Role of chronotype in physical activity, sedentary behaviour, and sleep among individuals with obesity

Giovanna Muscogiuri

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Chronotype

Subject's attitude that determines individual circadian preference in behavioral and biological rhythms related to the external light–dark cycle.

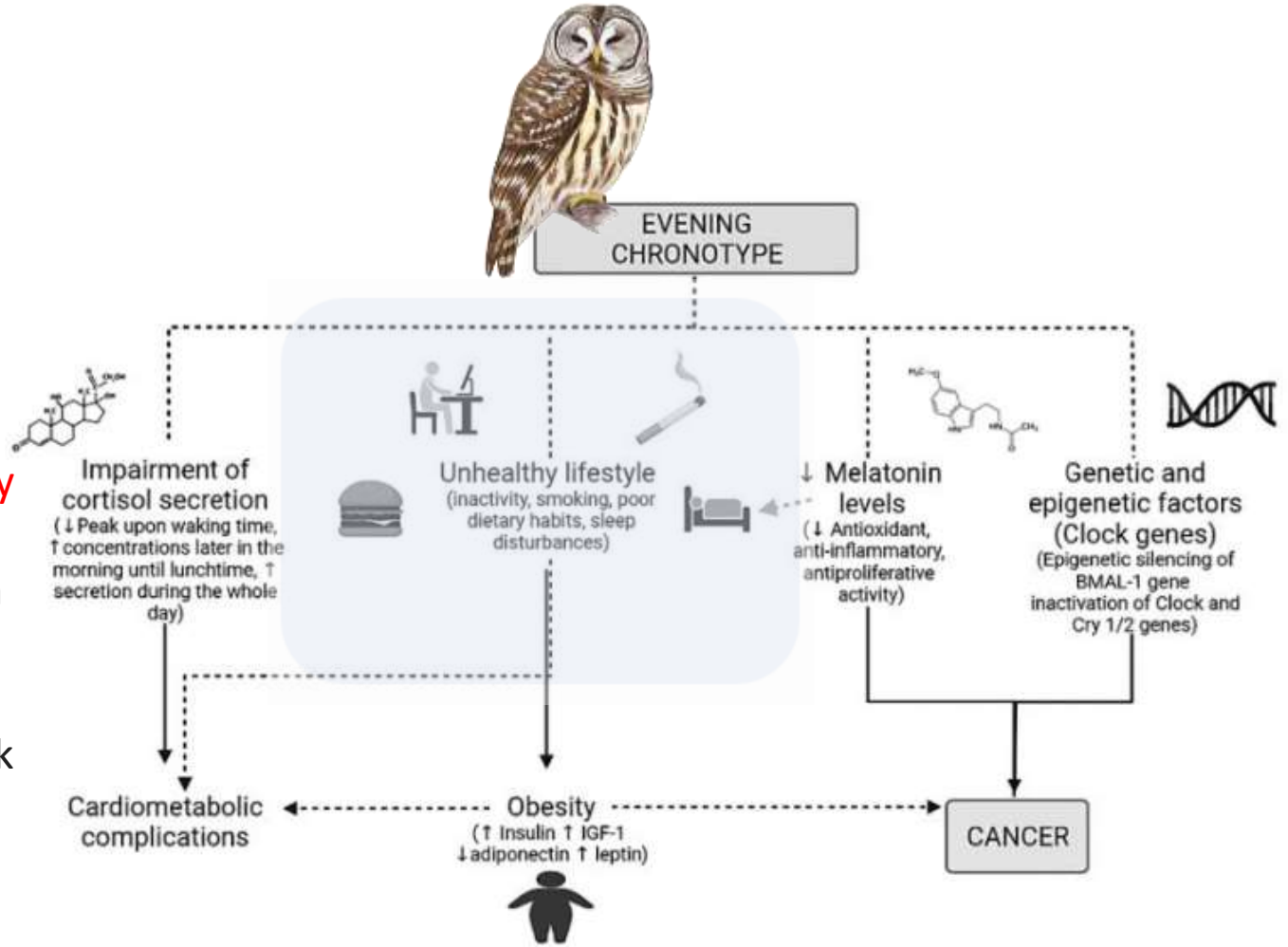
Horne & Ostberg, Int J Chronobiol, 1976

Review > Obes Facts. 2023;16(2):131-140. doi: 10.1159/000527691. Epub 2022 Nov 8.

