to testing, the participants performed a standardized warm-up consisting of 5 min of light walking, followed by dynamic lower limb mobility exercises. Each test was explained and demonstrated, and one familiarization trial was conducted.

Handgrip Strength (HG)

Handgrip strength was assessed using a calibrated hydraulic hand dynamometer (Jamar®, Model 5030 J1, Sammons Preston Rolyan, Bolingbrook, IL, USA). The participants were seated with the shoulder adducted and neutrally rotated, elbow flexed at 90°, forearm in a neutral position, and wrist slightly extended. Three maximal trials were performed for each hand, alternating sides, with 30 s rest intervals. The highest value obtained from the dominant hand was used for analysis. Values below 16 kg are indicative of probable sarcopenia in women, according to EWGSOP2 criteria [2].

Chair Rise Test (CRT)

Lower limb functional strength was assessed using the five-times sit-to-stand test. Participants were instructed to stand up and sit down five times as quickly as possible from a standardized armless chair with their arms crossed over their chest. Two trials were performed with a 1 min rest between attempts, and the shortest completion time was recorded. A lower time indicates better performance [9].

Gait Speed (GS)

Habitual gait speed was assessed over a central 6 m distance within an 8 m walkway, allowing for acceleration and deceleration phases to be measured. Two trials were performed at the usual walking speed, and the fastest trial was retained. Gait speed was calculated in meters per second, with values <0.8 m/s indicating reduced mobility [5,10].

Maximal Isometric Hip Extension (MIHE)

Hip extensor strength was evaluated using a fixed Crown Dorsal Dynamometer (Crown; Filizola, São Paulo, SP, Brazil) with a capacity of 200 Kgf. The participants performed three maximal voluntary isometric contractions lasting 3–5 s, with 60 s rest intervals. The highest force value was recorded and normalized to body mass (N/kg), following established reliability protocols [11].

Timed Up-and-Go Test (TUG)

The TUG test was used to assess dynamic balance and functional mobility. The participants stood from a seated position, walked 3 m, turned, returned, and sat down. Two trials were performed, and the best time was noted. Values >12 s were considered indicative of impaired mobility and increased fall risk [12].

2.5. Statistical Methods

Data normality was assessed using the Shapiro–Wilk test. Descriptive statistics were used to characterize the samples. Continuous variables are presented as mean ± standard deviation (or median ± IQR, where appropriate), and categorical variables as absolute and relative frequencies. Between-group comparisons were conducted using independent Student's *t*-tests or Mann–Whitney *U* tests as appropriate. The associations between muscle strength, muscle mass, metabolic rate, and functional performance variables were examined using Pearson's correlation coefficients. Statistical analyses were performed using GraphPad Prism® (version 8.4.2), with significance set at $p < 0.05$.

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3. Results

3.1. Anthropometric Characteristics of Participants

Table 1 shows the anthropometric characteristics of the 38 older women who participated in this study. The mean age was 69.9 ± 6.6 years, and the mean height was 1.6 ± 0.1 m. The average body mass was 64.5 ± 12.9 kg, resulting in a mean Body Mass Index (BMI) of 26.8 ± 5.0 kg/m², which places the group, on average, within the overweight category according to the World Health Organization (WHO) criteria (Table 1).

Central adiposity measurements revealed a mean waist circumference of 85.7 ± 10.3 cm and abdominal circumference of 91.4 ± 11.2 cm. The hip circumference averaged 103.1 ± 10.2 cm, leading to a mean waist-to-hip ratio (WHR) of 0.8 ± 0.1. The relaxed arm circumference was 28.2 ± 3.2 cm, and the forearm circumference was 24.5 ± 2.3 cm. Calf circumference, another important indicator for establishing lower limb muscle mass in elderly populations, had an average of 35.7 ± 3.8 cm.

Table 1. Descriptive statistics of the anthropometric parameters of the study participants. Values are presented as mean ± standard deviation (SD).

