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Ethnic differences in circulating soluble adhesion molecules: the Wandsworth Heart and Stroke Study

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ABSTRACT

The aim of this study was to investigate whether soluble adhesion molecule levels differ by ethnic group. Soluble plasma adhesion molecules [soluble P-selectin (sP-selectin), soluble E-selectin (sE-selectin), soluble intercellular adhesion molecule-1 (sICAM-1) and soluble vascular cell adhesion molecule-1 (sVCAM-1)] were measured in 261 white (120 females), 188 African origin (99 females) and 215 South Asian (99 females) individuals living in England. All were free from coronary heart disease, stroke and other cardiovascular disease, diabetes, drug therapy for hypertension or high lipids, hormone-replacement therapy or oral contraceptive pill. The results of the study indicated that there were important differences in the levels of adhesion molecules by sex and smoking. However, when adjusting for these and other potential confounders, there were no differences in levels between white subjects and individuals of South Asian origin. In contrast, people of African origin had significantly lower levels of sICAM-1 [Caribbean −30% (−36 to −23%); West African −22% (−29 to −15%), values are means (95% confidence intervals)], sVCAM-1 [Caribbean −14% (−19 to −8%); West African −10% (−17 to −3%)] and sP-selectin [Caribbean −10% (−17 to −2%); West African −24% (−31 to −16%)] than white individuals. In conclusion, circulating levels of some soluble adhesion molecules are lower in individuals of Caribbean or West African origin compared with white or South Asian individuals. These relationships may contribute to the low risk of coronary heart disease seen in people of African origin living in England.

INTRODUCTION

Coronary heart disease (CHD) varies widely between different ethnic groups [1]. In particular, individuals of African origin, both in Africa and when migrated to the Caribbean or to Europe, have much lower incidence of CHD [2]. This difference in risk cannot be attributed to ethnic differences in known CHD risk factors, such as serum lipid levels [3] or diabetes [4–5]. Thus ethnic differences in these and other risk factors for CHD, such as hypertension and smoking, only partially explain the known ethnic differences in CHD risk.

The formation of an atheromatous lesion and development of CHD can result from the activation of the cellular adhesion molecule pathway and expression of adhesion molecules [6]. Soluble adhesion molecules, which lack cytoplasmic and membrane spanning domains, are present in the circulation [7]. The origin,

Key words: atherosclerosis, cell adhesion molecules, cardiovascular disease, coronary disease, ethnicity.

Abbreviations: ARIC, Atherosclerosis Risk in Communities; BMI, body mass index; BP, blood pressure; CAA, carotid artery atherosclerosis; CHD, coronary heart disease; CI, confidence intervals; HDL, high-density lipoprotein; sICAM-1, soluble intercellular adhesion molecule-1; sVCAM-1, soluble vascular cell adhesion molecule-1; WHSS, Wandsworth Heart and Stroke Study.

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Table 1 Age- and sex-adjusted characteristics of 664 men and women aged 40–59 years of different ethnic groups living in Wandsworth, South London between 1994 and 1996

Values are means or percentages (95% C.I). *P* values are for test of heterogeneity between ethnic groups by analysis of co-variance or χ-*square* statistics. Social class of the head of household (see [3]): IV and V, semi-skilled and unskilled manual; IIINM + M, clerical and skilled manual; I + II, professional and managerial. There were no more than two values missing from any cell. *Geometric means.

