Webinar Will Begin Momentarily

Become an Orgain Ambassador Today!

Request an Orgain Ambassador account to access our on-line sampling portal so you can share Orgain products and discount offers with your patients or clients.

healthcare.orgain.com/ambassador

Orgain

Professional Education Series

Support. Inform. Educate. Empower.

The Physiological Connections Between Diet & Sleep and Associated Risks for Developing Chronic Diseases

TODAY'S AGENDA:

- Introduction & Housekeeping
- Speaker Introduction
- Presentation
- Q&A
- Closing

WEBINAR HOST:

Acacia Wright, RD, CD
Sr. Manager of Nutrition Communications
Orgain, LLC

WEBINAR PRESENTER:

Marie-Pierre St-Onge, Ph.D, CCSH, FAHA
Associate Professor of Nutritional Medicine,
Director of Columbia University Irving Medical Center Sleep center of Excellence

The Physiological Connections Between Diet & Sleep: Associated Risks for Developing Chronic Diseases

Marie-Pierre St-Onge, PhD, CCSH, FAHA

Associate Professor, Division of General Medicine

Director, Center of Excellence for Sleep & Circadian Research

Department of Medicine, Columbia University Irving Medical Center

COLUMBIA | Vagelos College of Physicians and Surgeons

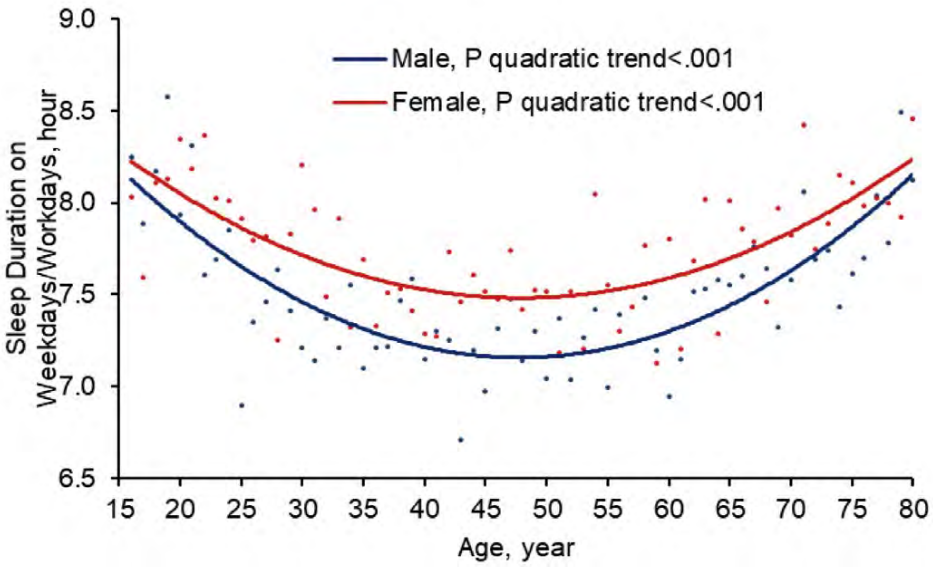
Learning Objectives

- Explain the relationships between sleep, obesity, and chronic diseases
  - Epidemiological evidence
  - Clinical intervention studies
- Describe mechanisms by which sleep influences obesity and chronic disease risk
  - Short & long-term effects of sleep restriction
  - Patterns of sleep
- Discuss influence of diet on sleep

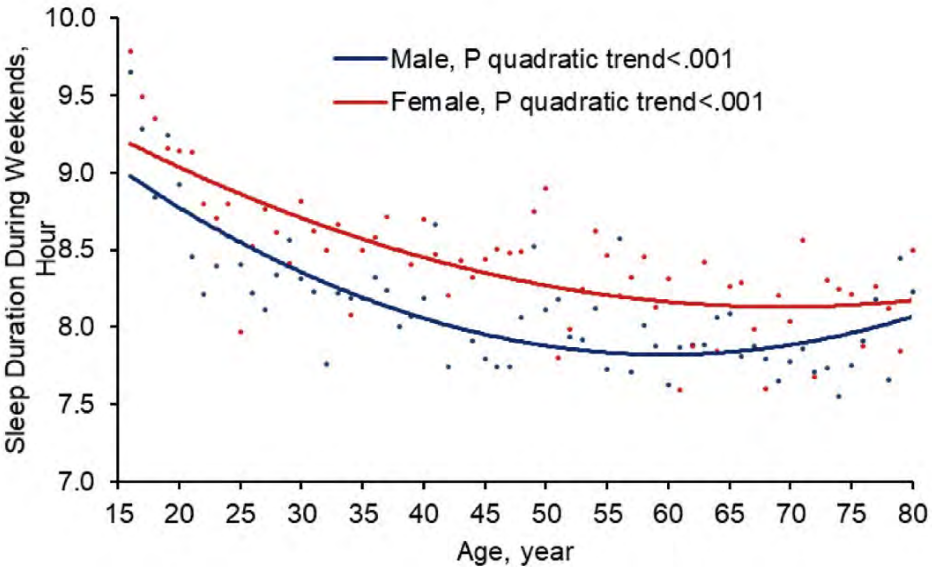
Hirshkowitz et al., Sleep Health 2015;1:40-3.

Sleep Duration in Males vs Females: Weekdays vs Weekends

Weekdays



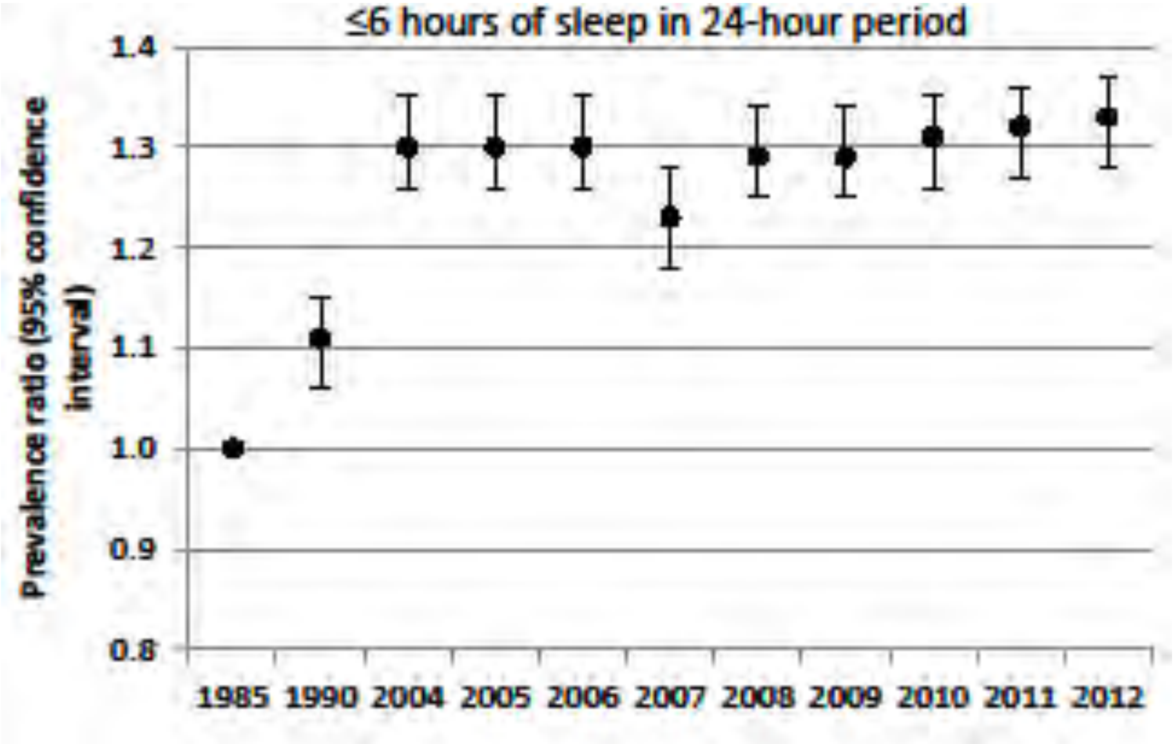
Weekends



In general, females report 20 minutes longer sleep than males across the lifespan & fewer report short sleep duration

Cao & Yang, Sleep Epidemiol 2022;2:100026.

Rising prevalence of short sleep in US adults



Age-adjusted prevalence of sleeping ≤6 h/night:

- 1985: 22.3%
- 2012: 29.2%

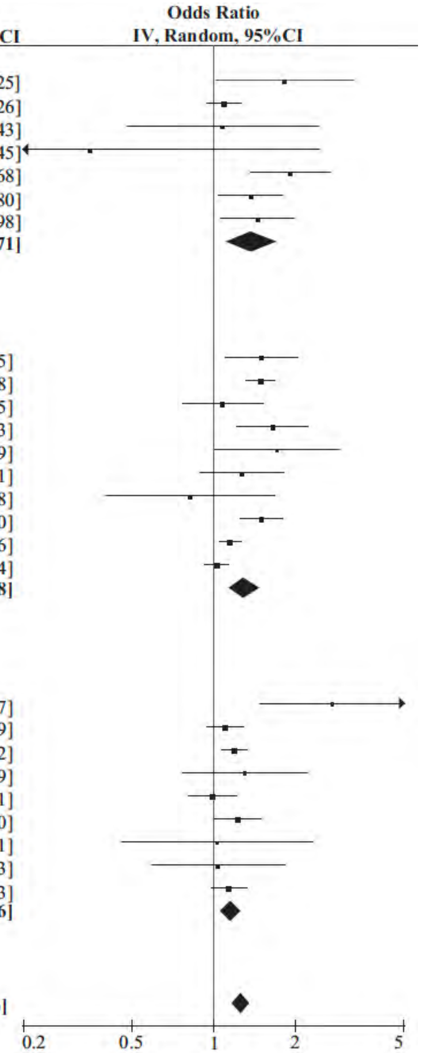
Age-adjusted prevalence of sleeping 7-8 h/night:

- 1985: 65.9%
- 2012: 62.8%

Ford et al. Sleep 2015;38:829-32.

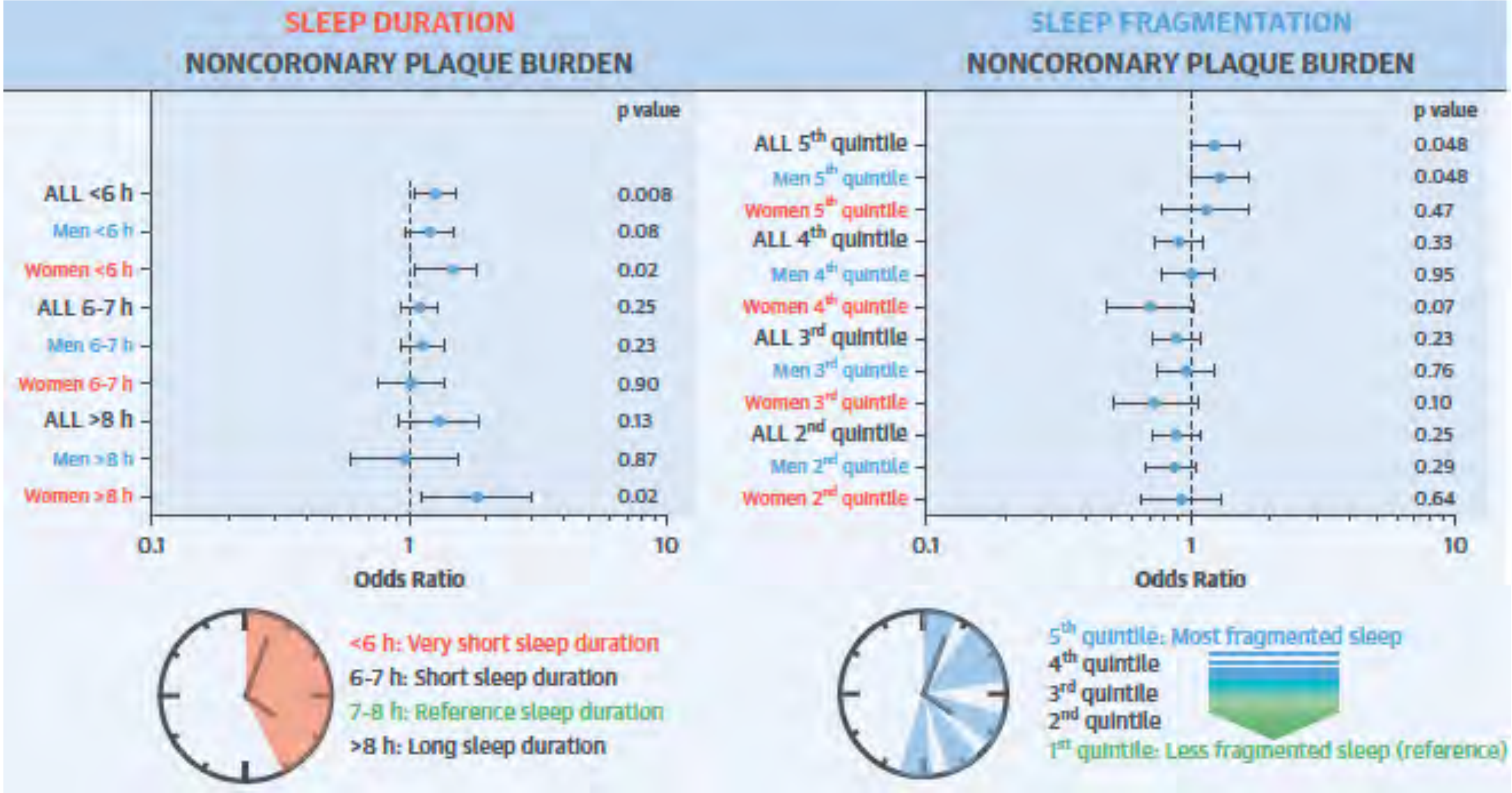
Increased odds of developing obesity in short sleepers

