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Association between arterial stiffness and walking capacity in older adults

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A R T I C L E I N F O

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A B S T R A C T

Background and aim: Arterial stiffening – a process that is largely due to intimal thickening, collagen disposition or elastin fragmentation – significantly contributes to cardiovascular events and mortality. There is also some evidence that it may negatively affect physical function. This study aimed to evaluate whether arterial stiffness was associated with measures of walking capacity in a large, population-based sample of highly aged older adults.

Methods: A population-based sample of 910 community-dwelling adults (aged 75, 80, or 85 years) were investigated in a cross-sectional observational study. Pulse wave velocity (PWV), a surrogate marker of arterial stiffness, was estimated based on the oscillometric recording of pulse waves at the brachial artery site. Walking capacity was assessed by 10-meter habitual walking speed, 10-meter maximum walking speed, and six-minute walk distance. We used multiple linear regression models to examine possible associations between PWV and parameters of walking capacity, and we adjusted the models for sex, age, socioeconomic status, anthropometry, physician-diagnosed diseases, prescription medication, smoking history, physical activity, and mean arterial pressure. Continuous variables were modelled using restricted cubic splines to account for potential nonlinear associations.

Results: Mean (standard deviation) 10-meter habitual walking speed, 10-meter maximum walking speed, and six-minute walk distance were 1.3 (0.2) m/s, 1.7 (0.4) m/s, and 413 (85) m, respectively. The fully adjusted regression models revealed no evidence for associations between PWV and parameters of walking capacity (all p-values >0.05).

Conclusion: Our results did not confirm previous findings suggesting a potential negative association between arterial stiffness and walking capacity in old age. Longitudinal studies, potentially taking additional confounders into account, are needed to disentangle the complex relationship between the two factors.

1. Background

Even in healthy individuals and in the absence of atherosclerotic disease, central elastic arteries are stiffening with increasing age (Kucharska-Newton et al., 2019; Vlachopoulos et al., 2015), a process that is largely due to intimal thickening, collagen deposition, or elastin fragmentation (Nagai et al., 1999; Virmani et al., 1991; Zieman et al., 2005). Arterial stiffening leads to a rise in systolic blood pressure and pulse pressure (Dart and Kingwell, 2001; Franklin et al., 1997), and it significantly contributes to cardiovascular events and mortality (Sutton-Tyrrell et al., 2005; Vlachopoulos et al., 2010). Besides these frequently shown associations, there is also some evidence that arterial stiffening may be negatively associated with physical function, including walking capacity (Brunner et al., 2011; Dvoretskiy et al., 2020; Watson et al., 2011).

Arterial stiffening has a number of negative pathophysiological consequences. These do not only refer to cardiac function, such as, e.g., increased left ventricular afterload, reduced coronary perfusion, increased myocardial work and myocardial deformation (Hwang et al., 2012; Lantelme et al., 2008), but also to the peripheral circulation.

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Arterial stiffening impairs the unique ability of the cardiovascular system to convert the marked pulsatile central blood flow into a smooth pattern that minimizes the dynamic stress on the smaller peripheral vessels (Mitchell, 2008; O'Rourke et al., 1984). In consequence, arterial stiffening may negatively affect the skeletal muscle microcirculation and thereby, potentially, skeletal muscle function (Payne and Bearden, 2006).

The clinical measure of pulse wave velocity (PWV) is widely used to operationalize arterial stiffness (Kohn et al., 2015). It is an estimate of the speed of the pressure wave traveling along the aortic and aorto-iliac pathway (Nemcsik et al., 2017), and thereby an indirect, surrogate measure of arterial stiffness – with higher PWV values indicating increased stiffness. While originally, PWV was measured invasively, a number or non-invasive methods have evolved over the past decades, including systems that derive PWV from a recording of pressure waveforms at the carotid and femoral artery using electrocardiography for synchronization, and – more lately – cuff-based systems that calculate aortic PWV based on the oscillometric recording of pulse waves at the brachial artery only (Townsend et al., 2015). Brachial cuff-based systems showed good validity in comparison to carotid-femoral measurements and they have the potential to facilitate PWV measurements in everyday clinical practice settings (Hametner and Wassertheurer, 2017; Nürnberger et al., 2011; Wassertheurer et al., 2010).

