ORIGINAL ARTICLE

Association between sleep duration and diabetes mellitus: Isfahan Healthy Heart Program

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Abstract

Background: Recent studies revealed an association between sleep disturbance and metabolic disorders, such as obesity and metabolic syndrome. An aim of this study was to assess the relation between sleep duration and diabetes mellitus in a representative sample of the Iranian population.

Materials and Methods: Participants were 12514 individuals, (6123 men and 6391 women) studied in the baseline survey of a community based program entitled Isfahan healthy heart program (IHHP). Sleep time was obtained by validated questionnaire. Diabetes mellitus was defined as fasting glucose over 126 mg/dl or 2 hour post prandial glucose at glucose tolerance test over 200 mg/dl, or if the patient was on diabetic medication. The relation between the sleep time and diabetes was examined using categorical logistic regression with adjustment for sex, body mass index and waist circumference.

Results: Compared with those, sleeping 7-8 hours per night, the individuals with sleeping time of 5 hours or less and aged <60 years had an increased odd ratio for diabetes and an impaired glucose tolerance. (OR = 1.37 and 95% CI = 1.13,1.67).

Conclusion: Sleep duration of 5 hours or less in individuals under age 60 years is associated with an increased prevalence of diabetes mellitus and an impaired glucose tolerance test. This finding should be confirmed in longitudinal studies.

Key words: Diabetes mellitus, glucose tolerance, sleep

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Background

Sleep quantity and quality is reported to be associated with an increased morbidity and mortality.[1,2] Previous studies have demonstrated that experimental restriction of sleep to <4 hours per night for 6 nights resulted in an impaired glucose tolerance (IGT) in young healthy adults.[3] Most of these studies have been conducted in western countries with different ethnic background. Furthermore, this experience is limited to large community-based studies,[4,5] and it is not clear whether the results are applicable to the Asian population.

Results from the High-risk and Population Strategy for Occupational Health Promotion (HIPOP-OHP) study in Japan suggests that difficulty in initiating sleep, but not sleep duration or difficulty in maintaining sleep, is associated with a higher risk of diabetes in relatively healthy Asian workers, even after adjusting for a large number of possible confounders.[6]

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In a number of cohort studies,[7-12] it has been shown that sleep disturbances including either an increased or decreased length of nocturnal sleep may increase an incidence of type-2 diabetes, with a higher rate in men than in women.

The present study aims to investigate the relation between the sleep duration and existing diabetes in a large representative sample of the Iranian population.

Materials and Methods

This cross-sectional study was conducted as a part of Isfahan Healthy Heart Program. (IHHP). It is a 6 year comprehensive integrated community based program for cardiovascular disease (CVD) prevention and control via reducing CVD risk factors and improvement of cardiovascular healthy behaviors.[13,14]

Participants were 12514 individuals aged over 19 years. 6123 men and 6391 women entered into the study. Sleep time was obtained by validated questionnaire.[13] The fasting blood glucose of all the participants and blood glucose of those without history of diabetes was measured 2 hours after giving a syrup containing 75 g of glucose powder using enzymatic method of oxidized glucose. Diabetes mellitus (DM) was defined as fasting glucose over 126-mg/dl, or 2-hour postprandial glucose (at glucose tolerance test) over 200 mg/dl, or if the subjects were on diabetic drug or on insulin medication. The 2-hour post-prandial glucose between 140 and 200 mg/dl and fasting glucose between 100 mg/dl and 126 mg/dl was considered as an IGT.

Data were presented as mean and percentiles. The association between diabetes mellitus or impaired glucose tolerance test and sleeping hours were tested with logistic regression models using 7-8 sleeping hours as the reference category. The analyzes were performed unadjusted and also with adjustments for possible confounding variables including age, sex, waist circumference (WC) and body mass index (BMI). Also, it was done separately for both the sexes and age groups over or below 60 years adjusted for BMI, and WC. *P* value below 0.05 was considered significant. All of the analyzes were performed by SPSS software version 15.00.

Result

The study populations consisted of 49.9% men and 51.1% women with a mean age of 38.89 (SD 14.93 years). In our study, 6.9% of the participants were diabetic, and 7.4% had an impaired glucose tolerance. Of the participants, 61% reported sleeping 7-8 hours per night, 30.3% reported sleeping 6 hours or less and 8.7% reported sleeping 9 hours or more. Subjects with lower sleep times were older and had a higher (BMI) and WC ($P < 0.01$) [Table 1]. Also, the frequency distribution of participants in different blood glucose level based on sleep duration categories was presented in Table 1.

Compared with sleep times of 7-8 hours per night, sleep times of <5 hours were associated with a higher odds ratio for IGT and DM. This association remained significant even after an adjustment for age, sex, BMI and WC. However, in subjects with sleep times of 9 hours or more, there was no significant association with IGT or DM [Table 2].

Secondary analyzes after stratification for sex and age demonstrated that an association of sleep time of 5 hours or less with IGT and DM in men and women and in those subjects younger than 60 years was significant after an adjustment with age, sex, WC and BMI, but this association was not significant for the subjects aged 60 years or more [Table 3].

