Predictors of cardiovascular risk factors in Tehranian adults: diet and lifestyle

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العوامل المنبِّئة بمخاطر الإصابة بالأمراض القلبية الوعائية لدى البالغين في طهران: النظام الغذائي ونمط الحياة

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الخلاصة: أجرى الباحثون دراسة لتقييم الدَّخْل الغذائي لدى 486 من البالغين الذين لا تقل أعمارهم عن عشرين عاماً، من المشاركين في الدراسة المتعلقة بالشحميَّات والغلوكوز في طهران. وبيَّنت الدراسة وجود ترابط إيجابي قوي بين مَنْسَب كتلة الجسم وبين دَخْل الكربوهيدرات (بيتا = 1.6، وP < 0.05)؛ ومستوى الغليسيريدات الثلاثية في المصل (بيتا = 2.4، وP < 0.5). وكذلك الوزن (بيتا = 1.1، وP < 0.05)، والعمر (بيتا = 1.6، وP < 0.05)، ودخل الكوليسترول (بيتا = 0.7، وقيمة الاحتمال أقل من P < 0.01)، وبين كولسترول البروتين الشحمي القليل الكثافة. كما بيَّنت الدراسة أن زيادة وحدة واحدة في مَنْسَب كتلة الجسم، أو في نسبة الخصر إلى الورك، أو في دخل الأحماض الدهنية المشبَّعة، تؤدي إلى زيادة في ضغط الدم الانبساطي، قدرها 0.6 و0.9 و1 مم زئبق على التَّوَالي (P < 0.05). كما دلَّت الدراسة على وجود ترابُط بين العوامل الغذائية وغير الغذائية وبين عوامل اختطار الإصابة بالأمراض القلبية الوعائية، وعلى دورها في التنبؤ بعوامل الاختطار هذه.

ABSTRACT We carried out a dietary intake assessment in 486 adults 20 from the Tehran Lipid and Glucose Study. There was a strong positive association between body mass index (BMI) and serum triglycerides (β = 1.6, $P < 0.05$) and carbohydrate intake and triglycerides (β = 2.4, $P < 0.05$). There was also an association between low-density lipoprotein cholesterol and weight (β = 1.1, $P < 0.05$), age (β = 1.6, $P < 0.05$) and cholesterol intake (β = 0.7, $P < 0.01$). For 1 unit increase in either BMI, waist to hip ratio or saturated fatty acid intake, diastolic blood pressure increased 0.6, 0.9 and 0.1 mmHg, respectively ($P < 0.05$). Dietary and non-dietary factors have an association with, and play a role as predictors of, CVD risk factors.

Facteurs prédictifs du risque cardio-vasculaire chez des adultes de Téhéran : alimentation et mode de vie

RÉSUMÉ Nous avons procédé à une évaluation des apports alimentaires chez 486 adultes à partir de l'étude de Téhéran sur les lipides et la glycémie. Il y avait une forte association positive entre l'indice de masse corporelle (IMC) et les triglycérides sériques (β = 1,6, p < 0,05) et l'apport en glucides et triglycérides (β = 2,4, p < 0,05). Il y avait en outre une association entre le cholestérol des lipoprotéines de base densité et le poids (β = 1,1, p < 0,05), l'âge (β = 1,6, p < 0,05) et l'apport en cholestérol (β = 0,7, p < 0,01). Pour toute augmentation d'une unité de l'IMC, du rapport tour de taille/tour de hanches, de l'apport en acides gras saturés, la pression artérielle diastolique augmentait de 0,6, 0,9 et 0,1 mmHg respectivement (p < 0,05). Des facteurs alimentaires et non alimentaires sont associés aux facteurs de risque de maladies cardio-vasculaires et jouent un rôle prédictif pour ces derniers.

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Introduction

Although significant reductions have occurred in the incidence of cardiovascular disease (CVD) since the mid-1970s, this is still the primary cause of morbidity and mortality in many countries [*1,2*]. Further progress in prevention depends on identifying the population at increased risk [*1*].

In various studies, both elevated systolic blood pressure (≥ 140 mmHg) and elevated diastolic blood pressure (≥ 90 mmHg) have been shown to be associated with a risk of CVD. In the 1980s, diastolic blood pressure was determined as the main risk factor of CVD [*3*]. It has been shown that elevated serum levels of low-density lipoprotein (LDL) cholesterol, total cholesterol and triglycerides, low levels of high-density lipoprotein (HDL) cholesterol and abnormal blood glucose levels are the dominant risk factors for CVD [*4,5*].