In older adults, measures of walking capacity have been shown to be predictive of falls (van Kan et al., 2009), hospitalisation (Cesari et al., 2005), and mortality (Cesari et al., 2005; Studenski et al., 2011). Deficits in walking capacity are associated with social isolation (Bevilacqua et al., 2021), anxiety and depression (Vink et al., 2008), and a reduced quality of life (Netuveli et al., 2006). Furthermore, the ability of older adults to maintain their independence and to stay in their own homes largely depends on their walking capacity (Reuben et al., 2004; von Bonsdorff et al., 2006). The research into correlates of walking capacity in old age may lead to novel approaches and treatment options to impede the age-related functional decline.

Studies on the relationship between PWV and walking capacity in old age are still scarce (Dvoretskiy et al., 2020). The Whitehall II study found a significant inverse association between PWV and habitual walking speed in middle aged to older adults, independent of various health conditions (Brunner et al., 2011). This was partly contradicted by the Health, Aging and Body Composition (Health ABC) Study which found an independent inverse association in older adults (aged 70 to 79 years) with peripheral arterial disease but not in those without the disease (Watson et al., 2011). Recently, Ogawa et al. (2020) demonstrated a significantly lower brachial-ankle PWV in those within the highest walking speed-tertile compared to those within the lowest walking speed-tertile in a sample of community-dwelling older adults (aged 65+). While the aforementioned studies used short-distance walking tests only, Gonzales (2013) used a 400 meter walk test and derived mean walking speed as well as distance walked within the first 2 min in a small sample of 21 older adults. A partial correlation analysis (adjusting for selected potential confounders) revealed a significant negative correlation between PWV and walking speed as well as distance. In summary, findings of existing studies on the relationship between PWV and walking capacity are inconsistent and limitations still include a scarcity of data on older adults aged 75+ and a limited selection of measures of walking capacity per study. Statistically, existing studies did not take the potential non-linearity of the relationship into account.

The present study aimed to evaluate if PWV (measured by a brachial cuff-based device) is associated with three different measures of walking capacity (10-meter habitual as well as maximum walking speed, and six-minute walk distance) in a large, population-based sample of older adults aged 75, 80, and 85 years. Measures that were taken into account when analyzing the potential associations between measures of PWV and walking capacity included sociodemographic and -economic factors, anthropometry, presence of chronic disease (cardiac disease, cerebral or cerebrovascular disease, diabetes, vascular disease), beta-blocker intake, antihypertensive medication, smoking history, habitual physical activity, and mean arterial pressure. In order to account for potential nonlinear associations, all continuous variables were modelled using restricted cubic splines (Harrell, 2015).

2. Methods

2.1. Study design

AGNES ("Active Ageing – Resilience and External Support as Modifiers of the Disablement Process") was an observational study of three age cohorts (75, 80, and 85 years) with 1021 participants (for sample size and power calculations please refer to the published study protocol) (Rantanen et al., 2018). Its cross-sectional data collection (September 2017 to December 2018) included phone and face-to-face interviews in people's homes, postal questionnaires, and assessments in the research center. AGNES was approved by the ethical committee of the Central Finland Health Care District (23 August 2017).

2.2. Target group, inclusion and exclusion

The study targeted adults aged 75, 80 and 85 living in postal areas within a 10 kilometer radius of the city center or within reach of local public transportation of the city of Jyväskylä, Finland. Inclusion criteria were: being aged 75, 80 or 85 years, living independently in the recruitment area, and providing written informed consent. Only those who were unwilling to participate or unable to communicate were excluded.