Reference	log[Odds Ratio]	SE	Weight, %	Odds Ratio IV, Random, 95%CI
Sleep duration: < 5 h				
Itani 2011 (women)	0.5988	0.2954	1.4	1.82 [1.02–3.25]
Itani 2011 (men)	0.0862	0.0755	6.5	1.09 [0.94–1.26]
Vgontzas 2013	0.077	0.4137	0.8	1.08 [0.48–2.43]
Watanabe 2010 (women)	-1.0498	0.9928	0.1	0.35 [0.05–2.45]
Watanabe 2010 (men)	0.6471	0.1733	3.1	1.91 [1.36–2.68]
Xiao 2013 (women)	0.3148	0.1406	4.0	1.37 [1.04–1.80]
Xiao 2013 (men)	0.3716	0.1598	3.5	1.45 [1.06–1.98]
Subtotal (95%CI)			**19.5**	**1.38 [1.11–1.71]**
Heterogeneity: Tau² = 0.04; Chi² = 13.93, df = 6 (P = 0.03); I^2 = 57%				
Test for overall effect: Z = 2.91 (P = 0.004)				
Sleep duration: 5.0–5.9 h				
Kobayashi 2012	0.4055	0.1582	3.5	1.50 [1.10–2.05]
Kobayashi 2018	0.3988	0.0618	7.1	1.49 [1.32–1.68]
Nagai 2013	0.077	0.1726	3.2	1.08 [0.77–1.55]
Stranges 2008	0.5008	0.154	3.6	1.65 [1.22–2.23]
Theorell-Haglöw 2014	0.5365	0.2686	1.7	1.71 [1.01–2.89]
Vgontzas 2013	0.239	0.1814	3.0	1.27 [0.89–1.81]
Watanabe 2010 (women)	-0.1985	0.3663	1.0	0.82 [0.40–1.68]
Watanabe 2010 (men)	0.4055	0.093	5.8	1.50 [1.25–1.80]
Xiao 2013 (women)	0.1398	0.0464	7.8	1.15 [1.05–1.26]
Xiao 2013 (men)	0.0296	0.0521	7.6	1.03 [0.93–1.14]
Subtotal (95% CI)			**44.1**	**1.30 [1.14–1.48]**
Heterogeneity: Tau² = 0.03; Chi² = 36.40, df = 9 (P = 0.0001); I^2 = 75%				
Test for overall effect: Z = 3.93 (P < 0.0001)				
Sleep duration: 6–7 h				
Gutiérrez-Repiso 2014	1.0043	0.3158	1.3	2.73 [1.47–5.07]
Kobayashi 2012	0.0953	0.0802	6.3	1.10 [0.94–1.29]
Kobayashi 2018	0.174	0.0542	7.5	1.19 [1.07–1.32]
McMahon 2019	0.2624	0.2672	1.7	1.30 [0.77–2.19]
Nagai 2013	-0.0101	0.1024	5.4	0.99 [0.81–1.21]
Stranges 2008	0.207	0.1005	5.5	1.23 [1.01–1.50]
Vgontzas 2013	0.0296	0.4113	0.8	1.03 [0.46–2.31]
Watanabe 2010 (women)	0.0392	0.2892	1.5	1.04 [0.59–1.83]
Watanabe 2010 (men)	0.131	0.0772	6.5	1.14 [0.98–1.33]
Subtotal (95% CI)			**36.3**	**1.16 [1.06–1.26]**
Heterogeneity: Tau² = 0.00; Chi² = 11.19, df = 8 (P = 0.19); I^2 = 28%				
Test for overall effect: Z = 3.21 (P = 0.001)				
Total (95% CI)			**100.0**	**1.26 [1.17, 1.36]**
Heterogeneity: Tau² = 0.02; Chi² = 64.15, df = 25 (P = 0.0001); I^2 = 61%				
Test for overall effect: Z = 5.98 (P < 0.0001)				
Test for subgroup diferences: Chi² = 3.54, df = 2 (P = 0.17), I^2 = 43.6%				



Costa Guimaraes et al. Nutr Rev 2022;80:983-1000.

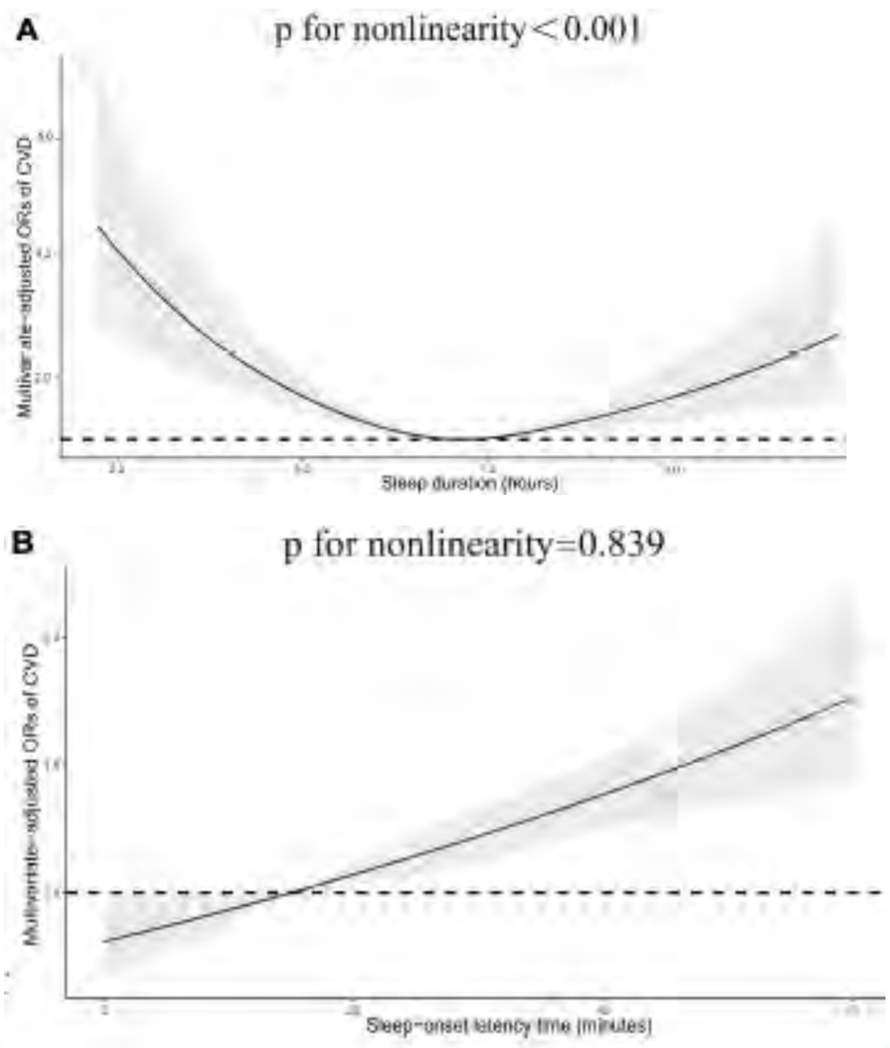
Increased subclinical atherosclerotic burden associated with poor sleep



Dominguez et al., J Am Coll Cardiol 2019;73:134-44.

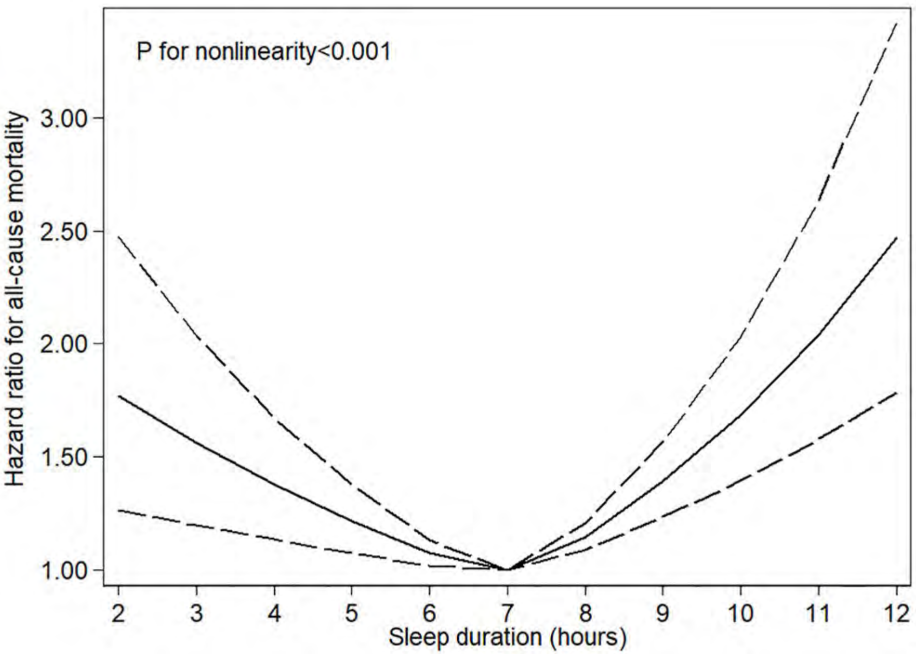
Increased odds of CVD in individuals with sleep problems: NHANES 2005-2008

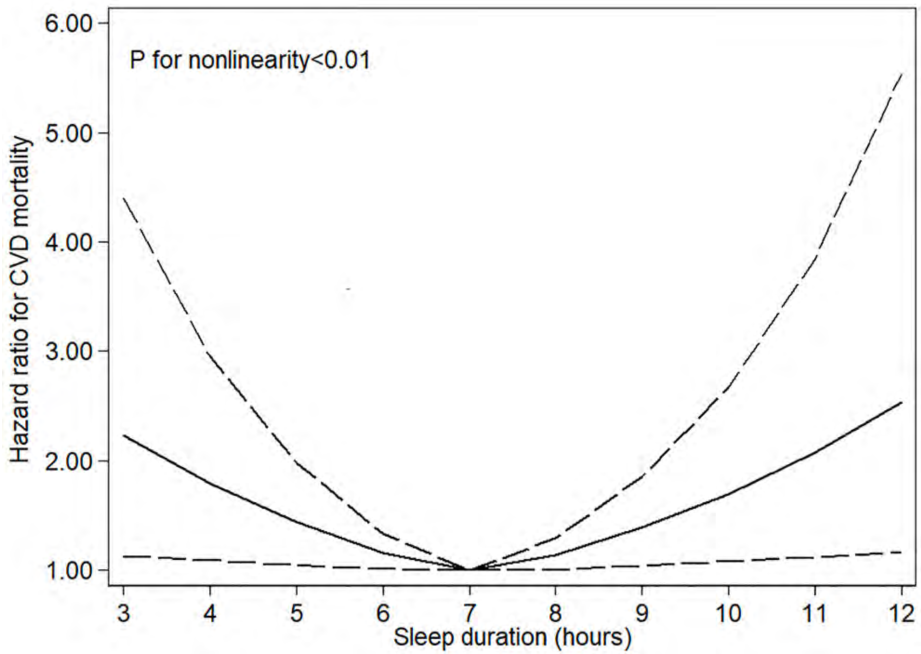
	Model 1 OR (95% CI) *P*	Model 2 OR (95% CI) *P*	Model 3 OR (95% CI) *P*
Sleep duration			
<7 vs. 7–8 h	1.57 (1.26, 1.97) ***P < 0.001	1.44 (1.16, 1.80) **P = 0.008	1.42 (1.13, 1.78) *P = 0.025
>8 vs. 7–8 h	1.54 (1.03, 2.31) *P = 0.047	1.51 (0.97, 2.33) P = 0.092	1.43 (0.92, 2.22) P = 0.163
Sleep-onset latency time			
<5 vs. 5–30 min	0.79 (0.59, 1.06) P = 0.130	0.77 (0.58, 1.03) P = 0.108	0.77 (0.57, 1.02) P = 0.121
>30 vs. 5–30 min	1.77 (1.35, 2.32) ***P < 0.001	1.57 (1.17, 2.11) *P = 0.012	1.59 (1.17, 2.15) *P = 0.025
Sleep problems			
No	Reference	Reference	Reference
Yes	1.96 (1.62, 2.38) ***P < 0.001	1.74 (1.42, 2.13) ***P < 0.001	1.75 (1.41, 2.16) **P = 0.001
OSA symptoms			
No	Reference	Reference	Reference
Yes	1.32 (1.08, 1.61) *P = 0.011	1.13 (0.91, 1.40) P = 0.303	1.12 (0.89, 1.40) P = 0.367
Daytime sleepiness			
No	Reference	Reference	Reference
Yes	1.75 (1.44, 2.13) ***P < 0.001	1.52 (1.25, 1.85) **P = 0.001	1.54 (1.25, 1.89) **P = 0.004



Kadier et al. Frontiers CV Med 2022;Aug 4.

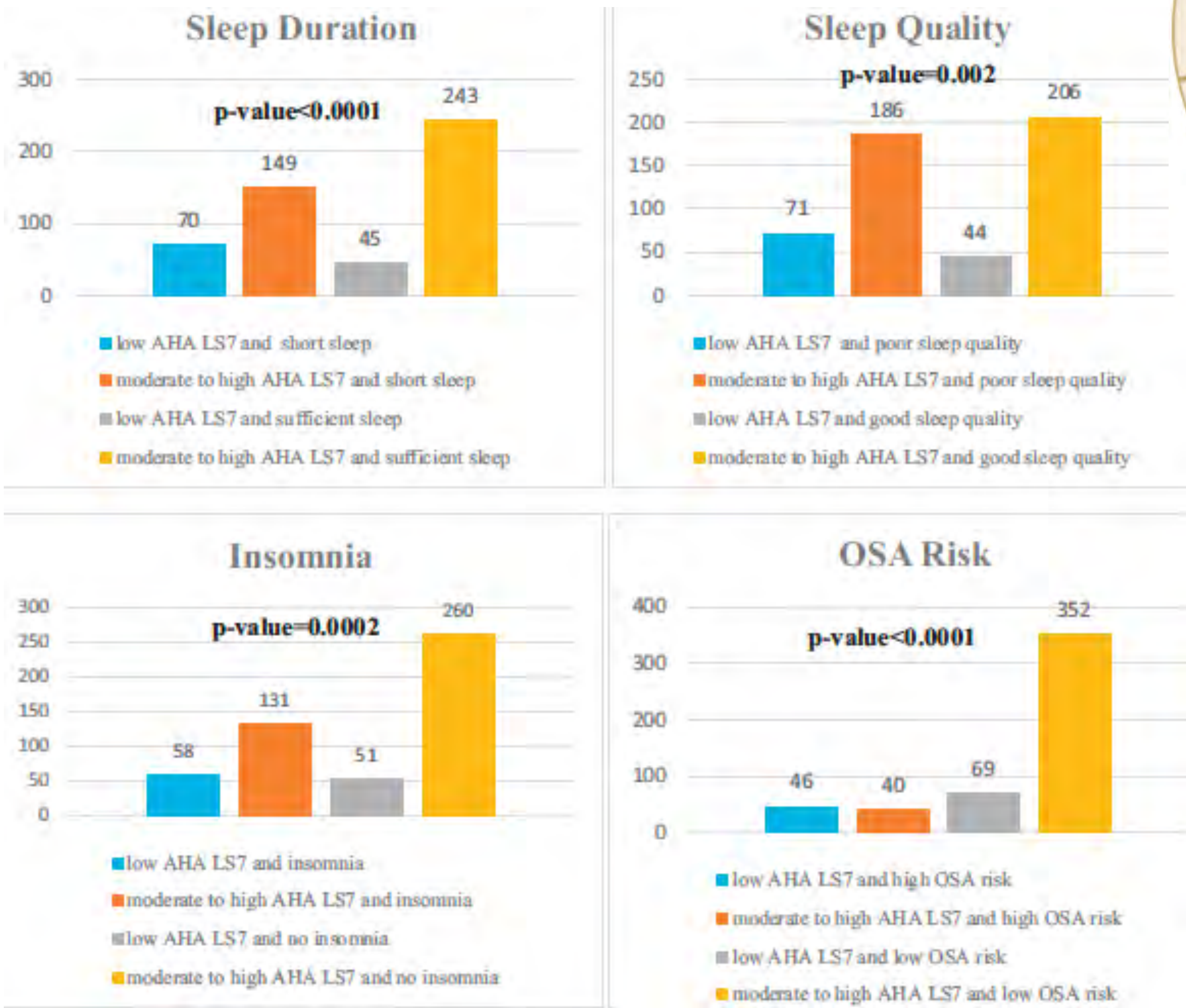
Increased risk of all-cause/CVD mortality in short & long sleepers, NHANES 2005-2014





Jin et al. Frontiers Pub Health 2002; July 15.

