Associations between Arterial Health and Sexual Function in Late-Middle-Aged Women

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Running Head: Arterial health and sexual function

Contributions: Viivi Virkkunen is the lead author of the paper. Päivi Polo-Kantola, Sari Stenholm, and Katja Kero are leaders of the study, coinvestigators, and coauthors. Teemu Niiranen and Olli Heinonen are coinvestigators and coauthors. Mari Koivisto was the statistician for the study.

Conflicts of interest: The authors have no conflicts of interest pertaining to this manuscript.

Funding: The Finnish Retirement and Aging Study (FIREA) was supported by grants from the Academy of Finland (grant numbers 286294, 294154, and 319246), the Ministry of Education and Culture, the Juho Vainio Foundation, and Competitive State Research Financing of the Expert Responsibility Area of Turku University Hospital.

The funders played no part in the study design; the data collection, analysis, and interpretation; the writing of the report; or the decision to submit the paper for publication.

Ethical approval: The Ethics Committee of the Hospital District of Southwest Finland approved the FIREA study (ETMK: 84/1801/2014).

Abstract

Objectives: Female sexual dysfunction is extremely common, but its etiology and contributory factors are poorly understood. The purpose of this study was to assess the relationship between arterial health and female sexual function in late-middle-aged women.

Study design: The sample for this cross-sectional study comprised 117 women (aged 60–64 years) who participated in the Finnish Retirement and Aging study.

Main Outcome Measures: Arterial health was measured according to the participants' pulse wave velocity (PWV), ankle-brachial index (ABI), blood pressure, and pulse pressure. Sexual function was measured using the Female Sexual Function Index (FSFI), which resulted in a total score and five sub-scores. Associations were examined using multivariable regression analyses, which considered relationship happiness, menopausal hormone therapy, smoking, alcohol use, body mass index, and depressive symptoms.

Results: Higher diastolic blood pressure was associated with a higher total FSFI score (β=0.213, p=0.013) and with higher desire (β=0.020, p=0.008), arousal (β=0.037, p=0.034), satisfaction (β=0.025, p=0.026), and pain (β=0.050, p=0.018) sub-scores. Also, higher ABI was associated with higher satisfaction sub-score (β=2.135, p=0.012) and lower pulse pressure with higher orgasm sub-score (β=0.031, p=0.037). After Bonferroni correction the associations were no longer statistically significant. Systolic blood pressure and pulse wave velocity were not associated with sexual function.

Conclusions: This study suggested a plausible association between higher diastolic blood pressure and good female sexual function in late-middle-aged women.

Keywords: sexual health, sexual dysfunction, arterial health, late-middle-age, blood pressure, woman

1. Introduction

Female sexual dysfunction (FSD) includes disorders related to sexual desire, arousal, orgasm, and pain [1]. Up to 43% of women in United States suffer from sexual dysfunction during their lifetimes [2]. Despite the high prevalence of FSD, its etiology and contributory factors are poorly understood but may relate to impaired arterial health. Female sexual response depends on genital blood flow, and vasculogenic impairments are known to be related to FSD [3,4]. Although the role of arterial health in the development of FSD has attracted increasing interest in recent years [5], it remains underinvestigated.

Previous studies on the association between arterial health and FSD have concentrated mainly on hypertension. According to earlier studies, FSD is more prevalent in hypertensive women than in normotensive women [6–8]. Furthermore, some [7], but not all [8], studies have claimed that FSD improves with antihypertensive treatment. In contrast, however, beta-blockers have shown to deteriorate sexual function in women [9].

