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RESEARCH

Central and peripheral arterial stiffness and sarcopenia in hospitalized older adults

Francesco Fantin[1] · Serena Nicolussi Paolaz[2] · Anna Giani[3] · Elisa Mattachini[3] · Elena Zoico[3] · Mauro Zamboni[3]

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Abstract

Objective Both sarcopenia and arterial wall stiffening are frequent findings among hospitalized older adults, and further insight should be gained to explore their pathophysiological mechanisms and possible correlations.

Methods 90 hospitalized geriatric patients (mean age 83.94 ± 6.6 years, 38.89% female, 36.7% sarcopenic) have been enrolled, and underwent clinical, comorbidity and biochemical assessment. Sarcopenia was investigated following the diagnostic algorithm according to European guidelines assessing muscular strength, using a portable dynamometer, and muscle mass by bio-impedance analysis (BIA); carotid-femoral pulse wave velocity (cfPWV), carotid-radial PWV (crPWV), femoral-pedal PWV (fpPWV) and cardio-ankle vascular index (CAVI) were obtained for each.

Results Sarcopenic patients ($n = 33$) were older ($p < 0.01$) than subjects without sarcopenia ($n = 57$). Sarcopenic patients presented higher CAVI (12.67 ± 3.12 vs. 10.91 ± 1.4, $p < 0.01$) and fpPWV, but not cfPWV and crPWV. In backward analysis muscle strength and comorbidity index resulted good indipendent variables of fpPWV (R^2 0.11), muscle strength, comorbidity index and sex could predict CAVI (R^2 0.22). When examining sarcopenia diagnoses determinants, in a logistic binary regression model and considering several possible covariates, fpPWV resulted a significant **indipendent variable** of sarcopenia along with age and sex.

Conclusion increased indexes of arterial stiffness are shown in sarcopenic hospitalized older adults as compared to hospitalized patients without sarcopenia; peripheral arterial segments of the lower limb appeared to be more involved in the stiffening process, as compared to central segments.

Keywords Sarcopenia · Arterial stiffness · Peripheral arterial stiffness · Femoral-pedal pulse wave velocity · Cardio-ankle vascular index

Introduction

Sarcopenia is a frequent finding among older adults, with even higher prevalence among hospitalized geriatric subjects [1]: it is defined as a progressive skeletal muscle deterioration (in terms of muscle quantity and quality), associated to increased likelihood of adverse outcomes including falls, fractures, physical disability and mortality [2]. Given the raising prevalence of sarcopenia, owing to the progressive aging of the general population, its burden is expected to gain weight [3], and further knowledge is needed to deeply understand its pathophysiology, in order to identify as many modifiable risk factors as possible. Interestingly, sarcopenia and arterial wall stiffening share several common risk factors, namely oxidative stress inflammation and insulin resistance [4, 5]. The underlying mechanisms are not fully understood, but noteworthy, both sarcopenia and arterial stiffness frequently occur with aging.

Along with muscle quantity, muscle quality results to be significantly impaired across aging [6]: in sarcopenic subjects increase in fibrosis, fat deposition inside and outside the muscles and alteration in fibre architecture have been frequently described [7]. Consolidated knowledge demonstrated that oxidative stress and inflammation are

✉ Francesco Fantin
francesco.fantin@unitn.it

1 Centre for Medical Sciences – CISMed, Department of Psychology and Cognitive Science – DIPSCO, Section of Geriatric Medicine, University of Trento, Rovereto, Italy

2 Division of Geriatric Meidcine, APSS, Rovereto, TN, Italy

3 Department of Medicine, Section of Geriatrics, University of Verona, Verona, Italy

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contributors to age-related muscle decline [8]. These age-related phenomena concomitantly affect different districts, and similar findings can be observed in arterial walls.

Arterial stiffening results from a multifaceted interplay of inflammatory signaling cascades and vascular remodeling processes [9], which progressively impair arterial wall elasticity and compliance [10], ultimately leading to an increase in Pulse Wave Velocity (PWV).

