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Abstract

Background: The relationship between alcohol consumption and arterial stiffness parameters remains unclear. This study aimed to analyze the association between alcohol consumption and arterial stiffness in young Spanish adults. Methods: A cross-sectional descriptive study was conducted, involving 501 participants (222 men and 279 women), aged 18–34 years, who were free from cardiovascular disease and recruited from the urban population of Salamanca. Arterial stiffness was assessed using the cardio-ankle vascular index (CAVI) and brachial-ankle pulse wave velocity (ba-PWV) with the Vasera VS-2000® device, and carotid-femoral pulse wave velocity (cf-PWV) with the Sphygmocor System®. Alcohol consumption was assessed using a standardized questionnaire and quantified in grams per week, then categorized into sex-specific tertiles. Results: The mean age was 26.5 years, higher in men. Mean values of vascular function parameters were: CAVI 6.13±0.75 (no sex differences), cf-PWV 5.60±1.29 m/s, and ba-PWV 10.80±1.01 m/s (both higher in men). Overall, systolic blood pressure, pulse pressure, and waist circumference were higher among individuals with greater alcohol consumption. Men in tertile 2 and women in tertile 3 reported less physical activity. In multinomial regression analysis, using tertile 1 as reference, a positive association was observed for ba-PWV with moderate alcohol consumption (β = 0.78, 95% CI: 0.63–0.98). Conclusions: Alcohol consumption was positively associated with ba-PWV, but not with cf-PWV or CAVI.

Keywords: alcohol consumption; vascular stiffness; young adults

Clinical trial registration: [ClinicalTrials.gov], identifier [NCT05819840].

1. Introduction

Alcohol consumption among adults aged 18–34 years is highly prevalent worldwide [1], in the European Union [2], and in Spain [3], with rates approaching 90%. During adolescence and early adulthood, alcohol use is widely normalized as a social activity, and episodes of drunkenness are often integrated into these interactions [4].

Arterial stiffness is strongly linked to aging, and accelerated stiffening is considered a marker of early vascular aging [5]. Noninvasive measures of arterial stiffness, such as carotid-femoral pulse wave velocity (cf-PWV), brachial-ankle pulse wave velocity (ba-PWV), and the cardio-ankle vascular index (CAVI), provide an integrated view of vascular health and are independent predictors of cardiovascular disease and all-cause mortality [6–9].

Several studies have reported that alcohol intake is associated with increased arterial stiffness [10–13], higher blood pressure [14–17], hypertriglyceridemia, and a greater incidence of type 2 diabetes [18]. Conversely, other studies suggest that moderate alcohol consumption, without binge-drinking episodes, may reduce the risk of coronary heart disease compared with abstinence [14,19], although some report no benefit [20–22]. There is general agreement that heavy alcohol intake is linked to increased cardiovascular risk and mortality [12,14,19,21], describing a J-shaped relationship between alcohol consumption, cardiovascular disease, and arterial stiffness [19,23–25]. These effects appear more pronounced in women [14,21]. It has also been suggested that the apparent benefits of low-to-moderate consumption may reflect confounding by healthier lifestyle habits among light drinkers [26]. Importantly, potential benefits of alcohol have only been demonstrated in epidemiological studies [14,21], without accounting for confounding factors such as age, ethnicity, sex, beverage type, or drinking pattern [19].

In summary, previous research suggests that heavy alcohol intake is a risk factor for increased arterial stiffness [10–13,23–25], even in adolescents [27]. Binge drinking also worsens arterial stiffness in young adults [28]. Consumption above 14 units per week shows a positive linear relationship with arterial stiffness, even among individuals under 50 years [13,29]. Some studies show that stiffness decreases within the first hour after alcohol ingestion [30,31], while chronic low-to-moderate consumption may reduce stiffness [25,32].

Taken together, these findings indicate that the relationship between alcohol consumption and arterial stiffness, when assessed with comprehensive vascular measures, remains unclear in young adults. Therefore, the primary objective of this study was to examine the association between alcohol consumption and arterial stiffness across the vascular tree in young Spanish adults.

2. Materials and Methods

2.1. Study Design

This study was part of the EVA-Adic project, whose protocol has been previously published [33]. The EVA-Adic study was a descriptive observational study conducted by the Primary Care Research Unit of Salamanca (APISAL) and registered at ClinicalTrials.gov (identifier: NCT05819840).

