

Body Silhouette Trajectories Across the Lifespan and Vascular Aging

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Body Silhouette Trajectories Across the Lifespan and Vascular Aging The Paris Prospective Study 3

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Abstract—Vascular aging is a major contributor to cardiovascular disease and can be quantified by higher carotid stiffness, intima-media thickness and diameter, and hypertension. Weight gain across the lifetime may be an important, modifiable determinant of vascular aging. We therefore aimed to assess lifetime body silhouette trajectories (a marker of weight change across the lifespan) in relation to vascular aging in late adulthood. We used cross-sectional data from a community-based cohort study ($n=8243$; age, 59.4; 38.7% women). A linear mixed model was used to assess trajectories of recalled body silhouettes from age 8 to 45 years. We assessed carotid artery properties (ultrasonography), resting hypertension (blood pressure $\geq 140/90$ mmHg or use of antihypertensives), and exaggerated exercise blood pressure, a marker of masked hypertension (systolic blood pressure ≥ 150 mmHg during submaximal exercise) at study recruitment when the participants were 50 to 75 years of age. We identified 5 distinct body silhouette trajectories: lean stable (32.0%), lean increase (11.1%), moderate stable (32.5%), lean-marked increase (16.3%), and heavy stable (8.1%). Compared with individuals in the lean-stable trajectory, those in the moderate-stable, lean-marked increase, and heavy-stable trajectories had higher carotid stiffness, intima-media thickness and diameter (odds ratios between 1.23 and 2.10 for highest quartile versus lowest quartile of manifestations of vascular aging; $P<0.05$) and were more likely to have resting hypertension and exaggerated exercise blood pressure, after adjustment for potential confounders (odds ratios between 1.31 and 1.60; $P<0.05$). Vascular aging was most prominent among individuals who were lean in early life but markedly gained weight during young adulthood and among those who were heavy in early life and maintained weight. (*Hypertension*. 2018;72:1095-1102. DOI: 10.1161/HYPERTENSIONAHA.118.11442.) • [Online Data Supplement](#)

Key Words: adiposity ■ blood pressure ■ carotid intima-media thickness ■ hypertension ■ vascular stiffness

Vascular aging, that is accumulation of functional and structural changes of vessels throughout life, is a major contributor to cardiovascular disease.¹ Key manifestations of vascular aging include arterial stiffening, higher carotid intima-media thickness (IMT), carotid diameter enlargement, and higher blood pressure (BP) at rest (resting hypertension) or during exercise (exaggerated exercise BP, a marker of masked hypertension that is otherwise missed by resting BP values²). These manifestations have all been associated with incident cardiovascular disease.²⁻⁵ Beyond the effect of age, vascular aging can be accelerated by exposure to poor lifestyle across the lifespan, and thus, may be a partly modifiable process.⁶

Given the global burden of obesity, understanding the effect of adiposity on vascular aging is of critical importance.

Evidence is currently incomplete, as most previous studies,⁷⁻¹⁵ but not all,¹⁶ have focused on adiposity only at specific age periods, that is, adulthood⁷⁻¹² or childhood/adolescence into young adulthood.¹³⁻¹⁵ Adiposity is, however, a dynamic and changing process starting early in life, that is body mass index (BMI) typically increases with age, in particular in young adulthood,¹⁷ and childhood obesity is often tracked into adulthood.¹⁸ A life course approach is, therefore, crucial to study the effect of adiposity on vascular aging. This will help to develop effective prevention strategies targeting the life period at which adiposity has a predominant influence on vascular health.⁶

Recalled body silhouettes at different ages have a moderate to good correlation with objectively measured adiposity

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at these different ages (see Table S1 in the [online-only Data Supplement](#) for a summary of previous studies).^{19–22} By combining recall of body silhouettes at different ages, it is possible to construct body silhouette trajectories over the life course.²³ Using this approach, body silhouettes trajectories have been shown to be associated with a higher incidence of type 2 diabetes mellitus^{24,25} and cardiovascular disease²⁵ and higher mortality.²³

We therefore calculated body silhouettes trajectories over the life course using self-recalled body silhouettes from age 8 to 45 years and quantified their association with vascular aging in late adulthood.

Methods

Data are available on request subject to approval by the PPS3 (Paris Prospective Study 3) scientific committee.

Study Population

The PPS3 (n=10157) is a community-based cohort study on novel markers for phenotypes of cardiovascular disease, as described previously.²⁶ In brief, individuals aged between 50 and 75 years were recruited at the Centre d'Investigations Préventives et Cliniques, a large preventive medical center in Paris (France), between June 2008 and June 2012. The Ethics Committee of the Cochin Hospital (Paris, France) approved the study. PPS3 was registered in the World Health Organization international clinical trial registry platform (NCT00741728).

