The relationship between sleep and obesity

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Introduction:

Strategies for preventing and treating obesity are complex and far greater than simply eating less and moving more. While multiple factors contribute to the growing obesity epidemic, studies have shown an important association between habitual sleep duration and obesity [1]. Possible mechanisms linking sleep and obesity include changes at the physiological level (hormonal metabolic changes) that may alter hunger and appetite as well as factors that reduce energy expenditure such as reduced thermogenesis, fatigue and decreased physical activity [2-4]. Reports suggest that the relationship between body mass index (BMI) and sleep is U-shaped rather than linear [4, 5]. Although BMI is the most reported measure of obesity, there are other indicators of adiposity such as fat mass, waist circumference or waist-to-hip ratio.

Recent studies have examined sleep patterns and other adiposity measures such as body composition. For example, Poggiogalle et al. [6] reported a negative association between fat mass and sleep duration and Ford et al. [7] have documented an inverse association with waist circumference. However, the results for BMI are inconsistent, some showing no association and some reporting negative or U-shaped associations [8]. These mixed findings highlight the need for additional study of body composition as it relates to sleep duration. Accordingly, the aim of this study was to examine the association between sleep duration and obesity using multiple measures/indicators of obesity in the Atlantic PATH cohort.

Methods:

Study design and sample
Data collection and recruitment of participants in the Atlantic region of Canada have been previously described [9]. In the current study, 31,174 participants provided data on sleep duration and over 24,000 provided both information on both sleep duration and anthropometric data. Participants that provided information on both of these parameters were used to assess the relationship between sleep duration and adiposity.

Assessment of sleep duration and adiposity measures
The estimate of the sleep duration based on an average number of hours per day and anthropometric data such as height, weight, waist and hip circumference among Atlantic PATH participants was collected from questionnaires at baseline recruitment. Standard anthropometric indexes (height, weight, hip and waist) were also collected by research nurses and bioelectrical

impedance was used to assess body composition. Both self-reported and measured height, weight, waist and hip circumference were used for calculating BMI and waist-to-hip ratios. The fat mass index and fat-free mass index were calculated by dividing fat mass and fat-free mass by height in meters squared, respectively [10]. Participants with a BMI of <18.5, 18.5-24.9, 25.0-29.9 and >30.0 were considered underweight, normal weight, overweight and obese, respectively. The waist-to-hip ratio was set at >0.90 for men and >0.85 for women [11]. Abdominal obesity was defined as having a waist circumference ≥102 cm for men and ≥88cm for women [9, 11]. Sleep categories (<5, 5-7, 7-9, 9-11 and >11 hours) were selected based on previously published work, suggesting a U-shaped curve with 7-9 hours being optimal and <5 or >11 hours resulting in an increased risk of disease/mortality [8, 12, 13].

Statistical analysis

Differences in anthropometric measures across different sleep duration categories was determined by the multivariate general linear model. Data is presented as means ± standard deviations (SD).

Results:

In all the sleep categories, more than 60% of participants in a defined category had a waist-to-hip ratio greater than recommended (<0.9 in men or <0.85 in women) (Table 1). Abdominal obesity was found in 65%, 56%, 51%, 52% and 56% of participants that slept >11 hours, 9-11 hours, 7-9 hours, 5-7 hours and less than 5 hours, respectively (Table 1). Within each sleep category, the percent of participants with a BMI of overweight or obese was 83%, 73%, 70%, 73% and 76% for participants that slept >11 hours, 9-11 hours, 7-9 hours, 5-7 hours and less than 5 hours, respectively (Table 1). Significant differences in weight, waist circumference, hip circumference, BMI, waist-to-hip ratio, percent fat mass, fat mass index and fat-free mass index were observed among sleep categories (Table 2).

Table 1: Adiposity measurements of participants with different sleep durations.