2.2. Study Population

A total of 501 individuals aged 18–34 years from the urban health area of Salamanca were selected by simple random sampling, using the individual health card database from urban primary care centers. Inclusion criteria were age between 18 and 34 years and residence in the urban health area. Exclusion criteria were terminal illness, inability to attend the research unit for assessments, or failure to provide written informed consent.

2.3. Variables and Measurement Instruments

All measurements and tests were performed within a period of less than 8 days by a team of previously trained investigators following standardized procedures. The quality of the measurements was monitored by an independent researcher.

2.3.1. Sociodemographic Variables and Personal History

At baseline, age and sex were recorded.

2.3.2. Lifestyle Factors

Alcohol Consumption. Alcohol intake was assessed using a structured questionnaire, which recorded the amount of alcohol consumed during the previous 7 days in grams per week. Alcohol use was further evaluated with the Alcohol Use Disorders Identification Test (AUDIT), which classifies consumption into low risk (0–7 points), medium risk (8–15 points), high risk (16–19 points), and dependence (≥20 points) [34]. The categories of abstainers, low risk, intermediate risk, and high risk were defined according to the criteria of the Spanish Ministry of Health [35]. Alcohol consumption was categorized into sex-specific tertiles.

Adherence to the Mediterranean Diet. Adherence to the Mediterranean diet was assessed with the Mediterranean Diet Adherence Screener (MEDAS), which has been validated in the Spanish population [36].

Tobacco: Smoking status was assessed using the standardized four-item questionnaire from the WHO MONICA study [37]. In addition, the number of years of smoking was recorded.

Physical Activity: Physical activity was assessed using the International Physical Activity Questionnaire-Short Form (IPAQ-SF) [38]. This questionnaire includes 7 items on the type and duration of physical activity performed during the past 7 days. The total result was expressed in metabolic equivalents of task per minute per week (MET-min/week).

2.3.3. Arterial Stiffness

Arterial stiffness was evaluated through carotid–femoral pulse wave velocity (cf-PWV), brachial–ankle pulse wave velocity (ba-PWV), and cardio–ankle vascular index (CAVI).

cf-PWV was measured using the SphygmoCor® device (AtCor Medical Pty Ltd., West Ryde, Australia) with participants in the supine position. The pulse wave at the carotid and femoral sites was obtained by estimating the delay relative to the R-wave of the ECG, and cf-PWV was calculated. Distance was measured with a measuring tape from the sternal notch to the carotid and femoral sensors [39].

ba-PWV and CAVI were measured with the VaSera VS-2000® device (Fukuda Denshi Co., Ltd., Tokyo, Japan). Electrodes were placed on the arms and legs, and a phonocardiographic sensor was positioned in the second intercostal space. Measurements were obtained while the participant remained silent and still. CAVI was calculated using the following equation: stiffness parameter $\beta = 2\varrho \times 1/(SBP - DBP) \times \ln(SBP/DBP) \times PWV$, where ϱ is blood density and PWV is measured between the aortic valve and the ankle. Measurements were considered valid after three cardiac cycles [40]. ba-PWV was calculated using the following equation: ba-PWV = (0.5934 × height (cm) + 14.4724)/tba, where tba is the time interval between the brachial and ankle pulse waves [41,42].

2.3.4. Cardiovascular Risk Factors

Laboratory Variables: Venous blood samples were obtained between 8:00 and 9:00 a.m. after an overnight fast and abstention from alcohol, tobacco, or caffeine for at least 12 hours. Samples were collected at APISAL and analyzed for glucose, total cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides, following standardized laboratory procedures.

Blood Pressure: was measured three times consecutively using a validated sphygmomanometer (Omron M10-IT®, Omron Healthcare, Kyoto, Japan). Measurements were taken on the dominant arm with the participant seated after resting for at least 5 minutes, using an appropriately sized cuff. The procedure followed the recommendations of the European Society of Hypertension (ESH) [43]. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were recorded, and pulse pressure (PP) was calculated as SBP minus DBP.

