Obesity, Physical Activity and Prevalence of Diabetes in Bahraini Arab Native Population

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A cross-sectional population-based study of 2128 residents aged 40-69 years was carried out in 1995 to determine the prevalence of diabetes and the association of obesity and physical activity with this disease. Subjects were invited to the clinic for interview, physical and laboratory examination. Venous blood samples were taken fasting and 2 hours after a 75 g oral glucose load. Using the 1985 WHO criteria, the overall prevalence rate of diabetes and impaired glucose tolerance (IGT) were 30% and 18%, respectively. In the age group 50-59 years prevalence was 29% in men and 35% in women. Mean body mass index (BMI) was 27.3 kg/m² in men and 28 kg/m2 in women. Only 13% of men and 1% of women walked at least 4 km/day. BMI was positively related to education and inversely related to physical activity. On average, subjects with diabetes were older, had higher monthly incomes and positive family history of diabetes. They also had higher mean BMI, waist-to-hip ratio (WHR), waist-to-height ratio (WHTR). Multiple logistic regression analysis shows that age, BMI (or WHR, WHTR), and less physical activity are independent risk factors of NIDDM. The prevalence of diabetes in Bahrain is increasing with economic development and changes from traditional to modernized lifestyle. Therefore, Bahraini people should attempt to retain certain features of their traditional lifestyle (physical activity, healthy eating, and moderate body weight).

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Epidemiological studies in the Arab populations have demonstrated high prevalence rates of diabetes mellitus[1-5]. Non-insulin-dependent-diabetes mellitus is a cause for growing public health concern in both developed and developing countries. In many countries, diabetes is now a leading cause of death, disability and high health care cost[6-8]. Various genetic, environmental and lifestyle factors influence diabetes aetiology and prognosis. Important differences in the frequency of diabetes and its complications have been reported between countries, ethnic and cultural groups[9,10].

Health services utilisation data of primary and secondary care for diabetes over a current 15-year duration in Bahrain show enlargement use of inhospital patients. The inhospital data review in 1992 has shown high admission rates of adult diabetics to the medical ward in Salmaniya Medical Centre, the main general hospital in Bahrain[11]. This study aimed to determine the prevalence of diabetes in Bahraini natives and associations with risk factors. The specific hypothesis to be tested was that diabetes and other metabolic complications of obesity would account for high diabetes rates in this population. No survey has been conducted before which represents the whole Bahraini native population and this led us to commence the present survey.

METHODS

The sample was designed as a single-stage, stratified, systemic random sample. The subjects were selected according to the latest National Census of Bahrain in 1991[12]. The sampling fraction has been set to a round value of 1/20, using this sampling fraction. The first individual was selected randomly and then every 19th individual in the census list was selected. The census list was sorted by region, block number, sex and age group.

All urban and rural areas of Bahrain were represented in eleven regions. A random sample of 2000 Bahraini native men aged 40-59 years and 2000 Bahraini native women aged 50-69 years in the year 1995 were selected. A stratified simple random selection of subjects, ensured that the age and sex distribution of sample was reflected. A probability sample was obtained in accordance with recommendations for sample surveys of health in developing countries[13]. The calculation of sample size was based on the precision required for the prevalence estimate. The exact 95% confidence limits for various rates and sizes of random samples, are based on the effects of sampling variability; the error is inversely proportional to the square root of sample size, so that doubling the sample size reduces the limits by about 30%.

The names of all "usual residents", men aged 40-59 and women aged 50-69 years were recorded. At the time of the survey, written and verbal information had been given to each household concerning the reasons for the survey and

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what it might entail for each individual. There were specific "motivators" for the survey who had the primary responsibility for liaison and for issuing invitations and re-invitations. As well as initial contact at the time of the census, each community region was contacted several days before the arrival of the survey team in that area. Additionally, all individuals were given an invitation letter (with instructions for fasting) within 2-3 days of their appointment. Subjects on diet or tablets for diabetes were not asked to fast. The newspaper, radio and television announcements and posters through the Health Education Department in the Ministry of Health were recruited for help in this survey. Subjects who required an official letter for their employer requesting the latter's co-operation in allowing the person time off from work to attend the survey were given.

