Ethnic differences in vascular function and factors contributing to blood pressure

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Abstract

Objective Indigenous populations experience greater proportions of cardiovascular disease, diabetes, and obesity, though lower rates of hypertension. This investigation evaluated blood pressure relationships with vascular measures, anthropometry, cultural identity, and smoking status among Canadian Indigenous and European adults.

Methods In 2013, in Vancouver, Canada, blood pressure, anthropometry, cultural identity, smoking status, pulse wave velocity (PWV), arterial compliance, baroreceptor sensitivity, and intima-media thickness (IMT) were directly measured among 58 Indigenous (39 ± 18 years, 31 female) and 58 age- and sex-matched European Canadian (42 ± 18 years) adults. Systolic (SBP) and diastolic (DBP) blood pressures were related to vascular measures, and hypertension was related to anthropometry, cultural identity, and smoking status.

Results Similar vascular measures were recorded between Indigenous and European adults, respectively (PWV 5.3 ± 2.4 vs. 6.2 ± 3.4 m s⁻¹, $p = 0.12$; IMT 0.59 ± 0.11 vs. 0.61 ± 0.11 mm, $p = 0.40$; and large arterial compliance 16.1 ± 6.4 vs. 17.5 ± 6.6 mL mmHg⁻¹ $\times 10$, $p = 0.26$). Similar relationships between vascular measures with SBP and DBP were identified between Indigenous and European adults (spectral baroreceptor sensitivity and SBP, $r = 0.48$, $p = 0.001$ vs. $r = -0.11$, $p = 0.44$; ethnic difference $p = 0.38$; PWV; and DBP, $r = 0.23$, $p = 0.09$ vs. $r = 0.06$, $p = 0.65$, ethnic difference $p = 0.23$). Anthropometry only related to blood pressures among Europeans. Cultural identity only related to blood pressures among Indigenous populations. Smoking was not related to hypertension.

Conclusion Similar vascular measures between Indigenous and European Canadians were identified among populations experiencing similar social determinants of health.

Résumé

Objectif Les populations autochtones sont proportionnellement plus touchées par les maladies cardiovasculaires, le diabète et l'obésité, mais leurs taux d'hypertension artérielle sont plus faibles. Nous avons évalué les relations entre la pression artérielle et les indicateurs vasculaires, l'anthropométrie, l'identité culturelle et l'usage du tabac chez des Canadiens adultes autochtones et d'origine européenne.

Méthode En 2013 à Vancouver, au Canada, nous avons obtenu à partir de mesures concrètes la pression artérielle, l'anthropométrie, l'identité culturelle, l'usage ou non du tabac, la vitesse de l'onde pulsatile (VOP), la compliance artérielle, la sensibilité des barorécepteurs et l'épaisseur de l'intima-média (ÉIM) pour 58 Canadiens adultes autochtones (39 ± 18 ans, 31

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femmes) et 58 Canadiens adultes d'origine européenne (42 ± 18 ans) assortis par âge et par sexe. La pression systolique (PS) et la pression diastolique (PD) ont été liées aux indicateurs vasculaires, et l'hypertension artérielle a été liée à l'anthropométrie, à l'identité culturelle et à l'usage du tabac.

Résultats Des indicateurs vasculaires semblables ont été enregistrés entre les adultes autochtones et d'origine européenne, respectivement (VOP $5,3 \pm 2,4$ c. $6,2 \pm 3,4$ m s^{-1} , $p = 0,12$; ÉIM $0,59 \pm 0,11$ c. $0,61 \pm 0,11$ mm, $p = 0,40$; compliance des grosses artères $16,1 \pm 6,4$ c. $17,5 \pm 6,6$ $\text{mL mmHg}^{-1} \times 10$, $p = 0,26$). Des relations semblables entre les indicateurs vasculaires et la PS et la PD ont été observées entre les adultes autochtones et d'origine européenne (sensibilité spectrale des barorécepteurs et PS $r = 0,48$, $p = 0,001$ c. $r = -0,11$, $p = 0,44$; différence ethnique $p = 0,38$; VOP; et PD $r = 0,23$, $p = 0,09$ c. $r = 0,06$, $p = 0,65$, différence ethnique $p = 0,23$). L'anthropométrie n'était liée à la pression artérielle que chez les sujets d'origine européenne. L'identité culturelle n'était liée à la pression artérielle que chez les sujets autochtones. Le tabagisme n'était pas lié à l'hypertension artérielle.