Anthropometric parameters (N=38)	Mean ± SD
Age (y)	69.9 ± 6.6
Height (m)	1.6 ± 0.1
Body mass (kg)	64.5 ± 12.9
BMI (kg/m²)	26.8 ± 5.0
Waist circumference (cm)	85.7 ± 10.3
Abdominal circumference (cm)	91.4 ± 11.2
Hip circumference (cm)	103.1 ± 10.2
Waste and hip ratio	0.8 ± 0.1
Upper Arm Circumference (cm)	28.2 ± 3.2
Forearm Circumference (cm)	24.5 ± 2.3
Calf Circumference (cm)	35.7 ± 3.8

3.2. Hemodynamic Parameters, Disease History, and Lifestyle Habits

The mean resting blood glucose level among participants was 107.2 ± 46.4 mg/dL. Regarding hemodynamic variables, participants had a mean systolic blood pressure (SBP) of 143.4 ± 16.5 mmHg and a mean diastolic blood pressure (DBP) of 80.1 ± 11.5 mmHg. These values resulted in a mean arterial pressure (MAP) of 101.2 ± 11.8 mmHg. The elevated SBP values indicated a prevalent hypertensive profile in the group, which was consistent with clinical history data, where 60.5% (n = 23) of the participants reported a diagnosis of hypertension. The resting heart rate (HR) was 72.3 ± 11.7 bpm, which can be considered within the expected physiological range for elderly individuals at rest.

Medical history revealed comorbidities that were frequently associated with aging. Hypertension was the most prevalent condition (60.5%), followed by diabetes mellitus (18.4%), hypothyroidism (10.5%), and dyslipidemia (7.9%). A small percentage of participants (2.6%) reported a history of cancer. These findings reflect the profile of comorbidities typical of the aging population that are associated with cardiometabolic disorders and sarcopenia.

Lifestyle habits were also evaluated. The prevalence of smoking was low, with only 10.5% (n = 4) of the participants reporting current tobacco use. Conversely, alcohol consumption was notably high, with 89.5% (n = 34) of the participants reporting weekly alcohol consumption. Although the frequency of alcohol consumption was high, data on the quantity or pattern of use (e.g., social vs. habitual drinking) were specified on weekends (Table 2).

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Table 2. Blood, disease, and lifestyle variables of the study participants.

Blood parameters	Mean ± SD
Blood glucose (mg/dL)	107.2 ± 46.4
SBP (mmHg)	143.4 ± 16.5
DBP (mmHg)	80.1 ± 11.5
MAP (mmHg)	101.2 ± 11.8
HR rest (bpm)	72.3 ± 11.7
Daily habits	N (%)
Smoker	4 (10.5%)
Alcohol consumption	34 (89.5%)
History of illness	N (%)
Hypertension	23 (60.53%)
Diabetes	7 (18.42%)
Dyslipidemia	3 (7.89%)
Hypothyroidism	4 (10.53%)
Cancer	1 (2.63%)

Blood glucose levels, hemodynamic parameters, disease history, and lifestyle habits of the participants. Blood glucose and resting hemodynamic values, including SBP, DBP, MAP, and resting heart rate (HR), were expressed as mean ± SD. The frequencies of smoking and alcohol consumption, as well as the prevalence of comorbidities such as hypertension, diabetes, dyslipidemia, hypothyroidism, and cancer, are presented as absolute values and percentages.

3.3. Physical Activity Modalities and Habits

The participants' profiles regarding regular physical activity habits showed diverse distributions across structured physical activity programs. Water aerobics was the most frequently practiced activity, with 47.4% (n = 18) of the participants reporting regular participation. Gymnastics was the second most prevalent activity (44.7%, n = 17), followed by yoga (42.1%, n = 16), reflecting a preference for low-impact group-based exercises that combined cardiovascular and flexibility components (Table 3).

Other reported activities included physical therapy and acupuncture (21.1%, n = 8), memory workshops (21.1%, n = 8), and dance (18.4%, n = 7). The activities with the lowest participation rates were Pilates (13.2%, n = 5), beauty salon programs (13.2%, n = 5), Tai Chi Chuan (15.8%, n = 6), choral singing (7.9%, n = 3), crafts (7.9%, n = 3), and global postural re-education (RPG) (5.3%, n = 2). These data suggest a strong bias toward social and holistic practices, with an emphasis on functional movement, balance, and cognitive skill development.

Regarding total physical activity, participants reported an average exercise frequency of 3.3 ± 1.2 days per week, with a perceived level of exertion (RPE) of 3.4 ± 1.4 on a 10-point scale, indicating predominantly light-to-moderate intensity. The session duration typically ranged from 45 to 60 min. In terms of exercise adherence, 31.6% (n = 12) of the participants had been practicing physical activities for more than 12 months, while 28.9% (n = 11) had participated for less than 3 months, suggesting a heterogeneous profile regarding exercise continuity.