2.3. Recruitment and participants

Participants were recruited from the Digital and Population Data Services Agency in Finland. Invitations were sent to 2791 people, 2348 were interviewed on the phone about their willingness to participate, baseline postal questionnaire and/or home interviews were completed by 1021 participants. Of these 1021 participants, 910 volunteered to take part in laboratory assessments at the research center. Those who participated in the laboratory assessments had a lower median age (78.5 vs. 79 years) and a higher self-rated health (47.4 vs. 30.2 % with good or very good health), and they were more frequently male (43.1 vs. 39.6 %) compared to those who only filled in the postal questionnaire and/or took part in the home interviews (for details on the recruitment process please see Portegijs et al. (2019)). Arterial stiffness measurements as well as the assessments of walking capacity were exclusively conducted at the research center; we therefore limited our analyses to these participants.

2.4. Main measures

All assessments of arterial stiffness and physical function were performed at the research center by trained assessors. For details on all measurement procedures, please refer to the published study protocol (Rantanen et al., 2018).

2.4.1. Walking capacity (outcome)

Habitual as well as maximum walking speed were assessed over a 10-meter distance using a light barrier system. Walking started five meters before the first light barrier (to allow for acceleration) and stopped well past the finish line (in order to avoid deceleration within the 10-meter distance). Participants performed two walks: 1) with the instruction to walk at their habitual speed, i.e., the speed they would use when going for errands; 2) with the instruction to walk as fast as possible, without compromising safety (Sakari-Rantala et al., 1998). During both walks, participants were allowed to use a walking aid, if needed.

Furthermore, participants performed a self-paced six-minute walk test (Holland et al., 2014; Simonsick et al., 2014). For safety reasons and in order to facilitate continuous walking performance over the entire test duration, participants were asked to walk at usual walking speed rather than maximal speed (Gremeaux et al., 2008). Participants were allowed to use a walking aid, if needed. Tests were performed on an indoor corridor with 40-meter lap length. The total distance walked within 6 min was measured.

2.4.2. *Arterial stiffness (main independent measure)*

Arterial stiffness was measured by a non-invasive cuff-based device (Diagnostic Station DS20, Schiller AG, Baar, Switzerland) that captures brachial blood pressure and pulse wave forms allowing to estimate the central aortic hemodynamics and PWV. Measurements were performed in a seated position (back resting against the chair backrest, feet flat on the floor, and legs uncrossed) after resting for at least 10 min to ensure hemodynamic stability. Participants were instructed to refrain from talking during the test. Each measurement started with a recording of brachial blood pressure followed by a pulse wave recording with the cuff inflated at the diastolic blood pressure level. Ten stable consecutive pulses were filtered and averaged by the device to calculate the central aortic pulse wave. Aortic pulse waves were calculated via a general transfer function, based on the modification of a certain frequency range in the recorded peripheral pressure waves (Wassertheurer et al., 2010; Wassertheurer et al., 2008). Based on these calculations, the central PWV was estimated (Endes et al., 2015; Nunan et al., 2012). A measurement was considered as being “valid” if >50 % of recorded pulse waves were usable for the estimation of PWV. Three measurements (with 1 min of rest in-between) were performed. In case of three valid measurements, the mean value of the second and third measurement was used for analysis; only if the difference between the second and third measurement was ≥0.5 m/s, the first measurement was taken into account and the mean value of the two closest measurements was used for analysis. In case of two valid measurements, the mean of these two measurements was used for analysis. In case of only 1 valid measurement, a “missing value” was assigned to the respective participant (Brunner et al., 2011; Endes et al., 2015; Reshetnik et al., 2017).

2.5. *Further measures*

Age and sex were obtained from the Digital and Population Data Services Agency in Finland in the context of the recruitment. Body height and waist circumference (mean of three subsequent measurements) were measured by an assessor. Socioeconomic status (perceived financial situation and years of education), smoking history, physician-diagnosed diseases (cardiac disease, cerebral or cerebrovascular disease, diabetes, and vascular disease) and prescription medication (beta-blocker and antihypertensive medication) were assessed by self-report (Rantanen et al., 2018). Habitual physical activity was assessed by the Yale Physical Activity Survey for older adults (YPAS), the total score was calculated (DiPietro et al., 1993). Mean arterial pressure was derived from the arterial stiffness measurements.