Conclusion Des indicateurs vasculaires semblables ont été observés entre des Canadiens autochtones et d'origine européenne dans des populations où les déterminants sociaux de la santé sont semblables.

Keywords First Nations · American Indians · Atherosclerosis · Pulse wave velocity · Intima-media thickness · Hypertension

Mots-clés Premières Nations · Indiens d'Amérique Nord · Athérosclérose · Vitesse de l'onde pulsatile · Épaisseur de l'intima-média · Hypertension artérielle

Introduction

Hypertension affects significant proportions of Western society, estimated at 24.8% of adults, and strongly predicts cardiovascular disease (CVD) (World Health Organization 2012; Labrova et al. 2005). Contributors to hypertension include vascular changes, obesity, and experiences of stress, including racism and stress associated with social determinants of health (Labrova et al. 2005; Reference Values for Arterial Stiffness' Collaboration 2010; Braveheart 1998; Krieger 2014; DeMarco et al. 2014; Reneman and Hoeks 1995; Gomez-Marcos et al. 2010). Subclinical CVD markers of vascular changes include intima-media thickness (IMT), pulse wave velocity (PWV), baroreceptor sensitivity (BRS), and arterial compliance (Labrova et al. 2005; Reference Values for Arterial Stiffness' Collaboration 2010; Reneman and Hoeks 1995; Gomez-Marcos et al. 2010). Obese individuals experience greater blood pressures and rates of hypertension through hormonal, neurovascular, and dietary factors (DeMarco et al. 2014). Individuals who experience stress, including racism and stress associated with social determinants of health, experience elevated blood pressures and hypertension rates (Braveheart 1998; Krieger 2014). Vascular measures may provide a more accurate indication of CVD development and progression beyond blood pressure (Labrova et al. 2005; Reference Values for Arterial Stiffness' Collaboration 2010; Reneman and Hoeks 1995; Gomez-Marcos et al. 2010).

Cardiovascular disease disproportionately affects Indigenous populations in North America (Foulds et al. 2012a). Conversely, we identified Indigenous populations experiencing lower hypertension rates than non-Indigenous populations (Foulds and Warburton 2014). Indigenous Canadians also experience greater burdens of social

determinants of health and racism (Rotenberg 2016; Dyck et al. 2015). Few comparisons of vascular measures among ethnic groups including Indigenous populations have been conducted to date, none evaluating PWV, BRS, or arterial compliance among Indigenous adults (Anand et al. 2001; Zhang et al. 2013). Measures of vascular structure and function may provide more accurate indications of CVD progression among Indigenous populations. The conflicting experiences of higher CVD rates with lower hypertension rates may be influenced by vascular measures, obesity, and social and cultural determinants.

This investigation evaluates blood pressure relationships with vascular and socio-cultural measures among Indigenous and European adults in British Columbia, Canada. The primary objective compared vascular measures across both ethnicities. The secondary objective evaluated the relationships of vascular measures with systolic (SBP) and diastolic (DBP) blood pressures. We hypothesized an interaction between vascular measures with SBP and DBP would be identified. Our hypothesis anticipated Indigenous adults would demonstrate weaker relationships between vascular measures with SBP and DBP among adults with low blood pressures and stronger relationships among adults with higher blood pressures. This interaction was hypothesized as individuals with lower burdens of social determinants of health, racism, and obesity may experience lower blood pressure with lower CVD progression, while the accumulation of contributing factors would drive a stronger relationship between blood pressure and vascular measures as CVD progression is experienced. The third objective evaluated vascular measures by smoking status among Indigenous adults. The fourth objective evaluated determinants of hypertension between ethnic groups, including body composition, cultural identity, and smoking status, to

identify significant contributors to hypertension among Indigenous adults.

Methods

Fifty-eight Indigenous adults, and 58 age- and sex-matched European adults, ≥ 19 years (19–91 years), from four communities around British Columbia volunteered to participate in this investigation and underwent a vascular assessment. In addition to University ethical approval, each Indigenous community reviewed and approved the project prior to participation of members of their respective communities. Testing was conducted within the local Indigenous communities with the assistance of Indigenous students and volunteers. Indigenous Experimental Medicine and Kinesiology student researchers conducted data collection and data analyses. Indigenous community volunteers coordinated participant recruitment and testing schedules. Both Indigenous and European participants were recruited from the same communities through the same Indigenous community members.