The extent to which non-responders were sought depend on the overall response rate, but normally involved at least one re-invitation while the survey team remained in the area. Appropriate survey sites were selected for each region in Bahrain and all health centres in Bahrain were recruited. Weight and height were recorded with the subjects wearing light clothing and without shoes. Accurate balance scales were used and weight was recorded to the nearest 0.1 kilogram. Height was recorded to the nearest centimeter, rounding up if midway, using a measuring rod.

The same person who recorded the height and weight in the same room recorded the waist and hip measurement. One layer of light clothing over underwear was acceptable. The observer kneeled or sat at an appropriate height in front of the subject, who breathed quietly and normally. A dressmaker's measuring tape was used, taking care that it was applied horizontally. Waist girth should be measured at the midpoint between the iliac crest and the lower margin of the ribs. An approximate indicator of this level may be ascertained by asking the subject to bend sideways. Hip girth was recorded as the maximum circumference around the buttocks posteriorly and indicated anteriorly by the symphysis pubis. Measures were made to the nearest 0.5 centimeter and repeated following both initial recordings. If there was variation greater than 2 cm between duplicate readings then a third was taken and recorded alongside the second.

Blood samples were taken after an over-night fast of 12-16 hours on the second visit to the clinic. Venous blood was taken for estimating plasma glucose, plasma cholesterol, and plasma triglyceride concentrations. Then 75 g glucose dissolved in 300 ml water was drunk in two or five minutes and the venous blood glucose concentration was re-estimated two hours later.

During the interval, the subjects were asked about their health using a pretested questionnaire. They were asked about theie family history of diabetes and physical activity. Physical activity was assessed by asking about walking distance on average week-days and weekend days and divided into three categories: < one kilometer (km), 1-3 ≥ 4km. Cycling was also assessed by asking about cycling distance on average weekdays and weekend days and divided into three categories: < one kilometer (km), 1-3 and ≥ 4 km.

Diabetes and impaired glucose tolerance were defined according to the 1985 World Health Organisation Criteria[14] for epidemiological studies, and were as follows:

1. NIDDM: FPG ≥ 140 mg/dl (7.8 mil/l) or 2-hr plasma glucose >200 mg/dl (11.1 mil/l), or history of physician-diagnosed diabetes.
2. And IGT: FPG <140mg/dl (7.8 mil/l) and 2-hr plasma glucose 140-199 mg/dl (7.8-11.1 mmol/l).
3. A history of physician-diagnosed diabetes, with or without current use of hypoglycaemic agents, will be differentiated newly diagnosed and previously known NIDDM.
4. Non-diabetic (normal): All those who not meet the above criteria for either NIDDM or IGT will be classified as having normal glucose tolerance.

The obesity was defined by body mass index (BMI) calculation as weight/height^2 (Kg/m^2). Overweight were defined as a body mass index ≥ 25 in men and women and obesity as a body mass index of ≥ 30 in both men and women.

Table 1. **Age and sex specific prevalence of diabetes mellitus* and IGT**

		Not diabetic				Diabetic					
		Normo-glyacemic		IGT		New cases		Old cases		Total prevalence	
Age-group	N	No	%	No	%	No	%	No	%	No	%
MEN											
40-49 years	668	404	60	111	17	71	11	82	12	153	23
50-59 years	506	276	55	80	16	46	9	104	20	150	29
Total	1174	680	58	191	16	117	10	186	16	303	26
WOMEN											
50-59 years	458	207	45	89	19	49	11	113	25	162	35
60-69 years	370	148	40	83	23	45	12	94	25	139	37
Total	828	355	43	172	21	94	11	207	35	301	36
GRANT TOTAL	2002	1035	52	363	18	211	11	393	20	604	30

*Diabetes defined by World Health Organization diagnostic criteria: New: Fasting plasma glucose FPG 7.8 mmol/l Or 2 hr plasma glucose 11.1 mmol/l. Previous: A history of physician-diagnosed diabetes, with or without current use of hypoglycemic agents. Not diabetic: IGT: FPG 7.8 mmol/l and 2-hr plasma glucose 7.8-11.1 mmol/l. Normo-glycaemic: FPG<6.1 mmol/l and 75g OGTT<11.2 mmol/l.