2.6. *Statistical analyses*

All measures were analyzed descriptively (numbers, percentages, means, medians and standard deviations as appropriate). Outcomes of walking capacity (10-meter habitual walking speed, 10-meter maximum walking speed, and six-minute walk distance) were analyzed by sex and age group. We additionally performed two-way analyses of variance (ANOVAs) with PWV and parameters of walking capacity as outcomes and age group, sex and their interaction as independent variables. We used multiple linear regression models to examine possible associations between PWV and the three outcomes of walking capacity. Besides PWV, sex, age group, self-rated economic situation, years of education, body height, waist circumference, presence of chronic disease (cardiac disease, cerebral or cerebrovascular disease, diabetes, vascular disease), beta-blocker intake, antihypertensive medication (other than beta-blocker), mean arterial blood pressure, smoking history, and physical activity were used as independent variables (potential confounders) using a stepwise approach (for details see Table 4). All continuous confounders were modelled using restricted cubic splines (i.e. “natural” splines) with four knots placed at specific percentiles of the variables to account for potential nonlinear associations (Harrell, 2015). Additionally, we assessed the evidence for a nonlinear relationship between PWV and the outcomes in the fully adjusted models. Specifically, we compared three models sequentially using likelihood ratio tests: 1) a model excluding PWV (the null model), 2) a model with PWV included linearly and 3) a model with PWV included as a spline as described above. Model fits were checked using diagnostic residual plots. Because there was little evidence for a nonlinear relationship between PWV and all three outcomes, we present the models where PWV was included linearly. We handled missing data using multiple imputation (Jakobsen et al., 2017; van Buuren, 2018). We imputed 50 datasets using predictive mean matching where all variables listed above served as predictors. Complete case analyses of the fully adjusted models were performed as sensitivity analyses. The fraction of missing observations for the outcomes 10-meter habitual walking speed, 10-meter maximum walking speed, and six-minute walk distance in the complete-case regression models were 12.4 %, 12.4 % and 15.1 %. All tests were two-sided, and the level of significance was set at 0.05.

3. Results

Participants (N = 910) had a median (interquartile range) age of 78.5 (75–80) years (Table 1). Descriptive analyses showed higher mean PWV values in older compared to younger age groups and higher mean values

Table 1
Participant characteristics (N = 910).

Characteristic	N	Category	%	Mean	SD	Median
Sex	910	Female	56.9			
Age group	910	74–75 years	47.7			
		78–80 years	32.1			
		83–85 years	20.2			
Body height (cm)	910			164.2	8.9	163.5
Waist circumference (cm)	907			96.7	12.6	97
Perceived financial situation	904	Very poor	0			
		Poor	1.8			
		Fair	37.6			
		Good	50.0			
		Excellent	10.4			
		Cannot say	0.2			
Education (years)	900			11.6	4.2	11
Smoking history (daily or almost daily for ≥1 year)	893	No	70.3			
		Yes, quit smoking	27.2			
		Yes, still smoking	2.5			
Physical activity (YPAS score points)	891			56.4	23.3	54
Cardiac disease	908	Yes	38.5			
Cerebral or cerebrovascular disease	905	Yes	7.7			
Diabetes	908	Yes	17.0			
Vascular disease	907	Yes	54.1			
Beta-blocker	904	Yes	37.8			
Hypertensive medication (other than beta-blocker)	904	Yes	56.4			
Mean arterial pressure (mm Hg)	857			112.7	16.4	111.5

SD – standard deviation; YPAS – Yale Physical Activity Survey for older adults.

Table 2
Descriptive analyses of pulse wave velocity and parameters of walking capacity by sex and age group.