Individual characteristics collected included age, sex, education, income, employment and self-reported smoking, drinking, physical activity, diabetes, hypertension, or other chronic conditions. Participants self-declared ethnicity, with First Nations and Métis participants classified as Indigenous, with no minimum status requirements. Ethnic identity, ethnic affinity, and cultural identity were evaluated using the Multigroup Ethnic Identity Measure questionnaire (Phinney 1992), with higher scores representing greater connections to ethnic identity and cultural affirmation. Physical activity categories and scores were determined using the Godin-Shephard Leisure Exercise Questionnaire (Godin and Shephard 1985). Anthropometric height, body mass, body mass index (BMI), and waist circumference were assessed (Foulds et al. 2016). World Health Organization principle definitions for obesity and abdominal obesity were used (World Health Organization 2000; James et al. 2001).

Resting seated blood pressure was measured following 5 min of seated rest using three automated measurements, 1 min apart, with averaged second and third measures (BP-TRU, VSM Medical, Vancouver, Canada) (Foulds et al. 2016). Hypertension was defined as using anti-hypertension medication or average measurements of ≥ 140 mmHg systolic or ≥ 90 mmHg diastolic (Williams et al. 2004).

Supine vascular assessments of vascular measures followed 5 minutes of supine rest. Measures of arterial compliance, autonomic function, PWV, and IMT were obtained using identical protocols to previous investigations in our laboratory (Foulds et al. 2016). Measures of arterial compliance

determine both large arterial capacitance vessel compliance and small oscillatory vessel compliance through diastolic pulse contour analysis with a modified Windkessel model. Autonomic function, both spectral and sequence analysis, was evaluated from a minimum 5 min of beat-by-beat blood pressure with three lead electrocardiogram (ECG). Central and peripheral PWV were determined from pulse wave contours at the carotid and femoral arteries, averaging 30 consecutive cardiac cycles to calculate the foot-to-foot pulse transit time between carotid and femoral (central PWV), and carotid and finger (peripheral PWV). Intima-media thickness was determined from averages of left and right common carotid artery at three imaging planes (anterior, lateral, and posterior) from five beat averages of the common carotid artery far-wall IMT within 1 cm of the carotid bulb.

Statistical analyses were performed using Statistica 9.0 (Stats Soft, Tulsa, OK). As large arterial compliance was not normally distributed, the natural log transformation was used for analysis. Pearson χ^2 test (categorical) and *t* tests for independent samples (continuous) determined ethnic differences. Comparisons of PWV were performed using ANCOVA adjusting for mean arterial pressure. Regression compared vascular measures across systolic blood pressure (SBP) and diastolic blood pressure (DBP). Ethnic differences in the regression slopes of vascular measures and SBP or DBP were evaluated using multiple regression. Discrete correlates of hypertension rates were compared across correlate and ethnic groups using 2×2 factorial ANOVA. Continuous correlates associated with hypertension status were compared within ethnic groups using regression and between ethnic groups using slope by slope ANCOVA analysis. Significance was set at $p < 0.05$.

Results

Similar ages, education, employment, income, and binge drinking habits were found between groups (Table 1). However, more Indigenous participants were divorced or separated, and smoking was greater among Indigenous participants. Across ethnic groups, similar prevalence of chronic conditions (hypertension, body composition, CVD, and diabetes) and physical fitness (physical activity, grip strength, aerobic fitness) were observed.

Table 2 outlines largely similar vascular measures between ethnicities, including blood pressure, IMT, and arterial compliance. European males demonstrated greater central PWV than Indigenous males, while no differences between females or for peripheral PWV were observed. Average BRS measures were similar among males. However, spectral BRS was greater among Indigenous females.