Associations between Life's Simple 7 and sleep quality in women



Women who slept ≥7 h/night have higher LS7 scores and are more likely to meet >4 metrics

Makarem et al. Sleep Health 2019;5:501-8.

Poor sleep is associated with poor dietary intakes in women

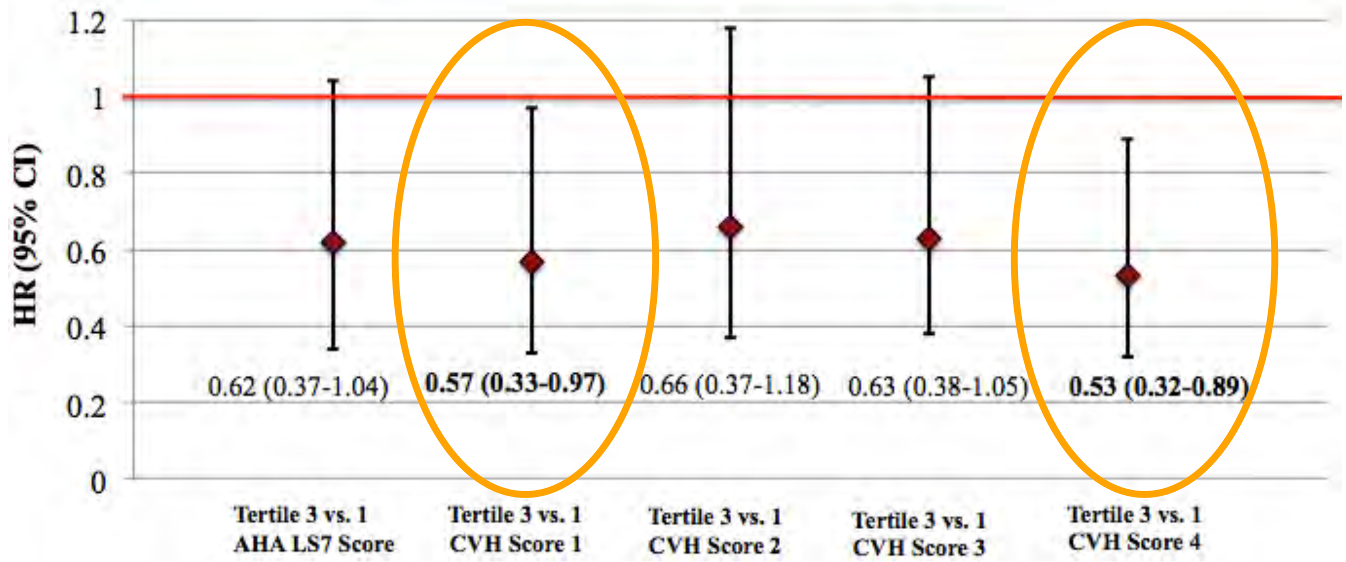
Predictor	Outcome	B (SE)	p-value
Sleep quality (PSQI >5 vs. ≤5)	Food weight	79.6 (49.1)	*0.106*
	Added sugars	3.41 (1.57)	**0.031**
	% Unsaturated fats	-1.41 (0.50)	**0.005**
	Energy intake	108 (82)	0.184
Sleep onset latency (≤ 15 m vs. > 60 m)	Food weight	235.2 (79.6)	**0.003**
	Added sugars	2.97 (2.59)	0.252
	% Unsaturated fats	-0.95 (0.83)	0.253
	Energy intake	426 (132)	**0.001**
Insomnia (Yes vs. No)	Food weight	116.0 (48.8)	**0.018**
	Added sugars	1.87 (1.58)	0.235
	% Unsaturated fats	-1.25 (0.50)	**0.013**
	Energy intake	205 (81)	**0.012**

*PSQI: Pittsburg Sleep Quality Index; SOL: Sleep Onset Latency; ISI: Insomnia Severity Index
**Models are adjusted for age, BMI, race/ethnicity, education, and health insurance status

Zuraikat et al. JAHA 2020;9:e014587.

Developing Life's Essential 8

Association of the AHA LS7 Score and Alternate CVH Scores that Include Sleep Metrics with CVD Incidence in Cox Proportional Hazards Models



CVH Score 1	CVH Score 2	CVH Score 3	CVH Score 4
Duration	Duration	Duration	Score 3 +
≥7h/night	Insomnia	Efficiency	Stable duration
<9h/night	OSA	OSA	Stable bedtime
	Sleepiness	Sleepiness	

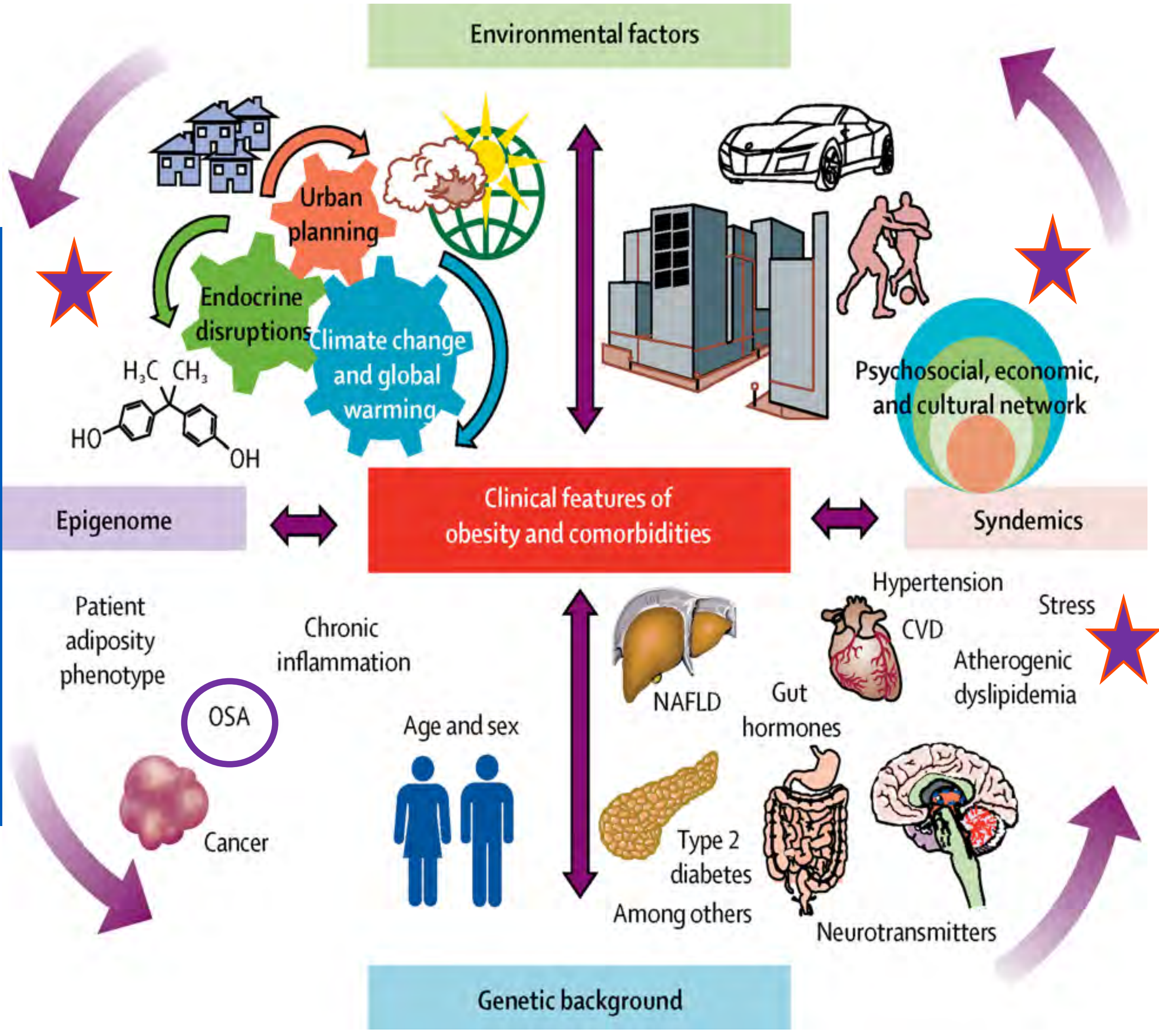
Makarem et al. JAHA, in press.

Findings from epidemiological studies

- Short sleepers have risk of obesity than adequate sleepers
- Short & disordered sleep is associated with higher CVD risk
- Poor sleep is associated with lifestyle behaviors that predict greater CVD risk

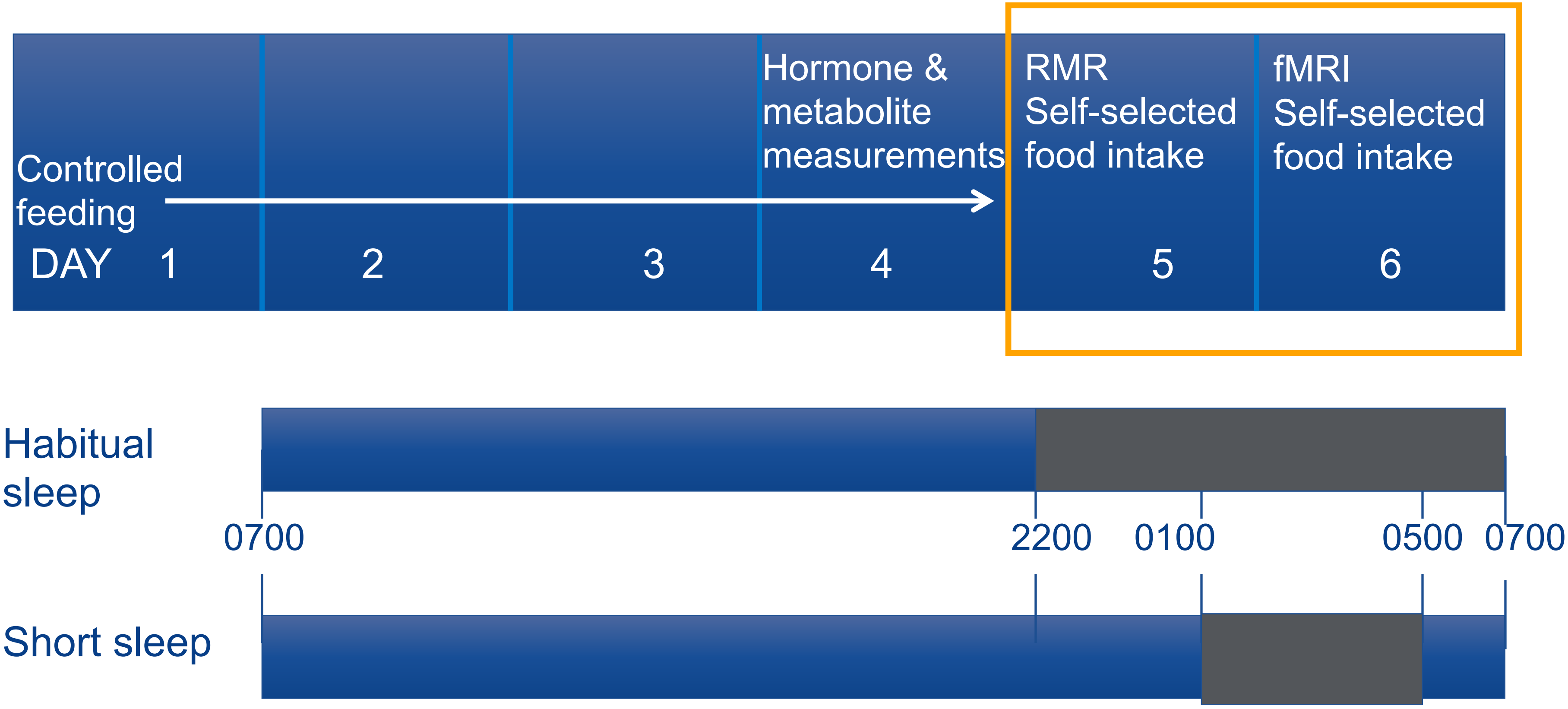
But what about causality?

Factors influencing risk of obesity & its comorbities



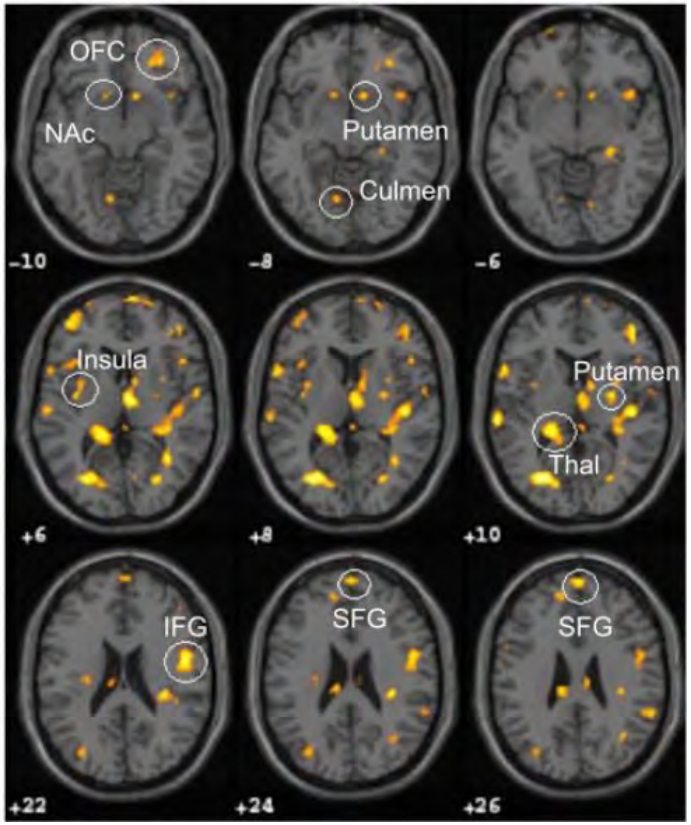
Fruhbeck et al. Lancet Diab Endocrinol 2018;6:164-6.