	White origin ($n = 261$)	South Asian origin ($n = 215$)	African origin ($n = 188$)	*P* value
BMI (kg/m^2)	25.7 (25.2 to 26.2)	25.5 (24.9 to 26.1)	27.3 (26.7 to 27.9)	<0.001
Waist/hip ratio	0.855 (0.847 to 0.863)	0.880 (0.872 to 0.889)	0.865 (0.855 to 0.874)	<0.001
Smoking:				<0.001
Current (%)	29 (24 to 35)	16 (11 to 21)	15 (10 to 21)	
Ex-smoker (%)	37 (31 to 43)	7 (4 to 10)	13 (8 to 17)	
Never smoked (%)	33 (27 to 39)	77 (71 to 83)	72 (66 to 78)	
Social Class:				<0.001
IV and V (%)	17 (13 to 22)	16 (11 to 21)	30 (23 to 36)	
IIINM + M (%)	46 (40 to 52)	39 (32 to 45)	47 (40 to 55)	
I and II (%)	37 (34 to 43)	46 (39 to 52)	23 (17 to 29)	
Systolic BP (mmHg)	123.4 (121.3 to 125.6)	125.8 (123.5 to 128.2)	127.1 (124.6 to 129.6)	0.081
Diastolic BP (mmHg)	78.8 (77.6 to 80.0)	81.6 (80.3 to 83.0)	83.0 (81.6 to 84.4)	<0.001
Total cholesterol (mmol/l)	6.2 (6.0 to 6.3)	5.7 (5.6 to 5.9)	5.5 (5.3 to 5.6)	<0.001
HDL cholesterol (mmol/l)	1.43 (1.38 to 1.47)	1.21 (1.16 to 1.25)	1.49 (1.43 to 1.54)	<0.001
Serum triacylglycerol (mmol/l)*	1.10 (1.04 to 1.16)	1.33 (1.26 to 1.42)	0.77 (0.73 to 0.83)	<0.001
Serum glucose (mmol/l)	5.01 (4.95 to 5.09)	5.07 (5.00 to 5.15)	4.94 (4.86 to 5.02)	0.052
Serum insulin (munits/l)*	6.8 (6.4 to 7.3)	10.4 (9.6 to 11.3)	7.8 (7.2 to 8.5)	<0.001
Plasma homocysteine (μmol/l)*	10.0 (9.7 to 10.4)	11.6 (11.1 to 12.1)	9.4 (9.0 to 9.8)	<0.001
Soluble adhesion molecule levels				
sICAM-1 (ng/ml)*	274 (263 to 286)	267 (255 to 280)	189 (180 to 199)	<0.001
sVCAM-1 (ng/ml)*	432 (418 to 446)	439 (424 to 455)	386 (372 to 401)	<0.001
sE-selectin (ng/ml)*	45.4 (43.9 to 47.8)	46.5 (43.9 to 49.2)	46.4 (43.8 to 49.3)	0.790
sP-selectin (ng/ml)*	72 (69 to 75)	72 (68 to 75)	57 (55 to 61)	<0.001

metabolism and function of these molecules is unclear, but their levels in serum or plasma can be readily determined, and one study [8] has demonstrated that soluble adhesion molecule levels correlate with their expression on endothelial cells. Hence a number of studies [9–13] have measured the level of soluble adhesion molecules as an indication of adhesion molecule expression and have demonstrated that the levels are associated with CHD and atherosclerosis. Interestingly, high-density lipoprotein (HDL)-cholesterol inhibits cytokine-induced expression of endothelial cell adhesion molecules [14]. Studies have shown that associations between serum triacylglycerols (triglycerides) and soluble adhesion molecule levels are adhesion-molecule-specific [12,10,15]. Furthermore, although Blankenberg et al. [10] and Hwang et al. [12] failed to show an association between soluble intercellular cell adhesion molecule-1 (sICAM-1) and serum triacylglycerols, other studies [16,17] have shown that individuals with hypertriglyceridaemia have higher levels of sICAM-1 and soluble vascular cellular adhesion molecule-1 (sVCAM-1). Although the evidence is not clear-cut, it is nevertheless possible that ethnic differences in serum lipid levels may influence the cellular adhesion pathways and provide a potential mechanism for the ethnic difference in CHD risk. The purpose of this study was to investigate (i) whether there are ethnic differences in plasma soluble adhesion molecule levels, and (ii) whether any differences between ethnic groups can be explained by associations with other cardiovascular risk factors.

MATERIALS AND METHODS

Subjects

The Wandsworth Heart and Stroke Study (WHSS) population of 1577 individuals comprises approximately equal numbers of white, black African (West African and Caribbean) and South Asian individuals (40–59 years), recruited from the lists of general practices in South London [3,4]. A list of the WHSS Group is given elsewhere [3]. For the present study, individuals were selected if they did not have diabetes, were not on hypertension or lipid-lowering medication, and were not taking the oral contraceptive pill or hormone-replacement therapy. Subjects were selected who did

Table 2 **Age-adjusted soluble adhesion molecule levels in different ethnic groups**

Values are geometric means (95 % CI). *P* values are for test of heterogeneity between different sex groups by analysis of co-variance.