2.3.5. Anthropometric Variables

Height was measured in centimeters using a calibrated stadiometer (Seca 222, Medical Scale® and Measurement Systems, Birmingham, UK), with the participant barefoot, standing upright

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against the wall, and at full inspiration. Waist circumference was measured with a flexible measuring tape, positioned parallel to the floor above the iliac crests, at the end of expiration, with the participant standing upright and without clothing. These procedures followed the recommendations of the Spanish Society for the Study of Obesity (SEEDO) [44]. Weight was measured in kilograms using the InBody 230® analyzer (Biospace), following the manufacturer's instructions. Body mass index (BMI) was calculated as weight (kg) divided by height squared (m^2) [45].

2.4. Statistical Analysis

Differences between means of variables with two categories were analyzed using the Student's t-test or the Mann–Whitney U test, as appropriate. For variables with more than two categories, analysis of variance (ANOVA) was applied, followed by the DMS post hoc test. Analysis of covariance (ANCOVA) was performed to adjust for potential confounding variables. The relationship between alcohol consumption and arterial stiffness was analyzed using multinomial logistic regression. The dependent variable was alcohol consumption categorized into tertiles, with the lowest tertile as the reference. Independent variables included cf-PWV, ba-PWV, and CAVI. Covariates included age (years), sex (male = 1; female = 0), mean Mediterranean diet adherence score, total physical activity (MET-min/week), pulse pressure (mmHg), LDL cholesterol (mg/dL), waist circumference (cm), and fasting plasma glucose (mg/dL). Statistical analyses were performed using SPSS for Windows, version 26.0 (IBM Corp., Armonk, NY, USA). A p-value < 0.05 was considered statistically significant. The statistician was blinded to clinical data. All analyses were conducted both overall and stratified by sex.

2.6. Ethical Considerations

The study protocol was approved by the Ethics Committee for Research with Medicines of the Health Area of Salamanca on 10 July 2021 (Ref. PI 2021 088671048) and on 24 July 2023 (Ref. PI 2023 071332). The study was conducted in accordance with the Declaration of Helsinki [46] and WHO recommendations. Data confidentiality was ensured according to the Spanish Law 3/2018 on Personal Data Protection and Guarantee of Digital Rights and the European General Data Protection Regulation (EU) 2016/679. Written informed consent was obtained from all participants prior to inclusion, after they had been informed about the examinations and questionnaires involved in the study.

3. Results

3.1. Participant Characteristics

The main characteristics of the study participants are presented overall and stratified by sex in Table 1. More women than men were included (279 vs. 222, $p < 0.05$). Men reported higher alcohol and tobacco consumption and performed more physical activity than women. Women had higher Mediterranean diet adherence scores than men. Men exhibited higher levels of LDL cholesterol, HDL cholesterol, triglycerides, blood pressure, and obesity-related parameters compared to women.

Table 1. General characteristics of participants, overall and by sex.

.	Global (n = 501)		Men (n=222)		Women (n=279)		
	Mean o n	**DS o %**	**Mean o n**	**DS o %**	**Mean o n**	**DS o %**	***p*-Value**
Age (years)	26.58	4.40	27.04	4.41	26.22	4.37	0.040
Lifestyle							
Alcohol (g/week)	48.80	73.59	61.54	91.14	38.66	53.90	< 0.001
Smokers. n (%)	70	14.0	28	12.61	42	15.05	0.434
Cigarettes/day	9.05	7.31	10.56	7.39	7.92	7.10	0.042

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MD (total score)	7.44	2.01	6.96	2.06	7.81	1.88	< 0.001
METS/min/week	2651	2490	3159	3130	2248	1730	< 0.001
Risk factors							
Total cholesterol (mg/dL)	170.16	28.66	170.98	29.77	169.52	27.79	0.573
LDL (mg/dL)	96.13	25.97	101.83	28.47	91.50	22.78	< 0.001
HDL (mg/dL)	58.30	12.85	52.20	10.84	63.12	12.26	< 0.001
Triglycerides (mg/dL)	83.11	44.24	95.55	55.70	73.19	28.80	< 0.001
Glucose (mg/dL)	81.10	12.43	82.35	16.20	80.09	8.18	0.044
SBP (mmHg)	110.94	11.56	118.61	10.29	104.84	8.46	< 0.001
DBP (mmHg)	68.08	7.78	70.15	8.11	66.44	7.11	< 0.001
PP (mmHg)	42.86	8.45	48.47	7.90	38.39	5.81	< 0.001
BMI (kg/m2)	24.04	3.80	25.30	3.65	23.03	3.63	< 0.001
Waist circumference (cm)	79.39	11.50	85.23	10.58	74.74	9.99	< 0.001
Arterial stiffness							
CAVI	6.13	0.75	6.16	0.75	6.10	0.74	0.341
cf-PWV (m/s)	5.60	1.29	5.95	1.18	5.33	1.30	< 0.001
ba-PWV (m/s)	10.80	1.01	11.20	1.05	10.48	0.84	< 0.001