In various epidemiological studies, a strong positive relationship has been reported between some dietary and non-dietary factors and risk factors for CVD. A number of studies have suggested that certain dietary factors as well as age, sex, weight, body mass index (BMI), waist to hip ratio (WHR), education and smoking may have an important link with CVD [*6–8*].

The aim of this study was to determine the predictors of diet and lifestyle-related CVD risk factors (total cholesterol, LDL, HDL, triglycerides, blood glucose and systolic and diastolic blood pressure) in adults residing in an urban district of Tehran. Determining the risk factors could provide data that would be useful in the development of an intervention programme to reduce CVD.

Methods

Study group

Tehran Lipid and Glucose Study was initiated in 1998 to determine the risk factors of arteriosclerosis among the urban population of Tehran and to develop population-based measures to control the rising trend of diabetes mellitus and dyslipidaemia. The study has 2 major components: phase 1, a cross sectional prevalence study of cardiovascular disease and associated risk factors, and phase 2, a prospective 20-year follow-up study [*9*]. A multistage stratified cluster random sampling technique was used to select 15 000 people aged 3 to 69 years from district 13 in the east of Tehran for the study. Details of the sampling process have been published previously [*10*]. Sample size was determined using a confidence interval of 95%, power of the study was 80%, attrition rate estimation 20% and an estimated rate of 13% for hyperlipidaemia.

A subsidiary group of 743 people ≥ 20 years from the Tehran Lipid and Glucose Study was randomly selected for dietary and lifestyle assessment. After excluding under- and over-reporters, i.e. energy intake:basal metabolic rate (EI:BMR) < 1.35 and ≥ 2.4 [*11*], 486 participants with no history of diabetes, myocardial infarction, cerebrovascular disease, pancreatitis or thyroid, renal or hepatic disorder, and not taking any lipid lowering agents, diuretics, beta-blockers, corticosteroids, androgens or fish liver oil remained in this study.

Weight and height were measured by a skilled technician using a calibrated digital electronic weighing scale (Seca 707; range 0.1–150.0 kg) and tape meter stadiometer. Waist and hip circumferences were also measured using standard protocols [*12*]. Body mass index [BMI = weight (kg)/ height^2 (m^2)] and waist to hip ratio [WHR = waist circumference (cm)/hip circumference (cm)] were calculated.

Dietary assessment

In face-to-face interviews, 2 × 24-hour dietary recalls were carried out. The first was performed at participants' homes and the second at the Tehran Lipid and Glucose Study clinic within 1–3 days of the first visit. These 2 days were normal days for the participants. The questionnaires were completed by trained dietitians who had at least 5 years experience in the Nationwide Food Consumption Survey project. The 24-hour dietary recall described reported intakes from midnight to midnight, meal by meal. The reliability and validity of 24-hour recalls has been proven in several studies [*13,14*]. To assist the participants to recall accurately, household utensils were used. Portion sizes of foods consumed were converted to grams using household measures and standard reference tables [*15*].

Data were entered to *Nutritionist III* software package and daily energy and nutrient intakes (carbohydrates, proteins and fats plus the micronutrients vitamins A, B, C, D, E and K and calcium, magnesium, potassium iron and selenium) for each individual were determined from the mean of the 2 × 24-hour dietary recalls.

The basal metabolic rate (BMR) was calculated based on age and sex according to standard equations [*16*]. We calculated the energy intake (EI) of participants according to 24-hour recall to determine the under- and over-reporters. Under-reporting of energy intake was defined as EI:BMR < 1.35 and over-reporting as > 2.39, thus, EI:BMR 1.35–2.39 was considered the normal reporting range for dietary intake. These values were established in line with previous studies [*11,17*].

Life style categories

Data related to cigarette smoking was used to classify the participants into 4 groups according to WHO guidelines [*18*]:

- daily smoker: smokes at least once a day (includes those who smoke every day but have to stop temporarily because of religious fasting or medical reasons);
- occasional smoker: smokes, but not every day;
- ex-smoker: formerly a daily or occasional smoker, but currently does not smoke at all;
- never smoked: never smoked before or smoked very rarely in the past.