	White origin			South Asian origin			African origin		
Adhesion molecule	Male ($n = 120$)	Female ($n = 141$)	*P* value	Male ($n = 99$)	Female ($n = 116$)	*P* value	Male ($n = 99$)	Female ($n = 89$)	*P* value
sICAM-1 (ng/ml)	284 (273 to 294)	265 (254 to 276)	0.014	274 (262 to 288)	259 (245 to 273)	0.10	202 (181 to 225)	179 (161 to 198)	0.11
sVCAM-1 ng/ml)	424 (407 to 442)	440 (421 to 459)	0.239	435 (412 to 458)	434 (410 to 459)	0.97	382 (362 to 403)	399 (379 to 419)	0.26
sE-selectin (ng/ml)	50.2 (46.8 to 53.8)	41.1 (38.1 to 44.3)	<0.001	52.0 (48.4 to 55.8)	41.4 (38.4 to 44.7)	<0.001	48.7 (44.3 to 53.4)	44.2 (40.4 to 48.2)	0.14
sP-selectin (ng/ml)	76 (72 to 80)	69 (65 to 73)	0.012	79 (74 to 84)	65 (61 to 70)	<0.001	62 (58 to 67)	53 (49 to 57)	0.004

not have any previous medical history of ischaemic heart disease or stroke. Of the 705 individuals that were identified, 664 had samples suitable for analysis. The characteristics of the 664 individuals were not significantly different from the 41 who did not have suitable samples. Of the individuals studied, 261 were white (120 females), 188 were of African origin (99 females) and 215 were of South Asian origin (99 females). People of African origin were all first-generation immigrants. The Local Ethics Committee approved the study and all participants gave their informed consent to participate.

Methods

Subjects, who had fasted overnight and had refrained from smoking or taking vigorous exercise, were seen between 08:00 am and 12:00 noon the following day. A detailed questionnaire was completed and height and weight were measured [3,4]. Blood pressure (BP) was taken with standard methods and an automated recorder [3,4]. Fasting blood was taken in the seated position without stasis [3].

Biochemical measurements

Adhesion molecule [soluble E-selectin (sE-selectin), soluble P-selectin (sP-selectin), sICAM-1 and sVCAM-1] measurements were performed, using commercially available ELISA kits (R& D Systems Europe Ltd, Abingdon, Oxon., U.K.), on heparinized plasma, which had been stored at $-40\,^{\circ}C$ and defrosted at room temperature prior to analysis. Intra- and inter-assay coefficients of variation were all $< 2.5\,\%$. Biochemical measurements were performed using standardized methods, as described previously [3,4,18].

Statistical analysis

Plasma levels of sE-selectin, sP-selectin, sVCAM-1 and sICAM-1 were all positively skewed; therefore analyses were performed on log-transformed data. Results are presented as geometric means and 95 % confidence intervals (CI). Differences between ethnic groups (adjusted for age and sex) were tested using analysis of co-variance. Caribbeans and West African individuals were compared separately, with white individuals as a reference, using multiple regression adjusting for age and sex, smoking, measures of obesity, social class, serum lipids, BP, serum insulin and plasma total homocysteine. Since the independent variables have been log-transformed prior to analysis, the regression coefficients (β) and 95 % CI were exponentiated and expressed as the percentage increase in adhesion molecules in each ethnic group compared with white individuals. Differences between ethnic groups in smoking and social class were adjusted using age standardization with the direct method [3]. $P < 0.05$ was considered statistically significant.

Table 3 Effect of smoking on soluble adhesion molecule levels

Values are geometric means (95 % C.I) adjusted for age, sex and ethnicity. *P* values are for test of heterogeneity between smoking groups by analysis of co-variance. There was no more than one value missing from any cell.

