Associations between physical activity, sedentary behaviour and sleep duration and quality

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Introduction

Lack of sleep and poor sleep quality has been linked to many poor physical and mental health outcomes including cardiovascular disease (CVD), depression, anxiety, diabetes, hypertension, obesity, and all-cause mortality [1-7]. Of note, sleep quality has not only been associated with poorer health outcomes, but has been shown to exacerbate associations between other unhealthy lifestyle behaviours and health outcomes [1-7]. Additionally, existing treatments for sleep disorders, while effective, may have side-effects. Physical activity (PA) has been suggested as a possible alternative treatment among general and chronic disease populations [2, 8, 9]. Engaging in regular PA has been linked to changes in sleep circadian rhythms, thermogenic regulation, body weight, physical fitness, anxiety, depression, and pain; any of which could be a possible mechanism by which PA impacts sleep. While emerging evidence suggests that sedentary behaviour (SB) may also be associated with poor self-reported sleep outcomes[10], very little research on SB and sleep associations was found. The goal of this report is to examine any associations between PA or SB and sleep duration or quality among a cohort of Atlantic Canadians.

Methods

Study Design and Participants

A detailed description of participant recruitment and data collection methods has been previously published [11]. Briefly, as part of the Canadian Partnership for Tomorrow Project (CPTP), Atlantic Partnership for Tomorrow's Health (PATH) recruited 31,173 participants, aged 35-69 years and currently living in Atlantic Canada, to complete a series of assessments. Self-report questionnaires including lifestyle behaviors, health outcomes, and physical measurements were collected.

Measures

Physical measures included height, weight, and waist circumference and were measured either by trained research personnel or were self-reported. Participants were asked to report their levels of domain-specific PA and SB using the International Physical Activity Questionnaire-Long Form (IPAQ) [12]. Total daily minutes and MET minutes were calculated for each domain, intensity, and overall activity. In order to estimate activity-related energy expenditure, MET-hours per day were multiplied by kilograms of body weight (1 MET = 1 kcal/kg/hour). Resting energy expenditure (REE) was estimated using the Shofield equation [13]. To calculate total energy expenditure (TEE), one MET was subtracted from each hour of active time to eliminate double counting of energy expenditure equivalent to REE for that time period, then the sum of REE and activity-related energy expenditure was multiplied by 1.1 to account for the energy expended during digestion. Therefore, TEE was estimated using the following equation:

TEE = [[REE - (total hours/d of activity×weight (kg))] + [MET hours/d×weight (kg)]]1.1

From here, Physical Activity Level (PAL) ratios were calculated by dividing TEE by REE and then used to classify activity levels into he following categories: inactive (<1.40), low active (1.40 to 1.59), active (1.6 to 1.89), and very active ($\geq$ 1.90) [14].

Sleep duration and sleep quality were measured with two items including asking participants to report in hours and minutes "On average, how many hours per day do you usually sleep, including naps?" and "How often do you have trouble going to sleep or staying asleep?" on a 5-point scale ranging from "never" to "all the time".

Analyses

Where available, objective physical measures were used in the analyses. In cases where clinic assessments were not available, self-reported data was used. Associations were explored using both chi-square and analyses of variance (ANOVA) for categorical (i.e., <5 hours, 5-6.99 hours, 7-8.99 hours, 9-10.99 hours, and ≥11 hours) and continuous measures (i.e., average hours per night) of sleep respectively.

Results

This study included data from 26,706 participants that had both energy expenditure measures and sleep data. PAL computation revealed 61.6% of the sample were considered inactive with a further 14.7% in the 'low active' category. The remaining 23.7% of the sample were considered 'active' or 'very active'. Tertiles were calculated from the data to assess SB, however, most of the sample were sedentary between four and seven hours per day (37.7%). Further detail by sex can be found in Table 1.

The majority of the sample (65.5%) reported getting between seven and nine hours of sleep per night with an average of 7.2 hours per night (SD = 1.26). In terms of sleep quality, the majority of the participants reported having sleep troubles 'some of the time' or less frequently (77.5%). Twenty-two percent indicated they had trouble sleeping 'most' or 'all of the time'. More detailed description of reported sleep duration and quality by sex can be found in Table 1.

Tables 2 and 3 detail the associations between PAL or SB and sleep duration or sleep quality categories. ANOVAs showed a significant difference in sleep duration among the PAL groups with 7.22, 7.18, 7.17, and 7.14 average hours of sleep for those inactive, low active, active, and very active, respectively (p=.002). Posthoc analysis revealed the difference between those participants who were inactive and very active (+0.082; p=.001). Within the categories, as sleep duration increased, the percentage of those inactive also increased. There was no clear trend for SB and sleep duration. U-shaped trends emerged with sleep disturbances either 'none of the time' or 'all of the time' at higher levels than 'some of the time' among those classified as very active. Sleep disturbances decreased for those sedentary less than 4 hours while they increased for those with more than 7 hours of sedentary time.