The EASO New Investigator Award in Clinical Research 2021: Role of Chronotype in Obesity

Giovanna Muscogiuri [1 2 3]

Subjects with evening chronotype have been reported to be at high risk of developing obesity, and this was mostly due to the tendency of these subjects to follow unhealthy lifestyle mostly characterized by sedentary behavior and high intake of unhealthy food. In addition, sleep disturbances are a common finding in subjects with evening chronotype that in turn could further contribute to the risk of obesity. The impairment of insulin sensitivity, melatonin, adiponectin, and clock genes function along with increase of leptin secretion detected in subjects with evening chronotype could also represent a favorable milieu for the onset of obesity-related cancer.



› Psychiatry Res. 2021 Mar;297:113722. doi: 10.1016/j.psychres.2021.113722. Epub 2021 Jan 14.

The effect of age and chronotype on seasonality, sleep problems, and mood

Yvonne Höller [1], Bryndís Elsa Gudjónsdottir [2], Stefanía Kristín Valgeirsdóttir [2], Gudmundur T Heimisson [2]

Seasonality refers to season-dependent fluctuations in sleep length, social activity, mood, weight, appetite, and energy level. This study aimed to estimate the differential contribution of chronotype and age on seasonality. A sample of n=410 participants were included in the study.

According to a path analysis, chronotype and age predict propensity for seasonality. However, sleep problems were linked to chronotype but not to age. Older adults seem to be more resistant to seasonal changes that are perceived as a problem than young and middle aged adults.

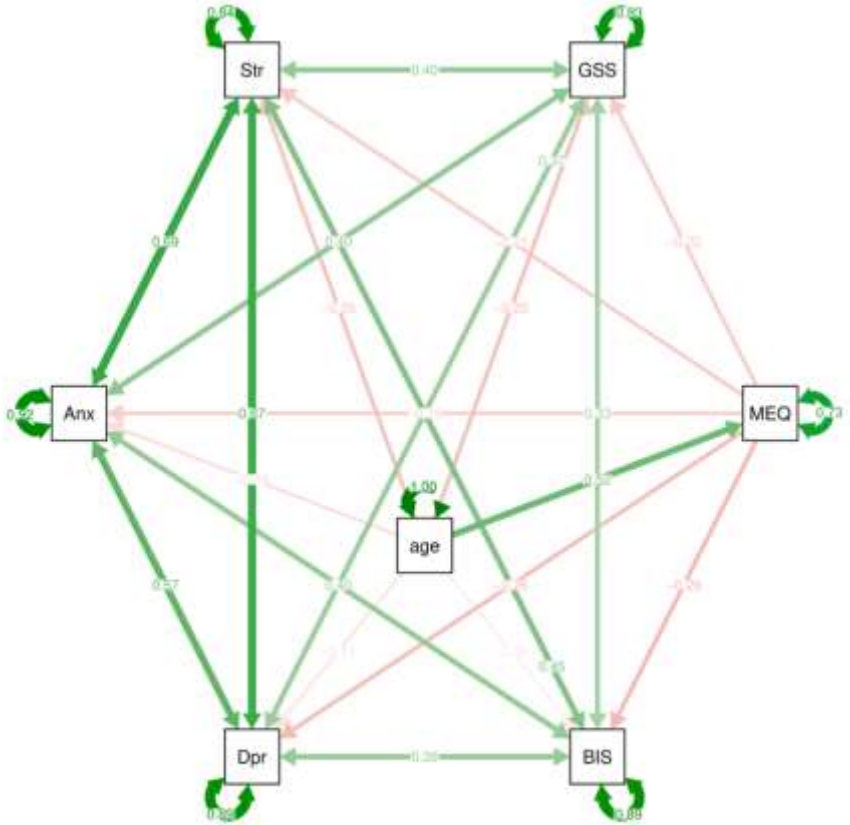


Fig. 1. Structural equation model for seasonality (GSS), chronotype (MEQ), sleep problems (BIS), age, depression (Dpr), anxiety (Anx), and stress (Str).