RESULTS

Prevalence of Diabetes

The crude prevalence rates for diabetes and IGT were 30% and 18% respectively. The age-specific prevalence rates of diabetes and IGT are presented in Table 1. In the age group 50-59 years, the prevalence of diabetes in women was 35% higher than in men (29%). Prevalence of IGT was also higher in women (19%) than in men (16%).

Comparison has been made between the prevalence of diabetes in this survey and the prevalence in other populations after age-adjusting to the age distribution of the Bahraini men and women in this survey. All prevalence rates of diabetes presented in Table 2 are based on surveys using oral glucose tolerance tests and WHO diagnostic criteria. The lowest prevalence rates (<4%) were seen in Chinese people, both among men and women. Moderate prevalence rates (5-10%) were seen in black American men. High prevalence rates (11-20%) were seen in Arab Omani men, American Mexican native men and black American women. Very high prevalence rates were seen in Arab Bahraini women and Arab Omani women, 35% and 24% respectively. The rates in Bahrain are higher than in other high-risk populations such as Omanis and Mauritius Indians, and are exceeded only by the prevalence rates of more than 50% observed in Pima and Papago American natives of Arizona.

Table 2. **Age-adjusted* prevalence(%) of diabetes mellitus in Bahrain compared with selected study populations**

Ethnic group	Age-Specific 40-44 yrs	45-49 yrs	50-54 yrs	55-59 yrs	Age-adjusted 40-59 yrs
MEN					
Chinese (Da Qing)	0.9	1.1	1.7	3.5	1.9
Americans (Black)	10.3	13.1	6.6	10.9	10.3
(Mexican)	13.9	18.5	8.4	30.8	19.0
Indians (Mauritius)	13.2	24.3	26.4	23.5	21.6
Arab (Oman)	16.6	15.1	16.7	26.4	19.2
(Bahrain)	17.6	27.4	24.7	31.9	24.4
Pima/Papago (Native Americans)	55.9	62.1	51.5	59.0	57.4

	Age-specific 50-54 yrs	55-59 yrs	60-64 yrs	65-69 yrs	Age-adjusted 50-69 yrs
WOMEN					
Chinese (Da Qing)	3.6	3.1	3.0	4.6	3.5
Americans (Black)	6.6	30.0	16.9	22.2	20.1
(Mexican)	17.4	36.5	26.1	50.6	34.6
Indians (Mauritius)	14.9	18.8	35.3	34.7	25.3
Arab (Oman)	20.2	24.3	18.8	31.6	23.8
(Bahrain)	30.3	36.9	36.8	36.1	35.1
Pima/Papago (Native Americans)	55.1	73.3	70.0	63.3	66.2

** All these rates were adjusted according to the Bahraini native population of this survey*

Association of obesity with diabetes

The mean BMI in diabetic men was 28 ± 4.7 and in non-diabetic was 27 ± 4.7 (p<0.001), while that in women were 29 ± 5.8 and 27 ± 5.5 in diabetic and diabetics respectively (p<0.001). Abdominal obesity was associated with diabetes in both men and women (Table 3). The mean WHR in diabetic men was 0.98 ± 0.09 and 0.95 ± 0.07 in non-diabetic men (P<0.001). In women the differences in mean waist-hip ratio between diabetic and non-diabetic participants were not significant, however waist-height, ratio (WHTR) was higher in diabetic and non-diabetic participants in both men and women. The mean WHTR in diabetic women was 0.64 ± 0.08 and 0.61 ± 0.08 in non-diabetic women (p<0.001).