Only a few studies have examined the relationship between atherosclerosis and FSD. In one case–control study, women with coronary artery disease experienced FSD and reduced sexual function more often than healthy controls [10]. Another case–control study examined the relationship between pulse wave velocity (PWV)—a marker for arterial stiffness and atherosclerosis [11]—and FSD in patients undergoing hemodialysis. Arterial stiffness was greater among women with FSD than among women without FSD. In addition, the same study found that a deteriorated ankle-brachial index (ABI)—a marker for peripheral artery disease [12]—was more prevalent among women with FSD [11]. These studies were limited by their small heterogenic populations. Both studies [10,11] examined FSD in women with vascular disease —coronary artery disease (10) or chronic kidney disease (11) — but the authors did not discuss the relationship between arterial health and FSD in otherwise healthy women. Both studies [10,11] diagnosed FSD based on the

Female Sexual Function Index (FSFI), but the latter study [11] did not investigate the connections between PWV, ABI, and FSFI sub-scores, which reflect different aspects of sexual function.

To address the gaps in the literature, we used a cross-sectional study to assess the associations between different indicators of arterial health and FSD among late-middle-aged women. We hypothesized that women with markers for deteriorating arterial health would have decreased sexual function.

2. Materials and Methods

2.1. Subjects

The study population consisted of women who participated in the Finnish Retirement and Aging Study (FIREA) [12,13]. The eligible population included all public-sector employees with expected retirement dates between 2014 and 2019. In 2012, they all worked in Southwest Finland in nine selected cities. Altogether, 6,679 participants, both women (n=5,490) and men (n=1,189), responded to at least one of the FIREA questionnaires. The Finnish-speaking participants with expected retirement dates between 2017 and 2019 and who were still employed were invited to participate in a clinical sub-study (n=773 total, n=647 women, and n=126 men). Of these, 241 women participated, 157 returned questionnaires regarding sexual function, and 137 answered at least one of the FSFI questions. Altogether, 117 women reported being in a relationship and were included in the analyses. The FIREA study was conducted in accordance with the Helsinki Declaration and was approved by the Ethics Committee of the Hospital District of Southwest Finland (ETMK: 84/1801/2014). All participants gave their written informed consent.

2.2 Measurements of Arterial Health

2.2.1 Arterial Stiffness (Pulse Wave Velocity)

Arterial stiffness was assessed with on carotid-femoral pulse wave velocity (PWV) measurements using a SphygmoCor PVx system with an MM3 electronics module and a Millar tonometer [14]. The women were asked to avoid heavy meals, caffeine, and tobacco for 3 hours and alcohol for 24 hours before the assessments. They also rested in a supine position for 5–10 minutes prior to examination. Three electrodes were attached to the body to record the timing of cardiac R-waves (times of pulse wave departures from the heart). The pulse waves were measured at the right femoral arteries and right common carotid arteries (times of pulse wave arrivals at the distal arteries). The distance between the manubrium sternum and the registration points was measured to provide a straight distance between the registration points. Transit time referred to the time delay between the bases of the two waveforms and the R-wave of the simultaneously recorded electrocardiogram. Subsequently, PWV was calculated by dividing the distance by the transit time (m/s). PWV measurements were performed twice and averaged for statistical analysis. A reasonable cut-off score for increased carotid-femoral PWV is >10m/s for the general population. Higher PWV values indicate arterial stiffening, which is a risk factor for future cardiovascular disease (CVD) [15].

2.2.2 Ankle-Branchial Index, Blood Pressure, and Pulse Pressure

Ankle-brachial index (ABI), blood pressure, and pulse pressure were measured with a Microlife Watch BP Office Central device. The women were asked not to eat or drink for 10 hours before examination, avoid tobacco for 4 hours, alcohol for 24 hours and heavy exercise during the preceding day prior to examination. Each woman sat on a chair and rested for 5 minutes before the examination. First, blood pressure was measured twice in both arms as a screening measure, and central blood pressure was measured from the arm that produced higher blood pressure values.

Thereafter, the ABI measurement was performed in the supine position, first on the right arm and ankle concurrently, and then on the left side. The ABI was calculated by dividing the ankle blood pressure by the brachial blood pressure. In addition, pulse pressure was calculated as the difference between systolic and diastolic blood pressure. Left-side ABI, blood pressure, and pulse pressure were used for the analyses in this study. A high ABI value indicated good peripheral arterial function, and an ABI value below 0.90 was considered a marker for peripheral arterial disease [16]. In Finland, the suggested upper limits for normal blood pressure are 140 mmHg for systolic pressure and 90 mmHg for diastolic pressure [17]. Sixty mmHg is considered the upper limit of normal pulse pressure [18].