Increased carotid-femoral PWV (cfPWV), evaluated by applanation tonometer, is a reliable predictor of mortality risk in different subset of patients [11, 12]. The evaluation fo cfPWV is part of the latest European guidelines on arterial hypertension [13]. The same method used for the evaluation of the elastic properties of the aorta (cfPWV) is also used for the functional evaluation of the muscular arteries of the upper limb (carotid-radial PWV, crPWV) and of the lower limb (femoral-pedal PWV, fpPwv). Cardio-ankle vascular index (CAVI) can evaluate arterial stiffness from a larger proportion of the arterial tree and is considered to be less dependent on blood pressure at the time of measurement [14, 15]; this evaluation usually also provides brachial-ankle PWV (baPWV) which is associated to cfPWV [16] although including both central and peripheral segments.

Thus, several different techniques can assess arterial stiffening, focusing on different arterial vessels, and some of them may be more representative of those pathophysiological conditions which connect arterial stiffness to sarcopenia. However, so far, evidence is rather scarce, and albeit previous studies pointed out the relationship between sarcopenia and increased arterial stiffness [17, 18], it should be acknowledged that different sarcopenia diagnostic criteria and different arterial stiffness indexes have been applied. There is need for further research in order to consolidate this knowledge. The aim of the present study is to explore the relationship between sarcopenia and indexes of peripheral and central arterial stiffness, in a cohort of geriatric patients hospitalized due to any reason, in order to widen the perspective on possible pathophysiological mechanisms.

Methods

Study population

90 older patients hospitalized at Geriatric Clinic of Verona University Hospital were enrolled in the present study. Exclusion criteria were: (I) limb amputation or history of surgical treatment to aorta, carotids, or femoral arteries; (II) severe peripheral arterial disease or proximal arterial stenosis; (III) atrial fibrillation or other major arrhythmias; (IV) severe behavioural disorders which could prevent a proper compliance to data collection.

A detailed clinical history, with particular mention to cardiovascular diseases and risk factors, and physical examination were recorded for each patient; the comorbidity burden was estimated by Charlson Comorbidity Index (CCI).

The study was approved by the Ethical Committee of the University of Verona.

Anthropometric variables

Body weight was measured with the patient barefoot and wearing light indoor clothing, to the nearest 0.1 kg (Salus scale, Milan, Italy); height was recorded to the nearest 0.5 cm using a stadiometer (Salus stadiometer, Milan, Italy), however, whenever patients could not stand in erect position, the last anamnestic height was recoded. BMI was calculated as body weight adjusted by stature (kg/m 2).

Arterial stiffness measurements

CAVI, blood pressure and heart rate were measured using VaSera-1500 (Fukuda-Denshi Company, LTD, Tokyo), as per the manufacturer's recommendations. BP cuffs were placed simultaneously on the four limbs and inflated two by two (right and left side). ECG was obtained by two electrodes placed on both arms; to obtain phonocardiography, a microphone was placed on the sternum (second rib space). Mean arterial Pressure (MAP) was calculated using the following formula: MAP=DBP+1/3 PP (where DBP stands for Diastolic Blood Pressure and PP for Pulse Pressure).

VaSera device calculates CAVI, on the basis of the Bramwell-Hill Formula [19, 20], by the following equation:

$$CAVI = a * \left(ln \frac{\frac{P_s}{P_d} * PWV^2 * 2\rho}{P_s - P_d} \right) + b$$

a and b are constants, ρ is considered the blood density, Ps stands for Systolic Blood Pressure (SBP), and Pd stands for DBP. By means of this device, heart-ankle PWV (haPWV) was calculated as the ratio between aortic valve to ankle length (automatically derived by software) and the time T taken by pulse wave to run this distance (T=tb+tba, tb=time from the second heart sound to the dicrotic notch at the brachial pulse wave form, tba=time from brachial to ankle pulse waves) [21].