Parameter	Sex	Age group	N	Mean	SD	Median
Pulse wave velocity (m/s)	Male	74–75	178	11.61	0.63	11.55
		78–80	128	12.37	0.63	12.35
		83–85	74	13.30	0.72	13.29
		Total	380	12.19	0.91	12.12
	Female	74–75	236	11.74	0.69	11.67
		78–80	145	12.77	0.72	12.85
		83–85	96	13.64	0.80	13.60
		Total	477	12.43	1.04	12.31
	Total		857	12.33	0.99	12.24
Habitual 10-meter walking speed (m/s)	Male	74–75	181	1.34	0.24	1.36
		78–80	132	1.26	0.24	1.27
		83–85	75	1.15	0.27	1.17
		Total	388	1.28	0.25	1.29
	Female	74–75	250	1.31	0.23	1.32
		78–80	158	1.21	0.22	1.22
		83–85	103	1.11	0.21	1.12
		Total	511	1.24	0.23	1.25
	Total		899	1.26	0.24	1.27
Maximum 10-meter walking speed (m/s)	Male	74–75	180	1.99	0.41	2.00
		78–80	132	1.84	0.43	1.84
		83–85	75	1.61	0.43	1.66
		Total	387	1.86	0.44	1.87
	Female	74–75	249	1.76	0.33	1.77
		78–80	158	1.59	0.33	1.64
		83–85	102	1.44	0.37	1.41
		Total	509	1.64	0.36	1.67
	Total		896	1.74	0.41	1.76
Six-minute walk distance (m)	Male	74–75	176	453.3	79.1	458.5
		78–80	126	420.3	80.4	420.5
		83–85	70	386.1	87.8	393.5
		Total	372	429.5	84.9	435.0
	Female	74–75	244	427.8	76.3	432.0
		78–80	152	390.6	76.4	388.0
		83–85	96	346.7	81.1	344.5
		Total	492	400.5	83.2	405.0
	Total		864	413.0	85.1	418.5

SD – standard deviation.

Table 4
Association of pulse wave velocity with parameters of walking capacity (N = 910, imputed dataset).

Outcome	Pulse wave velocity (m/s) (independent measure)			
	Model[a]	Coefficient	95 % CI	p
Habitual 10-meter walking speed (m/s)	1	0.04	0.01 to 0.06	0.003
	2	0.04	0.01 to 0.06	0.001
	3	0.02	−0.03 to 0.06	0.514
	4	0.01	−0.03 to 0.06	0.568
Maximum 10-meter walking speed (m/s)	1	0.05	0.02 to 0.09	0.004
	2	0.05	0.02 to 0.09	0.002
	3	−0.01	−0.09 to 0.07	0.817
	4	−0.01	−0.08 to 0.06	0.752
Six-minute walk distance (m)	1	12.6	3.8 to 21.5	0.005
	2	12.9	4.6 to 21.2	0.002
	3	4.1	−12.8 to 21.0	0.634
	4	2.6	−13.2 to 18.3	0.749

[a] Regression model 1 was adjusted for sociodemographic factors (sex, age group, economic situation, and education); model 2 was adjusted for sociodemographic and anthropometric factors (body height and waist circumference); model 3 was adjusted for sociodemographic, anthropometric and health-related factors (cerebral or cerebrovascular disease, cardiac disease, vascular disease, diabetes, beta-blocker, antihypertensive medication, and mean arterial pressure); and model 4 was adjusted for sociodemographic, anthropometric, health-related, and behavioral factors (physical activity and smoking history).

in women compared to men. Men had a faster walking speed and a farther 6-minute walk distance than women; walking speed and walk distance were slower and shorter respectively in older compared to younger age groups (Tables 2 and 3). Eighty-seven percent of the total sample had a habitual 10-meter walking speed of 1.0 m/s or higher. In the regression analyses adjusted for all independent variables, no significant association was found between PWV and the parameters of walking capacity (Table 4, model 4). Coefficients were close to zero for all three outcomes. The lower and upper bound of a confidence interval define the most plausible or compatible range for the population parameter based on the data and the model at some specific confidence level (Infanger and Schmidt-Trucksäss, 2019). Our data were compatible with a 0.03 m/s slower as well as a 0.06 m/s faster habitual walking speed; a 0.08 m/s slower as well as a 0.06 m/s faster maximum walking speed; and a 13.2 m shorter as well as a18.3 m farther 6-minute walk distance per additional m/s in PWV; as indicated by the lower and upper bounds of the 95 % confidence intervals. Values are below the cutoffs that are usually regarded as “substantial meaningful change” (0.1 m/s for changes in walking speed and 50 m for changes in 6-minute walk distance (Perera et al., 2006)). Results of the complete case analyses were not markedly different from the results of the analyses using the imputed dataset.