Effects of sleep restriction on energy balance & food intake regulation



Sleep restriction alters neuronal responses to foods

Food>Nonfood Restricted Sleep



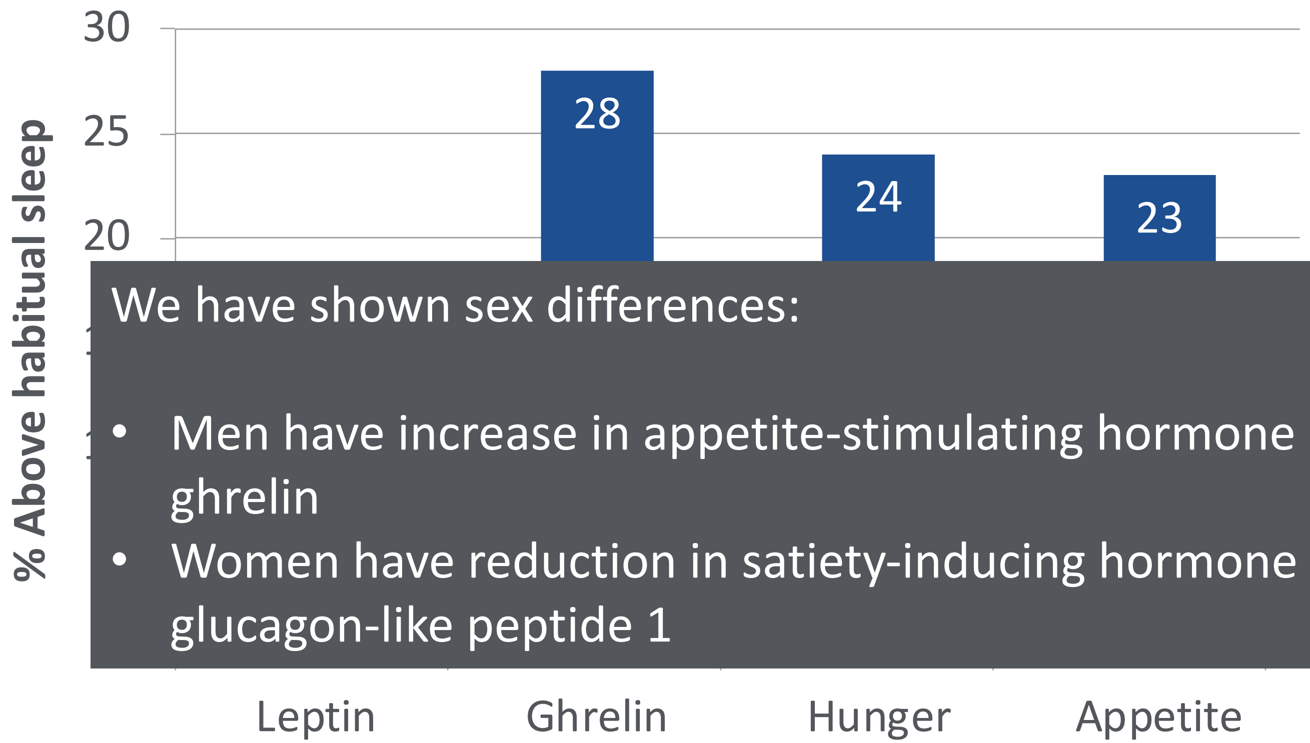
- Food stimuli increased regional brain activity in the OFC, insula, and regions of the basal ganglia and limbic system after restricted sleep
- Restricted sleep induces a state of greater responsiveness to food stimuli and heightened awareness of the rewarding properties of food

St-Onge et al., Am J Clin Nutr 2012;95:818-24.

How does the brain respond to food stimuli in the sleep restricted state?

- Unhealthy foods activate the areas of the brain associated with reward and hedonic functions
  - Restricting sleep can increase salience of unhealthy food
  - Restricting sleep promotes hedonic hunger
- During habitual sleep, up-regulation of the cognitive control centers
  - Could signify improved food restraint behavior

How does sleep influence homeostatic controls of food intake?



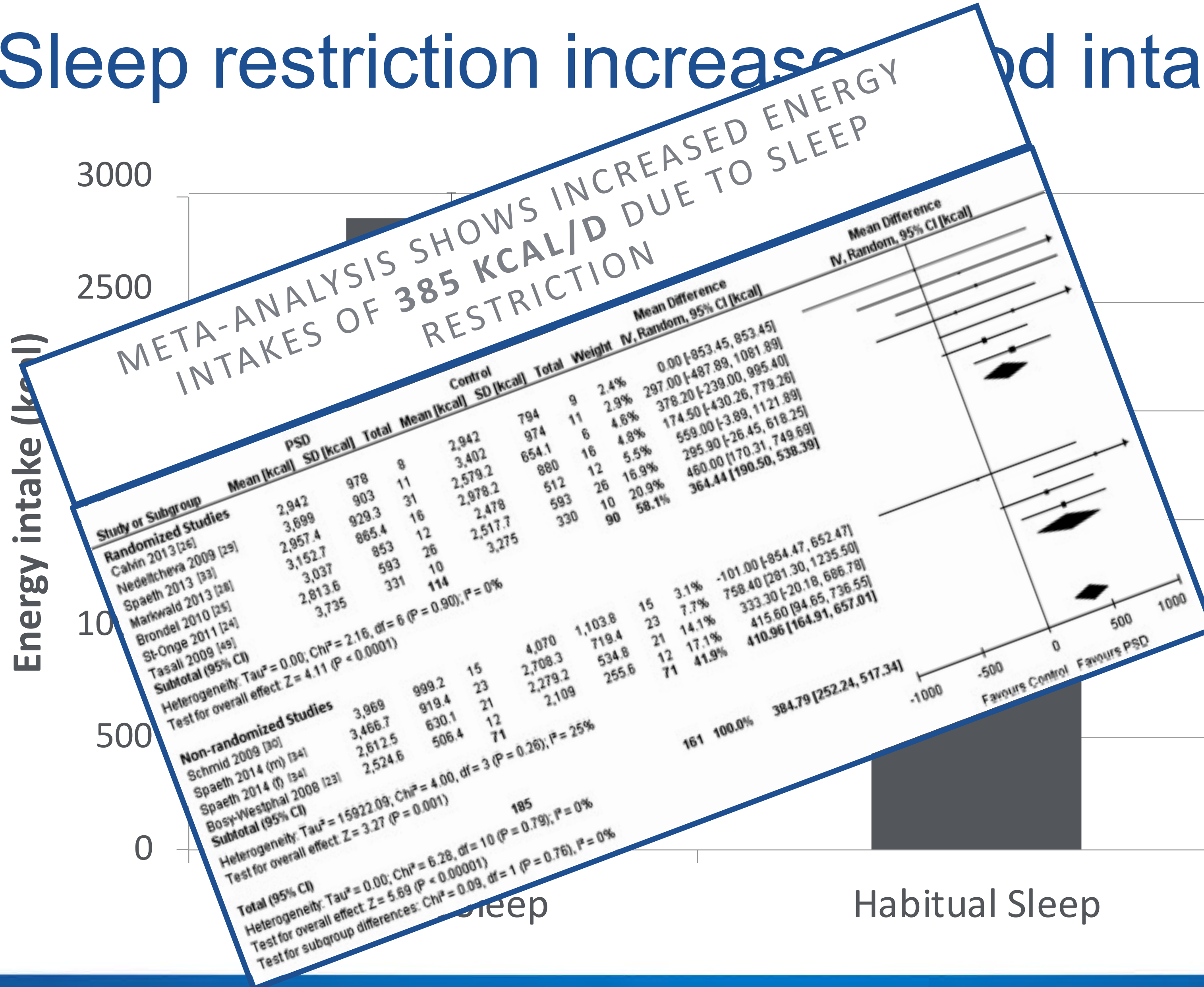
We have shown sex differences:

- Men have increase in appetite-stimulating hormone ghrelin
- Women have reduction in satiety-inducing hormone glucagon-like peptide 1

- Increase tended to be greatest for calorie-dense high carbohydrate foods
- Increase in appetite for fruits and vegetables of lesser magnitude

Spiegel et al., Ann Intern Med 2004;141:846-50.

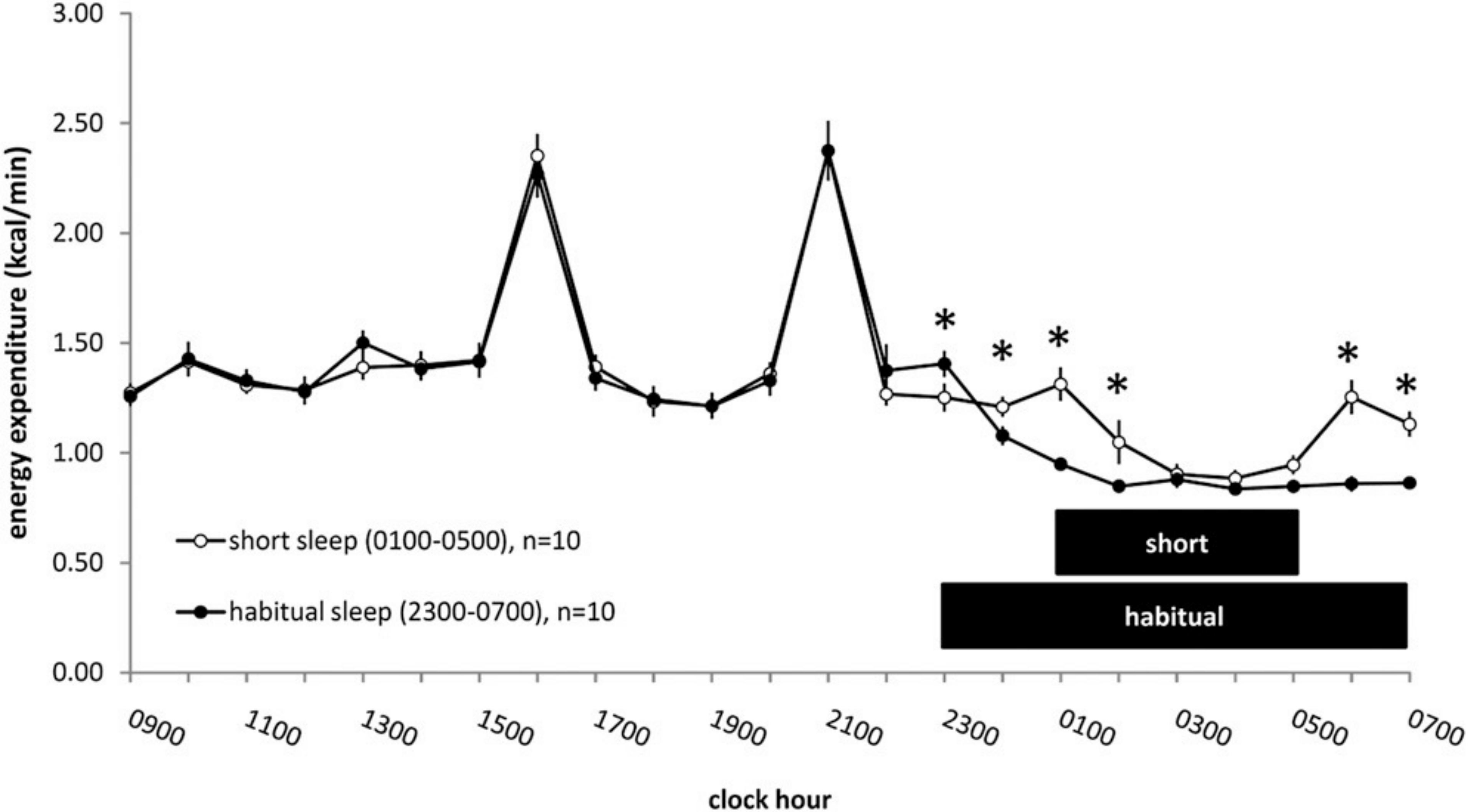
Sleep restriction increase[s f]ood intake



Study or Subgroup	PSD Mean [kcal]	PSD SD [kcal]	PSD Total	Control Mean [kcal]	Control SD [kcal]	Control Total	Weight	Mean Difference IV, Random, 95% CI [kcal]
Randomized Studies								
Calvin 2013 [26]	2,942	978	8	2,942	794	9	2.4%	0.00 [-853.45, 853.45]
Nedeltcheva 2009 [29]	3,699	903	11	3,402	974	11	2.9%	297.00 [-487.89, 1081.89]
Spaeth 2013 [33]	2,957.4	929.3	31	2,579.2	654.1	6	4.6%	378.20 [-239.00, 995.40]
Markwald 2013 [28]	3,152.7	865.4	16	2,978.2	880	16	4.8%	174.50 [-430.26, 779.26]
Brondel 2010 [25]	3,037	853	12	2,478	512	12	5.5%	559.00 [-3.89, 1121.89]
St-Onge 2011 [24]	2,813.6	593	26	2,517.7	593	26	16.9%	295.90 [-26.45, 618.25]
Tasali 2009 [49]	3,735	331	10	3,275	330	10	20.9%	460.00 [170.31, 749.69]
Subtotal (95% CI)			**114**			**90**	**58.1%**	**364.44 [190.50, 538.39]**
Heterogeneity: Tau² = 0.00; Chi² = 2.16, df = 6 (P = 0.90); I² = 0%								
Test for overall effect: Z = 4.11 (P < 0.0001)								
Non-randomized Studies								
Schmid 2009 [30]	3,969	999.2	15	4,070	1,103.8	15	3.1%	-101.00 [-854.47, 652.47]
Spaeth 2014 (m) [34]	3,466.7	919.4	23	2,708.3	719.4	23	7.7%	758.40 [281.30, 1235.50]
Spaeth 2014 (f) [34]	2,612.5	630.1	21	2,279.2	534.8	21	14.1%	333.30 [-20.18, 686.78]
Bosy-Westphal 2008 [23]	2,524.6	506.4	12	2,109	255.6	12	17.1%	415.60 [94.65, 736.55]
Subtotal (95% CI)			**71**			**71**	**41.9%**	**410.96 [164.91, 657.01]**
Heterogeneity: Tau² = 15922.09; Chi² = 4.00, df = 3 (P = 0.26); I² = 25%								
Test for overall effect: Z = 3.27 (P = 0.001)								
Total (95% CI)			**185**			**161**	**100.0%**	**384.79 [252.24, 517.34]**
Heterogeneity: Tau² = 0.00; Chi² = 6.28, df = 10 (P = 0.79); I² = 0%								
Test for overall effect: Z = 5.69 (P < 0.00001)								
Test for subgroup differences: Chi² = 0.09, df = 1 (P = 0.76), I² = 0%								

St-Onge et al., Am J Clin Nutr 2011;94:410-6.