Pulse Wave Velocity (PWV) was also measured using the portable device PulsePen (Diatecne, Milan, Italy) [22], and its software WPulsePen 2.3.3. A detailed description of PWV calculation was provided in previous studies [23, 24]; two transducers were used simultaneously, recording the arterial pulse curve of an arterial segment at the proximal point and at the distal point respectively.

As recommended by expert consensus [25], the distance between two artery points (central to peripheral) was multiplied by 0.8. Thus, the software calculated carotid-femoral PWV (cfPWV), which is considered representative of central elastic arteries [26], carotid-radial PWV (crPW) and femoral-pedal (fpPWV) which are proxy for peripheral arteries.

Biochemical analysis

Venous blood samples were obtained after the subjects fasted overnight. Plasma glucose was measured with a glucose analyser (Roche Cobas 8000, Monza, Italy). Cholesterol and triacylglycerol concentrations were determined with spectrophotometric method (Roche Cobas 8000, Monza, Italy). High-density-lipoprotein (HDL) cholesterol was measured by using the method of Warnick and Albers. LDL cholesterol was calculated using the Friedwald formula [27]. Creatinine was measured by a modular analyzer (Roche Cobas 8000, Monza, Italy); estimated Glomerular Filtration Rate (eGFR) was calculated by Cockroft-Gault formula. Finally, we evaluated the serum albumin concentration by a spectrophotometric method (Roche Cobas 8000, Monza, Italy).

Sarcopenia diagnosis

Sarcopenia assessment was performed in agreement to latest guidelines [2] (the EWGSOP 2 Consensus for Sarcopenia): subjects at risk for sarcopenia can be identified by the presence of risk factors, clinical symptoms, or validated questionnaires: then, specific tests (such as Handgrip and Chair Stand Test) can assess a reduce muscle strength, which is a pivotal feature of sarcopenia. The diagnosis can be confirmed assessing muscle mass quantity and quality, by means of Dual-energy X-ray absorptiometry (DXA), BIA, computed tomography (CT) scan or magnetic resonance imaging (MRI). All patients received SARC-F questionnaire [1], in order to identify subjects at risk of sarcopenia: SARC-F score >=4/10 identified patients at risk. Then, Handgrip test was used as proxy for muscular strength, using a portable dynamometer (JAMAR® Hydraulic Hand Dynamometer), measures were repeated three times, and the highest value was finally recorded; the normality threshold was considered 27 kg for male subjects and 16 kg for female [2].

Finally, all patients underwent Bioelectrical Impedance Analysis (BIA) to assess body composition; the impedance measurements were performed with a phase sensitive single frequency analyzer (BIA101 BIVA® PRO, Akern srl, Italy), which applies an alternating current of 250 µA at the frequency of 50 kHz. Measurements were made using tetrapolar configuration as described by Lukaski [28]. Phase angle, resistance and reactance were registered. The appendicular skeletal mass (ASM) was calculated using the raw measurements applied to the Sergi equation [29]. Appendicular skeletral mass has been evaluated and adjusted for patient's height, obtaining the Appendicular skeletral mass Index (ASMI).

Therefore, sarcopenia diagnosis has been made in presence of a suggestive SARC-F questionnaire, a positive Handgrip Test and ASMI < 7 Kg/m2 for male subjects and < 5.5 Kg/m2 for female [1].

Statistical analyses

Variables are shown as mean value ± standard deviation (SD), or as numbers and percentage. Variables not normally distributed were log-transformed before analysis. Independent samples t-tests were used to compare characteristics of patients with and without sarcopenia. Univariate analysis of covariance (ANCOVA) has been performed to compare arterial stiffness indexes between the sarcopenic and control subgroups, adjusting the effect of covariates, included upon physiological relevance. Backward linear multiple regression analysis was performed to evaluate the effect of selected variables (included upon physiological relevance) on arterial stiffness parameters (CAVI, baPWV, crPWV, fpPWV).