Chronobiol Int. 2012 Aug;29(7):955-60. doi: 10.3109/07420528.2012.699124.

Subjective sleep quality exclusively mediates the relationship between morningness–eveningness preference and self–perceived stress response

(N = 63 female university students)

Results

Evening types reported lower subjective sleep quality and longer sleep latency than morning types. Furthermore, evening types reported higher self-perceived stress after the task than morning types

TABLE 2. Regression analyses between PSQI components, MEQ, and stress response

PSQI component	β	*p*
Subjective sleep quality		
MEQ to subjective sleep quality	−.38	<.01
Subjective sleep quality to stress response	.31	<.05
Sleep latency		
MEQ to sleep latency	−.34	<.01
Sleep latency to stress response	.10	ns
Sleep duration		
MEQ to sleep duration	−.04	ns
Sleep duration to stress response	.07	ns
Habitual sleep efficiency		
MEQ to habitual sleep efficiency	−.14	ns
Habitual sleep efficiency to stress response	.15	ns
Sleep disturbances		
MEQ to sleep disturbances	−.09	ns
Sleep disturbances to stress response	.23	<.05
Use of sleeping medication*		
MEQ to use of sleeping medication	na	na
Use of sleeping medication to stress response	na	na
Daytime dysfunction		
MEQ to daytime dysfunction	−.25	<.05
Daytime dysfunction to stress response	.40	<.01

*None of the participants reported taking sleeping medication.

	M-types (n = 27) *M* (*SD*)	E-types (n = 28) *M* (*SD*)	$F_{1,53}$	*p*
Age	22.96 (2.19)	23.11 (3.20)	.04	ns
Morningness-Eveningness Questionnaire	59.74 (2.74)	40.93 (4.70)	325.92	<.001
Pittsburgh Sleep Quality Index	4.52 (1.87)	6.86 (3.00)	11.92	<.01
Subjective sleep quality	.70 (.47)	1.18 (.67)	9.26	<.01
Sleep latency	.96 (.85)	2.18 (1.61)	12.09	<.01
Sleep duration	.30 (.72)	.36 (.73)	.10	ns
Habitual sleep efficiency	.19 (.62)	.46 (.79)	2.10	ns
Sleep disturbances	1.07 (.27)	1.11 (.32)	.18	ns
Use of sleeping medication*	na	na	na	na
Daytime dysfunction	1.30 (.61)	1.57 (.69)	2.45	ns

J Health Psychol. 2021 Nov;26(13):2636-2647. doi: 10.1177/1359105320926530. Epub 2020 Jun 4.

Relationships between sleep, exercise timing, and chronotype in young adults

Emily E Glavin [1], McDerby Ceneus [1], Mira Chanowitz [1], Joanna Kantilierakis [1], Eytan Mendelow [1], Jacobo Mosquera [1], Andrea M Spaeth [1]

(N=909 college students)

Results

Evening chronotypes reported poorer sleep quality, greater daytime dysfunction, and less positive affect compared to morning/neither chronotypes.

Table 4. Sleep and mood measures by chronotype.