Similar relationships between vascular measures and SBP were between Indigenous and European adults, with no ethnic differences in these relationships identified. A

Table 1 Characteristics and health measures of participants in Vancouver, Canada, in 2013, by ethnic group mean $\pm$ SD, *n* (%)

	Indigenous (<i>n</i> = 58)	European (<i>n</i> = 58)	<i>P</i> value
Age (years) $\pm$ SD	38.6 $\pm$ 17.9	41.6 $\pm$ 18.3	0.37
Female, <i>n</i> (%)	31 (53.4)	31 (53.4)	1.00
Single, <i>n</i> (%)	22 (37.9)	21 (36.2)	0.85
Married or common-law, <i>n</i> (%)	25 (43.1)	32 (55.2)	0.20
Divorced or separated, <i>n</i> (%)	10 (17.2)	3 (5.2)	0.04
Less than high school education, <i>n</i> (%)	3 (5.2)	0 (0.0)	0.08
Only high school education, <i>n</i> (%)	5 (8.6)	9 (15.5)	0.26
More than high school education, <i>n</i> (%)	50 (86.2)	49 (84.5)	0.80
Unemployed, <i>n</i> (%)	7 (12.1)	6 (10.3)	0.77
Employed, <i>n</i> (%)	47 (81.0)	41 (70.7)	0.20
Retired or homemaker, <i>n</i> (%)	4 (6.9)	11 (19.0)	0.05
Annual income < \$20,000 per year, <i>n</i> (%)	21 (36.2)	15 (25.9)	0.23
Smoker, <i>n</i> (%)	12 (20.7)	1 (1.7)	0.001
Binge drink more than once a month, <i>n</i> (%)	10 (17.2)	7 (12.1)	0.44
Seated pulse rate (beats·min ⁻¹) $\pm$ SD	68.0 $\pm$ 11.4	69.6 $\pm$ 11.7	0.47
Hypertension (reported), <i>n</i> (%)	5 (8.6)	12 (20.7)	0.07
Hypertension (measured), <i>n</i> (%)	8 (13.8)	12 (20.7)	0.33
Use anti-hypertension medication, <i>n</i> (%)	2 (3.4)	6 (10.3)	0.15
Height (cm) $\pm$ SD	171.1 $\pm$ 10.5	171.3 $\pm$ 8.0	0.93
Body mass (kg) $\pm$ SD	82.0 $\pm$ 22.0	79.0 $\pm$ 18.6	0.43
BMI (kg·m ⁻²) $\pm$ SD	27.9 $\pm$ 7.0	27.0 $\pm$ 6.1	0.43
Waist circumference (cm) $\pm$ SD	89.6 $\pm$ 17.5	88.8 $\pm$ 16.0	0.81
CVD, <i>n</i> (%)	0 (0.0)	1 (1.7)	0.32
Family history of CVD ^a , <i>n</i> (%)	5 (8.6)	7 (12.1)	0.55
Diabetes, <i>n</i> (%)	1 (1.7)	3 (5.2)	0.31
Obesity, <i>n</i> (%)	15 (25.9)	13 (22.4)	0.67
Abdominal obesity, <i>n</i> (%)	18 (31.0)	18 (31.0)	1.00
Physically inactive, <i>n</i> (%)	8 (13.8)	6 (10.3)	0.57
Moderately active, <i>n</i> (%)	4 (6.9)	6 (10.3)	0.51
Physically active, <i>n</i> (%)	46 (79.3)	46 (79.3)	1.00

BMI, body mass index; CVD, cardiovascular disease; SD, standard deviation

^a Primary family member prior to age 55 (male) or 65 (female)

significant negative relationship between large arterial compliance and SBP among European adults was identified (Fig. 1a), while a trend towards significance was observed among Indigenous adults. Both European and Indigenous adults demonstrated significant negative relationships of small arterial compliance and SBP (Fig. 1b). Small and large arterial compliance relationships indicated lower arterial compliance was associated with greater SBP among both groups. Only Indigenous adults demonstrated significantly negative relationships of spectral (Fig. 1c) and sequence method (Fig. 1d) BRS and SBP. This relationship identified greater BRS among Indigenous adults with lower SBP and lower BRS among those with higher SBP. Neither group demonstrated relationships between central PWV and SBP (Fig. 1e). Both groups demonstrated significant positive relationships between overall IMT and

SBP (Fig. 1f), where a larger IMT was associated with a greater SBP.