A logistic binary regression model was built to evaluate the role of possible variables (age, female sex, fpPWV. glycemia, cholesterol, hypertension diagnoses, BMI, eGFR and MAP) on sarcopenia diagnoses.

A significance threshold level of 0.05 was used throughout the study. All statistical analyses were performed using SPSS 23.0 version for Windows (IBM, Armonk, New York, USA).

Results

The study population included 90 geriatric subjects (mean age 83.94 ± 6.6 years, of whom 38.89% female). Among them, 33 were diagnosed with sarcopenia, the remaining 57, without sarcopenia, represented the control group. The main characteristics of the study population are listed in Table 1.

Age was significantly higher in the sarcopenic group (86.42 ± 6.46 years vs. 83.51 ± 6.26 years, $p < 0.01$; Table 2). CCI resulted to be worse in sarcopenic subgroup (8.58 ± 2.67 vs. 6.88 ± 2.47, < 0.01). The subgroups were well matched with respect to blood tests, hemodynamic parameters and diseases such as hypertension, diabetes mellitus, ischemic heart disease and dyslipidaemia among groups.

As regards arterial stiffness indexes, a significant difference was depicted comparing CAVI between subgroups:

Table 1 Characteristics of the study population

	Mean ± SD
Age (years)	83.94 ± 6.6
Weight (kg)	68.63 ± 12.7
BMI (hg/m^2)	24.5 ± 3.8
SBP (mmHg)	125.17 ± 15.3
DBP (mmHg)	69.34 ± 8
MAP (mmHg)	87.95 ± 9.4
CAVI (m/s)	11.55 ± 2.3
Handgrip (kg)	20.23 ± 9.6
ASMI (Kg/m^2)	6.08 ± 1
cf. PWV (m/s)	13.53 ± 5.3
fp PWV (m/s)	9.15 ± 1.7
cr PWV (m/s)	7.33 ± 1.4
SARC-F	4.2 ± 3
CCI	7.5 ± 2.7
Total Cholesterol (mg/dL)	127.28 ± 33.4
Glycemia (mg/dL)	113.31 ± 45.9
LDL Cholesterol (mg/dL)	65.66 ± 28.5
HDL Cholesterol (mg/dL)	41 ± 15.4
Triglycerides (mg/dL)	103.07 ± 45.7
HB (g/dL)	11.62 ± 2.2
Creatinine (umol/L)	117.69 ± 74.2
eGFR (ml/min/1.73m2)	47.49 ± 22
Albumin (g/dL)	33.72 ± 4.7
Sarcopenia (n,%)	33; 36.7%
Sex Female (n,%)	35; 38.89%
Hypertension (n,%)	66; 73.3%
IHD (n,%)	15; 16.7%
Carotid atheromasia (n,%)	24; 26.7%
Diabetes (n,%)	21; 23.2%
Dyslipidemia (n,%)	36; 40%

BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; CAVI: Cardio Ankle Vascular Index; ASMI: Appendicular Skeletral Mass Index; cf. PWV: carotid-femoral pulse wave velocity; fpPWV: femoral-pedal pulse wave velocity; cr PWV: carotid-radial pulse wave velocity; CCI: Charlson Comorbidity Index; HB: hemoglobin; eGFR: glomerular filtration rate; IHD: Ischemic heart disease

significantly worse CAVI is described in sarcopenic patients (12.67 ± 3.12 vs. 10.91 ± 1.4, $p < 0.01$).

Even after adjustment for age, sex, arterial hypertension and CCI, CAVI remained increased in sarcopenic subjects (p 0.049), as shown in Fig. 1.

A significant difference was described for tonometric derived pulse wave velocities for arterial segments of the lower limb (fpPWV), which resulted to be higher in the sarcopenia subgroup, as compared to the control group (9.77 ± 1.95 vs. 8.8 ± 1.52 m/s, p 0.01). This difference was confirmed even after adjustment for age, sex, arterial hypertension and Comorbidity Index (p 0.014).