Table 3. **Characteristics of variables in men aged 40-59 years with and without diabetes**

MEN	Not diabetic	Diabetic	P value
Number surveyed	(n=892)	(n=303)	
Mean (SD) age (year)	49±5.7	50±5.6	<0.001
Clinical examination date			
Mean (SD) weight (Kg)	75.1±14.1	77.9±13.7	<0.004*
Mean (SD) waist (cm)	93.9±11.7	98.1±12.0	<0.001*
Mean (SD) hips (cm)	98.0±11.0	100.0±11.7	<0.008*
Mean (SD) BMI (Kg/m2)	27±4.7	28±4.7	<0.001*
Mean (SD) WHR	0.95±0.07	0.98±0.09	<0.001*
Mean (SD) WHTR	0.56±0.06	0.58±0.07	<0.001*
WOMEN			
Number surveyed	(n=540)	(n=293)	
Mean (SD) age (year)	59±5.3	60±5.3	0.361
Clinical examination date			
Mean (SD) height (cm)	153.9±6.0	153.5±5.3	0.39*
Mean (SD) weight (Kg)	64.2±14.3	69.5±15.5	<0.001*
Mean (SD) waist (cm)	94.3±11.9	98.8±12.9	<0.001*
Mean (SD) hips (cm)	99.7±12.4	103.9±13.0	<0.001*
Mean (SD) BMI (Kg/m2)	27±5.5	29±5.8	<0.001*
Mean (SD) WHR	0.94±0.08	0.95±0.08	0.150*
Mean (SD) WHTR	0.61±0.08	0.64±0.08	<0.001*

** P value based on t test for difference between two means P value based on chi square and odds ratio for difference between two proportions*

The relationship of diabetes to body mass index and waist-hip ratio was examined in logistic regression analyses (Table 4). In men both body mass index and waist-hip ratio were strongly predictive of diabetes. In women, body mass index was a far stronger predictor of diabetes than waist-hip ratio.

Table 4. **Logistic regression of obesity as a risk factor for diabetes by gender**

Risk factor	Men OR*	P	95% CI**	Women OR	P	95%CI
BMI groups						
<20 Kg/m²	1.0		(Reference)	1.0		(Reference)
20-24.9 Kg/m²	1.4	0.349	0.66,3.10	1.9	0.114	0.85,4.37
25-29.9 Kg/m²	1.8	0.114	0.86,3.92	3.3	0.004	1.47,7.30
30-39.9 kg/m²	2.4	0.027	1.10,5.17	4.3	<0.001	1.92,9.66
40+ Kg/m²	3.3	0.056	0.96,11.9	8.8	<0.001	3.00,26.1
Waist-hip ratio						
<0.85	1.0	(Reference)		1.0	(Reference)	
0.85-0.89	1.6	0.334	0.61,4.18	1.4	0.251	0.79,2.44
0.90-0.94	2.8	0.024	1.14,6.85	1.5	0.149	0.86,2.55
0.95-0.99	2.9	0.020	1.18,6.95	1.7	0.060	0.97,2.82
1.00-1.04	3.1	0.015	1.24,7,66	1.4	0.218	0.80,2.58
>1.04	4.5	0.001	1.80,11.6	1.8	0.051	0.99,3.29

** OR = Odds ratio ** CI = Confidence interval*

Association of physical activity with diabetes

The distance walked and cycling per average weekday was presented in Tables 5 and 6. The majority of people in Bahrain walk less than one kilometer on average weekdays. The men were more active than women. Only 6% of women aged 50-59 years were active by walking at least one km/day. The majority of people in Bahrain do not cycle; only 6% of men aged 40-49 years old were cycling and 9% of those aged 50-59 years old. Only 7 women reported were cycling.