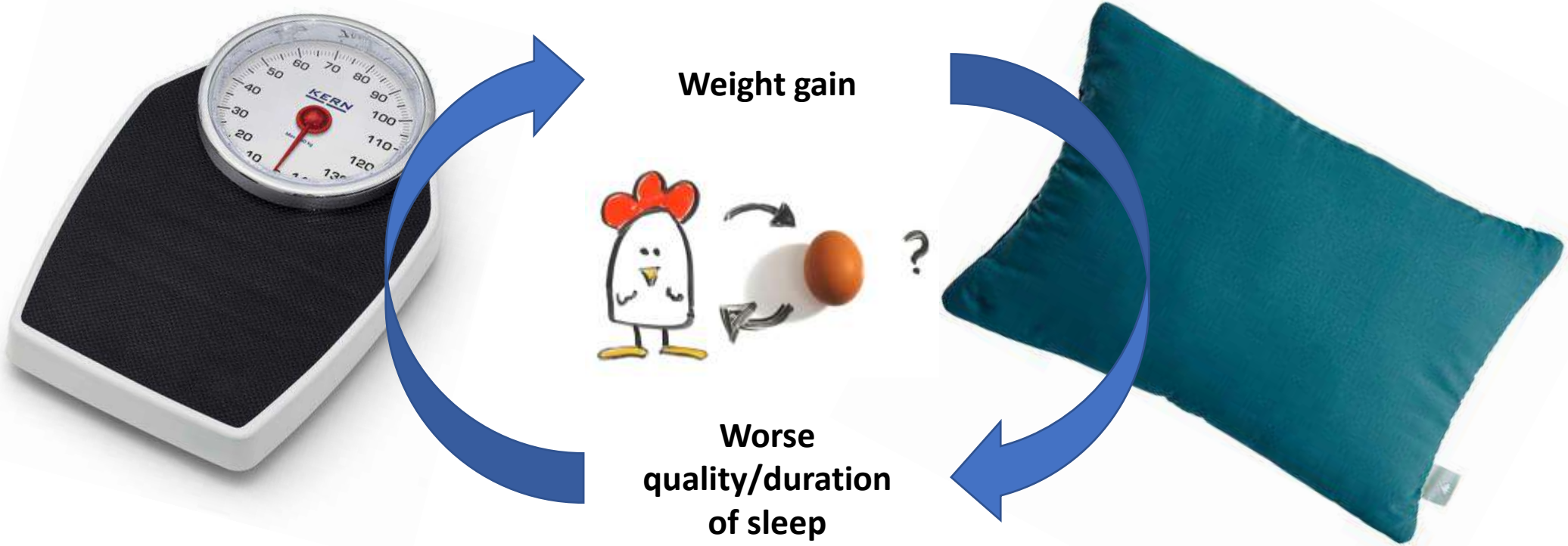
Variable/category	Morning chronotype	Neither chronotype	Evening chronotype	Significance
	M (*SD*) or *f* (%)	*M* (*SD*) or *f* (%)	*M* (*SD*) or *f* (%)	*p*-value
Sleep variables[a]				
Bedtime[b,c,d]	23:41 (1.11)	0:31 (1:02)	1:41 (1:10)	<0.001
Sleep latency (minutes)[c]	17.3 (15.0)	22.5 (19.2)	24.3 (21.4)	0.005
Sleep duration (hours)	7.1 (1.0)	7.0 (1.1)	6.8 (1.1)	0.021
Short sleep (<7 hours)	37 (32.3)	186 (35.0)	118 (45.4)	
Sufficient sleep (⩾7 hours)	78 (67.7)	347 (65.0)	142 (54.6)	
Time in Bed (hours)	7.7 (1.2)	7.9 (1.3)	8.0 (1.4)	0.220
Sleep efficiency (%)[b,c,d]	92.0 (7.2)	88.7 (8.8)	85.8 (9.4)	<0.001
PSQI				
Global Score[b,c,d]	4.89 (2.76)	5.87 (2.64)	6.85 (2.99)	<0.001
Poor sleeper (>5)	43 (61.6)	268 (52.3)	155 (63.3)	
Good sleeper (⩽5)	69 (38.4)	224 (43.8)	90 (36.7)	
Subjective sleep quality[b,c,d]	0.90 (0.65)	1.09 (0.61)	1.32 (0.65)	<0.001
Sleep latency[b,c,d]	0.89 (0.85)	1.16 (0.87)	1.39 (0.92)	<0.001
Sleep duration	0.69 (0.64)	0.75 (0.66)	0.85 (0.68)	0.046
Habitual sleep efficiency[c,d]	0.16 (0.42)	0.29 (0.64)	0.46 (0.73)	<0.001
Sleep disturbances	1.13 (0.54)	1.16 (0.50)	1.17 (0.52)	0.787
Use of sleep medications	0.16 (0.52)	0.25 (0.66)	0.32 (0.79)	0.088
Daytime dysfunction[c,d]	0.95 (0.88)	1.15 (0.86)	1.32 (0.89)	<0.001
Mood				
Positive affect[c,d]	48.7 (10.4)	47.4 (8.9)	44.5 (8.6)	<0.001
Anxiety	56.1 (10.0)	56.4 (8.0)	57.7 (8.0)	0.097
Depression	50.8 (10.1)	50.6 (8.9)	51.6 (9.0)	0.373
Anger	49.3 (11.2)	50.1 (9.7)	51.4 (10.0)	0.106