Discussion

The majority of participants in this cohort reported getting between 7 and 9 hours of sleep with some variation between the sexes. Of note, men reported significantly fewer sleep disturbances than women (p<.001). Our results showed that as sleep duration increased so did the proportion of those classified as inactive. Results also showed that a higher proportion of those who slept more than 11 hours and had sleep disturbances 'all the time' were also those who were sedentary for more than 7 hours. While there is less research on SB's link to sleep quality, existing data suggests a link similar to PA [10, 15].

More research is needed to confirm a link between SB and sleep duration and quality. Likewise, future research, including both observational and intervention studies, should incorporate objective measures of activity and sleep. Numerous wearable activity trackers also assess sleep. Validation studies on the accuracy and reliability of these sleep assessments are

needed, but this may be a promising and relatively inexpensive avenue for researchers that want

to assess the link between PA, SB, and sleep.

References

1. Duncan MJ, Kline CE, Vandelanotte C, Sargent C, Rogers NL, Di Milia L. Cross-sectional associations between multiple lifestyle behaviors and health-related quality of life in the 10,000 Steps cohort. Plos One. 2014;9(4):e94184-e. doi:10.1371/journal.pone.0094184.

2. Courneya KS, Segal RJ, Mackey JR, Gelmon K, Friedenreich CM, Yasui Y et al. Effects of exercise dose and type on sleep quality in breast cancer patients receiving chemotherapy: a multicenter randomized trial. Breast cancer research and treatment. 2014;144:361-9. doi:10.1007/s10549-014-2883-0.

3. Lambiase MJ, Gabriel KP, Kuller LH, Matthews KA. Temporal relationships between physical activity and sleep in older women. Medicine and Science in Sports and Exercise. 2013;45(12):2362-8. doi:10.1249/MSS.0b013e31829e4cea.

4. Yang P-Y, Ho K-H, Chen H-C, Chien M-Y. Exercise training improves sleep quality in middle-aged and older adults with sleep problems: a systematic review. Journal of Physiotherapy. 2012;58(3):157-63. doi:http://dx.doi.org/10.1016/S1836-9553(12)70106-6.

5. Klingenberg L, Sjödin A, Holmbäck U, Astrup A, Chaput JP. Short sleep duration and its association with energy metabolism. Obesity Reviews. 2012;13(7):565-77. doi:10.1111/j.1467-789X.2012.00991.x.

6. Kline CE, Sui X, Hall MH, Youngstedt SD, Blair SN, Earnest CP et al. Dose-response effects of exercise training on the subjective sleep quality of postmenopausal women: Exploratory analyses of a randomised controlled trial. BMJ Open. 2012;2(4). doi:10.1136/bmjopen-2012-001044.

7. Loprinzi PD, Cardinal BJ. Association between objectively-measured physical activity and sleep, NHANES 2005-2006. Mental Health and Physical Activity. 2011;4(2):65-9. doi:10.1016/j.mhpa.2011.08.001.

8. Buman MP, Phillips BA, Youngstedt SD, Kline CE, Hirshkowitz M. Does nighttime exercise really disturb sleep? Results from the 2013 National Sleep Foundation Sleep in America Poll. Sleep Medicine. 2014;15(7):755-61. doi:http://dx.doi.org/10.1016/j.sleep.2014.01.008.

9. Yang PY, Ho KH, Chen HC, Chien MY. Exercise training improves sleep quality in middle-aged and older adults with sleep problems: A systematic review. Journal of Physiotherapy. 2012;58(3):157-63. doi:10.1016/S1836-9553(12)70106-6.

10. Buman MP, Kline CE, Youngstedt SD, Phillips B, Tulio De Mello M, Hirshkowitz M. Sitting and television viewing: Novel risk factors for sleep disturbance and apnea risk? Results from the 2013 National Sleep Foundation Sleep in America poll. Chest. 2015;147(3):728-34. doi:10.1378/chest.14-1187.

11. Yu ZM, Parker L, Dummer TJB. Depressive symptoms, diet quality, physical activity, and body composition among populations in Nova Scotia, Canada: Report from the Atlantic Partnership for Tomorrow's Health. Preventive Medicine. 2014;61:106-13. doi:10.1016/j.ypmed.2013.12.022.

12. Craig CL, Marshall AL, Sjostrom M, Bauman AE, Booth ML, Ainsworth BE et al. International physical activity questionnaire: 12-country reliability and validity. Med Sci Sports Exer. 2003;35.