2.3 Evaluation of Sexual Function

Sexual function was assessed using the FSFI questionnaire [19], which is suitable for use with both sexually active and non-active women. The questionnaire evaluates sexual function over the preceding four weeks and includes 19 questions across 6 subdomains: desire (two questions), arousal (four questions), lubrication (four questions), orgasm (three questions), satisfaction (three questions), and pain (three questions). Sexual function is evaluated based on the FSFI sub-scores and total scores. Desire and satisfaction have a minimum score of 1, indicating "low desire" and "dissatisfaction." Arousal, lubrication, orgasm, and pain have a minimum score of 0, indicating "no sexual activity." Six is the maximum sub-score for each subdomain. The total scores range from 2 to 36, with a higher score indicating better sexual function. A total score ≤ 26 is considered the cutoff for FSD [19,20].

2.4. Confounding factors

Relationship happiness (happy/fairly happy/neither happy or unhappy/fairly unhappy/unhappy) was evaluated using a questionnaire and dichotomized as happy/unhappy. Those who reported being neither happy nor unhappy were classified as "unhappy." The use of menopausal hormone therapy

(MHT, yes/no) or lubricants (yes/no) was evaluated using a questionnaire and combined for the analyses. Smoking (nonsmokers [never or former]/current smokers) and alcohol consumption (beer, wine, and/or spirits, with excessive use defined as > 16 drinks per week [21]) were self-reported. Body mass index (BMI, kg/m^2) was calculated from the measured weight and height. Depressive symptoms were evaluated using the Beck Depression Inventory (BDI) [22]. Women self-reported any CVDs or symptoms (hypertension, myocardial infarct, stroke, claudication, etc.) previously diagnosed by a physician.

2.5. Statistical Analyses

After validation of the database, the data were transferred to JMP® Pro for Mac version 16.2.0 (SAS Institute, Cary, NC, USA) for statistical analyses. The characteristics of the study participants are presented as means and standard deviations (SD) for the continuous variables and as percentages (number, n) for the categorical variables. Because of the skewed distributions, the FSFI totals, and sub-scores are reported as medians and lower (Q1) and upper (Q3) quartiles. For all tests, the significance level was p=0.05.

The FSFI sub-score was calculated for each question that had a relevant answer, and missing values were substituted with the mean value for that question across all participants. The total scores were calculated for all questionnaires that had at least three subdomain questions partly or completely answered.

The associations between PWV, ABI, blood pressure, pulse pressure, FSFI total, and sub-scores were evaluated with separate multivariable linear regression models. Relationship happiness, MHT, smoking, alcohol use, BMI, and depressive symptoms were used as confounding factors in the analyses. FSFI score, PWV, ABI, blood pressure, pulse pressure, BDI score, and BMI were included in the models as continuous variables, whereas the rest of the confounding factors (relationship happiness, MHT, smoking, and alcohol use) were included as categorical variables.

Due to the large number of comparisons (7), we applied Bonferroni correction leading to a significance p-value of 0.007.

To examine selection bias, the basic characteristics and self-reported cardiovascular diseases and symptoms of the current study population (n=117) were compared with the FIREA clinical sub-study population (n=241) and female survey participants (n=5,263).

3. Results

The characteristics of the study population are shown in Table 1. The mean age was 62.3 years (1.0), and 82.9% reported being in a "fairly happy" or "very happy" relationship. The women were relatively healthy, with 17.4% diagnosed with hypertension and only 4.7% diagnosed with CVD. Compared to the FIREA survey and clinical sub-study female participants, the current study participants reported less often hypertension, they were more often married or cohabiting, and had higher occupational positions (Supplementary Table 1).