4. Discussion

We investigated a large, population-based sample of community-dwelling older adults aged 75, 80, and 85 years and did not find evidence for an association between PWV and three different parameters of walking capacity.

Our analyses showed an age-related decline of habitual and maximum walking speed and better walking capacity in men compared to women. This is in line with findings of large observational studies and meta-analyses (Bohannon and Williams Andrews, 2011; Cazzoletti et al., 2022; Kasovic et al., 2021). As expected, we found an age-related

Table 3
Results of two-way analyses of variance (ANOVAs) with PWV and parameters of walking capacity as outcomes and age group, sex and their interaction as independent variables.

Outcome	Effect	Degrees of freedom	F-value	p
Pulse wave velocity (m/s)	Main effect age group	2, 851	442.19	**<0.001**
	Main effect sex	1, 851	29.67	**<0.001**
	Interaction	2, 851	3.46	**0.032**
Habitual 10-meter walking speed (m/s)	Main effect age group	2, 893	48.89	**<0.001**
	Main effect sex	1, 893	5.49	**0.019**
	Interaction	2, 893	0.13	0.877
Maximum 10-meter walking speed (m/s)	Main effect age group	2, 890	54.44	**<0.001**
	Main effect sex	1, 890	78.65	**<0.001**
	Interaction	2, 890	0.57	0.568
Six-minute walk distance (m)	Main effect age group	2, 858	56.97	**<0.001**
	Main effect sex	1, 858	29.57	**<0.001**
	Interaction	2, 858	0.45	0.636

p-values $\le$0.05 are bolded.

increase of PWV. This relationship is well-known from the literature (Brunner et al., 2011; Mattace-Raso et al., 2010). PWV values were higher in women compared to men. This is in line with findings of the Berlin Aging Study II (N = 1100; mean age 75.6, SD 3.8 years) which applied a similar method to determine PWV and found slightly higher (mean difference 0.02 m/s, $p = 0.006$) PWV values in women (Pohrt et al., 2022). The Reference Values for Arterial Stiffness Collaboration (Mattace-Raso et al., 2010) reported a "negligible influence of gender on PWV" with higher values in males (difference of <0.1 m/s; $p = 0.04$) based on their analysis of data from 16867 individuals (mean age 55, SD 17; range 15 to 97 years) from eight European countries.

There have been a number of cross-sectional studies suggesting that there might be an inverse relationship between PWV and parameters of walking capacity in older adults. Brunner et al. (2011) investigated carotid-femoral PWV and usual walking speed over an 8-feet walking course in a large sample (N = 5286) of adults aged 55 to 78 years. The regression analysis (adjusted for several potential confounders including age, sex, mean arterial pressure, chronic disease and antihypertensive treatment) revealed a significant negative association between PWV (m/s) and walking speed (m/s) (coefficient −0.67; 95 % confidence interval −1.06 to −0.24). Ogawa et al. (2020) investigated 492 older adults between 65 and 96 years of age. In a multivariable regression analysis (adjusted for a high number of potential confounder including age, sex, body mass index, mean arterial pressure, smoking status, exercise status, and anti-hypertensive medication), higher brachial-ankle PWV (cm/s) was significantly associated to a lower maximum 6-meter walking speed (m/s) (coefficient −0.088; $p = 0.032$). Gonzales (2013) investigated a small (N = 21) sample of older adults aged 61 to 78. Participants performed a 400 meter walk test; mean walking speed of the whole test as well as distance walked within the first 2 min were derived. After adjustment for age, body mass index, waist circumference and systolic blood pressure, higher carotid-femoral PWV was negatively correlated to walking speed ($r = -0.48$; $p < 0.05$) and to 2-minute walk distance ($r = -0.51$; $p < 0.05$).