Body Silhouettes

We used body silhouettes adapted from Stunkard et al²⁷ At study recruitment, participants self-reported 1 of 7 pictorial body diagrams (somatotypes; Figure 1) that best depicted their body silhouette at ages 8, 15, 25, 35, and 45 years.

Manifestations of Vascular Aging

Carotid Stiffness, IMT, and Diameter

Carotid stiffness (ie, carotid distensibility coefficient [DC] and Young's elastic modulus [YEM]), IMT, and diameter were determined

using high-resolution echotracking as described previously and further detailed in the [online-only Data Supplement](#).²⁸ Carotid DC represents arterial stiffness and carotid YEM represents the stiffness of the arterial wall material at operating pressure. Please note that lower values of carotid DC but higher values of carotid YEM reflect greater arterial stiffness.

Resting Hypertension and Exaggerated Exercise BP

Resting BP was recorded in triplicate using an Omron 705 C oscillometric device and an appropriate-sized cuff after 10 minutes of supine rest, as described previously.²⁹ The mean of the last 2 measurements were used in the analysis. Resting hypertension was defined by a BP of $\geq 140/90$ mmHg and use of antihypertensive medication. In addition, BP was measured during a submaximal exercise step test.²⁹ After the resting BP measurements, participants performed the step test with the BP cuff left in situ to enable recording of 1 BP measurement in the shortest time immediately after participants had stopped exercise. The exercise test consisted of stepping up and down 2 steps for 2 minutes at your own pace. Exaggerated exercise BP was defined as an exercise systolic BP ≥ 150 mmHg irrespective of the use of antihypertensive medication.²⁹

Covariates

A self-administered questionnaire was used to obtain information on education level, smoking behavior (never, former, and current), depressive symptoms, physical activity, medication use, medical history, birth weight (categories <2.5 , 2.5 to 4, and >4 kg; data on exact birth weight were not available), and dietary habits. We divided education level into 3 categories: (1) low (no or primary education); (2) intermediate (secondary education), and (3) high (higher education or university). The validated Baecke score was used to estimate overall physical activity (higher scores indicating higher levels of physical activity).³⁰ Dietary habits were evaluated using a semiquantitative 18-item food frequency questionnaire.³¹ We considered the following dietary habits, as defined previously³¹: habitual breakfast (complete breakfast versus no complete breakfast), consumption of fish per week ($>4\times$ versus $\leq 3\times$), consumption of fresh fruit per week ($>4\times$ versus $\leq 3\times$), and consumption of vegetables per week ($>4\times$ versus $\leq 3\times$). Depression symptoms were assessed using the 13-items Questionnaire of Depression 2nd version, Abridged.³² We defined the presence of depressive symptoms by a Questionnaire of Depression 2nd version, Abridged score ≥ 7 or use of antidepressant medication. Prior cardiovascular disease was defined by a self-reported history of

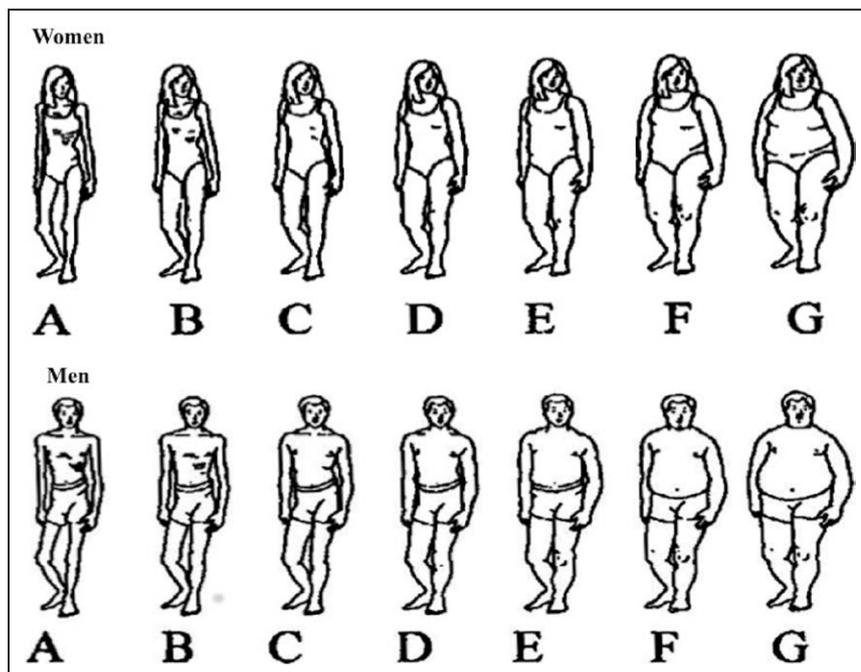


Figure 1. Body silhouettes. Body silhouettes for women and men in adults.

stroke, myocardial infarction and angina pectoris, and diabetes mellitus by use of glucose-lowering medication or a fasting blood glucose ≥ 7 mmol/L.