Table 2 shows the FSFI totals and sub-scores. The median total score was 25.9 points (Q1=19.4, Q3=30.7). Based on a cut-off threshold of ≤ 26 for FSD, 49.6% of the participants had FSD. Regarding the FSFI sub-scores, the lowest median score was 2.4 (Q1=1.8, Q3=3.0) for desire, followed by 4.1 (Q1=2.4, Q3=5.0) for arousal. The highest median score, 5.6 (Q1=3.6, Q3=6.0), was for pain, meaning that only a few women experienced pain during sexual activity.

3.1. Relationship between Arterial Health and Sexual Function

The median PWV was 7.97 m/s (SD=1.41). Of all the women, 89.0% had normal (<10 m/s) PVW. Table 3 shows the results of the multivariable regression analyses. No association was found between PWV and FSFI totals or sub-scores.

The median ABI was 1.23 (SD=0.13). ABI values were normal (ABI >0.9) in 96.4% of women. A higher ABI was associated with a higher satisfaction sub-score (β=2.135, SE=0.831, p=0.012). After Bonferroni correction the association vanished.

The mean systolic blood pressure was 137.6 mmHg (SD=19.1) and the mean diastolic blood pressure was 82.5 mmHg (SD 10.4). Of all the women, 26.5% had both elevated systolic blood pressure (≥140 mmHg) and elevated diastolic blood pressure (≥90 mmHg). Higher diastolic blood pressure was associated with higher desire (β=0.020, SE=0.007, p=0.008), arousal (β=0.037, SE=0.017, p=0.034), satisfaction (β=0.025, SE=0.011, p=0.026), and pain (β=0.050, SE=0.021, p=0.018) sub-scores and with a higher total score (β=0.213, SE=0.084, p=0.013). Furthermore, a borderline association was found between higher diastolic pressure and a higher lubrication sub-score (β=0.035, SE=0.019, p=0.066). After Bonferroni corrections the association between higher diastolic blood pressure and higher satisfaction sub-score remained as tendency, but the other p-values did not reach the statistical significance. No association was observed between systolic blood pressure and FSFI totals or sub-scores.

The median pulse pressure was 55.0 mmHg (13.7), and 26.5% of the women had increased pulse pressure (> 60 mmHg), which was associated with a lower orgasm score (β=0.031, SE=0.015, p=0.037). After Bonferroni correction associations vanished.

4. Discussion

In this study, we aimed to examine the associations between arterial health and sexual function in late-middle-aged women. We found that women with higher diastolic blood pressure had higher total FSFI scores, as well as from sub-scores higher desire, arousal, satisfaction, and pain. Even though these findings remained only as tendencies after statistical corrections they imply the importance of higher diastolic blood pressure for good female sexual function.

Women with higher ABI values had greater sexual satisfaction. However, this finding was sporadic and therefore most likely to be by change. Previous literature regarding the relationship between peripheral arterial health and FSD remains limited, but a Croatian case–control study with 92 participants, of which 34 were women, found that patients with FSD had lower ABI values than patients without FSD [11]. Despite the differences in the study designs our results were partly parallel with their results, yet our results were sole and thus should be confirmed.

A novel finding of our study was that higher diastolic blood pressure was associated with better sexual function. Of the FSFI sub-scores, higher diastolic blood pressure was associated with higher desire, arousal, satisfaction, as well as less pain and easier lubrication during sexual activity. The associations weakened after statistical corrections but remained still coherent. Previous literature has focused on exploring the associations between hypertension and FSD [13] but has not investigated the association between diastolic blood pressure and FSD. The mechanism behind this connection is unknown, but age-related decreases in diastolic blood pressure could offer an explanation. Beyond 50–60 years of age, diastolic pressure starts to decrease, despite systolic blood pressure continuing to increase, due to stiffening of the larger arteries [23]. A decrease in diastolic pressure may decrease peripheral tissue perfusion and lead to tissue hypoxia [24]. Vaginal engorgement and clitoral erection are thought to depend on genital blood flow [3,4]. Thus, deteriorating tissue perfusion could negatively affect sexual function and explain the positive association between higher diastolic pressure and sexual function.