Adhesion molecule	Current smoker ($n = 145$)	Ex-smoker ($n = 132$)	Never smoked ($n = 386$)	*P* value
sICAM-1 (ng/ml)	279 (263 to 295)	232 (218 to 248)	230 (222 to 239)	<0.001
sVCAM-1 (ng/ml)	395 (378 to 413)	425 (404 to 446)	424 (413 to 436)	0.019
sE-selectin (ng/ml)	49.6 (46.1 to 53.2)	46.9 (43.3 to 50.7)	44.7 (42.9 to 46.8)	0.074
sP-selectin (ng/ml)	72 (68 to 77)	67 (63 to 72)	65 (63 to 67)	0.018

RESULTS

Population characteristics and soluble adhesion molecule levels

There were marked ethnic differences in the cardiovascular risk factors (Table 1).

There were significant sex and ethnic differences in the soluble cell adhesion molecule levels, with no significant interactions between sex and ethnicity (Table 2). After adjustment for age and ethnicity, males had significantly higher levels of some of the adhesion molecules than females [differences: sICAM-1, 19.2 ng/ml ($P = 0.003$); sE-selectin, 8.4 ng/ml ($P < 0.001$); and sP-selectin, 9.7 ng/ml ($P < 0.001$)]. The levels in each ethnic group, adjusted for age and sex, are given in Table 1. The adhesion molecule levels of white and South Asian individuals were not significantly different, but, in contrast, individuals of African origin had significantly ($P < 0.001$) lower levels of s ICAM-1, sVCAM-1 and sP-selectin compared with both white and South Asian individuals.

Smoking

The effect of smoking was adhesion-molecule-specific (Table 3), in that there was no significant effect of smoking on sE-selectin, but current smoking was associated with significantly higher sP-selectin and sICAM-1 levels. In contrast, levels of sVCAM-1 were lower in current smokers.

Correlation analysis

Partial correlation analysis was performed between adhesion molecules and conventional cardiovascular risk factor variables (adjusted for age, sex and ethnicity; Table 4). Serum triacylglycerols were significantly positively associated with all the adhesion molecules, and serum cholesterol was positively associated with sICAM-1, sE-selectin and sP-selectin. There was a significant negative association between HDL-cholesterol and all the adhesion molecules. The waist/hip ratio was positively associated with sICAM-1, sVCAM-and sE-selectin. Body mass index (BMI) was associated with sE-selectin. Plasma glucose was positively associated with both sE-selectin and sP-selectin. Fasting insulin levels were positively associated with sE-selectin. A significant positive association between both systolic and diastolic BP was only present with sE-selectin.

Table 4 Partial correlation coefficients of associations between cellular adhesion molecules and cardiovascular risk factors

Adjusted for age, sex and ethnicity. $^*P \leqslant 0.05$, $^{**}P \leqslant 0.01$ and $^{***}P \leqslant 0.001$. #Analysis has been performed on $\mathrm{Log_e}$-transformed data.

	Adhesion molecule			
	sICAM-1	sVCAM-1	sE-selectin	sP-selectin
BMI	−0.04	0.05	0.19***	−0.05
Waist/hip ratio	0.09*	0.08*	0.21***	0.01
Systolic BP	0.04	0.03	0.17***	0.08
Diastolic BP	−0.002	−0.01	0.19***	0.03
Total cholesterol	0.09*	−0.01	0.14***	0.14***
HDL-cholesterol	−0.13***	−0.17***	−0.09*	−0.12**
Serum triacylglycerols#	0.24***	0.08*	0.19***	0.20***
Serum glucose	0.04	0.01	0.10*	0.10*
Serum fasting insulin#	0.03	0.02	0.20***	0.07
Plasma homocysteine#	0.13***	0.08*	0.04	0.06
sICAM-1#	–	0.18***	0.13***	0.22***
sVCAM-1#	0.18***	–	0.09*	0.10*
sE-selectin#	0.13***	0.09*	–	0.34***
sP-selectin#	0.22***	0.10*	0.34***	–

Table 5 Age-adjusted soluble adhesion molecule levels in African and Caribbean individuals

Values are geometric means (95 % CI). *P* values are for test of heterogeneity between groups by analysis of co-variance.