Table 3. Frequency distribution of exercise modalities and physical activity habits of participants.

Exercise modalities	N (%)
Water Aerobics	18 (47.4)
Gymnastics	17 (44.7)
Yoga	16 (42.1)
Physical Therapy and Acupuncture	8 (21.1)
Memory Workshop	8 (21.1)
Dance	7 (18.4)
Tai Chi Chuan	6 (15.8)

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Beauty Salon	5 (13.2
Pilates	5 (13.2)
Choir	3 (7.9)
Crafts	3 (7.9)
Global Postural Reeducation (GPR)	2 (5.3)
Physical activity habits	Mean ± SD
Frequency (days/week)	3.3 ± 1.2
Intensity (RPE)	3.4 ± 1.4
Duration (min)	45 to 60
Time (mouths)	N (%)
0 to 3	11 (28.9)
3 to 6	3 (7.9)
6 to 9	5 (13.2)
9 to 12	7 (18.4)
> 12	12 (31.6)

The number and percentage of individuals engaged in various forms of exercise, including water aerobics, gymnastics, yoga, Pilates, and Tai Chi Chuan. Physical activity habits were described by weekly frequency (days/week), perceived exertion intensity (rate of perceived exertion [RPE]), session duration, and duration of engagement (in months). These data provided an overview of the participants' exercise behaviors and adherence to physical activity routines.

3.4. Strength and Functional Performance

This study was based on the most current criteria for diagnosing sarcopenia, established by the EWGSOP2 algorithm, which is represented by the Find-Assess-Confirm Severity (F-A-C-S) pathway [2]. Initially, to identify clinical suspicion or symptoms associated with sarcopenia, the participants answered the SARC-F questionnaire. In this sense, 37% of the participants had a total score equal to or greater than 4, suggesting an increased risk of sarcopenia.

Subsequently, handgrip strength and chair rise tests were administered to assess participants with low muscle strength. As shown in Table 4, the average handgrip strength was 17.2 ± 5.5 kg, which is close to the thresholds suggestive of probable sarcopenia according to the EWGSOP2 guidelines. The five-repetition chair-rise test demonstrated an average duration of 12.0 ± 3.1 s. Similar to the handgrip test, the chair rise test also presented values close to the limits reported by the EWGSOP2.

The timed up and go (TUG) test revealed a mean performance time of 8.8 ± 1.6 s. Although this value remains below the frailty threshold, it suggests emerging functional mobility limitations in a subset of participants. The average gait speed was 1.2 ± 0.4 m/s, which is typically considered normal for community-dwelling older adults, but individual cases may exhibit clinically relevant slowness. The maximal isometric hip extension (MIHE) strength was 52.3 ± 15.3 kg, reflecting moderate variability in lower limb extensor strength across the participants (Table 4).

Table 4. Strength and functional performance tests were conducted among the study participants.

Strength and physical ability tests	**Mean ± SD**
HG (kg)	17.2 ± 5.5
Chair rise test (s for 5 rises)	12.0 ± 3.1
Timed Up and Go (TUG, s)	8.8 ± 1.6
Gait Speed (m/s)	1.2 ± 0.4
MIHE (kg)	52.3 ± 15.3

Values are presented as mean ± SD values are deviation for handgrip strength, maximal isometric hip extension strength, gait speed, timed up-and-go, and chair rise test. These assessments reflect upper and lower limb strength, mobility, balance, and functional capacity in daily activities. Abbreviations: CRT, chair rise test; GS, gait speed; HG, handgrip; MIHE, maximal isometric hip extension; TUG, timed up-and-go.

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3.5. Muscle Strength, Functional Performance, and Metabolic Parameters in Sarcopenic and Non-Sarcopenic Groups

When stratifying participants based on the presence of probable sarcopenia defined by handgrip strength (<16 kg vs. >16 kg), group means were compared for all functional and metabolic parameters, including CRT, GS, MIHE, MM, RMR, and TUG (Table 5). Older adults classified as having probable sarcopenia exhibited markedly reduced maximal isometric hip extension strength (MIHE: 43.7 ± 15.7 kg) compared to their non-probable sarcopenic counterparts (59.1 ± 11.1 kg; p = 0.001). Similarly, individuals with sarcopenia demonstrated slower GS (1.0 ± 0.3 m/s vs. 1.5 ± 0.5 m/s; p = 0.002), prolonged TUG (9.8 ± 1.9 s vs. 7.9 ± 0.7 s; p = 0.0002), and inferior CRT performance (13.8 ± 3.5 s vs. 10.5 ± 1.6 s; p = 0.0004).