In contrast to diastolic blood pressure, we found no association between systolic blood pressure and FSD. To best of our knowledge only two studies have considered systolic blood pressure and FSD [25]. In a cross-sectional study conducted in the United States with 635 postmenopausal women with hypertension, systolic blood pressure was not associated with FSFI total scores [25]. However, only 28.8% of the women in that study were sexually active. Another study was a Greek case-cohort study involving 417 young and middle-aged hypertensive (> 140/90mmHg) and normotensive women, which found that higher systolic blood pressure strongly correlated with worse sexual function based on FSFI scores [7]. The different results of the Greek study and our study may be due to the different study designs and differences in the study samples. The Greek study included 136 women treated for hypertension whose FSFI scores were low compared to those of both untreated hypertensive and normotensive women. Furthermore, the women using antihypertensive medication had the highest mean systolic blood pressure among the three groups. The authors suggested that inadequate control of hypertension and the use of beta-blockers were major determinants of FSD. In our study, most of the women were normotensive according to both the self-report and the actual blood pressure measurements.

The present study is the first to investigate the relationship between pulse pressure and FSD. Lower pulse pressure was associated with better ability to reach an orgasm during sexual activity. As discussed previously, with aging systolic blood pressure continues to increase, but diastolic blood pressure decreases [23] and therefore pulse pressure rises. High systolic pressure can lead to endothelial dysfunction, which reduces the bioactivity of nitric oxide [26,27]—an important factor in the regulation of genital tissue blood flow and genital arousal responses [28]. A decrease in diastolic pressure can reduce peripheral tissue perfusion[24]. Both mechanisms could explain the negative association between pulse pressure and sexual function. However, our finding could also be by chance finding since the association vanished after statistical corrections.

We could not confirm an association between the central arterial stiffness measured by PWV and FSD. So far only one prior study has investigated that association—the previously-mentioned Croatian case–control study on end-stage renal disease patients undergoing chronic hemodialysis [11]. PWV was found to be higher in patients with FSD compared to the non-FSD group [11]. In our study, almost all the women had normal PWV, and only a few reported CVD other than hypertension, whereas in the Croatian study, participants had end-stage renal disease, which has an at least partly vascular etiology [29]. In addition, different study designs and population sizes could explain the different results.

The strengths of our study include the use of a valid and widely used sexual function questionnaire [19,20]. This made it easier to compare our study outcomes with previously published data. Moreover, arterial health was measured using a variety of parameters that reflected both central and peripheral arterial health. Our study is the first to evaluate the relationship between arterial health and FSD in relatively healthy late-middle-aged women.

Our study has some limitations. First, our study sample was quite small, and the study cross-sectional; therefore, the causality between arterial health and sexual function could not be determined, and future follow-up studies with larger sample size are warranted. Second, majority of the women in our study had good cardiovascular health which can partly explain why associations found between arterial health parameters and sexual function were limited. Regarding the FSFI questionnaire, some participants left some questions unanswered. It is possible that those women could have had worse sexual function or no sexual activity or could have felt the issue too personal to discuss. It is plausible that conservative attitudes toward sexuality could be associated with greater FSD [30].

5. Conclusion

Despite the high prevalence of FSD, its etiology in women is poorly understood and recognized. According to our findings, statistically significant associations between arterial health and sexual function was not detected, but higher diastolic blood pressure and better sexual function tended to be associated in late-middle-aged women. However, as the literature of the field is limited, further research is highly essential.

6. Acknowledgments

The authors would like to thank all the participants for taking part in the FIREA study and the FIREA study staff members for their contributions to the data collection.