Adhesion molecule	Caribbean individuals ($n = 111$)	West African individuals ($n = 77$)	*P* value
sICAM-1 (ng/ml)	188 (171 to 207)	193 (172 to 217)	0.72
sVCAM-1 (ng/ml)	382 (364 to 401)	402 (380 to 426)	0.19
sE-selectin (ng/ml)	47.2 (43.4 to 51.3)	45.2 (40.9 to 49.9)	0.51
sP-selectin (ng/ml)	62 (59 to 67)	51 (47 to 55)	<0.001

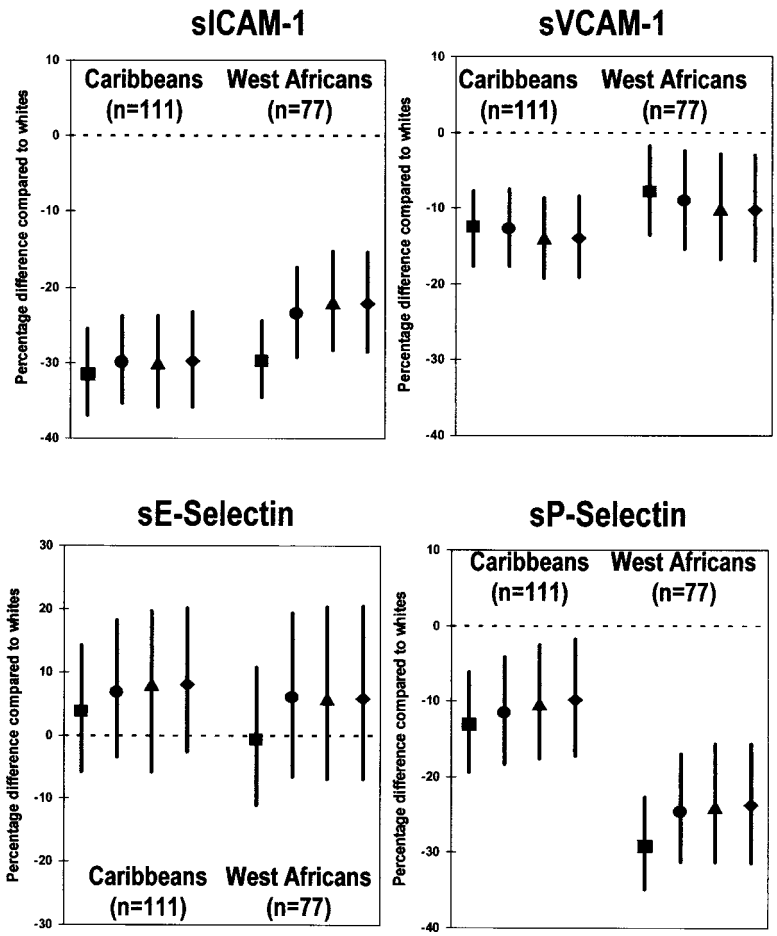

Figure 1 Multiple regression of adhesion molecules as dependent variables

Percentage difference in adhesion molecules in Caribbean and West African individuals compared with white individuals. Model 1 (■), adjustment for age and sex; model 2 (●), model 1 and adjustment for smoking; model 3 (▲), model 2 and adjustment for BMI, triacylglycerols and systolic BP; model 4 (◆), model 3 and adjustment for insulin.

Subgroup analysis within ethnic groups

Plasma sP-selectin levels were significantly lower in West African [51 ng/ml (47 to 55), $n = 77$] compared with Caribbean [62 ng/ml (59 to 67), $n = 111$] individuals ($P < 0.001$ age and sex adjusted) (Table 5). Moreover, there was a significant difference in smoking between the two groups. Given this and the associations between adhesion molecule levels and other cardiovascular risk factors, we used multiple regression to ascertain whether the difference in adhesion molecule levels between black and white individuals was present in both Caribbean and West African individuals and whether it persisted after adjustment for these factors. An increasing number of risk factors was adjusted for in each model, starting with age and sex adjustment in model 1 (Figure 1, and see Appendix Table 1 available at http:/www.clinsci.org/cs/104/cs1040591add.htm).