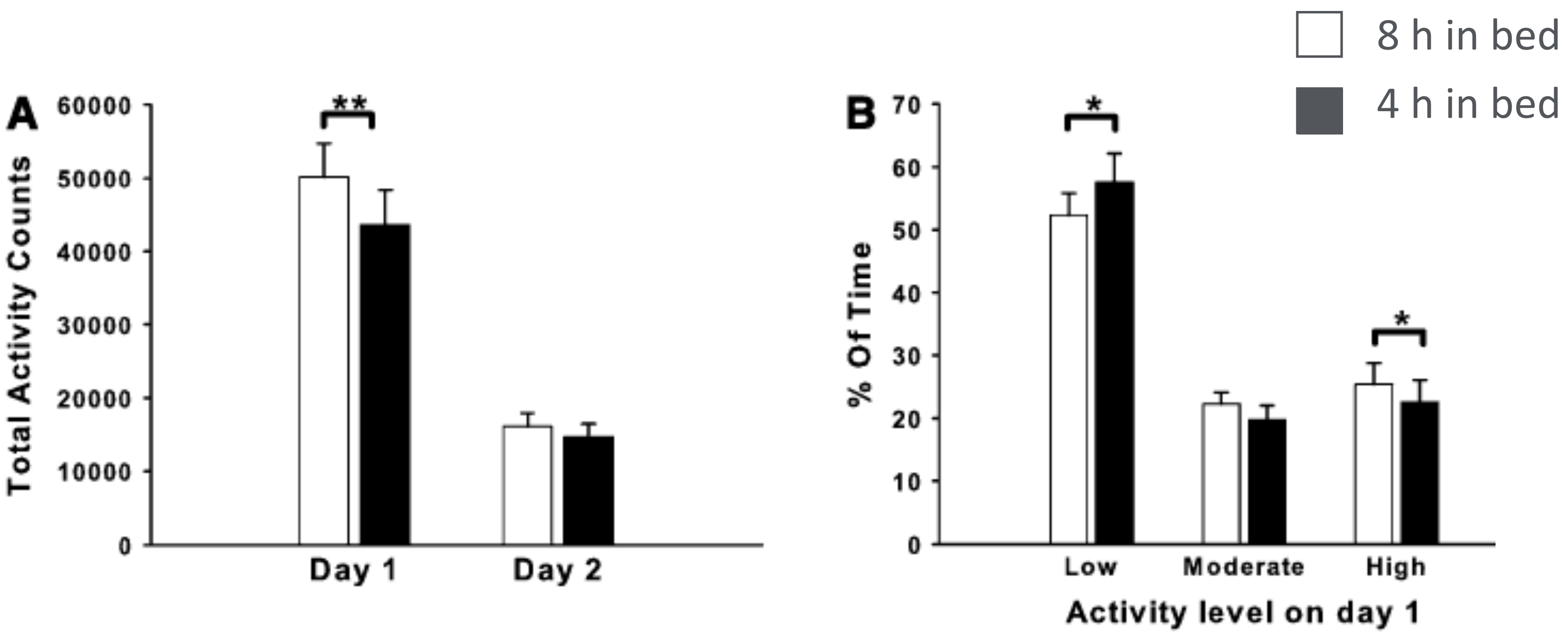
Impact of sleep restriction on 24-hour energy expenditure



Shechter et al., Am J Clin Nutr 2013;98:1433-9.

Acute sleep restriction reduces physical activity

- Men spent either 4 or 8 h in bed for 2 nights
- Energy expenditure was measured by actigraphy during outpatient (day 1) and inpatient (day 2) days



Schmid et al., Am J Clin Nutr 2009;90:1476-82.

Evidence of causality: Sleep restriction

2-week inpatient intervention:

- N=12 (9 M)
- Age 26.5±5.8 y
- BMI 24.6±3.7 kg/m^2
- Habitual sleep 7.4±1.0 h
  - SR=4.3±0.4 h/night
  - HS=8.0±0.5 h/night

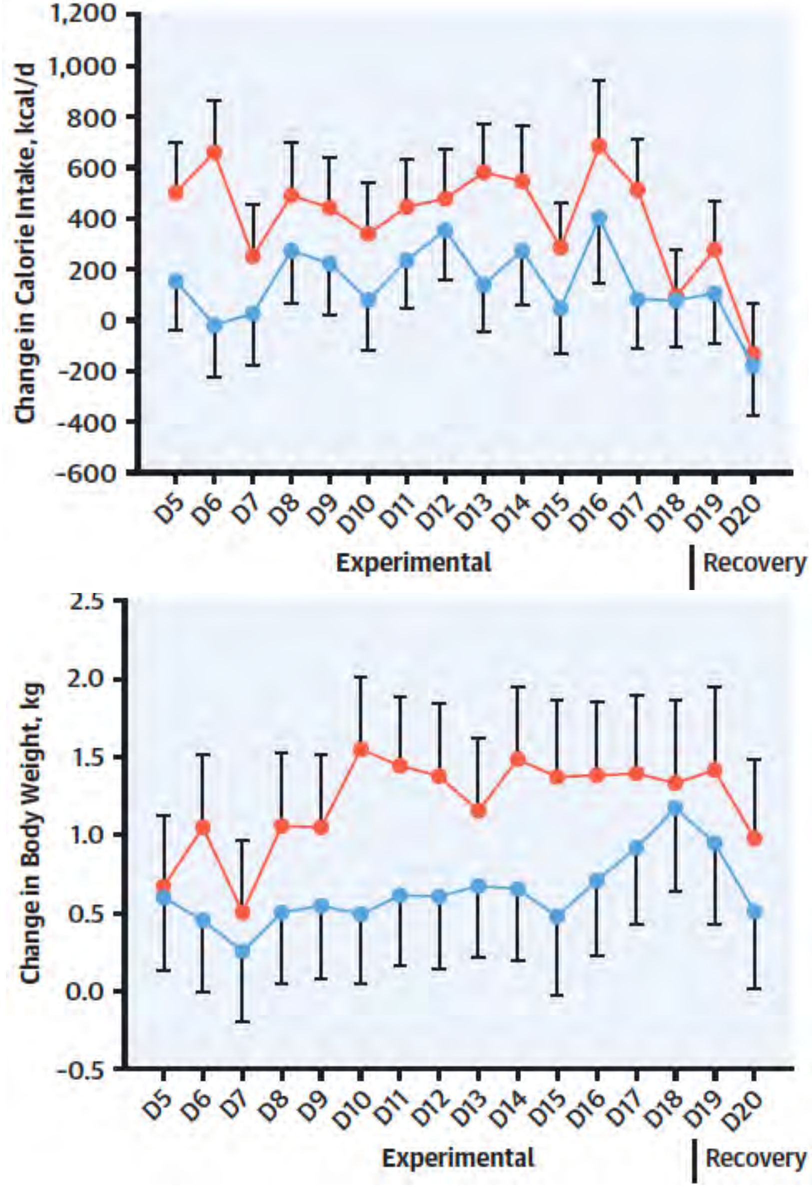
No difference in energy expenditure

Difference in energy intake between conditions:

- 257 kcal/d

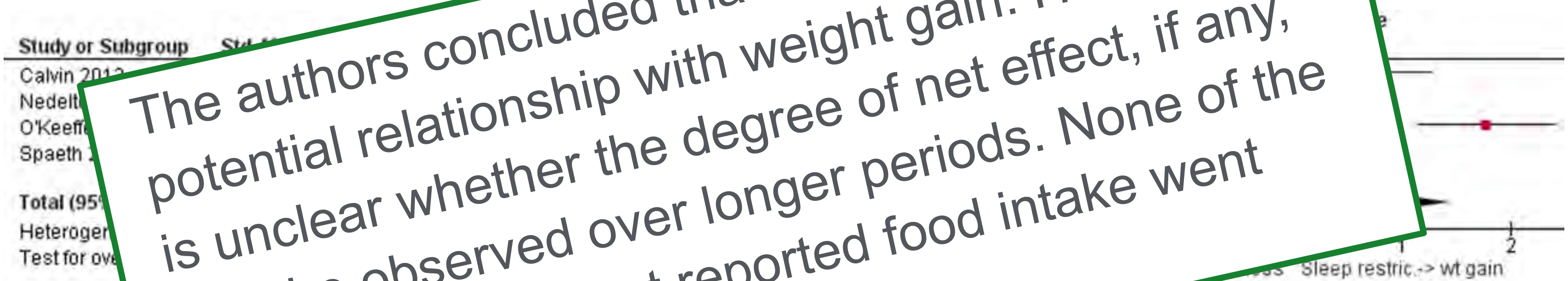
Difference in change in body weight:

- 0.5 kg



Covassin et al. J Am Coll Cardiol 2022;79:1254-65

Meta-analysis of randomized clinical trials of sleep restriction: Body weight

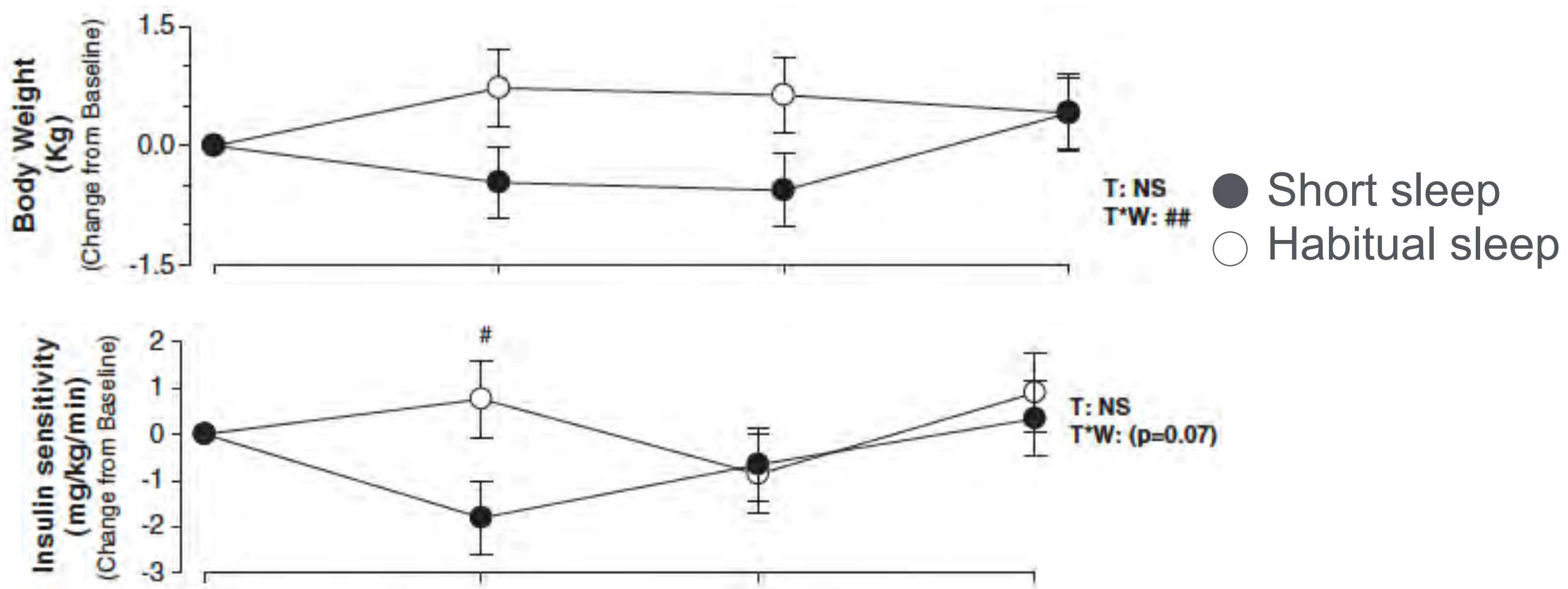


The authors concluded that "findings suggest a potential relationship with weight gain. However, it is unclear whether the degree of net effect, if any, may be observed over longer periods. None of the included studies that reported food intake went beyond 3 weeks in duration."

Capers et al. Obes Rev 2015;16:771-82.

Effect of longer, milder sleep restriction on body weight

- Young, healthy males, age 20-30 y, BMI 19-26 kg/m^2
- Randomized to maintain regular sleep (7-7.5 h/night) or restrict their sleep by 1.5 h for 3 weeks
  - Actual restriction 1 h:13 min-1 h:30 min



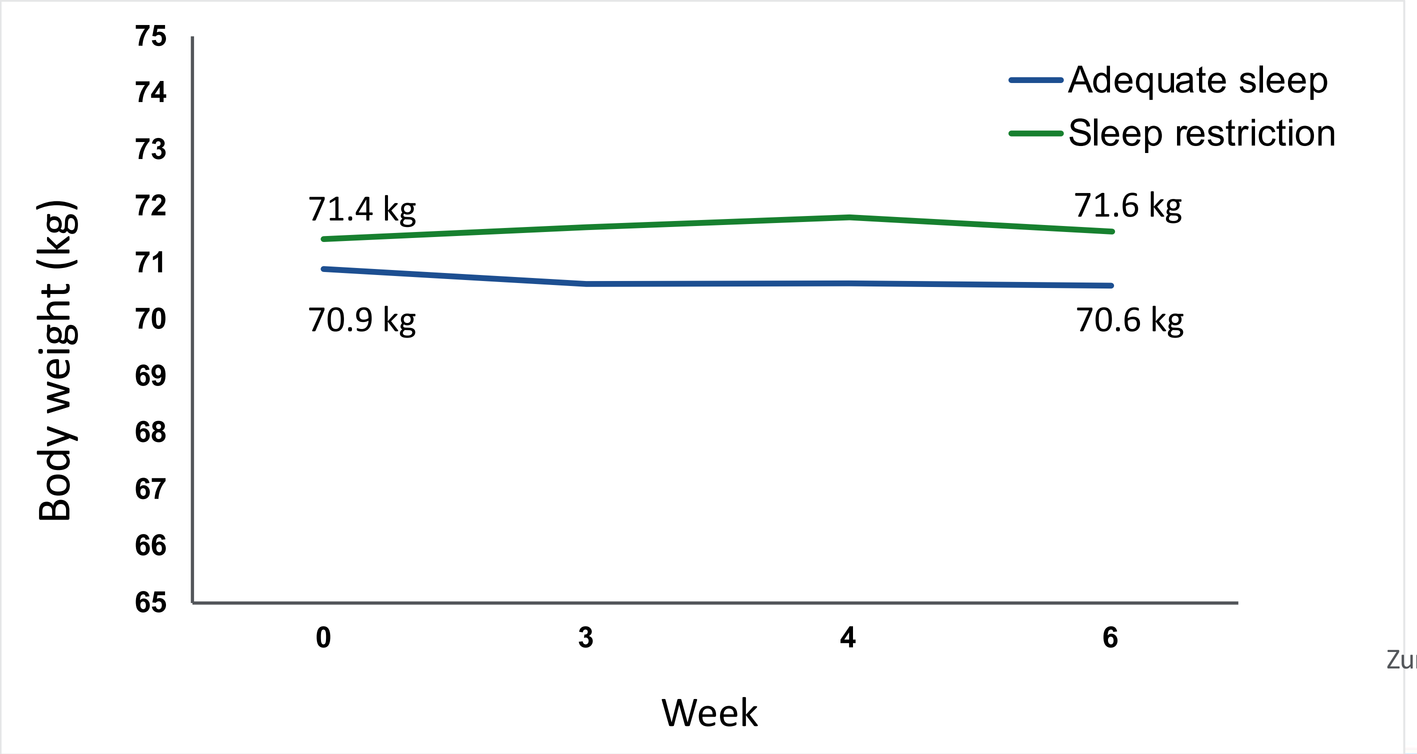
Robertson et al., Metabolism 2013;62:204-11.

Next step: What is the impact of 'life-like' sleep restriction conditions?