Continuous variables are expressed as mean ± standard deviation, and categorical variables as numbers and percentages. MD: Mediterranean diet; MET: metabolic equivalent of task; SBP: systolic blood pressure; DBP: diastolic blood pressure; PP: pulse pressure; BMI: body mass index; CAVI: cardio-ankle vascular index; cf-PWV: carotid–femoral pulse wave velocity; ba-PWV: brachial–ankle pulse wave velocity; p value: differences between men and women.

The characteristics of participants according to alcohol consumption tertiles are presented in Table 2. Participants in the third tertile exhibited higher SBP, PP, and waist circumference.

Table 2. Participant characteristics according to alcohol consumption tertiles.

.	**Abstainers/light drinkers (1st tertile) (n = 142)**		**Moderate drinkers (2nd tertile) (n=226)**		**Heavy drinkers (3rd tertile) (n=133)**		
	Mean o n	**DS o %**	**Mean o n**	**DS o %**	**Mean o n**	**DS o %**	***p* Value**
Age (years)	26.39	4.65	26.84	4.35	26.35	4.22	0.505
Lifestyle							
Smokers. n (%)	30	(21.12)	48	(21.23)	50	(37.59)	
Cigarettes/day	10.37	7.26	9.06	7.17	8.26	7.51	0.463
MD (total score)	7.50	1.98	7.57	1.95	7.14	2.11	0.135
METS/min/week	3002.10	2706	2459	1802	2604	3151	0.121
Risk factors							
Total cholesterol (mg/dL)	171.11	30.89	170.70	28.62	168.22	26.25	0.660
LDL (mg/dL)	97.30	28.47	97.33	25.12	92.77	24.41	0.235
HDL (mg/dL)	57.51	12.54	58.85	12.90	58.20	13.14	0.621
Triglycerides (mg/dL)	86.51	43.92	78.82	43.36	86.85	45.74	0.143
Glucose (mg/dL)	82.25	15.51	79.91	8.47	81.89	14.22	0.149
SBP (mmHg)	111.26	12.30	109.64	11.41	112.82	10.77	0.039
DBP (mmHg)	68.68	7.99	67.73	7.72	68.05	7.67	0.526
PP (mmHg)	42.58	9.12	41.91	7.86	44.77	8.43	0.007
BMI (kg/m2)	24.08	4.28	23.72	3.82	24.53	3.16	0.149
Waist circumference (cm)	78.97	12.27	78.38	11.41	81.55	10.55	0.037
Arterial stiffness							
CAVI	6.08	0.85	6.18	0.73	6.09	0.66	0.315
cf-PWV (m/s)	5.63	1.19	5.62	1.01	5.55	1.74	0.839
ba-PWV (m/s)	10.95	1.07	10.71	0.97	10.80	0.98	0.076

Values are expressed as mean ± standard deviation for continuous variables and as numbers and percentages for categorical variables. MD: Mediterranean diet; MET: metabolic equivalent of task; SBP: systolic blood pressure; DBP: diastolic blood pressure; PP: pulse pressure; BMI: body mass index; CAVI: cardio-ankle vascular index; cf-PWV: carotid–femoral pulse wave velocity; ba-PWV: brachial–ankle pulse wave velocity; p value: differences between consumption groups.

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The characteristics of men according to alcohol consumption tertiles are shown in Table 3. Men in tertile 2 performed less physical activity.

Table 3. Characteristics of men according to alcohol consumption tertiles.