Our findings are in line with those of Watson et al. (2011) in the Health ABC cohort study. They measured carotid-femoral PWV at baseline and usual walking speed on a straight 20-meter course over seven years in a large sample of older adults (N = 2172) initially aged 70 to 79 years. No significant association between PWV (standard deviations) and longitudinal walking speed (m/s) (coefficient −0.005; 95 % confidence interval −0.012 to 0.002) was found by mixed-effects models (adjusted for several potential confounders including age, sex, body mass index, systolic blood pressure, heart rate, smoking, physical activity, coronary heart disease, diabetes and hypertension) in the full cohort. However, they identified a statistically significant negative relationship between PWV (standard deviations) and walking speed (m/s) in the subgroup of participants affected by peripheral arterial disease (defined by an ankle-brachial index of <0.9; coefficient −0.028; 95 % confidence interval −0.047 to 0.010). Authors argued that central (carotid-femoral) arterial stiffness may be especially detrimental to walking capacity in those individuals who already have a compromised function of peripheral arteries. Comparably to our sample, the Health ABC cohort initially had a rather high mobility status with only 7 % having a walking speed of lower than 1.0 m/s.

Our findings are limited by the cross-sectional design including the inability to infer causality. Even though the AGNES study is population-based, the high age of our sample in combination with a relatively high burden of participating in the assessments at the study center (typically lasting about 3 h) probably led to a selection of healthier and more mobile older adults (Portegijs et al., 2019). We used three different tests of walking capacity, including a longer duration walking test, which presumably increases the sensitivity to capture small differences in walking capacity among well-functioning older adults (Sayers et al., 2006). However, for safety reasons, we asked participants to walk at usual instead of maximum walking speed during the six-minute walk test. Therefore, in our sample of rather well-functioning older participants, demands of the test might not have been high enough to render arterial stiffness and possibly insufficient leg perfusion during muscle contraction a performance-limiting factor.

While most previous studies on PWV and walking capacity used tonometry-based methods to estimate carotid-femoral PWV (Brunner et al., 2011; Gonzales, 2013; Watson et al., 2011), we applied an oscillometric method that uses pulse waves assessed at the brachial artery site only. A good agreement between methods has been demonstrated (Wassertheurer et al., 2010; Weber et al., 2011). However, both, tonometry-based as well as oscillometric measurements, only provide an estimate of the hemodynamics of central arteries, even though PWV is known to markedly vary along the complete arterial tree due to variations in arterial structure and geometry (Latham et al., 1985; Nichols and McDonald, 1972; Segers et al., 2009; Sugawara et al., 2010). Thereby local mechanical properties of peripheral arteries might be neglected which may have separate relationships with walking capacity in older adults (Gonzales, 2013). In support of this hypothesis, Gonzales et al. (2015) found that, after a fast-pace 400 meter walk test, older adults who felt more tired had a higher local stiffness of the superficial femoral artery but not of the carotid artery, than their counterparts who reported feeling more energetic after the test.

Strengths of the present study include the population-based approach and the large sample of highly aged individuals. In our analyses, we took the potential non-linearity of the relationship and a large number of potential confounders into account. Existing studies used quite comparable sets of potential confounders for adjusting their regression analyses (see above); future studies might choose to additionally measure and adjust for markers of chronic inflammatory processes that may affect both, arterial stiffness and walking capacity (Cesari et al., 2004; Marzetti et al., 2014; Yoon et al., 2020).

5. Conclusion

Our results did not confirm previous findings of cross-sectional studies suggesting a potential negative association between arterial stiffness and walking performance. Longitudinal studies are needed to disentangle the complex relationship between the two factors.

CRediT authorship contribution statement

Timo Hinrichs: funding acquisition, conceptualization, methodology, data curation, writing – original draft. **Erja Portegijs:** conceptualization, methodology, project administration, supervision, investigation, data curation, writing – review & editing. **Taina Rantanen:** funding acquisition, conceptualization, methodology, project administration, supervision, writing – review & editing. **Denis Infanger:** conceptualization, methodology, formal analysis, writing – review & editing. **Arno Schmidt Trucksäss:** conceptualization, methodology, writing – review & editing. **Laura Karavirta:** funding acquisition, conceptualization, methodology, project administration, supervision, investigation, data curation, writing – review & editing.

Declaration of competing interest

None of the authors have any conflicts of interest with any entity with regard to this study.

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