	Sleep Category (hours)				
	<5	**5-7**	**7-9**	**9-11**	**>11**
			n (%)		
Waist-to-hip ratio [a]	443 (65.44)	4021 (61.99)	10622(61.81)	1117 (64.94)	85 (67.46)
Abdominal Obesity [b]	381 (56.28)	3359 (51.71)	8763 (50.85)	970 (56.40)	80 (64.52)
BMI categories					
<18.5	7 (1.13)	42 (0.69)	135 (0.83)	16 (1.01)	3 (2.50)
18.5-24.9	142 (22.83)	1625 (26.66)	4669 (28.84)	414 (26.17)	18 (15.00)
25.0-29.9	226 (39.33)	2246 (36.85)	6063 (37.46)	572 (36.16)	35 (29.17)
>30.0	226 (36.33)	2182 (35.80)	5320 (32.87)	580 (36.66)	64 (53.33)

[a] Waist-to-hip ratio >0.90 for men and >0.85 for women.

[b] Waist circumference ≥102 cm for men and ≥ 88 cm for women.

Table 2: Adiposity measurements of participants with different sleep durations.

	Sleep Category (hours)					
	<5	**5-7**	**7-9**	**9-11**	**>11**	***P*-value**
			Mean (SD)			
Height, cm	160.04 (21.98)	162.20 (20.82)	162.51 (20.06)	161.56 (20.68)	160.73 (23.79)	0.388
Weight, km	79.22 (19.96)	79.48 (18.32)	78.54 (18.01)	79.21 (18.30)	85.16 (20.16)	0.025
Waist, cm	94.24 (16.45)	93.82 (16.21)	93.16 (15.81)	94.69 (16.10)	98.50 (20.81)	0.005
Hips, cm	105.61 (13.77)	105.46 (13.52)	105.07 (13.16)	106.06 (13.24)	108.23 (15.19)	0.073
Body mass index (BMI), kg/m^2	28.85 (6.57)	28.22 (5.84)	28.19 (5.86)	28.63 (6.22)	30.36 (6.70)	0.007
Waist-to-hip ratio	0.89 (0.11)	0.89 (0.11)	0.89 (0.10)	0.89 (0.11)	0.91 (0.17)	0.033
Percentage fat mass, %	34.33 (8.75)	33.41 (9.30)	33.46 (9.16)	34.25 (9.07)	34.31 (10.78)	0.008
Fat mass index, kg/m2	10.07 (7.08)	9.61 (8.76)	9.51 (4.69)	9.82 (5.08)	10.19 (5.67)	0.001
Fat free mass index, kg/m2	17.83 (3.81)	17.86 (4.26)	17.88 (4.55)	17.71 (4.35)	18.10 (4.81)	0.029

Discussion:

Results from previous studies examining sleep and obesity are inconsistent and few report on multiple measurements of adiposity [8]. This study examines the relationship between sleep duration and several measurements of adiposity in the Atlantic PATH cohort. The findings of this study demonstrate significant differences in anthropometric measures among different sleep duration categories. Specifically, those who sleep > 11 hours per day had the highest percent of participants defined as being obese through various classifications (Table 1). Previous reports suggest additional adiposity measures (such as waist circumference, waist-to-hip ratio, or % body fat) may also be associated with sleep duration; however, regardless of adiposity measure, several reports show no association [8]. Differences between studies may be due to the many factors that contribute to differences in adiposity measures and thus influence the relationship between sleep and obesity. For example, recent research suggests that sleep duration may be associated with BMI but only in certain age groups which may be due to different sleep needs/problems, stresses, hormonal changes across the lifecourse, or multiple morbidities that may impact sleep [13]. In addition, several pathways that regulate eating habits may be altered by sleep. For example, changes in endocrine function, such as altered levels of hormones that control appetite, have been reported in individuals with short sleep duration [2, 3]. More specifically, people sleeping less than 5 hours have raised ghrelin and lowered leptin levels [2, 3], hormones that stimulate appetite and inhibit hunger, respectively, thus influencing overall food/energy intake. The current study indicates clear differences in anthropometric measures with different sleep durations but the exact direction of the relationship is not fully understood. In future research, the Atlantic PATH data will be used to further examine the relationship between obesity and sleep using the multiple measurements of adiposity incorporated here and including other lifestyle factors such as physical activity, mental health, eating behaviors and the existence of other chronic diseases.

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