.	Abstainers/light drinkers (1st tertile) (n = 61)		Moderate drinkers (2nd tertile) (n=88)		Heavy drinkers (3rd tertile) (n=73)		
	Mean o n	**DS o %**	**Mean o n**	**DS o %**	**Mean o n**	**DS o %**	**p Value**
Age (years)	26.03	4.92	27.74	4.25	27.03	4.03	0.067
Lifestyle							
Smokers. n (%)	11	(18.03)	21	(23.86)	23	(31.51)	
Cigarettes/day	11.27	7.23	10.43	8.61	10.35	6.52	0.940
MD (total score)	7.20	1.91	7.00	2.19	6.73	2.03	0.413
METS/min/week	4011	3423	2704	1883	2996	3890	0.037
Risk factors							
Total cholesterol (mg/dL)	167.92	33.45	175.10	29.62	168.49	26.22	0.244
LDL (mg/dL)	99.74	31.32	106.62	28.37	97.77	25.40	0.120
HDL (mg/dL)	51.87	11.57	52.78	11.68	51.77	9.12	0.813
Triglycerides (mg/dL)	94.15	53.17	94.57	59.16	97.97	54.08	0.906
Glucose (mg/dL)	83.72	21.96	80.10	8.03	83.94	17.79	0.244
SBP (mmHg)	118.94	11.83	118.73	9.86	118.21	9.52	0.911
DBP (mmHg)	70.05	8.27	70.93	8.11	69.29	7.98	0.442
PP (mmHg)	48.89	8.67	47.80	7.42	48.92	7.83	0.596
BMI (kg/m2)	24.92	3.92	25.59	3.96	25.25	2.97	0.542
Waist circumference (cm)	83.20	11.46	86.19	10.57	85.76	9.72	0.209
Arterial stiffness							
CAVI	6.14	0.89	6.26	0.71	6.07	0.65	0.260
cf-PWV (m/s)	6.10	1.32	5.91	1.06	5.88	1.22	0.528
ba-PWV (m/s)	11.38	1.08	11.22	1.05	11.01	1.02	0.118

Values are expressed as mean ± standard deviation for continuous variables and as numbers and percentages for categorical variables. MD: Mediterranean diet; MET: metabolic equivalent of task; SBP: systolic blood pressure; DBP: diastolic blood pressure; PP: pulse pressure; BMI: body mass index; CAVI: cardio-ankle vascular index; cf-PWV: carotid–femoral pulse wave velocity; ba-PWV: brachial–ankle pulse wave velocity; p value: differences between consumption groups.

The characteristics of women according to alcohol consumption tertiles are shown in Table 4. Women in tertile 3 performed less physical activity.

Table 4. Characteristics of women according to alcohol consumption tertiles.

.	Abstainers/light drinkers (1st tertile) (n = 81)		Moderate drinkers (2nd tertile) (n=138		Heavy drinkers (3rd tertile) (n=60)		
	Mean o n	**DS o %**	**Mean o n**	**DS o %**	**Mean o n**	**DS o %**	**p-Value**
Age (years)	26.67	4.46	26.26	4.33	25.53	4.33	0.312
Lifestyle							
Smokers. n (%)	19	31.14	27	30.68	27	36.99	
Cigarettes/day	9.84	7.42	8.00	5.76	6.48	7.95	0.289
MD (total score)	7.73	2.01	7.93	1.70	7.65	2.11	0.553
METS/min/week	2242.38	1661.20	2302.70	1737.95	2128.19	1824.36	0.809
Risk factors							
Total cholesterol (mg/dL)	173.54	28.78	167.89	27.71	167.90	26.50	0.310
LDL (mg/dL)	95.41	26.12	91.31	20.75	86.54	21.77	0.080
HDL (mg/dL)	61.81	11.55	62.68	12.17	65.93	13.12	0.123
Triglycerides (mg/dL)	80.69	34.52	68.70	24.37	73.47	28.11	0.012
Glucose (mg/dL)	81.13	7.58	79.78	8.76	79.43	7.54	0.395
SBP (mmHg)	105.47	9.09	103.84	8.08	106.26	8.32	0.133
DBP (mmHg)	67.64	7.66	65.70	6.73	66.53	7.06	0.147
PP (mmHg)	37.83	6.07	38.15	5.47	39.73	6.09	0.124
BMI (kg/m2)	23.45	4.44	22.52	3.20	23.65	3.19	0.063
Waist circumference (cm)	75.78	11.96	73.41	8.88	76.42	9.22	0.081

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Arterial stiffness							
CAVI	6.03	0.82	6.14	0.73	6.11	0.67	0.582
cf-PWV (m/s)	5.27	0.95	5.44	0.94	5.14	2.16	0.295
ba-PWV (m/s)	10.62	0.94	10.37	0.75	10.54	0.88	0.092

Values are expressed as mean ± standard deviation for continuous variables and as numbers and percentages for categorical variables. MD: Mediterranean diet; MET: metabolic equivalent of task; SBP: systolic blood pressure; DBP: diastolic blood pressure; PP: pulse pressure; BMI: body mass index; CAVI: cardio-ankle vascular index; cf-PWV: carotid–femoral pulse wave velocity; ba-PWV: brachial–ankle pulse wave velocity; p value: differences between consumption groups.