Analytical Sample

Of the 10 157 participants, 539 individuals (5.3%) had missing data on body silhouettes at all ages, 95 (0.9%) on 4 years, 150 on 3 years (1.5%), 138 (1.4%) on 2 years, and 533 (5.2%) on 1 year. A total of 8702 (85.7%) individuals had no missing data. We calculated the trajectories in all individuals ($n=9020$; 88.8%) with available data on body silhouettes on ages ≥ 3 out of the 5 years and including the earliest (8 years) and the latest age (45 years). In addition, 777 individuals had missing data on manifestations of vascular aging. The final study sample therefore consisted of 8243 individuals. Excluded participants as compared with those included in the present analysis had a more unfavorable cardiovascular risk profile (see [online-only Data Supplement](#)).

Statistical Analysis

Analyses were performed using SAS version 9.4. The percentage of missing values with regard to potential confounders was minimal (maximum, 3.0%). We imputed these data using multiple imputations by chained equations (10 data sets). We used a group-based trajectory modeling approach implemented by SAS Proc Traj and as described in the [online-only Data Supplement](#) (expanded methods section, Tables S2 through S4 and Figures S1 and S2).³³ We identified 5 body silhouette trajectories based on the change in the Bayesian information criterion and classified them based on their visual appearance, that is lean stable, lean increase, lean-marked increase, moderate stable, and heavy stable. We then calculated the posterior probability for each participant being a member of 1 of 5 trajectories and assigned each participant into the trajectory to which their posterior probability was greatest. The average posterior probability for each trajectory ranged between 82% and 90% indicating good allocation of individuals to the trajectories.³³ Trajectories were initially calculated stratified by sex, but trajectories were almost identical for men and women. Hence, the trajectories are described without stratification by sex.

We used multinomial logistic regression to evaluate associations between body silhouette trajectories and quartiles of carotid DC, YEM, IMT, and diameter and logistic regression to evaluate associations with resting hypertension and exaggerated exercise BP. We used the lean-stable group as the reference category in all analyses. We modeled carotid DC, YEM, IMT, and diameter on a categorical scale because such categorization provides results that are easier to interpret (odds ratios). We used ordinal regression analyses to test the proportional odds assumption, that is whether or not there is a graded

association between body silhouette trajectories and manifestations of vascular aging. In addition, we used linear regression to evaluate the association between body trajectories and continuous values of carotid DC, YEM, IMT, and diameter and resting and exercise systolic BP. We adjusted for the following potential confounders based on previous literature^{10,13–15,34}: age, sex (only in analyses without sex-specific quartiles as the outcome), height, education, smoking, physical activity, dietary habits, heart rate, prior cardiovascular disease, diabetes mellitus, depressive symptoms, and use of lipid-modifying medication. Analyses with carotid DC, YEM, IMT, and diameter as the outcome were also adjusted for mean arterial pressure and use of antihypertensive medication.

We did several additional analyses: (1) we additionally adjusted the results for birth weight to test whether any of the tested associations could be explained by fetal growth; (2) to address residual confounding, we adjusted for cardiorespiratory fitness (as estimated by the validated NET-F [nonexercise testing cardiorespiratory fitness] algorithm²⁹) instead of physical activity, and we adjusted for fasting glucose instead of diabetes mellitus; (3) to address possible reverse causality, we repeated the analyses after excluding individuals with prior cardiovascular disease; (4) we repeated the analyses after excluding individuals whose trajectory assignment probability was $< 80\%$; (5) we stratified the analyses by age categories (≤ 55 , 55 to 65, and > 65 years) to evaluate whether associations were different according to the time difference between latest age of recalled body silhouette (45 years) and age at which vascular measurements were done; (6) we stratified the analyses by smoking behavior (never, current, and former) because previous studies²³ have suggested that the association between body silhouette and mortality differs according to smoking status; (7) we stratified the analysis according to resting BP ($< 140/90$ and $\geq 140/90$ mm Hg); (8) we additionally adjusted for current waist circumference or BMI to evaluate whether body silhouette trajectories may have any additional value in the association with vascular aging beyond measures of current adiposity; and (9) to evaluate the importance of increase of adiposity over the lifetime, we calculated the difference between the lean-marked increase trajectory, on the one hand, and the heavy-stable and moderate-stable trajectory, on the other, with regard to their association with manifestations of vascular aging.