Conversely, pulse wave velocities both for central (cfPWV) and peripheral arterial segments of the upper limb (crPWV), did not significantly differ between groups.

Backward regression analysis (Table 3) demonstrated that when considering fpPWV as a dependent variable and age, sex, arterial hypertension, CCI, strength and muscle mass as independent variables, both Comorbidity Index and muscle strength resulted significant indipendent variables of fpPWV (R^2 0.11). Another regression model was built using the same independent variables and considering CAVI as dependent variable: sex, Comorbidity Index and muscle strength resulted significant indipendent variables of CAVI accounting for the 22% of the variance.

When examining sarcopenia diagnoses determinants, in a logistic binary regression model (Table 4), and considering several possible covariates, fpPWV resulted a significant indipendent variable of sarcopenia (β 0.415, SE 0.163, 95%CI 1.101–2.083, p 0.01), along with age (β 0.131, SE 0.049, 95%CI 1.036–1.255, p 0.007) and sex (β -1.929, SE 0.675, 95%CI 0.039–0.546, p 0.004).

Table 2 Comparison between patients with and without sarcopenia

	WITH SARCOPENIA $n=33$			WITHOUT SARCOPENIA $n=57$			
	Mean		SD	Mean		SD	*p* value
Age (years)	86.42	±	6.46	82.51	±	6.26	< 0.01
CCI	8.58	±	2.67	6.88	±	2.47	< 0.01
Handgrip (kg)	14.09	±	5.61	23.79	±	9.72	< 0.01
ASMI (Kg/m^2)	5.74	±	0.89	6.28	±	1.01	0.01
cf. PWV (m/s)	14.35	±	6.29	13.06	±	4.65	0.31
fp PWV (m/s)	9.77	±	1.95	8.8	±	1.52	0.01
cr PWV (m/S)	7.32	±	1.73	7.33	±	1.26	0.97
CAVI (m/s)	12.67	±	3.12	10.91	±	1.4	< 0.01
MAP (mmHg)	88.79	±	8.97	87.39	±	9.59	0.5
SBP (mmHg)	125.45	±	13.83	125	±	16.23	0.89
DBP (mmHg)	70.52	±	8.14	68.67	±	7.97	0.3

CCI: Charlson Comorbidity Index; ASMI: Appendicular Skeletral Mass Index; cf. PWV: carotid-femoral pulse wave velocity; fpPWV: femoral-pedal pulse wave velocity; cr PWV: carotid-radial pulse wave velocity; CAVI: Cardio Ankle Vascular Index; MAP: mean arterial pressure; SBP: systolic blood pressure; DBP: diastolic blood pressure