3.2. Arterial Stiffness According to Alcohol Consumption Tertiles

Figure 1 shows the marginal means adjusted for age, Mediterranean diet adherence score, and physical activity according to alcohol consumption, overall and by sex, for cf-PWV (p = 0.81), ba-PWV (p = 0.075), and CAVI (p = 0.450), with no significant differences observed.

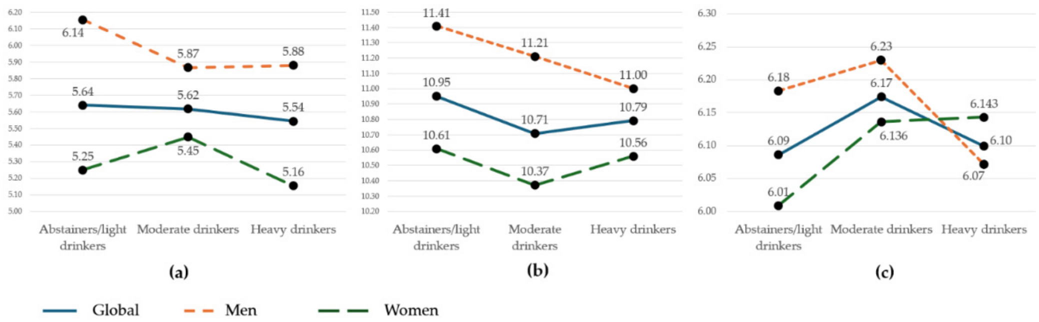

Figure 1. Marginal means of arterial stiffness parameters. Overall and sex-stratified marginal means according to alcohol consumption, adjusted for age, physical activity, and Mediterranean diet adherence. (a): cf-PWV; (b): ba-PWV; (c): CAVI.

3.3. Risk Drinking According to AUDIT

Figure 2 shows the classification of the study population based on AUDIT results. Most participants were classified as low risk (87.82%; 82.88% in men and 97.75% in women). High-risk drinking was observed in 0.80% of the population (0.90% in men and 0.70% in women).

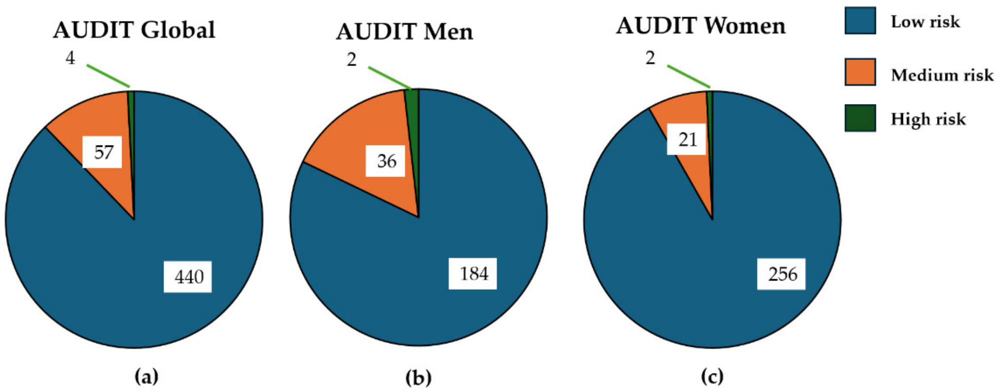

Figure 2. AUDIT results. Graphs show the total population according to alcohol consumption risk: overall (a), men (b), and women (c).

3.4. Association Between Alcohol Consumption and Arterial Stiffness

The correlation between alcohol consumption (g/week) and cf-PWV was Rho = 0.081 (p = 0.490), with ba-PWV Rho = 0.090 (p = 0.060), and with CAVI Rho = 0.082 (p = 0.641).