Regarding metabolic indicators, participants with probable sarcopenia exhibited a significantly lower estimated resting metabolic rate (RMR: 1008 ± 174 kcal/day) than those with non-probable sarcopenia (1149 ± 110 kcal/day; p = 0.004). MM was substantially reduced in the probable sarcopenic group (37.6 ± 4.2 kg vs. 41.5 ± 3.9 kg; p = 0.005).

Table 5. Study variables stratified by handgrip strength thresholds proposed by EWGSOP2.

Strength and physical ability tests	Mean ± SD		p-value
	< 16 kg	> 16 kg	
MIHE (kg)	43.7 ± 15.7	59.1 ± 11.1	0.001
GS (m/s)	1.0 ± 0.3	1.5 ± 0.5	0.002
TUG (s)	9.8 ± 1.9	7.9 ± 0.7	0.0002
CRT (s for 5 rises)	13.8 ± 3.5	10.5 ± 1.6	0.0004
RMR (kcal/day)	1008 ± 174	1149 ± 110	0.004
MM (kg)	37.6 ± 4.2	41.5 ± 3.9	0.005

Maximal Isometric Hip Extension (MIHE), Gait Speed (GS), Timed Up and Go (TUG), Chair Rise Performance (CRT), Resting Metabolic Rate (RMR), and muscle mass (MM) in older women stratified by handgrip strength thresholds proposed by the EWGSOP2.

3.6. Correlation Analysis

Trunk extension strength demonstrated robust positive associations with both RMR (r = 0.88) and MM (r = 0.88), highlighting the strong coupling between axial muscle strength and the components of lean body mass and RMR (Figure 1). Additionally, MIHE exhibited the strongest negative correlation with CRT (r = -0.96), indicating that individuals with greater trunk extensor strength performed chair rise test transitions more rapidly, reflecting enhanced lower body functional capacity.

MM also correlated positively with RMR (r = 0.82), reinforcing the metabolic relevance of the skeletal muscle in resting energy consumption. Conversely, MM was inversely associated with CRT (r = -0.86), GS (r = -0.75), and TUG (r = -0.73), suggesting that lower MM is related to impaired functional mobility and dynamic balance.

Additionally, HS was moderately and positively correlated with trunk extension (r = 0.64), RMR (r = 0.51), and MM (r = 0.57), indicating its role as a surrogate marker for general muscle strength and nutritional status. Furthermore, HS was moderately and inversely correlated with CRT (r = -0.64), GS (r = -0.53), and TUG (r = -0.57), which aligns with its clinical utility as an indicator of frailty and reduced physical performance.

The performance-based functional tests CRT, GS, and TUG exhibited strong positive intercorrelations (ranging from r = 0.81 to r = 0.92), reflecting the overlapping neuromuscular and balance demands inherent to these tasks. Collectively, these findings delineate a consistent pattern in which greater muscle strength and mass are associated with superior functional performance and higher metabolic rate, whereas decreases in these parameters are tightly linked to functional impairments, suggesting their potential as integrative markers for sarcopenia and frailty phenotypes.

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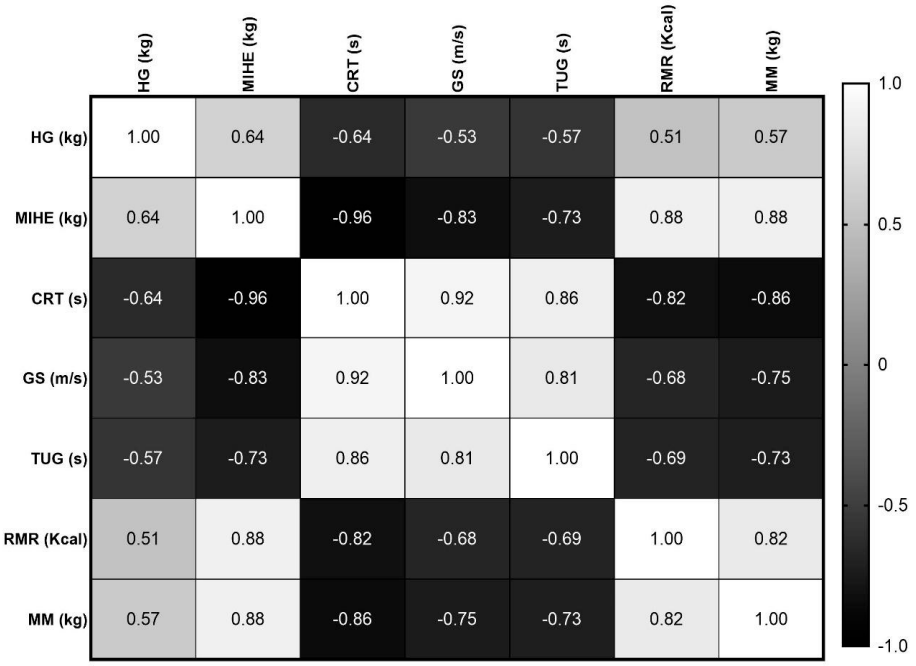