Table 5. **Number and percentage of Bahraini men and women walking distance/km on average week days**

	MEN				WOMEN			
No of km walking	40-49 yrs No	%	50-59 yrs No	%	50-59 yrs No	%	60-69 yrs No	%
<1 km	423	63	340	68	437	93	362	95
1.3 km	150	22	103	20	26	6	14	4
4 and above	98	15	59	12	5	1	2	1
Total	671	100	502	100	468	100	378	100

Table 6. **Number and percentage of Bahraini men cycling distance/km on average week days**

	Age group			
Cycling	40-49 years No	%	50-59 years No	%
Yes	42	6	43	9
No	629	94	460	91
Total	671	100	503	100

DISCUSSION

This is the first cross-sectional survey in Bahrain on the prevalence of diabetes mellitus based on blood parameters and associated risk factors in Bahraini natives. The overall diabetes prevalence (30%) in adults confirms that Bahrainis have extraordinary rates of diabetes. The main finding is the extremely high prevalence of diabetes in the Bahraini native population. Although there are variations in rates of diabetes by ethnic origin, even in the groups at lower risk the prevalence is among the highest in the world. Diabetes mellitus is present in 26% of men aged 40-59 years and 36% of women aged 50-69 years. When prevalence rates for the same age group (50-59 years) are compared, women had higher rates (35%) than men (29%). This sex difference in diabetes prevalence was removed by adjusting for BMI.

Prevalence of IGT (19% in women and 16% in men aged 50-59 years) was approximately two fold higher than the prevalence of newly diagnosed NIDDM in this study. This is in accordance with previously published studies of high-risk populations[15-18]. IGT is a relatively new clinical category, and its clinical significance is still under study. Several follow-up studies in middle-aged and younger populations have indicated that 50% of IGT subjects revert to normal glucose tolerance, 25% remain permanently glucose intolerant, and <25% progress to diabetes[19-21]. However, middle aged subjects with IGT have an approximately fourfold risk for developing diabetes compared with normoglycaemic subjects[17,20]. It has been suggested that high prevalence of IGT in relation to prevalence of NIDDM is an indicator that prevalence of NIDDM is increasing[22]. This would be consistent with the increase in hospital admissions for diabetes during the last 20 years and with the changes of socioeconomic status and life-style which have led to high prevalence rates of obesity and to low physical activity.

Based on the present survey data,about 35% of those with diabetes aged 40-69 years in Bahrain are undiagnosed. For comparison, 48% of all cases of diabetes in the USA and about one-third of all cases in England in this age group are undiagnosed[7,23].

Average body mass index, and prevalence of obesity (defined as BMI >30) were high in the Bahraini population, and higher in women (37%) than in men (22%). The prevalence of obesity and the average body mass index were lower than reported in surveys of population samples in Saudi Arabia[1] and Kuwait[24], but similar to a study in United Arab Emirates[2], where a community based survey among a Bedouin-derived population found that 27% of all urban residents aged 30-64 years old were obese (BMI $\geq$ 30).

In adult Kuwaitis[24] the mean BMI ($\pm$ standard deviation) was 28.3 ($\pm$ 5.3), the prevalence of overweight was found to be 70% (BMI $\geq$ 25) and the prevalence of obesity was 36% (BMI $\geq$ 30). Prevalence of obesity was higher among women than men.

In a study of Saudi Arabian women attending 15 health centres in urban and rural areas in the Riyadh region[25] whose mean age was 32.2 $\pm$ 11.7 years, the mean BMI was 29.2 $\pm$ 7.0 kgm^2. Only 26% of subjects were ideal weight (BMI <25 kg m^2), while 27% were overweight (BMI 25-29.9 kgm^2), 42% were moderately obese (BMI 30-40 kgm^2) and 5% were morbidly obese (BMI > 40kgm^2).