Education level was scored as follows: illiterate = 0; able to read and write = 2; elementary school = 5; junior high school = 9; high school graduate = 12; diploma = 14; university degree (Bachelor) = 16; Masters and General Practitioner (GP) = 18; doctor of Philosophy (PhD) and post-GP= 20. Based on the education level scoring, individuals were classified into 3 groups: low: ≤ 5, moderate: 6–12 and highly educated > 12.

Serum lipid analysis

A blood sample was drawn between 7:00 and 9:00 into Vacutainer® tubes after a 12–14 hour overnight fast. Samples were taken in a sitting position and centrifuged within 30 to 45 minutes of collection. All serum lipid analyses were done at the Tehran Lipid and Glucose Study research laboratory on the day of collection. The analyses of samples were performed using the Selectra 2 auto-analyser (Vital Scientific, Spankeren, Netherlands). Total cholesterol and triglycerides were assayed using enzymatic colorimetric tests with cholesterol esterase and cholesterol oxidase and glycerol phosphate oxidase (Total

Cholesterol and Triglycerides kits, Pars Azmon Inc., Tehran). We measured HDL after precipitation of the apolipoprotein B-containing lipoproteins with phosphotungstic acid. Assay performance was monitored every 20 test intervals using the lipid control serum, Precinorm (normal range) and Precipath (pathologic range) wherever applicable (Boehringer Mannheim, Germany; cat. no. 1446070 for Precinorm and 171778 for Precipath). Lipid standard (Pars Azmon Inc., Tehran) was used to calibrate the Selectra 2 auto-analyser each day. We calculated LDL according to the Friedewald equation [*19*].

Blood pressure measurement

Participants were initially made to rest for 15 minutes, following which a qualified physician measured blood pressure twice in a seated position. There was at least a 30-second interval between the 2 measurements. These 2 evaluations of blood pressure were done following the measurement for determining peak inflation level using a standard mercury sphygmomanometer calibrated by the Iranian Institute of Standards and Industrial Researches. The cuff was placed on the participant's right arm (at heart level) and inflated at as high an increment rate as possible until the cuff pressure was 30 mmHg above the level at which the radial pulse disappeared. The systolic blood pressure was defined as the appearance of the first sound (Korotkoff phase 1) and diastolic blood pressure was defined as the disappearance of the sound (Korotkoff phase 5) during deflation of the cuff at a 2–3 mm/second decrement rate of the mercury column. Before measuring the blood pressure, we checked that the participants had not been drinking tea or coffee, engaging in physical activity or smoking and that they did not have a full bladder. The mean of the 2 measurements was recorded as the participant's blood pressure. Hypertension was defined as a systolic blood pressure ≥ 140 mmHg or a diastolic blood pressure ≥ 90 mmHg [*20*].

Statistical analysis

Data were analysed using *SPSS*, version 9.05. Stepwise linear regression was used to determine the predictors of CVD.

Results

Mean (standard deviation) fasting blood glucose was 116 (12) mg/dL. Mean (standard deviation) total cholesterol was 210 (43) mg/dL, LDL 134 (36) mg/dL, HDL 42 (12) mg/dL and triglycerides 173 (107) mg/dL.

Data for BMI and WHR are shown in Table 1. In men, BMI was higher in age group 30–39 compared to age group 20–29 but the difference was not statistically significant. There was no change in BMI over the age of 40. Median BMI was 23, 26, 25 and 25 for age groups 20–29, 30–39, 40–49 and ≥ 50 years respectively. In women, BMI increased with age. The median was 22, 25, 28 and 29 for age groups 20–29, 30–39, 40–49 and ≥ 50 years respectively. There was a significant difference between the BMI of women ≥ 50 years and that of women in other age groups ($P < 0.01$ compared with 20–29 year olds and $P < 0.05$ compared with the other groups).