7. References

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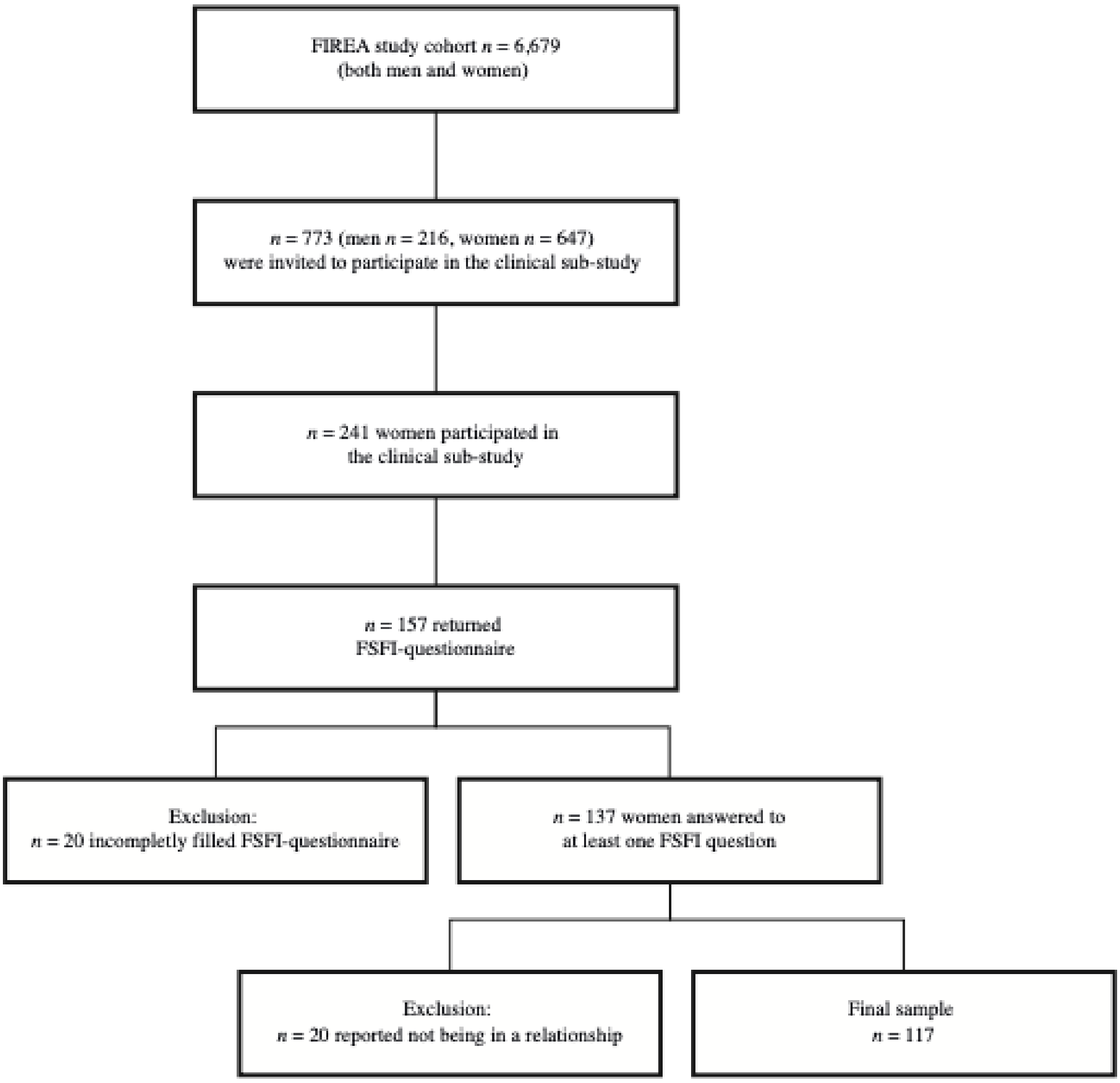
Figure 1. Flowchart of the study



Notes: FIREA Finnish Retirement and Aging Study. FSFI Female Sexual Function Index.