Results of the multinomial regression analysis are shown in Figure 3. For each 1 cm increase in cf-PWV, the β coefficient for belonging to the moderate consumption group vs. abstainer/low consumption was 0.99 (95% CI: 0.82–1.19) and for excessive consumption 0.90 (95% CI: 0.74–1.10). For each 1 cm increase in ba-PWV, the β coefficient for moderate vs. abstainer/low consumption was 0.78 (95% CI: 0.63–0.98) and for excessive consumption 0.78 (95% CI: 0.61–1.02). For each 1-unit increase in CAVI, the β coefficient for moderate vs. abstainer/low consumption was 1.17 (95% CI: 0.84–1.61) and for excessive consumption 1.13 (95% CI: 0.78–1.62).

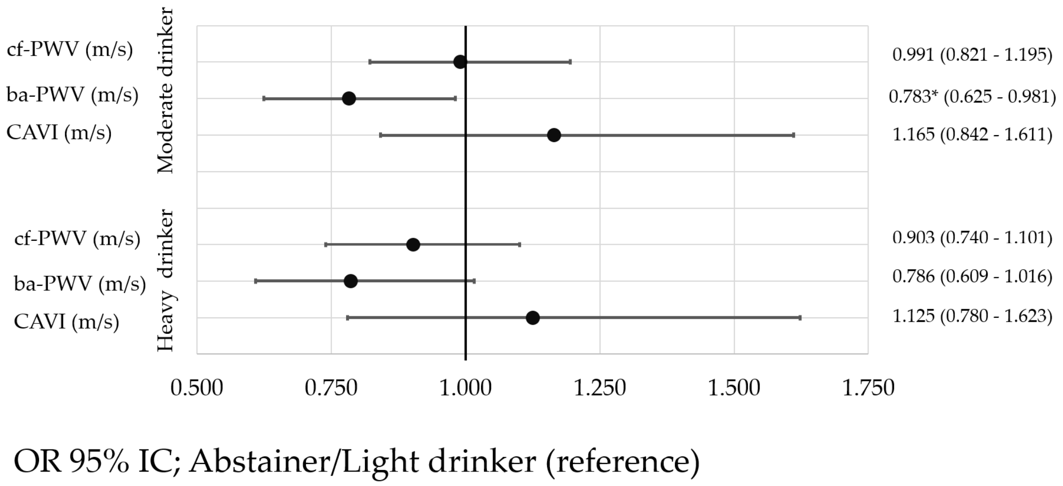

Figure 3. Association between alcohol consumption and arterial stiffness measurements. Multinomial regression analysis using alcohol consumption as the dependent variable and cf-PWV, ba-PWV, and CAVI as independent variables. Adjusted for age, sex, Mediterranean diet adherence, physical activity, pulse pressure, fasting glucose, LDL cholesterol, and waist circumference. cf-PWV: carotid–femoral pulse wave velocity; ba-PWV: brachial–ankle pulse wave velocity; CAVI: cardio-ankle vascular index. *p < 0.05.

4. Discussion

This study provides new insights into the relationship between alcohol consumption and arterial stiffness (measured by cf-PWV, ba-PWV, and CAVI) in adults aged 18–34 years. In this population, we found that moderate alcohol consumption was associated with lower ba-PWV values compared to abstainers, suggesting a potential protective effect of moderate alcohol intake.

4.1. Arterial Stiffness Values

The ba-PWV values observed in our study are similar to those reported in Japanese populations by Nishiwaki et al., 2025 (10.70 m/s) [47] and Nakao et al. (11.13 m/s) [48], as well as in the Thai population by Jaruchart et al., 2016 (10.77 m/s) [49]. In contrast, Yufu et al. reported higher averages in a Japanese cohort (12.01 m/s) [50], consistent with the Asian average reported by Yiming et al., 2017 (12.0 m/s) [51]. Lower averages have been reported in two populations: Baier et al. in a German cohort (9.3 m/s) and Satish et al. in an Indian cohort (9.94 m/s) [52]. The cf-PWV values in our study are comparable to those reported in India by Satish et al., 2021 (5.8 m/s) [52]. For European populations, the mean values are lower than reference values published in 2010 for individuals under 30 years (6.2 m/s) and 30–39 years (6.5 m/s). More recent European studies, such as Agbaje et al. for the UK (6.12 m/s) [54] and Baier et al. for Germany (7.3 m/s) [55], also report higher cf-PWV values than those found in our study. In the Americas, Diaz et al. found higher values in Argentina (6.1 m/s) [56], as did studies in the United States [57–59]. Regarding CAVI, Nishiwaki et al. [60] reported lower values (5.8) in men aged 18–21, while Russian populations aged 18–28 show similar values (5.87) [61]. Conversely, higher CAVI values have been observed in Mongolia (6.5) [62], while Chinese cohorts show similar values to ours (6.4) [63], although other authors have reported higher means (6.7) [64]. In the United States, values similar to ours have been reported in this age range [65]. Differences among studies may be due to small sample sizes, differing age ranges within "young adults," sampling methods, or real regional differences, such as lower cardiovascular risk in Spain and Mediterranean countries compared to other regions.