Figure 1. Correlation matrix heatmap illustrating the strength and direction of linear relationships among neuromuscular functions [handgrip strength (GP), maximal isometric hip extension (MIHE), chair rise test (CRT), gait speed (GS), TUG, resting metabolic rate (RMR), and muscle mass (MM)]. Pearson's correlation coefficients were color-coded, ranging from perfect positive (r = +1.0, white) to perfect negative correlations (r = -1.0, black).

4. Discussion

The present observational pilot study demonstrated that maximal isometric hip extension strength, gait speed, and functional mobility measures provide clinically relevant information for identifying sarcopenia in community-dwelling Brazilian older women, extending beyond the diagnostic capacity of handgrip strength alone. Women classified as having probable sarcopenia according to the EWGSOP2 criteria exhibited markedly lower hip extensor strength, poorer functional performance, reduced muscle mass, and diminished resting metabolic rate, reinforcing the multidimensional nature of sarcopenia. Notably, hip extensor strength showed strong associations with chair-rise performance, gait speed, and TUG outcomes, supporting its role as an integrative marker of postural control, locomotion, and metabolic health in older adults.

4.1. Anthropometric and Cardiometabolic Profile as a Substrate for Sarcopenia Risk

The anthropometric profile of the individuals participating in this study elucidates a demographic predominantly composed of older women residing within the community, who are primarily categorized as overweight, demonstrating a preserved measurement of calf circumference while simultaneously exhibiting elevated levels of central adiposity, as indicated by increased waist and abdominal circumferences. This trend is notably corroborated by extensive epidemiological studies conducted on Brazilian populations, which reveal a concerningly high incidence of both overweight and sarcopenic obesity in older women, even among those who maintain a socially active lifestyle, as referenced in various studies [17–19,27]. The clinical significance of central adiposity cannot be overstated, as it has been empirically linked to detrimental outcomes such as diminished muscle quality, ineffective metabolic functioning, and an accelerated decline in physical capabilities, especially among women [28,32].

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Furthermore, the elevated rates of hypertension and diabetes documented within the current sample resonate with prior research findings that emphasize the tendency for cardiometabolic comorbidities to cluster within aging female populations, illustrating their intricate relationship with the underlying pathways associated with sarcopenia [22,25]. It has been well established that metabolic disorders, including hypertension and type 2 diabetes, intensify muscle catabolism while simultaneously disrupting the regulation of resting metabolic rates, thereby reinforcing the complex, multidimensional framework that characterizes sarcopenia as a multifactorial condition [1,12].

4.2. Physical Activity Patterns and Their Functional Implications

Despite the undeniable existence of various cardiometabolic risk factors among the participants involved in this study, it was observed that these individuals consistently engaged in physical activity on a regular basis, predominantly favoring low-impact and group-oriented modalities such as water aerobics, gymnastics, and yoga, which are popular in this demographic. This exercise profile reflects the common preferences for physical activity among older women in Brazil and aligns with findings from numerous population-based studies that indicate a tendency for individuals to adopt socially oriented and moderate-intensity activities. However, it is important to note that such activities may not adequately stimulate the maximal neuromuscular adaptations that are necessary for optimal physical performance and health outcomes, as indicated in previous research [19,26].