IFSO
International Federation for Surgery of Obesity & Metabolic Disorders

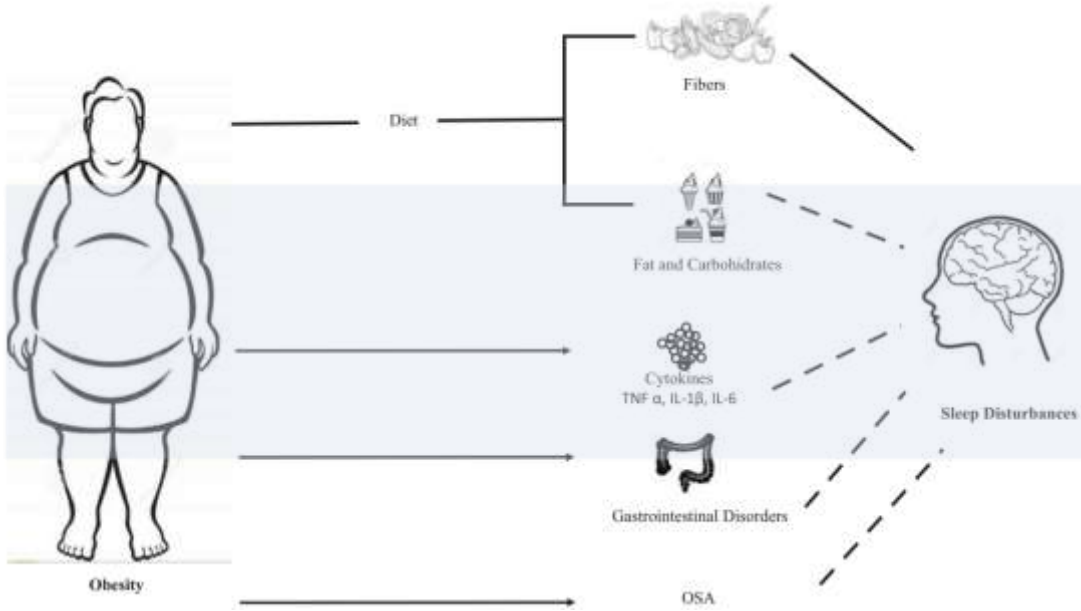
Review > Crit Rev Food Sci Nutr. 2019;59(13):2158-2165. doi: 10.1080/10408398.2018.1506979.
Epub 2018 Oct 18.

Obesity and sleep disturbance: the chicken or the egg?

Giovanna Muscogiuri [1], Luigi Barrea [1], Giuseppe Annunziata [1], Carolina Di Somma [2], Daniela Laudisio [1], Annamaria Colao [1], Silvia Savastano [1]



There is an association between obesity with sleep disorders and vice versa, but … WHO COMES FIRST?



Sleep disorders

Obesity

Table 1. Mechanism of action of sleep disturbance-related hormones in promoting obesity.

Hormones	Sleep disturbance – related changes	Mechanism of action
Cortisol	↑	High cortisol levels causes overeating, impairs glucose homeostasis, insulin-resistance, and increases visceral fat accrual
Ghrelin	↑	High ghelin levels increase calorie intake, mostly sweet foods
Leptin	↑	Sleep disturbance has been associated to leptin-resistance and consequent increased leptin levels which results in increased hunger.
Endocannabinoid System	↑	2-arachidonoylglycerol (one of the most abundant ligand of endocannabinoid receptors) rhythm is amplified and the peak is delayed and extended, increasing hunger
Melatonin	↓	Decreased levels of melatonin causes weight gain, chronic inflammation and increased oxidative stress, thus blunting glucose metabolism.