- To establish if there is a causal relation between sustained, mild sleep restriction (SR) and obesity risk using a randomized crossover clinical intervention
  - 2 phases of 6 weeks with either habitual (adequate) sleep or sleep reduced by 1.5 h (delayed bedtimes)
  - Participants have adequate sleep duration, >7 h/night, at screening
  - Determine effects of SR on body weight, body composition, and other lifestyle behaviors

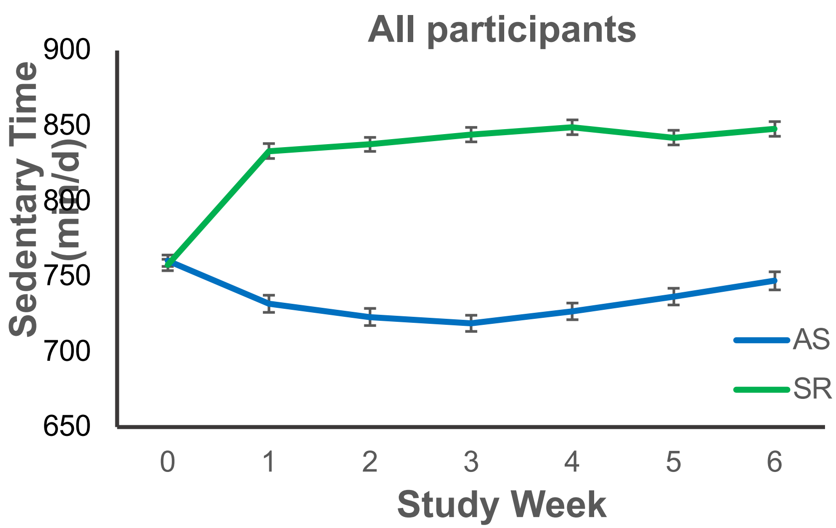
Mild Sleep Restriction Increases Body Weight

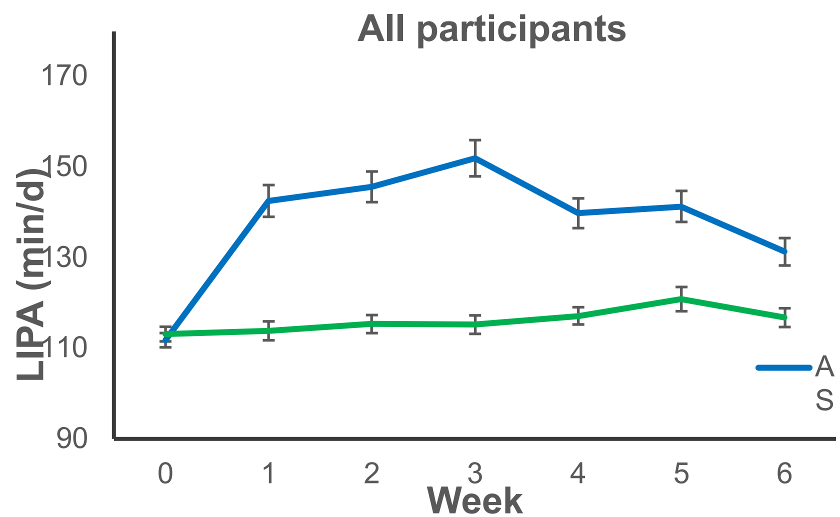
- Sleep restriction results more eating occasions and longer eating window
  - This is associated with higher energy intakes and worse diet quality



Zuraikat et al., in preparation.

Sleep restriction increases sedentary behavior & light physical activity in men and women



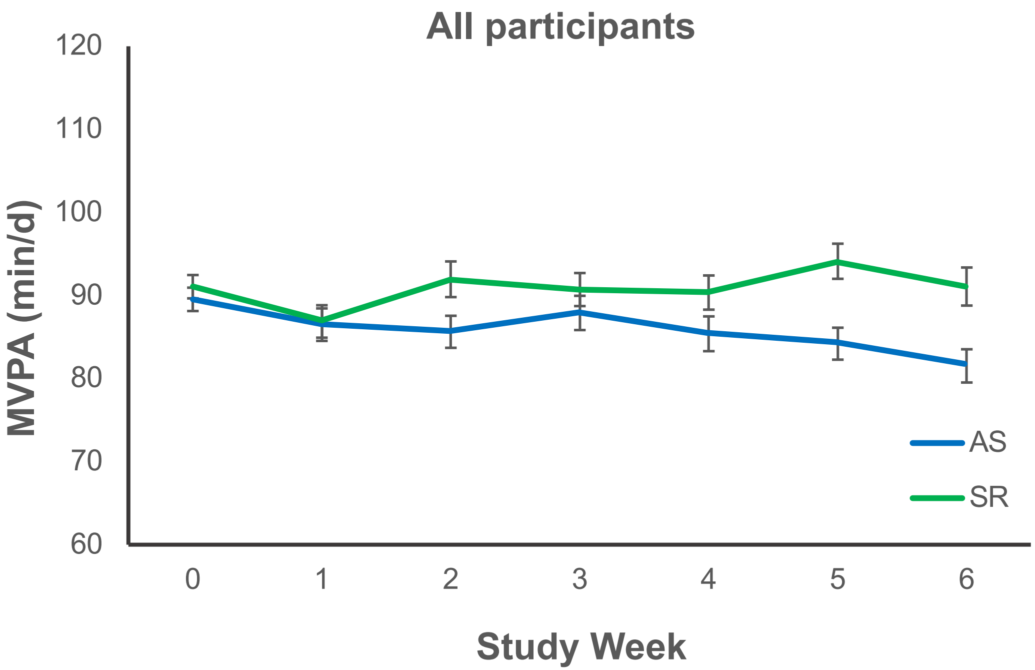


Increased by 12.5±1.1 min/d over 6 wk in SR vs AS (P<0.0001)

Increased by 1.1±0.4 min/d over 6 wk in SR relative to AS (P<0.01)

Zuraikat et al. Circulation 2021;143:O35.

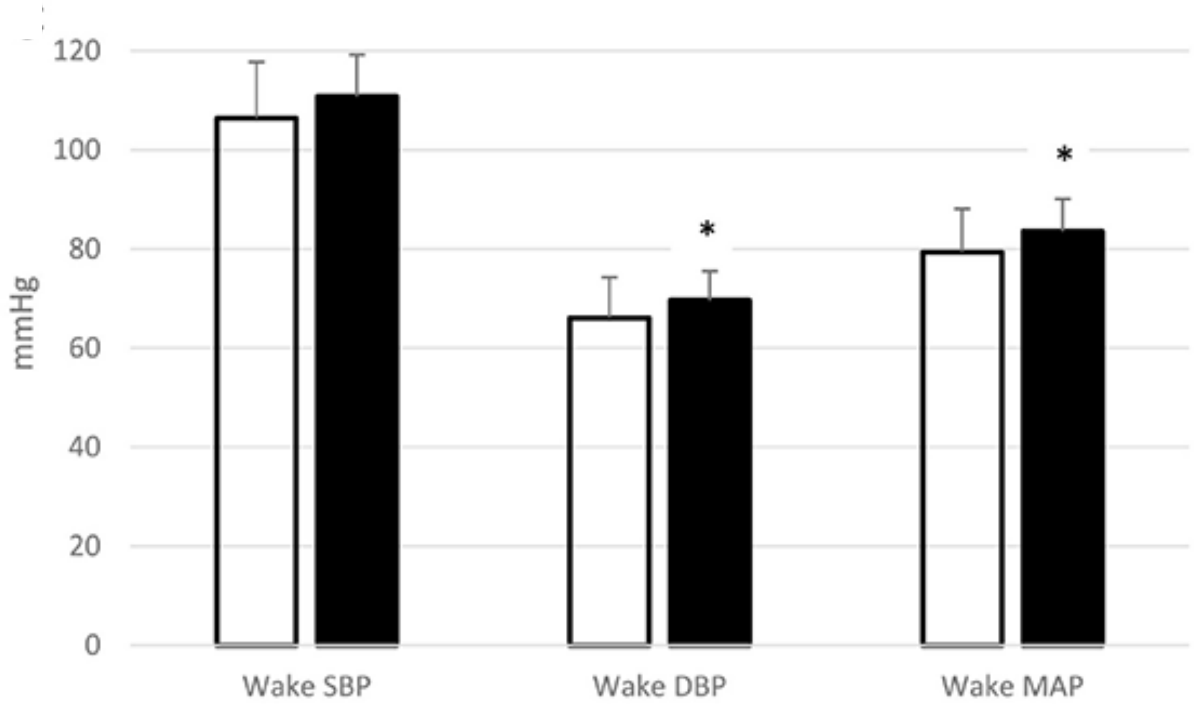
Impact of Sleep Restriction on Moderate-to-Vigorous Physical Activity in Men and Women



Increased by 1.1±0.4 min/d over 6 wk in SR relative to AS (P<0.01)

Zuraikat et al. Circulation 2021;143:O35.

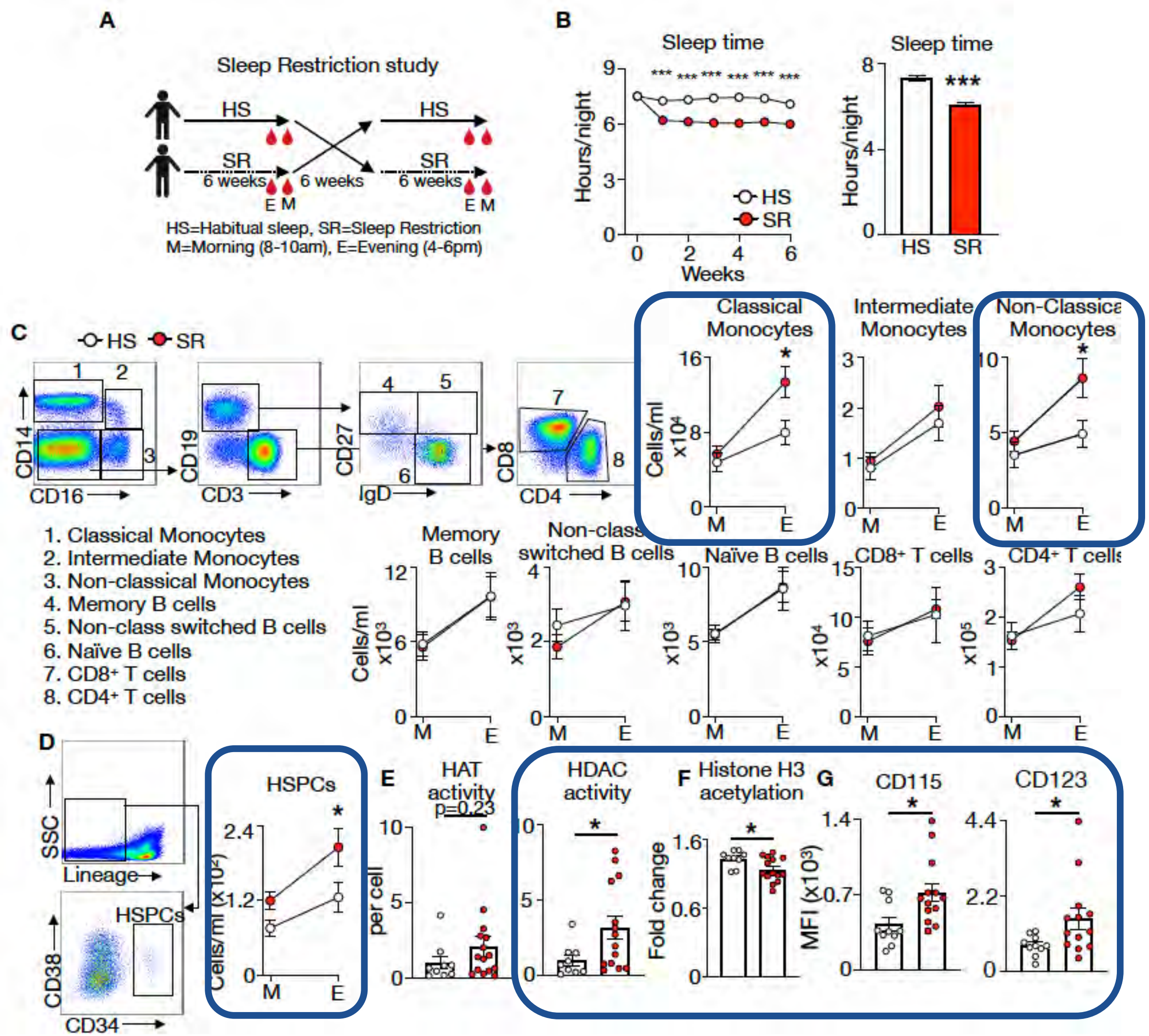
Higher blood pressure in women undergoing short sleep duration



The effects of sleep restriction on 24-h systolic blood pressure were almost twice as high in post-menopausal compared to pre-menopausal women

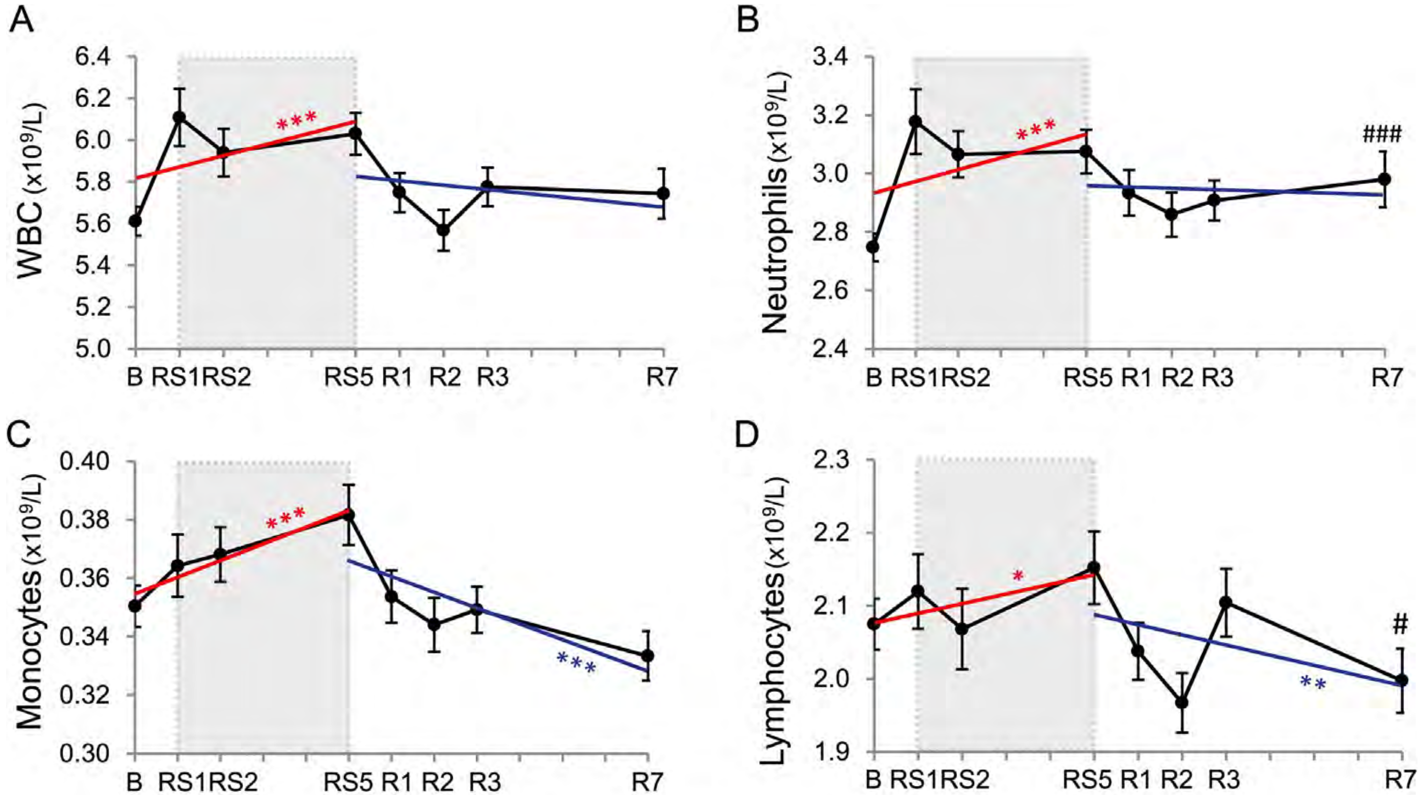
St-Onge et al. Am Heart J 2020;223:12-22.
Makarem et al. Hypertens 2021;77:e50-2.