When adjusted for multiple confounders, both Caribbeans and West Africans still had significantly lower levels of sICAM-1 [−30 % (−36 % to −23 %) and −22 % (−29 % to −15 %) respectively], sVCAM-1 [−14 % (−19 % to −8 %) and −10 % (−17 % to −3 %) respectively] and sP-selectin [−10 % (−17 % to −2 %) and −24 % (−31 % to −16 %) respectively] than white individuals (Figure 1).

Similar results to those shown in Figure 1 were obtained when using waist/hip ratio (rather than BMI), HDL-cholesterol (rather than triacylglycerols) and diastolic (rather than systolic) BP (see Appendix Table 2 available at http:/www.clinsci.org/cs/104/cs1040591add.htm). The addition of homocysteine and social class to model 4 had no effect on the results (see Appendix Table 2 available at http:/www.clinsci.org/cs/104/cs1040591add.htm). Analysis of the South Asian individuals showed that there were no differences between white and South Asian individuals when adjusting for all of the confounders as shown in model 4 (including homocysteine), and that there were no differences in levels between Hindus and Muslims or between vegetarians and non-vegetarians (see Appendix Table 3

available at http:/www.clinsci.org/cs/104/cs1040591add.htm).

DISCUSSION

Main findings

Apparently healthy people of first-generation black African origin living in England have significantly lower levels of sICAM-1, sVCAM-1 and sP-selectin, but not sE-selectin, than white individuals living in the same area. These differences (between 10 and 30 % lower levels) are independent of differences in smoking rates, socio-economic background, degree of obesity, lipids, insulin, homocysteine and BP levels, and are present in both Caribbeans and West African individuals. If these findings were to indicate a causal link, they would be consistent with the lower CHD morbidity and mortality rates seen in black individuals in England and Wales.

Intriguingly, British South Asian individuals, who experience a higher morbidity and mortality from CHD compared with white individuals, do not have higher adhesion molecule values than white individuals. There are a number of possible explanations for these differences. It is possible that adhesion molecules are less important in the development of CHD in this group and that other factors acting through different mechanisms may be more important. It is also possible that there may be interactions with other risk factors not measured in our present study, or some underlying genetic susceptibility may explain these differences. However, although many studies have shown that soluble adhesion molecules are associated with CHD risk factors, the mechanisms and factors which govern the rate of cell-surface shedding or clearance of these factors are still unclear. The possibility that genetic differences in these processes may influence the levels in different ethnic groups, therefore, has to be considered.

External validity and comparison with other studies

Our present study found relationships between adhesion molecules and a number of traditional risk factors for cardiovascular disease, including sex. Although the evidence is still controversial, the results are consistent with the evidence that men have a higher CHD risk than women [19,20].

A number of studies have examined the association between soluble adhesion molecule levels and cardiovascular risk factors. However, the results have not been entirely consistent and there are a number of reasons that could account for this. Nevertheless, in our present study, in agreement with Demerath et al. [19], current smoking was a significant predictor of sICAM-1 and sP-selectin levels, whereas sE-selectin levels were not, and there was a small, but significant, decrease in sVCAM-1 levels in current smokers. Quitting tobacco smoking is associated with a dramatic decline in circulating sICAM-1 [21], which might be due to the effect of cigarette smoke particulates on protein kinase C activity and adhesion molecule expression [22]. Consistent with some studies [17,23], adhesion molecule levels were positively associated with serum cholesterol and triacylglycerols and negatively associated with HDL-cholesterol. Interestingly, HDL-cholesterol levels are negatively associated with CHD and they inhibit cytokine-induced expression of endothelial cell adhesion molecules [14]. A previous study [8] has also shown that E-selectin is increased in hypertensive individuals, and we observed a significant association between systolic and diastolic BP and sE-selectin levels. However, the ethnic differences in soluble adhesion molecule levels persisted even after adjustment for sex, age, smoking and other risk factors.