Historical studies[26,27] suggest that the high rates of obesity in the Arabian Peninsula are a relatively recent phenomenon. It has been hypothesized that native Arabs have a genetic predisposition to overweight in an environment of abundant food and decreased energy expenditure. Continuing high fat intakes in combination with low physical activity may contribute to the increasing prevalence of obesity.

Obesity is the most important determinant of risk of NIDDM within populations. Central obesity, as measured by the waist girth, the waist/hip ratio or the waist/height ratio, has generally been found to show stronger associations than body mass index with diabetes[28].

Several epidemiological studies have shown associations between WHT and prevalence of diabetes, independent of BMI[10,21]. In Bahrainis, prevalence of diabetes was strongly related to waist girth and waist-height ratio in both men and women.

Waist-hip girth ratio was related to diabetes in men but not in women: as both waist and hip girth were associated with glucose intolerance. The reason for this is not clear; it may be that waist-hip girth ratio does not reliably discriminate women with central obesity from women with peripheral obesity in this population. It is notable that the average waist-hip ratios in women in this population were far higher than in other populations.

Levels of physical activity in the population were generally low, especially in women. In populations where physical activity levels are very low, questions about physical inactivity - such as time spent sitting at work or watching television - may be more useful measures of energy expenditure than questions about physical activity. Low physical activity is likely to predispose to NIDDM through its effect on obesity, and possibly also through effects on insulin sensitivity that are not mediated through effects on obesity. Physical activity has been advocated[29] for primary prevention of NIDDM, but randomised trials to establish the specific intensities and duration that are protective ate not available. The inverse association of physical activity with obesity is consistent with a protective effect on NIDDM.

CONCLUSION

These data indicate that BMI, abdominally distributed fat, and physical inactivity are important independent risk factors for both IGT and NIDDM in Bahrain. Attributable risk factors from Mauritius suggest that population wide modification of levels of these risk factors could potentially result in substantially lower occurrence of NIDDM (and IGT). Such interventions should be attempted in high-risk populations. The prevalence of diabetes in Bahrain is increasing with economic development and changes from traditional to modernised lifestyle, especially where people have a lower level of education and socioeconomic development. Therefore, Bahraini people should attempt to retain certain features of their traditional lifestyle (physical activity, healthy eating, and moderate body weight). Increased knowledge of risk factors for diabetes may help to prevent a further rapid increase in the prevalence of diabetes in Bahrain.