Results

Body Silhouette Trajectories and Study Characteristics

We identified 5 distinct trajectories of body silhouette (Figure 2). Overall, 32.0% ($n=2641$) of the participants maintained a lean body shape from age 8 until 45 years (lean-stable

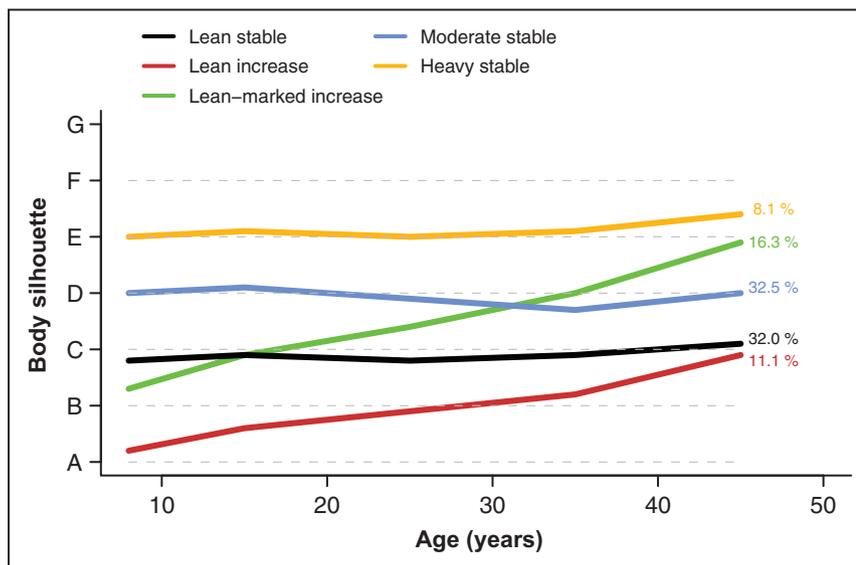


Figure 2. Trajectories of body silhouettes. Trajectories of body shape by age in women and men combined. Mean body shape levels on y axis were estimated from trajectory models. Percentages represent the proportion of the study population in each trajectory.

group); 11.1% (n=917) started lean and then had a moderate increase in body shape (lean increase); 32.5% (n=2677) had a medium body shape and maintained weight (moderate stable); 16.3% (n=1340) started lean and then had a substantial gain of weight (lean-marked increase); and 8.1% (n=668) started heavy and maintained weight (heavy stable). Characteristics of the total study population and according to body silhouette trajectory are shown in Table 1.

Association With Manifestations of Vascular Aging

Individuals in the trajectories moderate stable, lean-marked increase, and heavy stable compared with those in the lean-stable

trajectory had higher odds of having a lower carotid DC, higher YEM, higher IMT, and higher diameter (Figure 3 and Table 2). In addition, individuals in the trajectories lean increase, moderate stable, lean-marked increase, and heavy stable compared with those in the lean-stable trajectory had higher odds of having resting hypertension and exaggerated exercise BP (Figure 3 and Table 2). The results of the ordinal regression analysis showed that the proportional assumption was met for all analyses, except for the analyses with carotid diameter as the outcome (Table S5). When carotid DC, YEM, IMT, and diameter and resting and exercise systolic BP were modeled as continuous variables, results were qualitatively similar (Table 3).

Table 1. Characteristics for the Total Study Population and According to Body Silhouette Trajectory*