Table 1 Basic Characteristics (n=117).

	n	Mean (SD)	%
Age (years)	115	62.3 (1.0)	
Happy relationship	117		82.9
MHT user	116		29.3
Local estrogen user	116		48.3
Local lubricant user	116		21.6
Smoking	112		4.5
Alcohol risk use	115		9.6
BMI (kg/m^2)	112	25.7 (3.6)	
BDI sum score	115	5.6 (4.6)	
Hypertension	109		17.4
CVD	107		4.7
PWV (m/s)	109	7.97 (1.41)	
ABI	112	1.23 (0.13)	
Systolic Blood Pressure (mmHg)	113	137.6 (19.1)	
Diastolic Blood Pressure (mmHg)	113	82.5 (10.4)	
Pulse Pressure (mmHg)	113	55.0 (13.7)	

Notes: MHT Menopausal hormone therapy; BMI Body mass index; BDI Beck's Depression Inventory; CVD Cardiovascular disease; PWV Pulse wave velocity; ABI Ankle-brachial index

Table 2 FSFI scores in the study population (n=117).

FSFI score	n	Median (Q1, Q3)
Desire	116	2.4 (1.8, 3.0)
Arousal	116	4.1 (2.4, 5.0)
Lubrication	116	4.8 (3.3, 5.7)
Orgasm	116	4.4 (2.4, 5.6)
Satisfaction	111	4.8 (4.0, 6.0)
Pain	115	5.6 (3.6, 6.0)
Total	115	25.9 (19.4, 30.7)

Notes: FSFI Female Sexual Function Index

Table 3 Associations between arterial health and sexual function (n=117).

	PWV			ABI			Systolic Blood Pressure			Diastolic Blood Pressure			Pulse Pressure		
	n	β	p	n	β	p	n	β	p	n	β	p	n	β	p
Desire	102	0.040	0.518	106	0.788	0.178	106	0.006	0.159	106	0.020	0.008	106	-0.001	0.870
Arousal	102	0.141	0.324	106	1.815	0.179	106	0.001	0.912	106	0.037	0.034	106	-0.021	0.128
Lubrication	103	0.018	0.905	106	2.424	0.097	107	-0.001	0.952	107	0.035	0.066	107	-0.023	0.127
Orgasm	103	0.101	0.495	106	1.057	0.478	107	-0.006	0.572	107	0.032	0.099	107	-0.031	0.037
Satisfaction	99	0.047	0.627	103	2.135	0.012	103	0.006	0.377	103	0.025	0.026	103	-0.005	0.592
Pain	102	-0.003	0.986	106	2.257	0.161	106	0.008	0.526	106	0.050	0.018	106	-0.017	0.317
Total	102	0.532	0.452	106	10.096	0.126	106	0.019	0.709	106	0.213	0.013	106	-0.099	0.148

Notes: PWV pulse wave velocity; ABI ankle-brachial index; Adjusted with relationship happiness, MHT (Menopausal hormone treatment), smoking, alcohol risk use, BMI (Body mass index) and depressive symptoms; Bonferroni correction for multiple testing, statistical significance level p=0.007

Supplementary Table 1 Comparison between the study population and the FIREA clinical substudy.

	Study population (n=117)	FIREA clinical substudy female participants (n=241)	FIREA survey cohort female participants (n=5263)
Age (years), mean (SD)	62.3 (1.0)	62.4 (1.0)	62.8 (1.7)
Married or cohabiting, %	81.7	68.2	68.8
Occupational status, %			
High	36.5	32.4	27.3
Intermediate	38.3	36.9	31.7
Low	25.2	30.7	41.0
Smoking, %	3.8	3.8	10.7
Alcohol risk use, %	8.1	9.5	8.3
Hypertension, %	17.4	23.9	38.5
Body mass index (kg/m^2), mean (SD)	25.7 (3.6)	26.1 (4.7)	26.8 (4.7)*
Pulse wave velocity (m/s), mean (SD)	7.97 (1.41)	7.8 (1.3)	NA
Ankle Brachial Index, mean (SD)	1.23 (0.13)	1.25 (0.15)	NA
Systolic blood pressure (mmHg), mean (SD)	137.6 (19.1)	137.0 (18.4)	NA
Pulse pressure (mmHg), mean (SD)	55.0 (13.7)	54.8 (13.5)	NA

Notes: * Based on self-reported body weight and height.