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REFERENCES

1. Al-Nuaim AR. Prevalence of glucose intolerance in urban and rural communities in Saudi Arabia. Diabet Med 1997;14:595-602.
2. Asfour MG, Lambourne A, Soliman A, et al. High prevalence of diabetes mellitus and impaired glucose tolerance in the Sultanate of Oman: results of the 1991 national survey. Diabet Med 1995;12:1122-25.
3. El Mugamer IT, Zayat AAS, Hossain MM, et al. Diabetes, obesity and hypertension in urban and rural people of Bedouin origin in the United Arab Emirates. J Trop Med Hyg 1995;98:407-15.
4. Bacchus RA, Bell JL, Madkour M, et al. The prevalence of diabetes mellitus in male Saudi Arabs. Diabetologia 1982;23:330-2.
5. Musaiger AO, Al-Roomi KA. Prevalence of risk factors for cardiovascular diseases among men and women in an Arab Gulf community. Nutr Health 1997;11:149-57.
6. Gulliford MC. Controlling non-insulin-dependent diabetes mellitus in developing countries. Int J Epidemiol 1995;24[Suppl 1]:S53-9.
7. Harris MI, Hadden WC, Knowler WC, et al. Prevalence of diabetes and impaired glucose tolerance and plasma glucose levels in US population aged 20-74 yr. Diabetes 1987;36:523-34.
8. King H, Finch C, Collins A, et al. Glucose tolerance in Papua New Guinea: ethnic differences, association with environmental and behavioral factors and possible emergence of glucose intolerance in a highland community. Med J Aust 1989;151:444-6.
9. Langer O, Langer N, Piper JM, et al. Cultural diversity as a factor in self-monitoring blood glucose in gestational diabetes. J Assoc Acad Minor Phys 1995;6:73-7.
10. Haffner SM, D'Agostino R, Saad MF, et al. Increased insulin resistance and insulin secretion in nondiabetic African-Americans and Hispanics compared with non-Hispanic whites. The Insulin Resistance Atherosclerosis Study. Diabetes 1996;45:742-8.
11. Bahrain Health Information Centre. Annual report 1993. Ministry of Health, State of Bahrain.
12. The Bahrain Central Statistics Organisation. Bahrain Census survey 1991. CSO, State of Bahrain.
13. Welsh Heart Health Survey. Clinical survey results. In: Technical reports No. 20. Cardiff: Wales.
14. WHO Study Group. Diabetes mellitus. Technical report series No. 727. Geneva, World Health Organization, 1985.
15. King H, Rewers M. Global estimates for prevalence of diabetes mellitus and impaired glucose tolerance in adults. Diabets CAre 1993;16:157-77.
16. Zimmet P, Faaiuso S, Whitehouse S, et al. The prevalence of diabetes in rural and urban Polynesian population of Western Samoa. Diabetes 1981;130:45-51.
17. King H, Zimmet P, Raper LR, et al. The natural history of impaired glucose tolerance in the Micronesian population of Nauru: a six-year follow-up study. Diabetologia 1984;26:39-43.
18. Knowler WC, Pettit DJ, Savage PJ, et al. Diabetes incidence in Pima Indians: contributions of obesity and parental diabetes. Am J Epidemiol 1981;113:144-56.
19. Keen H, Jarrett RJ, McCartney P. The ten-year follow-up of the Bedford Survey (1962-1972): glucose tolerance of diabetes. Diabetologia 1982;22:73-78.
20. Jarrett RJ, Keen H, Fuller JH, et al. Worsening of diabetes in men with impaired glucose tolerance ("borderline diabetes"). Diaberologia 1979;16:25-30.
21. Ohlson LO, Larsson B, Bjorntorp P, et al. Risk factors for type 2 (non-insulin-dependent) diabetes mellitus: thirteen and one-half years follow-up of the participants in a study of Swedish men born in 1913. Diabetologia 1987;31:798-805.
22. Dowse DG, Qin H, Collins VR, et al. High prevalence of NIDDM and impaired glucose tolerance in Indian, Creole and Chinese Mauritians. Diabetes 1990;39:390-6.
23. McKeigu PM, Ferrie JE, Pierpoint T, et al. Association of Early-Onset Coronary Heart Disease in South Asian Men with glucose intolerance and Hyperinsulinemia. Circulation 1993;87:152-61.
24. Al-Esa AN. Prevalence of obesity among adult Kuwaitis: a cross-sectional study. Int J Obes Relat Metab Disord 1995;19:431-13.
25. Al-Shammari SA, Khoja TA, Al-Maatouq MA, et al. High prevalence of clinical obesity among Saudi females: a prospective, cross-sectional study in the Riyadh region. J Trop Med Hyg 1994;97:183-8.
26. Al-Awadi F, Amine EK. Overweight and obesity in Kuwait. J Roy Soc Hlth 1989;109:175-9.
27. Emara M, Abdella N, Luqman W, et al. Excess body fat distribution and glucose homeostasis in obese Arab women. Diabetic Medicine 1988;5:369-71.
28. Golay A, Chen N, Chen YD, et al. Effect of central obesity on regulation of carbohydrate metabolism in obese patients with varying degrees of glucose tolerance. J Clin Endocrinol Metab 1990;71:1299-304.
29. Lynch J, Helmrich SP, Lakka TA et al. Moderately intense physical activities and high levels of cardiorespiratory fitness reduce the risk of non-insulin-dependent diabetes mellitus in middle aged men., Arch Intern Med 1996;156:1307-14.