Study Population Characteristics	Total Study Population, n=8243	Body Silhouette Trajectory				
		Lean Stable, 32.0%; n=2641	Lean Increase, 11.1%; n=917	Moderate Stable, 32.5%; n=2677	Lean-Marked Increase, 16.3%; n=1340	Heavy Stable, 8.1%; n=668
General characteristics						
Age, y	59.4 (6.2)	59.4 (6.1)	60.3 (6.4)	59.3 (6.3)	59.2 (6.3)	58.8 (5.9)
Men	61.3 (5057)	61.6 (1626)	71.5 (656)	55.3 (1481)	74.0 (991)	45.4 (303)
Education						
Low	27.7 (2281)	24.3 (643)	28.2 (259)	26.5 (710)	34.1 (457)	31.7 (212)
Middle	30.2 (2490)	31.3 (827)	27.5 (252)	30.8 (825)	29.4 (394)	28.7 (192)
High	41.2 (3393)	43.2 (1140)	43.0 (394)	41.8 (1119)	36.0 (482)	38.6 (258)
Smoking						
Current	14.4 (1190)	13.4 (353)	14.3 (131)	15.6 (418)	13.2 (177)	16.6 (111)
Former	33.8 (2790)	32.7 (863)	35.8 (328)	32.8 (877)	37.9 (508)	32.0 (214)
Never	51.5 (4247)	53.9 (1419)	49.7 (456)	51.5 (1378)	48.7 (653)	51.0 (341)
Prior cardiovascular disease	1.8 (151)	1.3 (35)	2.2 (20)	2.0 (54)	2.3 (31)	1.6 (11)
Diabetes mellitus	3.7 (302)	2.0 (52)	3.8 (35)	3.4 (90)	6.9 (93)	4.8 (32)
Heart rate, bpm	62 (9)	61 (9)	61 (9)	61 (9)	63 (9)	62 (9)
Body mass index, kg/m ²	25.1 (3.6)	23.7 (3.0)	24.1 (3.0)	25.2 (3.4)	26.7 (3.5)	27.8 (4.5)
Physical activity (Baecke score)	6.9 (1.6)	6.9 (1.6)	6.8 (1.6)	6.9 (1.5)	6.9 (1.6)	6.8 (1.6)
Depressive symptoms	11.8 (974)	9.8 (258)	10.5 (96)	12.8 (342)	12.6 (169)	16.3 (109)
Antihypertensive medication	14.7 (1209)	11.9 (315)	16.0 (147)	14.2 (381)	19.0 (255)	16.6 (111)
Lipid-modifying medication	13.2 (1089)	10.9 (288)	15.0 (138)	12.4 (331)	18.0 (241)	13.6 (91)
Manifestations of vascular aging						
Carotid distensibility coefficient, kPa ⁻¹ ×10 ⁻³	22.0 (8.0)	22.6 (7.9)	22.3 (8.3)	21.8 (8.1)	21.0 (7.7)	21.7 (7.9)
Carotid Young's elastic modulus, kPa	4.93 (2.22)	4.76 (2.06)	4.92 (2.23)	4.97 (2.28)	5.19 (2.34)	4.95 (2.24)
Carotid intima-media thickness, μm	638 (116)	628 (112)	641 (119)	640 (116)	650 (119)	646 (115)
Carotid diameter, mm	7.16 (0.71)	7.10 (0.67)	7.18 (0.70)	7.13 (0.71)	7.31 (0.71)	7.16 (0.78)
Resting hypertension	35.2 (2904)	29.5 (779)	37.5 (344)	35.8 (958)	41.9 (562)	39.1 (261)
Resting blood pressure						
Systolic blood pressure (mm Hg)	131 (16)	129 (16)	132 (16)	130 (16)	133 (16)	131 (16)
Diastolic blood pressure (mm Hg)	76 (10)	75 (10)	76 (10)	75 (10)	77 (10)	76 (9)
Exaggerated exercise blood pressure	44.8 (3695)	40.5 (1069)	45.0 (413)	45.6 (1221)	50.4 (675)	47.5 (317)
Exercise systolic blood pressure, mm Hg	152 (19)	150 (19)	151 (19)	152 (19)	155 (19)	154 (19)

Data are means (SD) or % (n).

*Because of missing data, numbers or percentages for some variables do not sum to group totals or to 100%, respectively.