Similar relationships between vascular health measures and DBP were observed between Indigenous and European adults, where no ethnic differences in these relationships were identified. Significant negative relationships were identified among both European and Indigenous adults for large (Fig. 2a) and small (Fig. 2b) arterial compliance with DBP. European and Indigenous adults with greater DBP were found to have lower arterial compliance. Significant relationships between spectral (Fig. 2c) and sequence (Fig. 2d) method BRS and DBP were only observed among Indigenous adults, where a larger DBP was associated with lower BRS values. No significant relationships between BRS and DBP were observed among European adults. European adults did not demonstrate a significant relationship between PWV and DBP

Table 2 Vascular health measures of participants in Vancouver, Canada, in 2013, by ethnic group and sex mean $\pm$ SD

	Male			Female			Overall		
	Indigenous (<i>n</i> = 27)	European (<i>n</i> = 27)	<i>P</i> value	Indigenous (<i>n</i> = 31)	European (<i>n</i> = 31)	<i>P</i> value	Indigenous (<i>n</i> = 58)	European (<i>n</i> = 58)	<i>P</i> value
Systolic blood pressure (mmHg)	122.1 $\pm$ 16.9	121.7 $\pm$ 19.5	0.94	115.5 $\pm$ 16.9	113.2 $\pm$ 21.7	0.64	118.6 $\pm$ 17.1	117.2 $\pm$ 21.0	0.69
Diastolic blood pressure (mmHg)	72.5 $\pm$ 9.4	72.9 $\pm$ 11.9	0.87	71.9 $\pm$ 7.9	69.1 $\pm$ 9.4	0.21	72.2 $\pm$ 8.6	70.9 $\pm$ 10.7	0.48
Overall IMT (mm)	0.61 $\pm$ 0.13	0.61 $\pm$ 0.13	0.99	0.57 $\pm$ 0.08	0.61 $\pm$ 0.10	0.17	0.59 $\pm$ 0.11	0.61 $\pm$ 0.11	0.40
Central PWV (m s ⁻¹)	5.6 $\pm$ 2.5	7.4 $\pm$ 3.6	0.04	5.1 $\pm$ 2.3	5.0 $\pm$ 2.7	0.95	5.3 $\pm$ 2.4	6.2 $\pm$ 3.4	0.12
Peripheral PWV (m s ⁻¹)	11.8 $\pm$ 4.1	13.4 $\pm$ 5.2	0.25	12.3 $\pm$ 3.9	12.5 $\pm$ 4.5	0.83	12.1 $\pm$ 4.0	12.9 $\pm$ 4.8	0.29
Large arterial compliance (mL mmHg ⁻¹ $\times$ 10)	17.7 $\pm$ 6.5	17.6 $\pm$ 6.2	0.95	14.6 $\pm$ 6.0	17.3 $\pm$ 7.0	0.11	16.1 $\pm$ 6.4	17.5 $\pm$ 6.6	0.26
Small arterial compliance (mL mmHg ⁻¹ $\times$ 100)	8.9 $\pm$ 3.7	8.6 $\pm$ 4.1	0.77	6.3 $\pm$ 2.3	7.4 $\pm$ 2.5	0.08	7.5 $\pm$ 3.3	8.0 $\pm$ 3.4	0.49
Spectral BRS (ms mmHg ⁻¹)	10.0 $\pm$ 6.6	12.8 $\pm$ 5.1	0.12	16.1 $\pm$ 9.9	11.2 $\pm$ 5.7	0.03	13.3 $\pm$ 9.0	11.9 $\pm$ 5.4	0.38
Up sequence BRS (ms mmHg ⁻¹)	17.9 $\pm$ 13.2	18.7 $\pm$ 10.0	0.81	21.3 $\pm$ 11.5	21.1 $\pm$ 12.1	0.96	19.5 $\pm$ 12.4	19.9 $\pm$ 11.1	0.46
Down sequence BRS (ms mmHg ⁻¹)	16.0 $\pm$ 8.7	18.2 $\pm$ 9.1	0.41	24.9 $\pm$ 15.7	18.6 $\pm$ 12.1	0.14	20.1 $\pm$ 13.1	18.4 $\pm$ 10.6	0.16
All sequence BRS (ms mmHg ⁻¹)	16.9 $\pm$ 10.5	19.3 $\pm$ 9.5	0.42	23.0 $\pm$ 12.4	19.5 $\pm$ 11.4	0.32	19.9 $\pm$ 11.7	19.4 $\pm$ 10.4	0.85

BRS, baroreceptor sensitivity; IMT, intima-media thickness; PWV, pulse wave velocity; SD, standard deviation

(Fig. 2e), though Indigenous adults demonstrated a trend towards significance with greater PWV possibly associated with greater DBP. Indigenous adults demonstrated a significant positive relationship between IMT and DBP, with individuals with greater DBP having larger IMT measures (Fig. 2f). A trend towards significance was observed for the positive relationship between IMT and DBP among European adults.