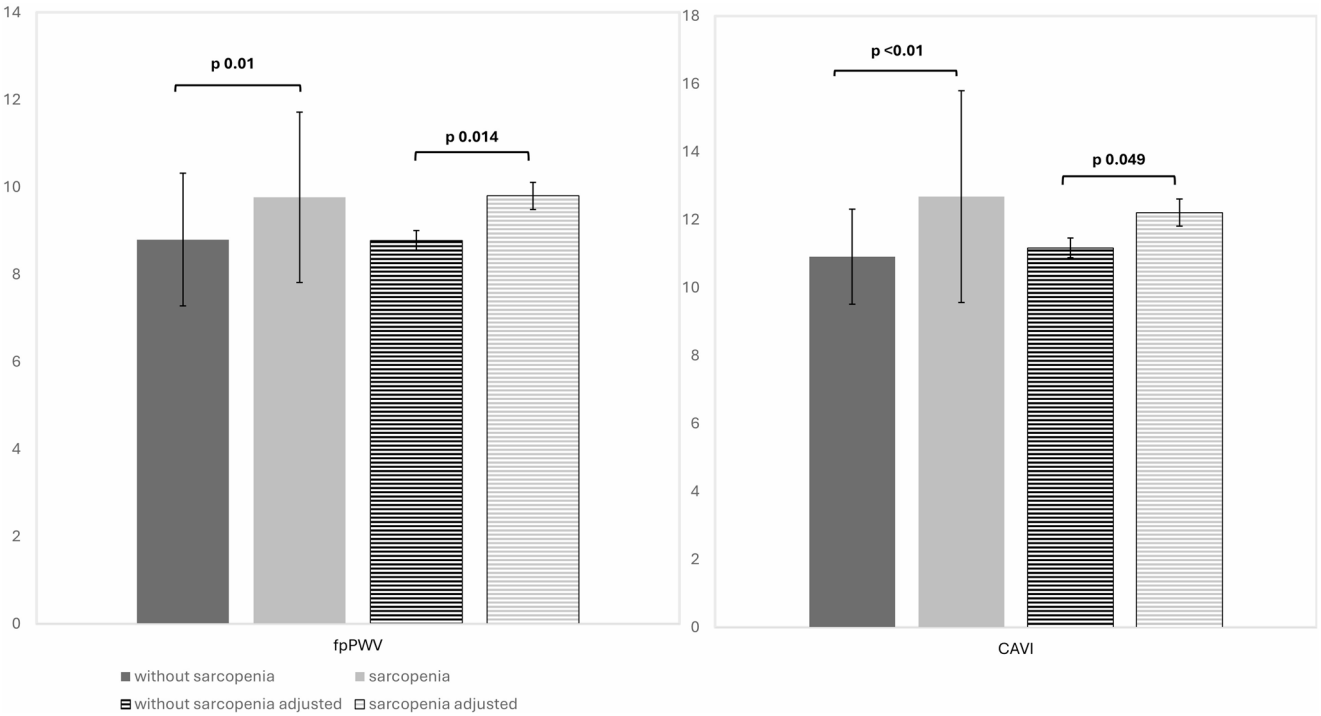

Fig. 1 (left): comparison of fpPWV in patients with and without sarcopenia, before (plain colour) and after (striped) adjustment for age, sex, arterial hypertension and Charlson Comorbidity Index; (right) comparison of CAVI in patients with and without sarcopenia, before (plain colour) and after (striped) adjustment for age, sex, arterial hypertension and Charlson Comorbidity Index. fpPWV: femoral-pedal pulse wave velocity; CAVI: Cardio Ankle Vascular Index

Table 3 Final models of backward regression models considering FpPWV and CAVI as dependent variables and age, sex, arterial hypertension, HR, glycemia, BMI and creatinine clearance as independent variables

		B	S.E.	standardized β	*p*	R^2
fpPWV						0.113
	Constant	9.156	0.683		<0.001	
	CCI	0.124	0.067	0.19	0.066	
	Handgrip	-0.046	0.018	-0.255	0.014	
CAVI						0.216
	Constant	12,418	1,043		<0.001	
	Sex	-1,54	0,515	-0,323	0,004	
	CCI	0,192	0,087	0,218	0.03	
	Handgrip	-0,084	0,026	-0,347	0.002	

fpPWV: femoral-pedal pulse wave velocity; CCI: Charlson Comorbidity Index; CAVI: Cardio Ankle Vascular Index

Table 4 Logistic Binary Regression, considering Sarcopenia Diagnoses as dependent variable and age, sex (female), fpPWV. Glycemia, cholesterol, Hypertension diagnoses, BMI, eGFR and MAP as independent variable

	β	S.E.	OR	95% C.I.		p
Age	0.131	0.049	1.140	1.036	1.255	0.007
Female sex	-1.929	0.675	0.145	0.039	0.546	0.004
fpPWV	0.415	0.163	1.515	1.101	2.083	0.011
glucose	0.008	0.006	1.008	0.997	1.019	0.170
cholesterol	0.000	0.010	1.000	0.982	1.019	0.967
hypertension	0.214	0.618	1.239	0.369	4.157	0.729
BMI	-0.138	0.078	0.871	0.748	1.014	0.076
eGFR	-0.007	0.015	0.993	0.965	1.022	0.623
MAP	0.003	0.029	1.003	0.947	1.061	0.931

fpPWV: femoral-pedal pulse wave velocity; BMI: body mass index, eGFR: estimated glomerular filtration rate; MAP: mean arterial pressure