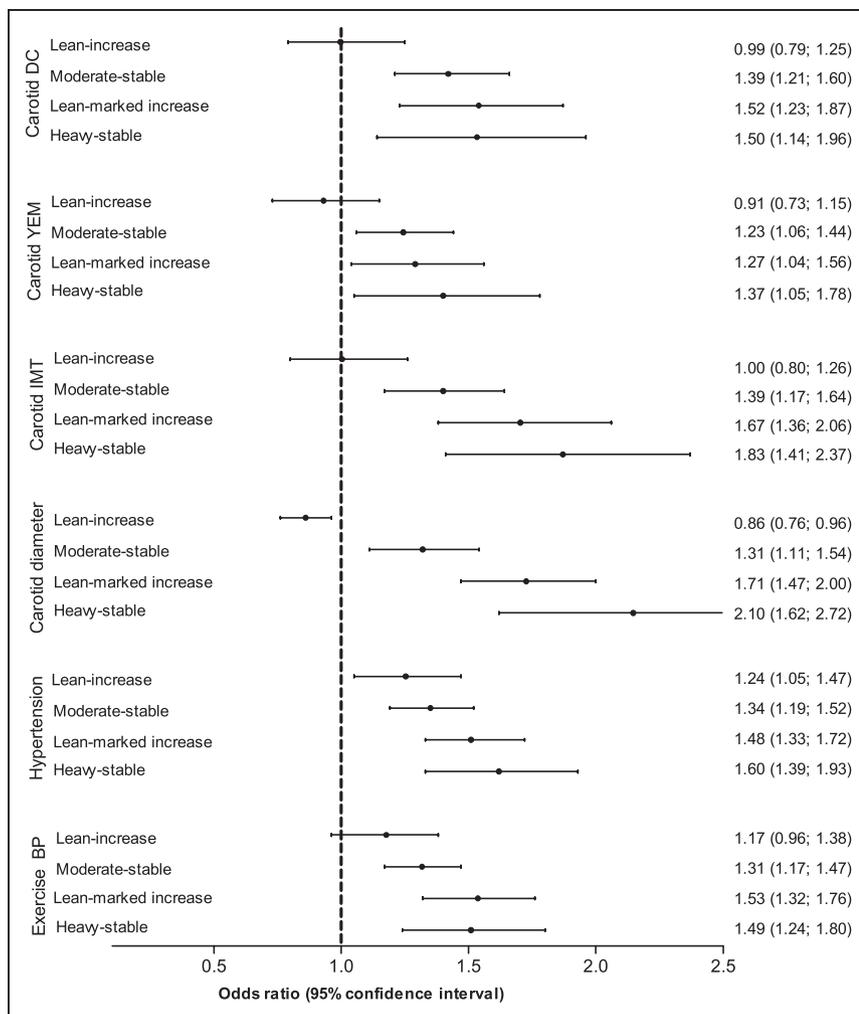


Figure 3. Associations between body silhouette trajectories and manifestations of vascular aging: carotid distensibility coefficient (DC; quartile 1 vs quartile 4); carotid Young's elastic modulus (YEM; quartile 4 vs quartile 1); carotid intima-media thickness (IMT; quartile 4 vs quartile 1); carotid diameter (quartile 4 vs quartile 1); resting hypertension (blood pressure $\geq 140/90$ mm Hg or use of antihypertensive medication); and exaggerated exercise blood pressure (exercise BP; exercise systolic BP ≥ 150 mm Hg). The lean-stable group served as the reference group in all analyses. Results are adjusted for age, sex (only in analyses without sex-specific quartiles as the outcome), height, education, smoking, physical activity, dietary habits, heart rate, prior cardiovascular disease, diabetes mellitus, depressive symptoms, and use of lipid-modifying medication. Analyses with carotid DC, YEM, IMT, and diameter as outcome were also adjusted for mean arterial pressure and use of antihypertensive medication. For cutoff values of sex-specific quartiles of carotid artery properties, see the [online-only Data Supplement](#).

Additional Analyses

Results did not materially change when we additionally adjusted for birth weight (Table S6), cardiorespiratory fitness (Table S7), fasting glucose (Table S8), or after excluding individuals with prior cardiovascular disease (n=171; Table S9). In addition, when we repeated the analyses after excluding individuals whose trajectory assignment probability was <80% (n=2209), effect estimates for the associations between body trajectories and manifestations of vascular aging became higher (Table S10). Furthermore, results were qualitatively similar in individuals aged ≤ 55 , 55 to 65, and >65 years (Table S11) and in never, former, and current smokers (Table S12). Body silhouette trajectories were associated with carotid DC, YEM, IMT, and diameter and exaggerated exercise BP irrespective of resting BP category (Table S13). Adjustments for current waist circumference (Table S14) or BMI (Table S15) attenuated the associations between body silhouette trajectories and manifestations of vascular aging. The attenuation was less for the lean-marked increase than for the heavy-stable trajectory. Some body silhouette trajectories, most often moderate-stable and lean-marked increase, remained statistically significantly associated with some manifestations of vascular aging. Finally, the lean-marked increase trajectory, as compared with the moderate-stable trajectory, had a statistically significant higher odds of some

manifestations of vascular aging (ie, greater carotid IMT and diameter and exaggerated exercise BP; Table S16). There were no differences between the lean-marked increase and heavy-stable trajectory (Table S16).

Discussion

We evaluated the association between recalled body silhouettes over the lifespan and various manifestations of vascular aging in late adulthood. We found that participants who remained heavy from 8 to 45 years and even those who were lean in childhood but gained weight in young adulthood had the highest values of carotid stiffness, IMT, and diameter and highest odds of resting hypertension and exaggerated exercise BP, indicating evidence of advanced vascular aging. In contrast, those who maintained a stable-lean body silhouette had the lowest values of carotid stiffness, IMT, and diameter and lowest odds of resting hypertension and exaggerated exercise BP. These findings suggest that prevention of weight gain across the life course, in particular in young adulthood, is important to promote healthy vascular aging.