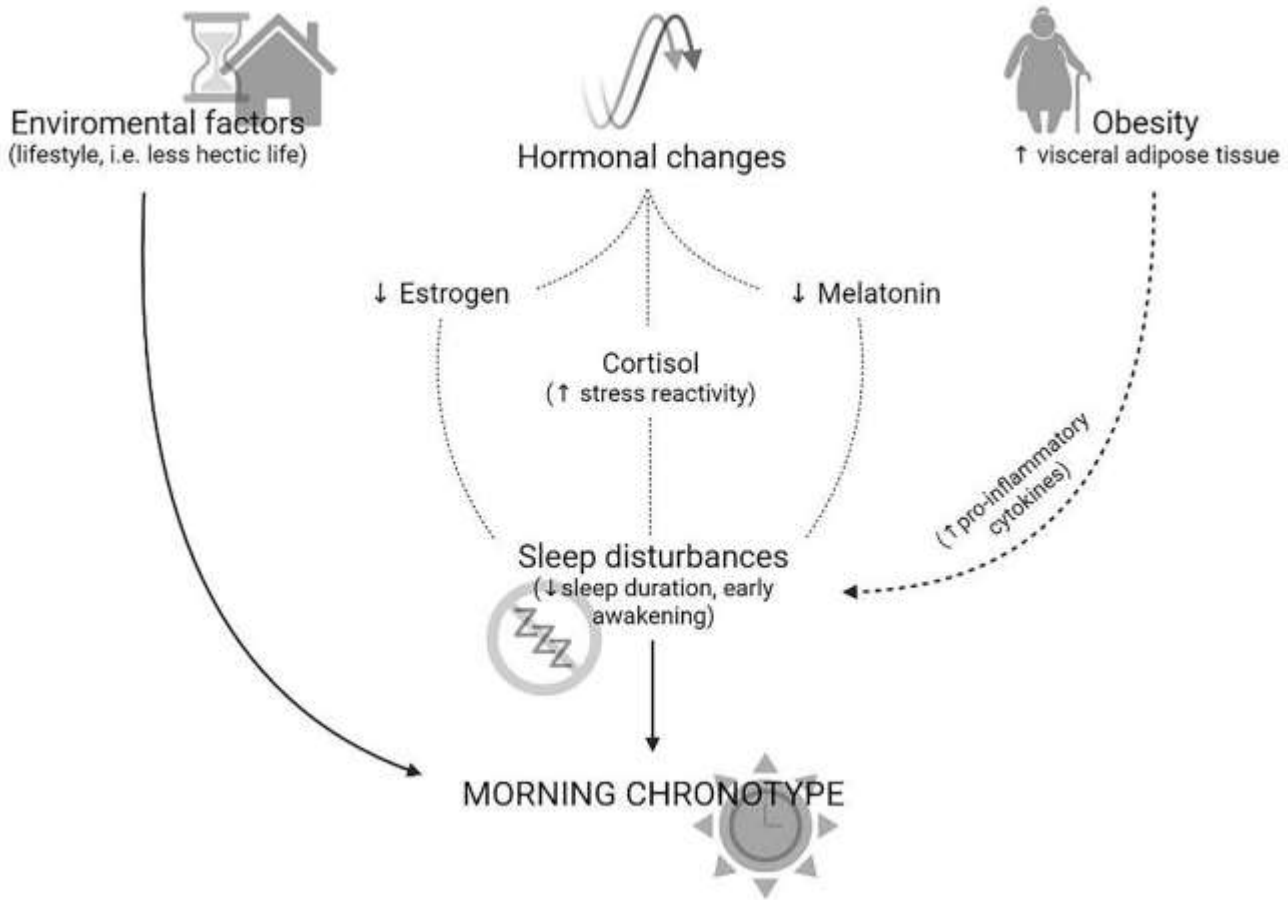
Muscogiuri et al., Int J of Food Science and Nutrition, 2021

Current Obesity Reports (2022) 11:254–262
https://doi.org/10.1007/s13679-022-00479-9

METABOLISM (M DALAMAGA, SECTION EDITOR)

Chronotype and Sleep Quality in Obesity: How Do They Change After Menopause?