The notable prevalence of light-to-moderate perceived exertion experienced by the participants, combined with the varied levels of adherence to these exercise regimens, may serve as a partial explanation for the observed clustering of functional performance and muscle strength values that were found to be alarmingly close to the thresholds established by EWGSOP2. While it is undeniable that engaging in such low-impact activities contributes positively to the maintenance of mobility and balance among older adults, there remains a significant concern that these types of exercises may not provide sufficient stimuli to preserve the levels of lower-limb and trunk strength that are critically required to effectively prevent the progression of sarcopenia, a condition that poses serious health risks to the aging population [29,30].

4.3. Functional Performance and EWGSOP2-Based Sarcopenia Screening

In alignment with the recommendations set forth by the EWGSOP2, a noteworthy and significant proportion of individuals participating in the study demonstrated SARC-F scores that indicated an elevated risk of developing sarcopenia, a condition characterized by the progressive loss of muscle mass and strength, which was further corroborated by their handgrip strength and chair rise performance metrics that were alarmingly close to the diagnostic thresholds established for this condition [2]. Nevertheless, a deeper examination of the functional assessments conducted revealed a more intricate and nuanced pattern of results, suggesting that while the mean gait speed and timed up-and-go (TUG) scores remained comfortably within the acceptable ranges typically allocated for older adults residing in the community, the individual variability observed among participants hinted at the possibility of early functional decline in a specific subset of individuals, thereby reinforcing the emerging concept that gait speed should be regarded as a vital sign reflecting functional health [5,10].

In contrast, the performance recorded during the chair rise and TUG tests, both of which are fundamentally reliant on the strength and functionality of the lower limb and trunk musculature, exhibited a markedly greater ability to discriminate between varying levels of physical capability than the assessment of handgrip strength alone. This lends further credence to previous research findings that have established a strong correlation between lower body strength and the presence of mobility limitations, as well as the associated risk of falls among older adults [6–9].

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4.4. Maximal Isometric Hip Extension Strength as an Integrative Marker

One of the most significant and central findings derived from the comprehensive analysis conducted in this study is the notably pronounced reduction in maximal isometric hip extension strength, particularly among women classified as having probable sarcopenia based on the established handgrip thresholds set forth by the EWGSOP2. This observation is in complete alignment with a robust body of evidence that consistently indicates that the strength of the lower limb and proximal muscle groups is more effective than handgrip strength at predicting various outcomes, such as slow gait speed, functional decline, and the onset of frailty, as noted in prior literature references [3,13,14].

Furthermore, the musculature responsible for hip extension and the trunk plays an essential and pivotal role in facilitating postural control, enabling gait propulsion, and assisting in the transitions from sitting to standing, which collectively renders maximal isometric hip extension (MIHE) a biomarker that is both biomechanically and functionally relevant in geriatric health [4,11]. Additionally, the robust and strong inverse association observed between MIHE and the time taken to rise from a chair in this study serves to further reinforce its ecological validity, thereby supporting the argument for its utilization as an integrative indicator of neuromuscular efficiency and functional independence among the elderly population.

4.5. Muscle Strength, Metabolic Rate, and Muscle Mass Interdependence

The significant and marked decline in the resting metabolic rate, along with a noticeable reduction in muscle mass observed among participants who are likely suffering from sarcopenia, underscores the intricate relationship that exists between neuromuscular functionality and overall metabolic health, thereby indicating the critical role of muscle tissue in maintaining metabolic homeostasis. It is well established that skeletal muscle serves as the primary and most influential determinant of resting energy expenditure, meaning that any reductions in muscle mass and strength directly correlate with a downregulation of metabolic functions and an increased susceptibility to declines in physical functionality and health outcomes over time [20,21].

The robust and compelling correlations that have been identified between the metrics of muscle mass, resting metabolic rate, and measurement of muscle integrity and health (MIHE) are in alignment with both interventional studies and longitudinal research evidence, which collectively demonstrate that alterations in muscle function typically precede and can reliably predict changes in metabolic rate in older adult populations [1]. These significant findings build upon and extend previous observations, providing compelling evidence that both axial and lower limb strength may act as more sensitive and effective proxies for assessing metabolic health than the traditional measure of handgrip strength alone, thereby offering new insights into the complex interplay between muscle function and metabolic regulation.

4.6. Functional Test Interrelationships and Sarcopenia Phenotyping

The robust and significant interrelationships that exist among chair-rise performance, gait speed, and the Timed Up and Go (TUG) assessment highlight the common neuromuscular requirements and balance challenges that are inherent to these functional tasks, thereby providing substantial empirical support for the concurrent application of these measurements in the phenotyping of sarcopenia, as evidenced by previous studies [8,31]. Furthermore, the moderate correlations observed between handgrip strength and both functional and metabolic variables serve to emphasize the importance of handgrip strength as a global indicator of muscle functionality, albeit one that lacks specificity when discerning nuanced aspects of muscular health.