One previous study¹⁶ retrospectively linked BMI measured in childhood and from an age of 36 to 60–64 years to carotid IMT and BP measured at an age of 60 to 64 years. This study found that in particular individuals who remained overweight from 36 to 60–64 years as compared with those

Table 2. Association Between Body Silhouette Trajectories and Manifestations of Vascular Aging—Results of Intermediate Quartiles

Manifestations of Vascular aging	Body Silhouette Trajectories			
	Lean Increase	Moderate Stable	Lean-Marked Increase	Heavy Stable
Carotid distensibility coefficient				
Q3 vs Q4	1.14 (0.91–1.42)	1.25 (1.07–1.47)	1.19 (0.98–1.43)	1.22 (0.95–1.56)
Q2 vs Q4	1.17 (0.93–1.47)	1.28 (1.09–1.51)	1.32 (1.09–1.60)	1.25 (0.97–1.61)
Q1 vs Q4	0.99 (0.79–1.25)	1.39 (1.21–1.60)	1.52 (1.23–1.87)	1.50 (1.14–1.96)
Carotid Young’s elastic modulus				
Q2 vs Q1	1.13 (0.90–1.41)	1.26 (1.08–1.48)	1.17 (0.97–1.41)	1.17 (0.92–1.50)
Q3 vs Q1	1.08 (0.86–1.36)	1.24 (1.06–1.45)	1.21 (1.00–1.47)	1.15 (0.90–1.48)
Q4 vs Q1	0.91 (0.73–1.15)	1.23 (1.06–1.44)	1.27 (1.04–1.56)	1.37 (1.05–1.78)
Carotid intima-media thickness				
Q2 vs Q1	1.01 (0.81–1.25)	1.01 (0.87–1.17)	1.15 (0.95–1.39)	1.48 (1.16–1.89)
Q3 vs Q1	1.13 (0.90–1.41)	1.12 (0.96–1.32)	1.33 (1.10–1.69)	1.32 (1.03–1.69)
Q4 vs Q1	1.00 (0.80–1.26)	1.39 (1.17–1.64)	1.67 (1.36–2.06)	1.83 (1.41–2.37)
Carotid diameter				
Q2 vs Q1	1.05 (0.84–1.31)	1.14 (0.97–1.33)	1.32 (1.09–1.50)	1.71 (1.36–2.19)
Q3 vs Q1	1.11 (0.88–1.39)	1.17 (1.00–1.38)	1.32 (1.09–1.61)	1.63 (1.28–2.09)
Q4 vs Q1	0.86 (0.76–0.96)	1.31 (1.11–1.54)	1.71 (1.47–2.00)	2.10 (1.62–2.72)

Values are odds ratio (95% CI). Results adjusted for age, height, education, smoking, physical activity, dietary habits, heart rate, mean arterial pressure, use of antihypertensive medication, prior cardiovascular disease, diabetes mellitus, depressive symptoms, and use of lipid-modifying medication. Lean-stable trajectory served as the reference in all analyses. For cutoff values of sex-specific quartiles, see the [online-only Data Supplement](#).

without overweight during this time period had higher carotid IMT and systolic BP at an age of 60 to 64 years. We extend these results by investigating trajectories of adiposity across a wider age range and by investigating a larger number of manifestations of vascular aging. In our study, a marked increase in weight during young adulthood as compared with maintaining a lean weight was associated with a 0.9 kPa/10³ lower carotid DC and 20 μm higher carotid IMT, which is equivalent to ≈5 years of normal aging.^{35,36}

Some methodological issues warrant consideration. First, body silhouettes may represent an alternative to objectively and repeatedly measured adiposity manifestations across the life course in large observational studies when lifetime objective adiposity measures are not available.^{26–28} However, some

previous studies^{21,37} found a systematic bias in reporting of body silhouettes: individuals with low BMI tended to overestimate their body size, whereas those with normal or high BMI tended to underestimate their body size. This may have led to an underestimation of the associations between body silhouette trajectories and manifestations of vascular aging. Confirmation of our results in a longitudinal study that prospectively evaluates adiposity over the life course would therefore be ideal. Second, we evaluated whether the associations between body trajectories and vascular aging were independent of BMI and waist circumference in late adulthood. However, these analyses should be interpreted with caution because adjustment for adiposity in late adulthood is likely to be an overadjustment, that is such adjustment controls not

Table 3. Association Between Body Silhouette Trajectories and Continuous Measures of Manifestations of Vascular Aging