To date, no studies have compared adhesion molecule levels in South Asian individuals, African individuals living in the United Kingdom or Africa and white individuals. However, the Atherosclerosis Risk in Communities (ARIC) study has compared the levels in a small number of African Americans with a much larger group of white individuals. African Americans have a higher CHD morbidity and mortality than black people of African origin living in England. However, despite this, the ARIC study has shown that African Americans without CHD have lower levels of sICAM-1 and sVCAM-1, but not sE-selectin, compared with white Americans without CHD [12].

The ARIC study also demonstrated that incident CHD and carotid artery atherosclerosis (CAA) was associated with an increase in sICAM-1 and sE-selectin, but not sVCAM-1, in both white and black individuals. This indicates that, in both black and white individuals, there is an increase in specific adhesion molecule levels with CHD and CAA. Indeed, the percentage increase in both sE-selectin and sICAM-1 levels in black individuals with CHD or CAA was higher than that in white individuals. This might suggest that the adhesion molecule pathway might be more responsive to disease in black individuals, although alternative explanations are also possible. Furthermore, the ARIC study demonstrated that the level of sICAM-1 was a significant predictor of CHD, even when adjusted for potential confounders, including race. But, as the numbers of black individuals were small, they were unable to investigate the predictive value in black and white individuals separately.

Strengths and limitations

Our present study is population-based and used random sampling from the general population coresident in an inner city borough with a high proportion of ethnic minority populations. The participants lived within the same geographical area and this might have mitigated

some potential effects of differences in environmental background, including differences in socio-economic status. The present study examined first-generation immigrants of ethnic minority groups with both parents born in the country of origin and belonging to the same ethnic background, thus markedly reducing the possible impact arising from an unknown degree of admixture. We used standardized methods across all ethnic groups, thus minimizing systematic bias. Moreover, our selection criteria excluded possible effects due to disease status or pharmacological treatment.

Adhesion molecule measurements were performed on plasma samples, which have been stored at −40 °C for up to 7 years, unlike a previous study [15], which used non-fasting serum samples that had been stored at −20 °C for 20 years.

Potential limitations of our present study include its cross-sectional design, which means it cannot establish a cause–effect relationship. Moreover the decision to exclude diabetics, treated individuals and women on the oral contraceptive pill or hormone-replacement therapy has led to exclusions which varied by ethnic group. Although this limits the generalizability of our findings to a rather healthy population, it does provide a valid assessment of differences in adhesion molecules due to ethnic background.

Implications

There have been inconsistencies in the literature regarding the associations between adhesion molecules and CHD risk factors and with regards to their importance as predictors of CHD events. Ridker et al. [13], in initially healthy people, indicated that sICAM-1 has a predictive value, whereas de Lemos et al. [24] demonstrated that sVCAM-1 appears to be less important. Moreover, in a recent prospective study of high-risk CHD individuals, Tanne et al. [25] demonstrated that elevated concentrations of sICAM-1 are associated with increased risk of ischaemic stroke. Furthermore, in diabetic patients [26] and patients with documented CAD [10], sVCAM-1 was shown to be the most important marker. In contrast, Malik et al. [15] concluded that adhesion molecule levels do not predict CHD. These discrepancies may be due to the smaller sample size of some of the studies, study design, interpretation of the results or the selection, sex and ethnic origin of the subjects. Furthermore, there have been a number of concerns [27,28] raised with regards to the design and conclusions that can be drawn from the study by Malik et al. [15].

Conclusions

Our present study is the first to look at large numbers of male and female individuals from different ethnic backgrounds. We have shown that ethnic differences in soluble adhesion molecule levels and associations between them and cardiovascular risk factors can be specific to the type of adhesion molecule. This may be particularly important, as the different adhesion molecules are responsible for different parts of the inflammatory process and may have varying importance in different groups of individuals [29]. These factors clearly need to be taken into account in future studies along with sample size and patient selection. Moreover, results from one population cannot be readily extrapolated to other groups [28]. The possibility that cardioprotective mechanisms are present in individuals of African origin and that they manifest some of their actions through the adhesion molecule pathway, and the possibility that there may be underlying genetic differences in genes controlling the adhesion molecules, which may be related to ethnicity, warrant further investigation.

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