Recent research indicates that exclusive reliance on handgrip strength as a sole determinant may lead to an underestimation of the prevalence of sarcopenia among older female populations, especially in cases where these individuals exhibit preserved strength in their upper limbs while simultaneously experiencing significant impairments in their lower limb functionality [15,16,24]. The

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findings of the current investigation lend credence to this hypothesis and are consistent with previous Brazilian studies that have illustrated a modest level of agreement between the instruments outlined by the EWGSOP2 and the varying prevalence estimates that arise depending on the specific strength metrics that are utilized in the assessment [23,31].

4.7. Integrative Interpretation

The aggregate findings presented in this study collectively elucidate a coherent and discernible pattern, indicating a significant correlation between the reductions observed in lower limb and trunk strength and the concomitant impairments in various dimensions of functional performance, muscle mass, and resting metabolic rate, thereby underscoring the intricate interdependencies that characterize these physiological phenomena. This integrative phenotype not only reinforces but also aligns with the increasingly prevalent consensus among researchers and practitioners in the field that sarcopenia, particularly in the context of older women, is most effectively characterized and assessed through function-oriented evaluations that place a strong emphasis on lower limb capabilities, as opposed to relying solely on isolated measurements of upper limb strength, which may not fully capture the multifaceted nature of this condition [3,30,32].

4.8. Study Limitations

This study is limited by its cross-sectional design, which prevents any causal or temporal inference regarding whether lower limb/trunk strength, gait speed, muscle mass, and resting metabolic rate influence each other over time. The sample was small (n = 38) and drawn from a single community-based program of physically independent older women in Cabo Frio, which increases the risk of selection bias and substantially narrows the generalizability to men, frailer adults, institutionalized populations, or other regions. Key exposures and covariates were also measured with constraints that could introduce misclassification or residual confounding, including reliance on BIA for muscle quantity (sensitive to hydration and less definitive than reference methods such as DXA), self-reported health/lifestyle information when documentation was unavailable, and an analytic approach based mainly on bivariate group comparisons and Pearson correlations without multivariable adjustment (or control of multiple testing), which leaves observed associations vulnerable to confounding variables. Even with these limitations, the study provides useful preliminary evidence linking readily deployable functional measures to key metabolic and body composition indicators in community-dwelling older women, helping to refine hypotheses and guide better-powered longitudinal research.

5. Conclusions

In summary, this study provides evidence that the strength of maximal isometric hip extension exhibits a robust correlation with various indicators of functional performance, muscle mass, and resting metabolic rate, specifically within the population of older women living independently in the community. Although the measurement of handgrip strength continues to serve as a valuable tool for screening based on the criteria established by the EWGSOP2, assessments focusing on the strength of the lower limbs and trunk seem to provide a more comprehensive understanding of the multifaceted nature of functional and metabolic impairments experienced by individuals.

The integration of function-oriented assessment measures, including maximal isometric hip extension strength, gait speed evaluations, and various mobility tests, has the potential to enhance the classification and understanding of sarcopenia phenotypes, thereby facilitating the earlier identification of women who may be at an elevated risk of experiencing functional decline in both community settings and broader public health contexts. Consequently, this highlights the pressing need for a more nuanced approach to the assessment of sarcopenia that transcends traditional measures and incorporates a wider array of functional evaluations to better identify and address the needs of vulnerable populations with sarcopenia.

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Abbreviations

The following abbreviations are used in this manuscript.

BIA	Bioelectrical Impedance Analysis
BMI	Body Mass Index
CRT	Chair Rise Test
DBP	Diastolic Blood Pressure
EWGSOP2	European Working Group on Sarcopenia in Older People 2
GS	Gait Speed
HG	Handgrip Strength
HR	Heart Rate
MAP	Mean Arterial Pressure
MIHE	Maximal Isometric Hip Extension
MM	Muscle Mass
RMR	RMR: Resting Metabolic Rate
RPE	Rate of Perceived Exertion
SARC-F	Sarcopenia Risk Questionnaire
SBP	Systolic Blood Pressure
TUG	Timed Up-and-Go
WHO	World Health Organization
WHR	Waist-to-Hip Ratio

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