Differences in vascular measures and SBP and DBP between Indigenous smokers and non-smokers are outlined in Table 3. Comparisons of vascular measures between European smokers and non-smokers were not performed in order to preserve anonymity of the lone European smoker. Indigenous smokers were of similar age and sex. Lower DBP was recorded among smokers compared to non-smokers. Indigenous smokers were also found to have higher small and large arterial compliance.

Table 4 outlines correlates of hypertension between ethnicities. Education and employment statuses were not associated with hypertension. Physically inactive Indigenous adults had higher rates of hypertension than Indigenous adults who were moderately active or physically active. Obesity and abdominal obesity were only associated with hypertension among Europeans. Age was significantly associated with hypertension for both groups. Waist circumference and BMI were associated with hypertension only among Europeans. Conversely, ethnic identity, ethnic affinity, and cultural identity were significantly associated with hypertension only among Indigenous populations.

Discussion

This investigation uniquely evaluates vascular measures and hypertension among Indigenous and European populations, including an analysis of influencing factors. Participants were recruited through similar methods from the same communities, with similar health status and characteristics. As social determinants of health, including education, income, and employment are known to influence health outcomes, and disproportionately affect Indigenous Canadians, similarities of these determinants between groups facilitate comparisons while minimizing confounding variables (Rotenberg 2016; Dyck et al. 2015). In this investigation, hypertension was only associated with obesity measures and statuses among Europeans. A stronger ethnic identity was associated with lower hypertension rates among Indigenous adults, with no association among European adults. Smoking status was not found to be related to hypertension experiences.

Measures of IMT, PWV, arterial compliance, and BRS in this investigation were generally more favourable than previous reports of generally healthy populations, likely reflecting the generally healthy status of participants (Reference Values for Arterial Stiffness' Collaboration 2010; Fjeldstad et al. 2008; Tank et al. 2000; Roman et al. 2012). We previously associated blood pressures, arterial compliance, IMT, and BRS with age in this Indigenous population (Foulds et al. 2016). Similar relationships between blood pressure and vascular measures were observed between Indigenous and

Fig. 1 Ethnic differences in the relationship between systolic blood pressure and vascular health measures of large arterial compliance (a, $p = 0.60$), small arterial compliance (b, $p = 0.48$), spectral method

baroreceptor sensitivity (c, $p = 0.38$), sequence method baroreceptor sensitivity (d, $p = 0.99$), central pulse wave velocity (e, $p = 0.18$), and intima-media thickness (f, $p = 0.48$)

Fig. 2 Ethnic differences in the relationship between diastolic blood pressure and vascular health measures of large arterial compliance (a, $p = 0.41$), small arterial compliance (b, $p = 0.29$), spectral method

baroreceptor sensitivity (c, $p = 0.50$), sequence method baroreceptor sensitivity (d, $p = 0.86$), central pulse wave velocity (e, $p = 0.23$), and intima-media thickness (f, $p = 0.81$)

Table 3 Vascular health measures of Indigenous participants in Vancouver, Canada, in 2013, by smoking status mean $\pm$ SD