Trajectories	Carotid Distensibility Coefficient, kPa ⁻¹ ×10 ⁻³	Carotid Young’s Elastic Modulus, kPa	Carotid Intima-Media Thickness, μm	Carotid Diameter, mm	Resting Systolic Blood Pressure, mm Hg	Exercise Systolic Blood Pressure, mm Hg
Regression coefficient (95% CI)						
Lean stable	Reference					
Lean increase	0.2 (–0.3 to 0.8)	1 (–14 to 17)	2 (–6 to 10)	–0.02 (–0.06 to 0.03)	1 (0 to 3)	0 (–1 to 2)
Moderate stable	–0.6 (–1.9 to –0.3)	16 (5 to 27)	13 (7 to 19)	0.06 (0.03 to 0.10)	1 (0 to 2)	2 (1 to 4)
Lean-marked increase	–0.9 (–1.4 to –0.4)	22 (8 to 35)	18 (11 to 25)	0.14 (0.10 to 0.18)	2 (1 to 3)	3 (2 to 5)
Heavy stable	–0.7 (–1.3 to –0.1)	12 (–6 to 30)	23 (14 to 32)	0.16 (0.10 to 0.21)	2 (1 to 3)	4 (3 to 6)

Results are adjusted for age, sex, height, education, smoking, physical activity, dietary habits, heart rate, prior cardiovascular disease, diabetes mellitus, depressive symptoms, and use of lipid-modifying medication. Analyses with carotid distensibility coefficient, Young’s elastic modulus, intima-media thickness and diameter as outcome were also adjusted for mean arterial pressure and use of antihypertensive medication.

only for adult body size but also for change in body weight across the life course. Furthermore, adulthood adiposity is likely to be on the causal path from childhood adiposity to accelerated vascular aging.²³ Nevertheless, these analyses showed that trajectories moderate stable, lean-marked increase, and heavy stable remained statistically significantly associated with some manifestations of vascular aging. Furthermore, the attenuation was less for the lean-marked increase trajectory than for the heavy-stable trajectory. This may suggest that body trajectories can have additional predictive value beyond current objective measures of adiposity, in particular the lean-marked increase trajectory, but future prospective studies are needed to address this issue. Third, additional analyses suggested that increase in adiposity over the lifetime (ie, lean-marked increase trajectory) may be at least as strongly associated with vascular aging as accumulation of high adiposity (ie, moderate-stable and heavy-stable trajectories). However, these analyses should also be interpreted with caution because of risk of false-positive findings because of multiple testing.

Several mechanisms may underlie the association between life course adiposity and vascular aging. Weight gain in young adulthood has been associated with sympathetic overactivity, insulin resistance, low-grade inflammation, and lower adiponectin and higher leptin levels.³⁸ These factors may accelerate age-related fragmentation and depletion of elastin and deposition of collagen in the vascular media, thickening of the media layer, and compensatory arterial remodeling.¹ Ultimately, this may manifest as advanced vascular aging. In addition, body silhouette trajectories were associated with higher carotid stiffness, IMT, and diameter and exaggerated exercise BP even in individuals with normal resting BP, suggesting that the effect of body adiposity on vascular aging is not only explained by increased resting BP. This is also in accordance with exaggerated exercise BP being associated with incident cardiovascular disease and mortality even among people with apparently controlled resting BP.²

Strengths of the present study include the detailed phenotypes of carotid artery properties in a large sample size with core-lab centralized reading. Furthermore, we were able to study various manifestations of vascular aging which enabled us to test the consistency of our associations.

The present study has several limitations. First, we did not have information about long-term lifestyle patterns including physical activity and dietary habits. These patterns may in part explain the observed findings. Second, the derived body silhouette trajectories are data driven, and may, therefore, vary by cohort. Third, birth weight was self-reported, which is less accurate than actual birth weight. Finally, no data were available on insulin resistance. Insulin resistance may partly explain the association between body silhouette trajectories and vascular aging.

In conclusion, a life course approach enables identification of body silhouette trajectories from age 8 to 45 years that are associated with vascular aging. Vascular aging was most prominent among individuals who were lean in early life but gained weight during young adulthood and among those who were heavy in early life and maintained a heavy weight.

Perspectives

The present study results suggest that healthy behaviors and environments to prevent weight gain across the life course, especially during young adulthood, are important to promote healthy vascular aging. Future studies should investigate determinants of lifetime trajectories of body silhouettes for development of strategies to promote healthy vascular aging.

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Disclosures

None.

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Novelty and Significance

What Is New?

- The association between adiposity over the life course and vascular aging in late adulthood is unknown.

What Is Relevant?

- Weight gain across the lifetime may be an important, modifiable determinant of vascular aging.

Summary

We used a novel method to estimate adiposity trajectories across the life course using recalled body silhouettes from age 8 up to 45 years. Vascular aging was most prominent among individuals who were lean in early life but markedly gained weight during young adulthood and among those who were heavy in early life and maintained weight.