13. Schofield WN. Predicting basal metabolic rate, new standards and review of previous work. Human nutrition Clinical nutrition. 1985;39 Suppl 1:5-41.

14. Trumbo P, Schlicker S, Yates AA, Poos M. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. Journal of the American Dietetic Association. 2002;102(11):1621-30. doi:10.1016/S0002-8223(02)90346-9.

15. Mitchell JA, Godbole S, Moran K, Murray K, James P, Laden F et al. No Evidence of Reciprocal Associations between Daily Sleep and Physical Activity. Medicine and Science in Sports and Exercise. 2016;48(10):1950-6. doi:10.1249/MSS.0000000000001000.

Table 1. Description of PA, SB, sleep duration, and sleep quality among a cohort of Atlantic Canadians by sex.

	Women n (%)	Men n (%)	p value
PAL score (N=27178)			
Inactive	11885 (62.7)	4869 (59.3)	<.001
Low active	2856 (15.1)	1142 (13.9)	
Active	2045 (10.8)	965 (11.7)	
Very Active	2175 (11.5)	1241 (15.1)	
Sedentary behaviour (N=27662)			
≤4 hours	5886 (30.9)	2602 (30.2)	.089
4.01-6.99 hours	7208 (37.9)	3215 (37.3)	
≥7 hours	5945 (31.2)	2806 (32.5)	
Sleep Duration (N=30569)			
< 5 hours	587 (2.8)	212 (2.3)	<.001
5 to > 7 hours	5120 (24.1)	2446 (26.3)	
7 to < 9 hours	13968 (65.6)	6045 (65.1)	
9 to < 11 hours	1523 (7.2)	547 (5.9)	
≥ 11 hours	82 (0.4)	39 (0.4)	
Trouble sleeping (N=31057)			
None of the time	2125 (9.8)	1645 (17.5)	<.001
A little of the time	5759 (26.6)	3137 (33.4)	
Some of the time	8372 (38.7)	3069 (32.7)	
Most of the time	4053 (18.7)	1186 (12.6)	
All of the time	1352 (6.2)	359 (3.8)	

Note: PA=Physical activity, SB=Sedentary behaviour; PAL=Physical Activity Level.

Table 2. Comparison of PA and SB measures among sleep duration categories.

		Sleep duration n (%)					p value
		<5	5-<7	7-<9	9-<11	≥11	
PAL	Inactive	245 (51.9%)	2625 (58.5%)	7284 (60.4%)	715 (60.1%)	34 (66.7%)	<.001
	Low active	82 (17.4%)	632 (14.1%)	1778 (14.7%)	148 (12.4%)	8 (15.7%)	
	Active	72 (15.3%)	546 (12.2%)	1451 (12.0%)	148 (12.4%)	3 (5.9%)	
	Very active	73 (15.5%)	681 (15.2%)	1549 (12.8%)	178 (15.0%)	6 (11.8%)	
Sedentary time	<4 hours	238 (35.4%)	1968 (29.5%)	5568 (30.8%)	575 (31.6%)	25 (26.3%)	<.001
	4-6.99 hrs	259 (38.5%)	2429 (36.4%)	6903 (38.2%)	695 (38.2%)	33 (34.7%)	
	≥7 hrs	175 (26.0%)	2277 (34.1%)	5613 (31.0%)	547 (30.1%)	37 (38.9%)	

Note: PA=Physical activity, SB=Sedentary behaviour; PAL=Physical Activity Level.

Table 3. Comparison of PA and SB measures among sleep quality categories.

		Sleep Quality n (%)					p value
		None of the time	A little of the time	Some of the time	Most of the time	All of the time	
PAL	Inactive	953 (57.1%)	3645 (60.9%)	4099 (60.0%)	1835 (59.8%)	499 (54.1%)	<.001
	Low active	229 (13.7%)	859 (14.4%)	1023 (15.0%)	414 (13.5%)	157 (17.0%)	
	Active	216 (12.9%)	688 (11.5%)	832 (12.2%)	388 (12.7%)	115 (12.5%)	
	Very active	272 (16.3%)	793 (13.2%)	877 (12.8%)	429 (14.0%)	151 (16.4%)	
Sedentary time	<4 hours	1038 (30.9%)	2509 (30.7%)	3187 (31.5%)	1331 (29.2%)	396 (28.3%)	<.001
	4-6.99 hrs	1294 (38.5%)	3131 (38.4%)	3745 (37.0%)	1734 (38.0%)	493 (35.2%)	
	≥7 hrs	1027 (30.6%)	2524 (30.9%)	3176 (31.4%)	1494 (32.8%)	511 (36.5%)	

Note: PA=Physical activity, SB=Sedentary behaviour; PAL=Physical Activity Level.