Discussion

Sleep disturbances are common in general population. There are increasing evidence from large screening surveys about the role of sleep disorders as a new cardiovascular risk factor. Sleep disorders are not only independent risk factors, but also potentiate severity of the other risk factors, such as diabetes, hypertension obesity, mental stress and, etc.[15-16]

In our study, sleep duration of 5 hours or less in people under the age 60 is associated with an increased prevalence of DM and IGT. However, sleep duration over 9 hours do not increase prevalence of these metabolic disturbances. In most recent studies, a U-shaped association is reported between the sleep duration and DM, sleep duration over 9 hours and under 5 hours is associated with an increased prevalence of IGT and DM.[3,5,7,12,17]

The differences between our study and other studies about an effect of sleeping longer than 9 hours may be explained by the role of sympathetic nervous system in stress, it is documented that sleep disorders are associated with an increased activity of the sympathetic nervous system,[18,19] this in turn could increase glycogen-breakdown and gluconeogenesis, and this would induce an insulin resistance. There are reports that poor glycemic control is associated with psychological distress.[20-23] If in our population daily stress is strong enough to increase an insulin resistance, reducing daily awakening hours by increasing sleep hours may reduce an incidence of insulin resistance and this effect may compensate the effect of sleeping more than 9 hours. Our study revealed no significant relation between the DM and IGT in individuals aged 60 years. This may be due to the changes that take place in physiology of metabolic effect of sleep deprivation with aging. According to one recent study, decreased sleep-duration does not predict overweight or obesity (another metabolic effect of sleep deprivation) in older woman (aged >50 years)

Table 1: Basic characteristics of the study participants

Characteristic	≤5	6	7-8	≥9	total	*P*-value
Number of subjects (%)	1447 (11.6)	2336 (18.7)	7622 (61)	1087 (8.7)	12492	NA
Age (year)[Θ]	47.35 (16.19)	40.52 (14.36)	37.26 (14.08)	35.49 (15.81)	38.89 (14.93)	<0.01
Female sex (%)[ю]	50.1	47.5	51.1	60	51.1	<0.01
Body mass index[Θ]	26.21 (5.12)	26 (4.68)	25.32 (4.68)	25.02 (5.08)	25.52 (4.78)	<0.01
Waist circumference[Θ]	93.30 (13.57)	92.23 (13.48)	89.86 (13.13)	88.40 (13.63)	90.57 (13.37)	<0.01
Glucose regulation (%)[ю]						
Normal glucose tolerance	78.7	86.3	86.9	86.5	85.7	<0.01
Impaired glucose tolerance	9.8	7.2	7	6.7	7.4	
Diabetes mellitus	11.5	6.5	6.1	6.7	6.9	

[Θ]Indicates chi-square test (%). [ю]Indicates ANAOVA test mean (SD)

Table 2: Data for diabetes mellitus and impaired glucose tolerance by reported usual time in subjects

Usual sleep time per night	Model					
	1		2		3	
	DM	IGT	DM	IGT	DM	IGT
≤5	2.09 (1.72, 2.53)	1.54 (1.26, 1.88)	1.47 (1.20, 1.80)	1.27 (1.03, 1.56)	1.62 (1.33, 1.99)	1.27 (1.04, 1.57)
6	1.08 (0.89, 1.31)	1.04 (0.86, 1.25)	1.02 (0.84, 1.25)	1.01 (0.84, 1.22)	0.92 (0.75, 1.13)	0.97 (0.80, 1.16)
≥9	1.11 (0.86, 1.45)	0.96 (0.74, 1.24)	1.03 (0.79, 1.35)	0.91 (0.70, 1.18)	1.10 (0.83, 1.44)	0.94 (0.72, 1.23)

DM=Diabetes mellitus, IGT=Impaired glucose tolerance test, Data are given as odds ratio (95% confidence interval) for the presence of DM or IGT relative to normal glucose tolerance from categorical logistic regression models using 7-8 hours of sleep per night as the reference category. Model 1 was unadjusted; Model 2, adjusted for age, sex and Model 3, adjusted for age, sex, waist circumference and body mass index

Table 3: Diabetes mellitus or impaired glucose tolerance by reported usual sleep time

Variable	Number of subject	≤5	6	≥9	*P*-value
Sex					
Male	5653	1.35 (1.06, 1.71)	0.96 (0.77, 1.71)	1.14 (0.82, 1.58)	0.07
Female	6046	1.54 (1.26, 1.89)	0.94 (0.78, 1.14)	0.94 (0.73, 1.21)	0.00
Age (year)					
<60	10157	1.34 (1.10, 1.63)	0.94 (0.79, 1.11)	0.97 (0.77, 1.22)	0.02
≥60	1542	1.08 (0.83, 1.41)	0.87 (0.64, 1.18)	1.09 (0.73, 1.63)	0.60

Data are given as odds ratio (95% confidence interval) for the presence of either DM or IGT relative to normal glucose tolerance from categorical logistic regression models using 7-8 hours of sleep per night as reference category. Analyzes are adjusted for age sex, waist circumference and body mass index

in contrast to younger woman.[24] It should be noted that our study has two potential limitations, first, as the study utilized a cross-sectional design, it cannot prove a casual relationship, second, sleep time was self-reported and was not directly measured, therefore, patient's co-operation could be a confounding factor.

As all of these associations have been documented by cross-sectional studies, they should be confirmed by longitudinal studies.

Conclusion

Sleep duration of 5 hours or less in individuals aged <60 years is associated with an increased prevalence of diabetes mellitus even after adjusting for body mass index, waist circumference and sex. Improvement of sleep quality and normalization of sleep length could lead to a better glucose tolerance and lower long-term risk for type-2 diabetes.

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