	Smokers ($n = 12$)	Non-smokers ($n = 45$)	<i>P</i> value
Female, n (%)	5 (41.7)	26 (57.8)	0.33
Age (years)	38.7 $\pm$ 14.4	38.8 $\pm$ 18.9	0.98
Systolic blood pressure (mmHg)	113.6 $\pm$ 15.8	120.1 $\pm$ 17.5	0.25
Diastolic blood pressure (mmHg)	67.3 $\pm$ 6.3	73.4 $\pm$ 8.8	0.03
Overall IMT (mm)	0.60 $\pm$ 0.10	0.59 $\pm$ 0.12	0.86
Central PWV ($m\ s^{-1}$)	5.2 $\pm$ 2.1	5.3 $\pm$ 2.5	0.85
Peripheral PWV ($m\ s^{-1}$)	12.5 $\pm$ 3.6	12.0 $\pm$ 4.1	0.74
Large arterial compliance ($mL\ mmHg^{-1} \times 10$)	20.3 $\pm$ 7.4	15.8 $\pm$ 8.2	0.049
Small arterial compliance ($mL\ mmHg^{-1} \times 100$)	9.5 $\pm$ 4.2	7.1 $\pm$ 2.8	0.02
Spectral BRS ($ms\ mmHg^{-1}$)	10.1 $\pm$ 8.9	14.2 $\pm$ 9.0	0.21
Up sequence BRS ($ms\ mmHg^{-1}$)	16.9 $\pm$ 8.9	20.3 $\pm$ 13.4	0.46
Down sequence BRS ($ms\ mmHg^{-1}$)	16.3 $\pm$ 9.1	21.3 $\pm$ 14.0	0.30
All sequence BRS ($ms\ mmHg^{-1}$)	16.8 $\pm$ 8.7	20.7 $\pm$ 12.4	0.36

BRS, baroreceptor sensitivity; IMT, intima-media thickness; PWV, pulse wave velocity; SD, standard deviation

Table 4 Correlates of hypertension rates among Indigenous and European participants in Vancouver, Canada 2013

Correlate	Indigenous			European			<i>P</i> value ^a
	<i>n</i>	Hypertension		<i>n</i>	Hypertension		
		<i>n</i>	%		<i>n</i>	%	
Not obese	43	4	9.3	45	6	13.3	0.56
Obese	15	4	26.7	13	6	46.2	0.30
<i>P</i> value		0.10			0.01		
Not abdominally obese	40	4	10.0	40	4	10.0	1.00
Abdominally obese	18	4	22.2	18	8	44.4	0.17
<i>P</i> value		0.22			0.002		
Moderately active or active	50	5	10.0	52	9	17.3	0.29
Physically inactive	8	3	37.5	6	3	50.0	0.67
<i>P</i> value		0.04			0.06		
More than high school	50	6	12.0	49	9	18.4	0.38
High school or less	8	2	25.0	9	3	33.3	0.73
<i>P</i> value		0.33			0.32		
Employed	47	5	10.6	41	6	14.6	0.58
Not employed	11	3	27.3	17	6	35.3	0.67
<i>P</i> value		0.16			0.08		
	B	SE	<i>P</i> value	B	SE	<i>P</i> value	<i>P</i> value ^a
Age (year)	0.0	0.002	<0.001	0.01	0.0	0.001	<0.001
BMI (kg m ⁻²)	0.0	0.01	0.62	0.04	0.0	<0.001	<0.001
Waist circumference (cm)	0.0	0.003	0.23	0.01	0.0	<0.001	<0.001
Godin physical activity score ^b	—	0.001	0.08	—	0.0	0.06	0.03
Ethnic identity score ^c	—	0.04	0.003	−0.05	0.0	0.51	0.02
Ethnic affinity score ^c	—	0.05	0.02	−0.02	0.0	0.78	0.11
Cultural identity score ^c	—	0.05	0.01	−0.03	0.0	0.65	0.04

BMI, body mass index; SE, standard error; SD, standard deviation

^a Between ethnic groups

^b (Godin and Shephard 1985)

^c (Phinney 1992)

European adults, suggesting blood pressure is appropriately evaluating subclinical CVD among Indigenous populations. The elevated CVD experience among Indigenous adults is likely caused by factors contributing to blood pressure and hypertension, including factors of age, physical inactivity, obesity measures, and cultural identity identified in this investigation (Labrova et al. 2005; Reference Values for Arterial Stiffness' Collaboration 2010; Reneman and Hoeks 1995; Gomez-Marcos et al. 2010; Foulds et al. 2012a). Contributions of age and physical inactivity to experiences of hypertension are expected, as previously reported (HJA et al. 2016; Myers et al. 2015). While this investigation did not identify smoking as a contributing factor to hypertension, possibly due to the small number of smokers evaluated, smoking likely contributes to CVD experiences (Messner and Bernhard 2014).