Sleep restriction increases hematopoeisis



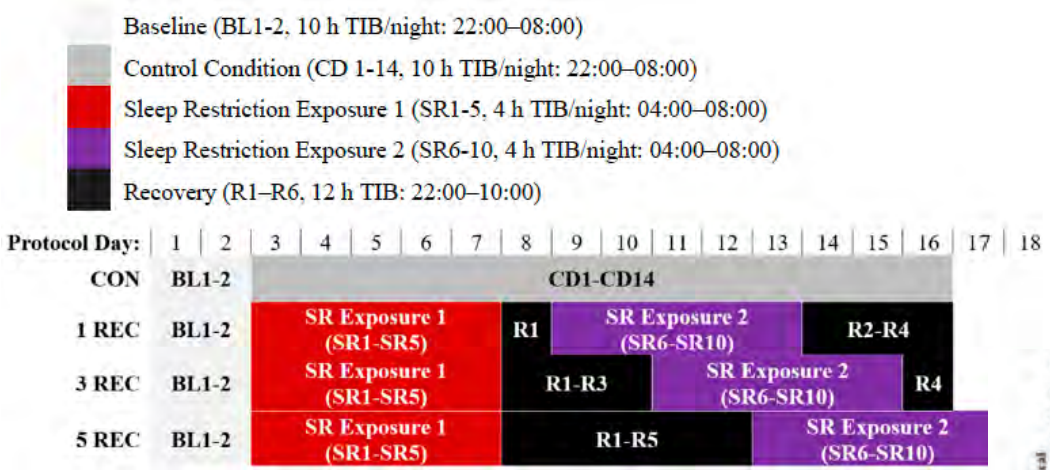
McAlpine et al. J Experimental Med 2022;219:e20220081.

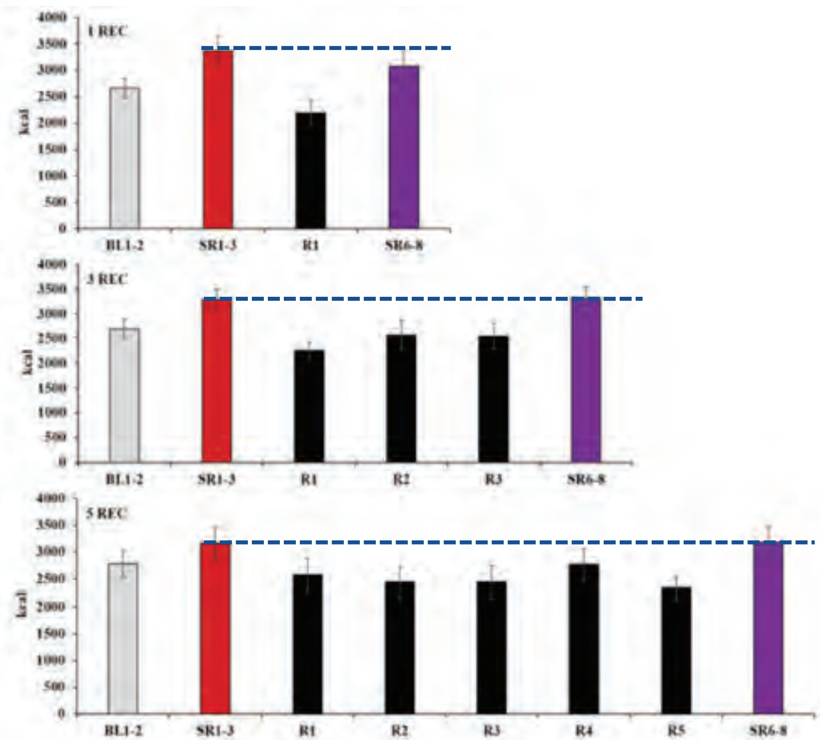
Impact of short & catch-up sleep on cardiometabolic risk factors



Lasselin et al. Brain Behav Immun 2015;47:93-9.

Impact of short & catch-up sleep on food intake





No evidence of acclimation from repeated exposures to sleep restriction, regardless of the number of recovery nights

Spaeth et al. Nutrients 2020:12:2694.

Dietary intakes across different categories of sleep variability in MESA

Diet Outcome	Sleep Duration SD				P-value for trend
	≤ 60 min (n=673)	61-90 min (n=529)	91-120 min (n=392)	> 120 min (n=311)	
aMed Score	**4.27 ± 1.82**	**4.08 ± 1.86**	**4.11 ± 1.81**	**4.05 ± 1.80**	**<0.01**
Fruits	**1.34 ± 0.98**	**1.31 ± 1.08**	**1.31 ± 1.08**	**1.28 ± 1.09**	**0.002**
Vegetables	1.18 ± 0.85	1.17 ± 0.87	1.19 ± 0.89	1.23 ± 0.95	0.212
Whole grains	**0.63 ± 0.50**	**0.60 ± 0.48**	**0.59 ± 0.49**	**0.56 ± 0.52**	**<0.001**
Nuts/Seeds	**0.33 ± 0.35**	**0.27 ± 0.34**	**0.26 ± 0.34**	**0.23 ± 0.30**	**<0.01**
Legumes	0.15 ± 0.17	0.17 ± 0.23	0.17 ± 0.21	0.16 ± 0.23	0.802
Red meat	0.24 ± 0.19	0.22 ± 0.20	0.25 ± 0.21	0.24 ± 0.20	0.090
Fish	**0.15 ± 0.15**	**0.16 ± 0.20**	**0.17 ± 0.16**	**0.20 ±0.20**	**<0.01**
Alcohol	3.41 ± 9.32	3.17 ± 7.84	2.69 ± 5.60	2.70 ± 6.18	0.873
MUFA	14.33 ± 4.01	14.14 ± 3.94	14.23 ± 4.05	14.45 ± 4.04	0.358
Saturated fat	**10.41 ± 3.21**	**10.52 ± 3.06**	**10.16 ± 3.18**	**10.60 ± 3.22**	**0.043**
Energy intake	**1692 ± 770**	**1688 ± 775**	**1735 ± 869**	**1778 ± 914**	**0.01**

Diet variables energy adjusted as: servings/1000 kcal (fruits, vegetables, whole grains, nuts/seeds, legumes, red meat, fish), %kcal (MUFA, SFA), g/1000 kcal (alcohol)

Zuraikat et al. Circulation 2021;143:MP05.

High sleep variability & short sleep duration associated with reduced weight loss

- Participants in PREDIMED-Plus, a Mediterranean diet intervention with vs without caloric restriction
  - Adults, 55-75 y, with BMI 27-40 kg/m^2

	Tertiles of sleep variability (h)					Sleep variability (h)	
	1 (lowest)	2	3 (highest)	*p* Value 2 vs 1	*p* Value 3 vs 1		*p* Value
Weight, kg							
n	630	629	629			1888	
12-month change	−2.3 (−2.6 to −2.0)	−2.1 (−2.5 to −1.8)	−1.7 (−2.0 to −1.4)			−2.1 (−2.2 to −1.9)	
Difference vs first tertile[a]	0 (ref.)	0.1 (−0.3 to 0.5)	0.5 (0.1 to 0.9)	0.553	0.020	0.95 (0.06 to 1.8)	0.037
Difference vs first tertile[b]	0 (ref.)	0.1 (−0.3 to 0.6)	0.5 (0.1 to 0.9)	0.548	0.021	0.88 (−0.01 to 1.8)	0.052
Body mass index, kg/m^2							
n	628	628	627			1888	
12-month change	−0.8 (−0.9 to −0.7)	−0.8 (−0.9 to −0.6)	−0.6 (−0.7 to −0.5)			−0.7 (−0.8 to −0.7)	
Difference vs first tertile[a]	0 (ref.)	0.06 (−0.1 to 0.2)	0.2 (0.04 to 0.4)	0.481	0.016	0.36 (0.03 to 0.7)	0.033
Difference vs first tertile[b]	0 (ref.)	0.05 (−0.1 to 0.2)	0.2 (0.04 to 0.4)	0.507	0.015	0.34 (0.01 to 0.7)	0.043
Waist circumference, cm							
n	600	599	599			1888	
12-month change	−2.5 (−3.0 to −2.1)	−2.6 (−3.0 to −2.1)	−1.9 (−2.3 to −1.4)			−2.3 (−2.6 to −2.1)	
Difference vs first tertile[a]	0 (ref.)	−0.2 (−0.8 to 0.4)	0.4 (−0.1 to 1.0)	0.496	0.148	0.7 (−0.5 to 1.9)	0.247
Difference vs first tertile[b]	0 (ref.)	−0.1 (−0.7 to 0.4)	0.4 (−0.2 to 1.0)	0.536	0.156	0.6 (−0.6 to 1.7)	0.345

Papandreou et al. Int J Obes 2020;44:330-9.

Sleep stability & body composition

N=36 women

Age ≥20 y

BMI 20-33 kg/m²

Habitual sleep ≥7 h/night

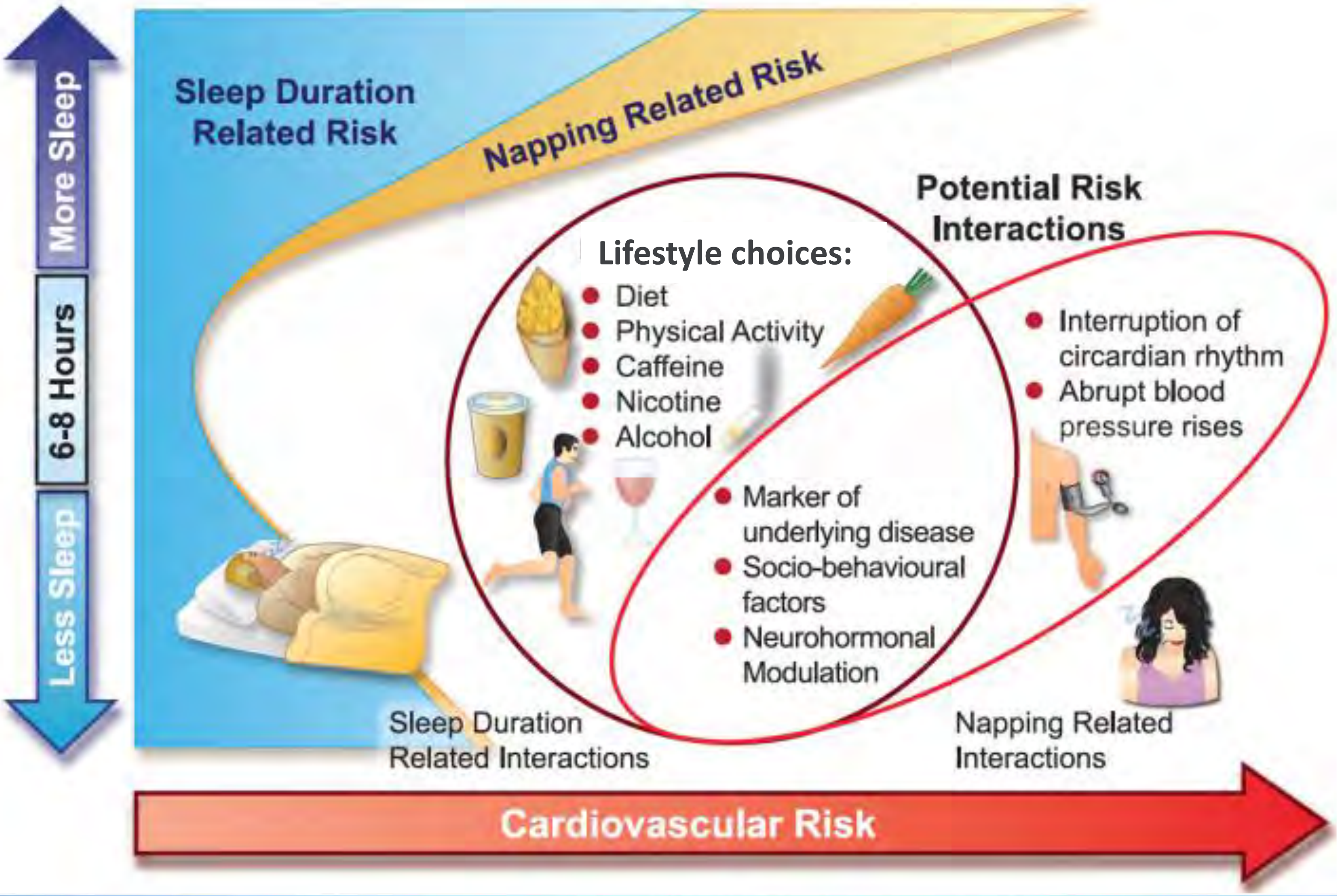
Undergoing 6-wk period of maintained adequate sleep with prescribed bed and wake times based on usual habits

Grouped by change in bedtime variability from screening

Variable	Increased/same bedtime variability ($N = 8$)	Reduced bedtime variability ($N = 29$)	P value*
Age, years	36.9 ± 15.0	34.4 ± 11.8	0.621
Race			0.663
White	5 (63)	14 (48)	
Other	3 (37)	15 (52)	
Baseline weight, kg	62.2 ± 5.0	66.5 ± 7.8	0.153
Baseline BMI, kg/m²	23.5 ± 2.1	25.1 ± 3.0	0.190
Baseline sleep duration, min	453.3 ± 29.3	455.2 ± 30.2	0.875
Baseline bedtime	12:00 a.m.	10:48 p.m.	0.109
Baseline bedtime SD, min	49.7 ± 9.5	57.2 ± 27.4	0.218
Weight change, kg	0.48 ± 1.19	−0.66 ± 1.37	0.059
TAT change, L[a]	0.63 ± 0.41	−0.52 ± 0.98	<0.001
VAT change, L	0.05 ± 0.17	−0.03 ± 0.10	0.297
SAT change, L	0.56 ± 0.31	−0.48 ± 0.86	<0.001
WBV no lungs change, L	0.23 ± 0.91	−0.75 ± 0.90	0.016
IMAT change, L	0.03 ± 0.03	−0.01 ± 0.12	0.134
SM change, L	−0.08 ± 0.49	−0.19 ± 0.47	0.602
Leukocyte platelet aggregates, %[b]	8.42 ± 16.59	−8.42 ± 10.82	0.011

St-Onge et al. Int J Obes 2020;44:1803-6.