Discussion

Our study shows that sarcopenic hospitalized older adults display increased indexes of peripheral and systemic arterial stiffness as compared to hospitalized patients without sarcopenia; peripheral arterial segments of the lower limb seem to be more involved in the stiffening process, as compared to central. On the other hand, even sarcopenia, mainly in the legs, could be related to the increased arterial stiffness.

As expected, in our study subjects with sarcopenia were older than controls. This result is in line with consolidated knowledge, which pinpoints increased sarcopenia prevalence across aging [30, 31]. In our study population we found a remarkable prevalence of sarcopenia (36.6%) and this is probably due to the hospital setting of our study population. We showed in a previous study by Rossi et al. [32] a sarcopenia prevalence of about 25% in acute setting. This difference is probably due to the higher age of our study population.

The main finding of the present study is the increased arterial stiffness in sarcopenic subjects. Although there is a certain lack of knowledge regarding the detailed mechanisms connecting arterial stiffening and sarcopenia, our findings complement several previous studies, which underlined the association between impaired muscle quality and different indexes of pulse wave velocity. On the other hand, sarcopenia, mainly in the legs, could be involved in the increased arterial stiffness.

These results may open the perspective on several pathophysiological speculations.

The Health ABC study previously demonstrated that impaired muscle quality, measured by CT scan and DXA, are negatively related to cfPWV [17], suggesting the role of impaired peripheral circulation on muscular decline. Further evidence outlined a negative correlation between muscle mass and PWV, albeit considering different techniques both for muscle mass and for arterial stiffness assessment [33].

According to our data, central arterial stiffness, namely cfPWV, did not significantly differ between patients with and without sarcopenia. On the other hand, we found a significant difference when considering fpPWV and CAVI. The difference is confirmed even after adjustment for multiple variables. According to this evidence, central aorta and peripheral arterial vessels might be differently involved in the stiffening process, and techniques aimed at evaluating muscular (peripheral) arteries might better represent the vascular impairment associated to sarcopenia. Albeit based on different approaches, several previous studies outlined increased arterial stiffness in presence of low muscle mass and quality, actually relying on CAVI (or CAVI-derived baPWV) assessment, which is known to include also peripheral segments [21]; however, to the best of our knowledge, our study is the first showing significant difference in fpPWV. Sampaio and colleagues [18], demonstrated a negative and independent association between CAVI and Skeletal Muscle Index (derived by BIA) in a population of 175 Japanese community-dwelling subjects, older than 65 years. These data have been confirmed even in a European ad Caucasian population [34]: Skeletal muscle Index was found to be related to increased CAVI in a cohort of 366 adults older than 45 years. Another study [35] demonstrated that decreased thigh muscle mass (measured by CT scan) is associated to augmented baPWV in male subjects; the same study outlined that on top of several confounding parameters, baPWV was an independent risk factor for sarcopenia, in male subjects, along with age, height, scarce physical activity and free testosterone levels. Muscle/fat ratio, measured by CT scan and total body DXA, was negatively associated to baPWV in a cohort of 526 apparently healthy adults [36]; similarly, in the J-SHIPP study, led on 1024 older subjects without known cardiovascular diseases, baPWV resulted to be negatively related to muscle mass and positively related to visceral adipose tissue [37]. Our results confirm and complement the above-mentioned evidence: most of the other studies correlated arterial stiffness to muscle mass measurements or to body composition evaluations; in our research, instead, we applied the sarcopenia diagnostic algorithm, as recommended by guidelines [2], focusing on the clinical assessment, on SARC-F questionnaire, Handgrip test and muscle mass evaluation. Furthermore, single indexes of arterial stiffness were provided in previous studies (either CAVI, or baPWV); conversely, we investigated arterial stiffness measuring different parameters, namely CAVI, cfPWV, fpPWV and crPWV. Noteworthy, among the parameters that we presented, more than one (CAVI and fpPWV) appeared to be significantly different in patients with and without sarcopenia.