The distribution of participants according to cigarette smoking and education level for different age group is shown in Table 2. The distribution of people based on smoking habits varied significantly with age. The highest proportion of daily smokers was in the 30–39 year old group. All the women in the 20–29 year group fell into the group who had never smoked. Only 1% of women were smokers at the time of

Table 1 **Quartiles of body mass index (BMI) and waist to hip ratio (WHR) for different age groups**

Age group (years)	Men							Women						
		BMI quartile (kg/m²)			WHR quartile				BMI quartile (kg/m2)			WHR quartile		
	n	25th	50th	75th	25th	50th	75th	*n*	25th	50th	75th	25th	50th	75th
20–29	33	20	23	26	0.80	0.85	0.88	66	20	22	25	0.71	0.74	0.80
30–39	66	23	26	28	0.86	0.89	0.92	67	22	25	28	0.76	0.80	0.86
40–49	81	23	25	28	0.88	0.92	0.96	47	25	28	32	0.78	0.85	0.90
≥ 50	64	24	25	28	0.90	0.94	1.0	39	26	29**	32	0.84	0.90*	0.94

**P* < 0.05.
***P* < 0.01 compared to 20–29 years age group.

the study; 23% of men, however, were classified as daily smokers.

There was no difference between age groups for years of education.

The results for the stepwise linear regression for a number of variables are shown in Table 3. Weight ($\beta = 1.18$), age ($\beta = 2.1$), saturated fatty acids ($\beta = 0.9$) and vitamin C intake ($\beta = 0.81$) were the predictors of total serum cholesterol. Carbohydrate intake and BMI were the predictors of triglycerides. Weight, age and cholesterol intake were the predictors of LDL cholesterol. There was a negative correlation between weight and HDL cholesterol. There was a positive correlation between WHR, saturated fatty acids and systolic and diastolic blood pressure as well as between BMI, WHR, cigarette smoking, saturated fatty acid intake and diastolic blood pressure. There was a negative correlation between calcium intake and diastolic and systolic blood pressure. BMI,

Table 2 **Distribution of participants according to cigarette smoking and education level for different age groups**

Age group (years)	Cigarette smoker (%)				Education level[a] (%)		
	Never	Ex	Occasional	Daily	Low	Moderate	High
*Men**							
20–29	81	7	0	11	4	71	25
30–39	59	8	0	32	7	73	20
40–49	60	16	1	23	23	60	17
≥ 50	60	19	2	19	41	37	22
Total	63	12	2	23	20	59	21
*Women**							
20–29	100	0	0	0	2	82	16
30–39	98	0	0	2	18	71	11
40–49	95	2	0	2	51	39	10
≥ 50	97	0	0	3	73	23	3
Total	98	5	0	1	28	54	18

[a]*Low ≤ 5 years; moderate 6–12 years; high > 12 years.*
**P < 0.05 for smoking and education level.*

Table 3 **Regression equation for determining the relationship between certain nutritional and non-nutritional factors and cardiovascular disease risk factors**

Risk factor[a]	Regression equation	R^2
Total cholesterol	58.2 + 1.18(weight)** + 2.1(age)** + 0.9(SFA intake)* + 0.8(vitamin C intake)**	0.44
Triglycerides	–35.4 + 1.6(BMI)* + 2.4(carbohydrate intake)*	0.22
HDL	67.7 – 0.6(weight)***	0.40
LDL	4.3 + 1.1(weight)* + 1.6(age)* + 0.7(cholesterol intake)**	0.25
Systolic blood pressure	70.1 + 48.1(WHR)** – 0.7(fibre)* – 0.8(education level)* + 0.17(SFA intake)* – 0.4(calcium intake)*	0.21
Diastolic blood pressure	41.4 + 0.6(BMI)* + 0.9(WHR)* + 0.1(SFA)** + 0.1(smoking)* – 0.04(calcium intake)*	0.20
Blood glucose	45.3 + 0.1(BMI)** + 0.1(WHR)* – 0.09(zinc intake)*	0.22

*$P < 0.05$; **$P < 0.01$; **$P < 0.001$.
[a]Dependent variable.
R = multiple correlation coefficient.
SFA = saturated fatty acids.
BMI = body mass index.
HDL = high density lipoprotein cholesterol.
LDL = low density lipoprotein cholesterol.
WHR = waist to hip ratio.

WHR and zinc intake were the predictors of blood glucose.