Blood pressures were similar between Indigenous and European populations. The observed 20.7% hypertension among Europeans in this study is consistent with worldwide estimates (World Health Organization 2012). The Indigenous hypertension rates of 13.8% may be clinically lower and are consistent with previous literature (Foulds and Warburton 2014). The association of obesity and hypertension among Europeans is expected (Foulds et al. 2012b). However, the lack of association between obesity and hypertension among Indigenous participants has previously been reported among American Indians (Howard et al. 1996). This lack of association between obesity and blood pressure among Indigenous adults suggests other factors may more greatly influence blood pressure, and subsequent CVD, among Indigenous populations.

Colonization and differential experiences of stress, including racism, likely influence blood pressures, and subsequent CVD, among Indigenous adults (Rotenberg 2016; Dyck et al. 2015). While this investigation recruited similar populations in terms of income, education, employment, and marital status, inherent differences in experiences and generational impacts of historical traumas such as residential schools exist between these populations (Rotenberg 2016; Dyck et al. 2015; Walters and Simoni 2002). The Indigenist Stress-Coping Model highlights the links between historical trauma, discrimination, and personal life experiences with health risks and experiences (Walters and Simoni 2002). Highlighted in this model, cultural buffers including identity attitudes and enculturation can mediate this relationship, thus influencing health risks and experiences (Walters and Simoni 2002). This Indigenist Stress-Coping Model is supported by our findings through the associations of cultural identity measures with hypertension experiences. Stronger ethnic identity reflects individual's feelings of belonging within their ethnic group, having pride in this identity and having positive attitudes towards their ethnic group, reflecting identity attitudes identified as cultural buffers in this model (Phinney 1992; Walters and Simoni 2002). Similarly, enculturation as a cultural buffer in

this model is supported by associations between our participants' reports of cultural affinity and hypertension experiences (Phinney 1992; Walters and Simoni 2002). Together, our findings and the Indigenist Stress-Coping Model identify cultural connections, cultural affinity, and cultural identity as important determinants of health and significant contributors to subclinical CVD among Indigenous Canadians. These influences of cultural identity add further support for social determinants of health, historical traumas, discrimination, and colonialism as significant contributing factors to elevated rates of CVD among Indigenous Canadians (Rotenberg 2016; Dyck et al. 2015; Walters and Simoni 2002). As such, Indigenous Canadians' continued experiences with colonialism will likely continue to influence rates of CVD and other chronic diseases.

This investigation is limited by the sample size. A larger sample size may have identified significantly lower hypertension or significant relationships between PWV and DBP among Indigenous adults. Because this sample of participants is largely healthy and relatively free of chronic condition, the similarities in vascular health between Indigenous and European adults observed in this investigation may not continue with aging, development of chronic diseases and differences in social determinants of health. As Indigenous populations represent many distinct nations with their own history, culture, and background, results from one nation may not reflect the experiences of another nation (Waldrum et al. 2006). As Indigenous populations experience greater burdens of CVD, diabetes, and obesity, with concurrent lower hypertension rates, understanding contributing factors to hypertension and subclinical CVD, including important cultural identity and socio-cultural factors, is important for addressing health inequalities (Foulds et al. 2012a; Foulds and Warburton 2014; Foulds et al. 2011). Further investigation is required to more fully examine the association of subclinical CVD and blood pressure among Indigenous populations and better understand the contribution of racism, historical trauma, cultural connections, and cultural identity with hypertension and CVD experiences.

Conclusions

Indigenous and European adults of similar age, sex, demographics, and health status experience similar vascular health status. Cultural identity was identified as a significant positive determinant of health among Indigenous participants, while obesity was identified as a contributing factor to hypertension only among European adults. Vascular measures appear to appropriately evaluate CVD risks among Indigenous populations, while contributing factors such as cultural identity likely play an important role in the development of CVD among Indigenous peoples. Further investigation on the impact of

cultural identity and cultural engagement on the experience and development of CVD for Indigenous peoples should be enacted. Interventions to enhance cultural engagement as part of a CVD prevention and treatment strategy should be investigated.

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Compliance with ethical standards

Ethics approval was obtained through the Clinical Research Ethics Board at the University of British Columbia and written informed consent was obtained from each participant prior to data collection.

Conflict of interest The authors declare that they have no conflict of interest.

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