As above mentioned, CAVI evaluates arterial stiffness considering a wide portion of the arterial tree, taking into account the peripheral segments. Thus, the difference between patients with and without sarcopenia may be potentially explained by the difference in peripheral arterial segments, in particular of the lower limb, which appear to be stiffer in sarcopenic subjects. Noteworthy, age-related increases in peripheral artery stiffness are less marked than in the central arteries [38]. This intriguing result sheds light on a possible pathophysiological mechanism, which may unveil a vicious circle. Impaired vascular perfusion, directly associated to increased arterial stiffening [39] can be interpreted as a cause of muscular deterioration, occurring both as histological and functional abnormalities [39]. From a different perspective, muscular alterations typical of sarcopenia, namely local (and systemic) inflammation, fibrosis and fat infiltration [8], are known to be part of a complex

interplay of myokines [7] which potentially affect vascular stiffening as well.

Our data do not allow to draw unique conclusions regarding the causality of these mechanisms. Backward analysis identified muscle strength as a major indipendent variable of CAVI and cfPWV and this may endorse the hypothesis that muscle changings might affect vascular stiffening. However, a reciprocal effect of sarcopenia and arterial stiffness can be hypothesized as we found even that peripheral arterial stiffness (fpPWV) was a significant indipendent variable of sarcopenia.

Moreover, it should be noted that subjects involved in other studies, were substantially considered healthy individuals; conversely, our population was made of hospitalized patients, with a remarkable comorbidity burden, which is known to play a role in vascular stiffness [40]. Anyway, even after adjustment for Comorbidity Index, CAVI and fpPWV remained increased in sarcopenic subjects.

Some limitations should be acknowledged when interpreting our findings. First, the small dimension of the sample size might have affected the significance of some correlations; however, a wide characterization of the stiffness status of these patients has been provided, and different stiffness indexes have been used to corroborate the results. Due to the cross-sectional nature of this study, we were not allowed to draw causality conclusions, nor to evaluate the implications of our findings on clinical outcomes. We acknowledge that the prevalence of sarcopenia might appear rather high in our study, as compared to the general population, but all our subjects were hospitalized, therefore presenting a remarkable risk factor for sarcopenia.

In conclusion, our study described increased indexes of systemic and peripheral arterial stiffness in sarcopenic hospitalized older adults as compared to hospitalized patients without sarcopenia, and lower limb arterial segments appeared to be more involved in the stiffening process, as compared to upper limb and central segments. On the opposite sarcopenia could be, mainly in the legs, a determinant of increased peripheral arterial stiffness.

The findings of this study suggest a potential link between sarcopenia and increased arterial stiffness, particularly at the level of peripheral arteries in the lower limbs. The muscle alterations observed in sarcopenic individuals may contribute biologically to impaired vascular compliance through mechanisms that are not yet fully understood but may involve shared inflammatory, metabolic, and structural pathways.

From a clinical standpoint, the observed association raises the possibility that vascular dysfunction may play a contributory role in the pathophysiology of sarcopenia. This highlights the importance of an integrated approach to the management of older adults, where assessment of vascular health might offer additional insights into musculoskeletal decline. Further longitudinal studies are warranted to clarify the directionality and causality of this relationship, and to explore whether targeting vascular stiffness could represent a novel strategy in the prevention or treatment of sarcopenia.

Author contributions FF, EZ and MZ wrote the research project. EM and SNP collected data. FF, SNP and AG wrote the main manuscript text. AG prepared the figure. All authors reviewed the manuscript.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Competing interests The authors declare no competing interests.

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