Sleep is Integral to Good Lifestyle Habits Compatible With Cardiovascular Health



Wang et al, Eur Heart J 2018;0:1-10.

Food intake during a controlled diet vs ad lib diet when sleep is sufficient

Nutrient content	Controlled diet	Ad lib diet
Energy, kcal	**2055**	**2518**
Protein, %En	17	14
Carbohydrates, %En	53	54.6
Fat, %En	31	32.7
Saturated fat, %En	**7.5**	**10**

St-Onge et al. J Clin Sleep Med 2016;12:19-24.

Sleep after a controlled diet vs ad lib diet

Sleep parameter	Controlled diet	Ad lib diet	P-value
Total sleep time, min	453.5 ± 44.4	455.1 ± 30.2	0.86
Stage 1, min	52.3 ± 21.8	56.2 ± 18.8	0.18
Stage 2, min	240.3 ± 42. 9	245.8 ± 35.5	0.45
Slow wave sleep, min	**29.3 ± 13.9**	**24.6 ± 12.8**	**0.043**
Rapid-eye movement sleep, min	91.6 ± 17.8	96.4 ± 18.2	0.19
Sleep onset latency, min	**16.9 ± 11.1**	**29.2 ± 23.1**	**0.0085**
Arousals	143.2 ± 52.1	143.4 ± 51.9	0.98

St-Onge et al. J Clin Sleep Med 2016;12:19-24.

Relation between diet and sleep after a day of ad lib intakes

Sleep parameter	Fiber, g	Sugar, %En	Non-sugar/non-fiber CHO, %En	Saturated fat, %En
Stage 1, % sleep time	**-0.19 ± 0.07**	0.08 ± 0.17	0.04 ± 0.03	0.03 ± 0.21
Slow wave sleep, % sleep time	**0.26 ± 0.11**	-0.18 ± 0.25	-0.04 ± 0.04	**-0.71 ± 0.32**
Arousals	-0.11 ± 0.81	**4.34 ± 1.86**	**0.66 ± 0.31**	2.17 ± 2.40

Data suggest that a high-fiber diet, with low intake of sugars, is associated with better sleep depth and architecture

Could diet improve sleep in those with sleep disorders??

St-Onge et al. J Clin Sleep Med 2016;12:19-24.

Adherence to Mediterranean Diet associated with sleep quality at 1 y

Predictor	Outcome	β (SE) [b]	*p*-Value	β (SE) [c]	*p*-Value
aMed diet score	PSQI total score	−0.30 (0.10)	<0.01	−0.31 (0.08)	<0.0001
	Sleep onset latency	−0.61 (0.65)	0.35	−0.71 (0.59)	0.23
	Sleep efficiency	1.20 (0.35)	<0.001	1.21 (0.33)	<0.001
	Sleep disturbances	−0.30 (0.12)	0.01	−0.35 (0.10)	<0.001
Fruits and vegetables	PSQI total score	−0.16 (0.07)	0.02	−0.19 (0.05)	<0.001
	Sleep onset latency	−0.41 (0.44)	0.36	−0.31 (0.40)	0.44
	Sleep efficiency	0.56 (0.24)	0.02	0.52 (0.22)	0.02
	Sleep disturbances	−0.18 (0.08)	0.03	−0.15 (0.07)	0.02
Legumes	PSQI total score	−0.10 (0.16)	0.55	−0.24 (0.13)	0.06
	Sleep onset latency	−1.13 (1.03)	0.27	−1.21 (0.94)	0.20
	Sleep efficiency	1.36 (0.55)	0.01	1.46 (0.52)	<0.01
	Sleep disturbances	0.17 (0.19)	0.39	−0.08 (0.16)	0.62
Nuts	PSQI total score	0.01 (0.21)	0.96	0.02 (0.17)	0.92
	Sleep onset latency	0.09 (1.35)	0.95	0.25 (1.23)	0.84
	Sleep efficiency	−0.47 (0.72)	0.51	−0.36 (0.68)	0.60
	Sleep disturbances	−0.26 (0.25)	0.31	−0.09 (0.20)	0.65
Dark breads	PSQI total score	−0.68 (0.39)	0.08	−0.55 (0.30)	0.07
	Sleep onset latency	−0.94 (2.48)	0.71	−1.09 (2.26)	0.63
	Sleep efficiency	2.07 (1.33)	0.12	1.96 (1.26)	0.12
	Sleep disturbances	−0.43 (0.47)	0.36	−0.67 (0.38)	0.08

Zuraikat et al. Nutrients 2020;12:2830.

Odds ratio for associations between Mediterranean diet score and sleep: MESA Exam 5

Alternate Mediterranean Diet Score	Sleep duration 6-7 h/night vs <6 h/night	Sleep duration 7-8 h/night vs <6 h/night	Sleep duration >8 h/night vs <6 h/night	Insomnia Symptoms vs None
Moderate-High Score				
Model 1	1.30 (1.03-1.63)	1.05 (0.82-1.34)	0.83 (0.60-1.14)	0.81 (0.67-0.97)
Model 2	1.32 (1.05-1.66)	1.05 (0.82-1.34)	0.84 (0.61-1.16)	0.81 (0.68-0.98)
Model 3	1.38 (1.07-1.78)	1.05 (0.80-1.38)	0.97 (0.68-1.40)	0.82 (0.67-1.00)
Model 4	1.43 (1.08-1.88)	1.05 (0.78-1.40)	0.95 (0.64-1.42)	0.85 (0.68-1.06)

Model 1 is adjusted for age, sex, race/ethnicity
Model 2 is additionally adjusted for education
Model 3 is additionally adjusted for cigarette smoking, intentional exercise, and total energy intake
Model 4 is additionally adjusted for BMI, hypertension, diabetes, depressive symptoms, AHI, anti-depressant and anti-psychotic medications, insomnia symptoms or sleep duration

Castro-Diehl et al. Sleep 2018;41:zsy158.

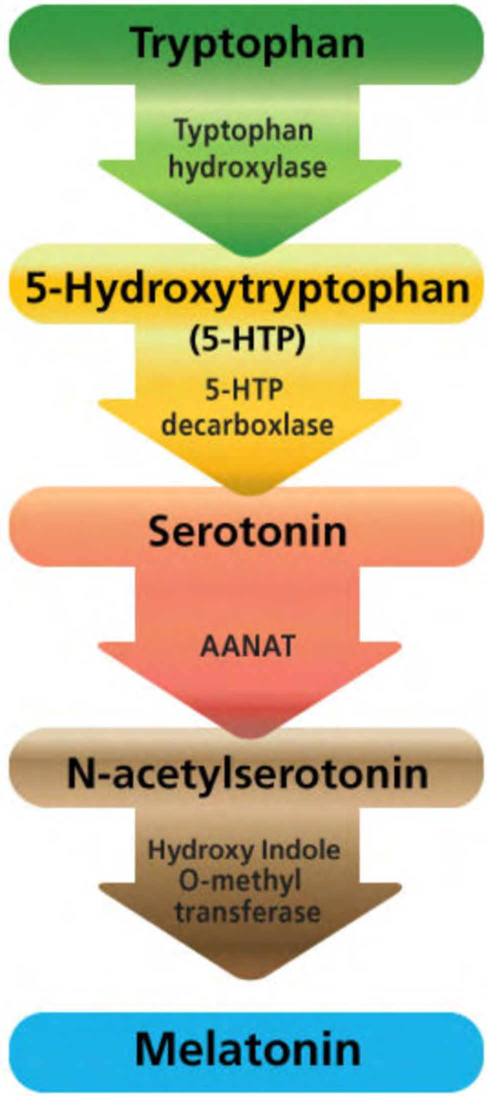
Odds ratio for associations between change in Mediterranean diet score and sleep: MESA Exams 1 & 5

Alternate Mediterranean Diet Score	Sleep duration 6-7 h/night vs <6 h/night	Sleep duration 7-8 h/night vs <6 h/night	Sleep duration >8 h/night vs <6 h/night	Insomnia Symptoms vs None
No change vs decrease				
Model 1	1.05 (0.77-1.45)	1.11 (0.79-1.54)	1.08 (0.71-1.65)	0.64 (0.49-0.83)
Model 2	1.07 (0.78-1.47)	1.10 (0.79-1.54)	1.09 (0.71-1.68)	0.64 (0.49-0.83)
Model 3	1.04 (0.74-1.45)	1.13 (0.80-1.60)	1.13 (0.72-1.80)	0.65 (0.50-0.85)
Model 4	0.98 (0.68-1.40)	1.06 (0.73-1.55)	0.96 (0.57-1.61)	0.61 (0.45-0.82)
Increase vs decrease				
Model 1	1.35 (1.04-1.75)	1.30 (0.98-1.71)	1.04 (0.72-1.50)	0.90 (0.73-1.11)
Model 2	1.36 (1.05-1.76)	1.29 (0.98-1.71)	1.04 (0.72-1.50)	0.90 (0.73-1.11)
Model 3	1.30 (0.99-1.71)	1.26 (0.94-1.69)	1.18 (0.80-1.75)	0.90 (0.72-1.12)
Model 4	1.34 (0.99-1.80)	1.30 (0.95-1. 79)	1.15 (0.74-1.77)	0.92 (0.72-1.17)

Castro-Diehl et al. Sleep 2018;41:zsy158.

Biological plausibility for diet impact on sleep

- Tryptophan:
  - Essential amino acid
  - Primary substrate for melatonin synthesis
- Carbohydrates and gut microbiome involved in Trp metabolism
- Various dietary nutrients involved in enzymatic conversions of Trp to melatonin



Cofactor Vitamin B6

Cofactor Vitamin B6

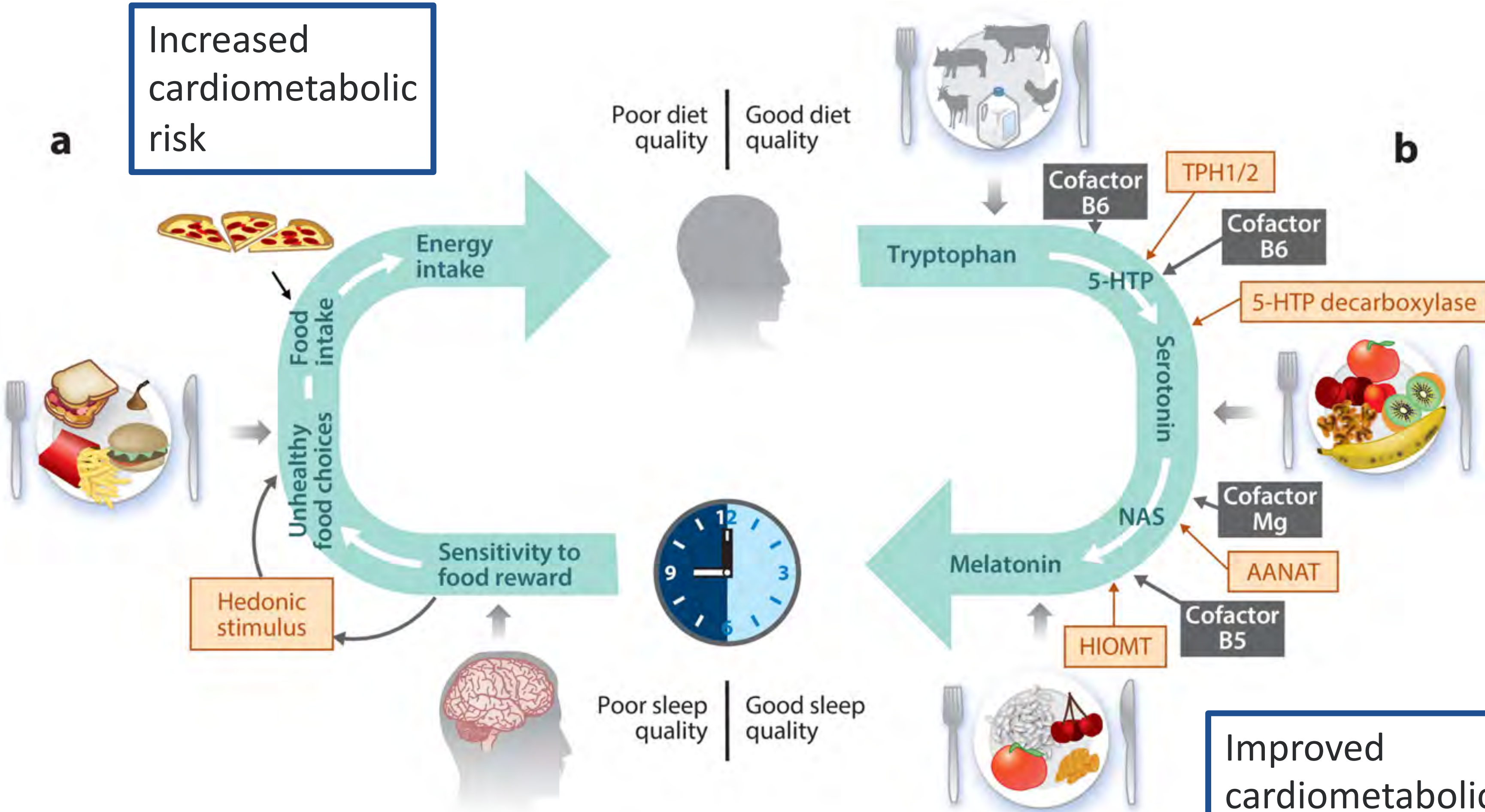
Cofactor Magnesium

Cofactor Vitamin B5

Zuraikat et al. Ann Rev Nutr 2021;41:309-32.

Cycles of lifestyle behaviors & health

Increased cardiometabolic risk



Improved cardiometabolic health

Zuraikat et al. Ann Rev Nutr 2021;41:309-32.

Thank you!

RAs & Fellows:

- Faris Zuraikat, PhD
- Rocio Barragan-Arnal, PhD
- Amy Roberts, Ph.D
- Ayanna Campbell, MS
- Ismel Salazar, MS
- Justin Cochran, MS
- Samantha Scaccia, MS
- Many IHN MS Students

Collaborators:

- Brooke Aggarwal, EdD
- Sanja Jelic, MD
- Blandine Laferrère, MD
- Ari Shechter, Ph.D

Funding:

- R01HL091352
- R01HL128226
- R01HL155670
- AHA 16SFRN27950012
- NYONRC DK-26687
- CTSA ULRR000041

Thank you for joining us today.

Become an Orgain Ambassador Today!

Request an Orgain Ambassador account to access our on-line sampling portal so you can share Orgain products and discount offers with your patients or clients.

healthcare.orgain.com/ambassador

Orgain

Professional Education Series

Support. Inform. Educate. Empower.

WEBINAR HOST:

Acacia Wright, RD, CD
Sr. Manager of Nutrition Communications
Orgain, LLC

Acacia.Wright@orgain.com

WEBINAR PRESENTER:

Marie-Pierre St-Onge, Ph.D, CCSH, FAHA
Associate Professor of Nutritional Medicine, Director of Columbia University Irving Medical Center Sleep Center of Excellence

ms2554@cumc.columbia.edu

GENERAL INQUIRIES:

medinfo@orgain.com