Discussion

We found correlations between certain nutritional and non-nutritional factors and some CVD risk factors. There was a significant positive correlation between weight and total cholesterol, LDL and HDL and between WHR and blood glucose and both systolic and diastolic blood pressure. Zhao et al. showed an increase in blood pressure with increasing WHR and BMI in 6276 middle aged and elderly people in rural China [*21*]. Kroke et al. showed that BMI, WHR and skeletal body build were independently associated with the prevalence of hypertension. The biological mechanism is still unclear and needs further exploration [*22*]. Gus et al. showed that BMI > 27 kg/m^2 was strongly associated with increased risk of hypertension [*23*]. In a study on 3282 girls, there was a strong relationship between WHR and blood pressure. Obesity therefore has a close association with hypertension, characterized by an expanded blood volume and increased cardiac output. Hypertension results when vascular resistance is increased due to an increased cardiac output. But it seems that this type of hypertension is multifactorial, as are the other types [*24*].

The correlation of anthropometric indices and blood pressure may be related to mutation in the β3-adrenergic receptor gene Trp64Arg. This mutation has been seen in people with obesity and diabetes, which had similar effects on weight, BMI, abdominal fat and blood pressure [*25*]. In our study, weight was a good predictor of total cholesterol and LDL. Mehta et al. observed an association between BMI, weight, hypercholesterolaemia and hyperinsulinaemia [*26*]. Waist circumference is also strongly linked to obesity-associated risks and Zhu et al. believed that this was more closely linked to cardiovascular disease risk factors than BMI [*27*]. It has also been reported that increase in BMI in hypercholesterolaemic girls was greater than in normocholesterolaemic girls [*28*]. There was a stronger association between BMI and blood pressure and lipid profile in hypercholesterolaemic patients. Increased lipid profile is, however, associated with increase in age. In the present study, age was a good predictor of increased serum cholesterol and LDL [*29*].

Education level is another factor which may be related to the risk of CVD. In a cross-sectional study in Chongqing, China, those with the highest education level had the lowest prevalence of hypertension. It was emphasized that education played an important role in public health for the control of high blood pressure [*30*]. In our study too, there was an association between education level and systolic blood pressure. This may be a result of the enhanced knowledge educated people have and the increased attention they pay to their diet.

According to a Spanish study, cigarette smokers had the highest blood pressure [*31*]. In the present study, smoking was a predictor of increase in diastolic blood pressure.

Among the nutritional factors, carbohydrate intake was associated with serum triglyceride. Cholesterol intake was related to serum LDL and saturated fatty acid intake with serum cholesterol. Jorde and Bonaa mentioned an inverse correlation between calcium intake and systolic and diastolic pressure in Norway [*32*]. Cappuccio et al. reported an inverse relationship between calcium intake and blood pressure [*33*]. Ascherio et al. showed that calcium had an important role in blood pressure, and adequate intake of calcium might reduce the risk of hypertension [*34*]. We also found a significant negative correlation with systolic and diastolic blood pressure in men and in women ($P < 0.05$). Some studies reported the effect of calcium only in men [*34*], while others reported this only in women [*35*]. There are some mechanisms that may be responsible for this effect of calcium such as the natriuretic effect, regulation of the sympathetic nervous system and prevention of vessel constriction [*36*]. The failure to show a significant relationship between calcium intake and blood pressure reported in some studies may also be a result of incorrect assessment of calcium intake or lack of control for confounding factors [*37,38*]. Goldberg et al. found a reduction in systolic and diastolic blood pressure after increasing the ratio of polyunsaturated fatty acids:saturated fatty acids in the diet [*39*]. It has also been reported that high amounts of polyunsaturated fatty acids had no effect on blood pressure and the effect that vegetarian diets have is related to the high amount of potassium in these diets [*36*].

Previous studies have shown that participants with abnormal glucose tolerance have more adverse CVD risk factor profiles than individuals with normal glucose tolerance [*40,41*]. In our study, the role of BMI and WHR as the predictors of blood glucose level may have contributed to insulin resistance. Zinc intake was inversely related to blood glucose, which might be related to the presence of zinc in the structure of insulin.

Not measuring blood homocystein levels or salt intake were limitations of this study. Accurate blood pressure assessment along with good quality control were among the positive components of this research.

The significance of the association between certain dietary and non-dietary factors and CVD needs, therefore, to be considered in the management and prevention of these diseases. The findings of this study can help physicians to take into account the effect of these factors in predicting CVD and to bring them to the attention of patients who are at risk.

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