Sex-specific analysis in our study showed lower ba-PWV and cf-PWV values in women compared to men. Similar differences have been reported in Korean populations by Cho et al. [66], and in European [67], UK [54], and US [58] populations. In contrast, CAVI values were higher in men in our study, although the difference was not significant. Comparable findings have been reported in Japanese [68,69] and Korean [70] populations. Namekata et al. observed significant sex differences in CAVI, but their cohort included adults aged 20–70 years [69].

4.2. Alcohol Consumption and Arterial Stiffness

Numerous studies have explored the relationship between alcohol intake and arterial stiffness, showing that excessive alcohol consumption is associated with higher cf-PWV [12], ba-PWV [29], and CAVI [23]. The EVA study, conducted in Spanish adults aged 35–75 years, reported a J-shaped association between alcohol and cf-PWV [23], consistent with findings in the UK population [12]. J-shaped curves between ba-PWV and alcohol intake have also been observed in Korean [71] and Japanese [32,72] cohorts. While high alcohol intake has been linked to increased arterial stiffness in adolescents [27], few studies have focused on individuals aged 18–35. Our study observed a U-shaped relationship between alcohol intake and ba-PWV, though the results were not statistically significant. Increased cf-PWV associated with alcohol intake has been reported in American populations aged 18–30 [28,57], whereas Canadian cohorts did not show such differences [17]. No previous studies have assessed CAVI in relation to alcohol consumption in this age group. The EVA study, which used CAVI in an older adult population, found a U-shaped association with alcohol [23]. In our younger cohort, we observed an inverted U-shaped relationship between alcohol consumption and CAVI.

Acute alcohol intake can transiently reduce arterial stiffness within 60 minutes of consuming a minimal dose of 3.3 mL/kg body weight [31], in both general and younger populations (<35 years) [73]. However, the long-term effect of alcohol on arterial stiffness remains controversial, as these changes may involve structural, functional, or combined vascular alterations [74]. Potential mechanisms for improved arterial elasticity include increased HDL cholesterol, reduced LDL oxidation [75], decreased platelet aggregation and fibrogenesis, enhanced fibrinolysis, and improved insulin sensitivity [76]. These findings may have implications for the early identification of modifiable lifestyle factors related to vascular aging in young adults. Further studies are needed to deepen the understanding of this relationship.

4.3. Limitations and Strengths

This study presents the following limitations: Causality cannot be established due to the observational nature of the study. Given the relatively small sample size and the predominance of female participants, comparisons between sexes should be interpreted with caution. The selected population was from an urban setting, which limits the generalizability of the results to other populations. Alcohol consumption, smoking status, adherence to the Mediterranean diet, and physical activity were assessed using self-reported questionnaires, and the group classified as non-drinkers did not distinguish between lifetime abstainers and former drinkers.

The strengths of this study include: It is the first study to focus on the relationship between alcohol consumption and vascular parameters in individuals aged 18 to 34 years. Multiple measures of arterial stiffness were used, and the researchers collecting data on the study variables were trained and followed a standardized protocol.

5. Conclusion

Alcohol consumption was positively associated with ba-PWV but not with cf-PWV or CAVI.

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Abbreviations

The following abbreviations are used in this manuscript:

cf-PWV	carotid–femoral pulse wave velocity
ba-PWV	brachial–ankle pulse wave velocity
CAVI	cardio-ankle vascular index
AUDIT	Alcohol Use Disorders Identification TEST
MEDAS	Mediterranean Diet Adherence Screener
IPAQ-SF	International Physical Activity Questionnaire-Short Form
METs-min/week	metabolic equivalent of task
SBP	systolic blood pressure
DBP	diastolic blood pressure
PP	pulse pressure
BMI	body mass index

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