Ludovica Verde[1] · Luigi Barrea[1,2] · Claudia Vetrani[3] · Evelyn Frias-Toral[4] · Sebastián Pablo Chapela[5,6] · Ranil Jayawardena[7,8] · Giulia de Alteriis[3] · Annamaria Docimo[3] · Silvia Savastano[1,3] · Annamaria Colao[1,3,9] · Giovanna Muscogiuri[1,3,9]



Review > Int J Environ Res Public Health. 2022 Aug 5;19(15):9646. doi: 10.3390/ijerph19159646.

Association between Chronotype, Physical Activity and Sedentary Behaviour: A Systematic Review

Nuria Sempere-Rubio [1], Mariam Aguas [2,3], Raquel Faubel [4,5]

N=23 studies (505375 participants)

Results

Evening chronotypes are associated with less physical activity and more time in sedentary activities.

It occurs independently of the instruments used to collect information about chronotype and physical activity.

The association could be mitigated in young populations and university stages.

› Nutrients. 2020 May 9;12(5):1354. doi: 10.3390/nu12051354.

Chronotype and Adherence to the Mediterranean Diet in Obesity: Results from the Opera Prevention Project

Giovanna Muscogiuri [1 2], Luigi Barrea [1 2], Sara Aprano [1 2], Lydia Framondi [1 2], Rossana Di Matteo [1 2], Daniela Laudisio [1 2], Gabriella Pugliese [1 2], Silvia Savastano [1 2], Annamaria Colao [1 2 3], On Behalf Of The Opera Prevention Project

N=172 participants. Obesity was present in most of the enrolled subjects.

Parameters	Morning Type n = 100, 58.1%	Neither Type n = 50, 29.1%	Evening Type n = 22, 12.8%	p-Value
Gender				
Males	34, 34.0	13, 26.0	2, 9.1	p = 0.18
Females	66, 66.0	37, 74.0	20, 90.9	
Lifestyle Habits				
Age (years)	55.5 ± 13.7	43.0 ± 17.4 [a,b]	55.3 ± 11.9	<0.001
Smoking				
Yes (n, %)	7, 7.0	11, 22.0	8, 36.4 [a,c]	p < 0.001
No (n, %)	93, 93.0	39, 78.0	14, 63.6 [a,c]	
Physical activity				
Sedentary (n, %)	39, 39.0	26, 52.0	19, 86.4 [a,c]	p < 0.001
Moderate (n, %)	61, 61.0	24, 48.0	3, 13.6 [a,c]	

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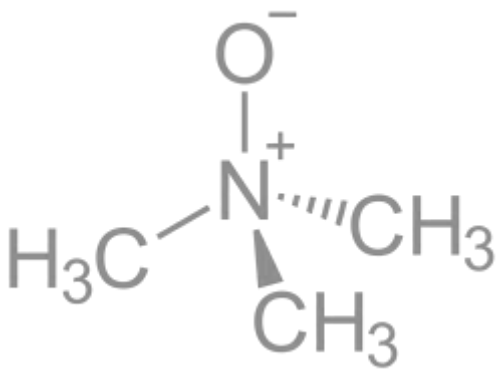
Observational Study > Nutrients. 2021 May 14;13(5):1671. doi: 10.3390/nu13051671.

Association of the Chronotype Score with Circulating Trimethylamine N-Oxide (TMAO) Concentrations

Luigi Barrea [1 2], Giovanna Muscogiuri [2 3 4], Gabriella Pugliese [2 3], Chiara Graziadio [2], Maria Maisto [5], Francesca Pivari [6], Andrea Falco [7], Gian Carlo Tenore [5], Annamaria Colao [2 3 4], Silvia Savastano [2 3]

N = 247 participants



Parameters	Morning Type n = 154, 62.3%	Neither Type n = 30, 12.2%	Evening Type n = 63, 25.5%	p-Value
Gender				
Males (n, %)	41, 26.6%	12, 40.0%	47, 74.6%	χ^2 = 42.7
Females (n, %)	113, 73.4%	18, 60.0%	16, 25.4%	**p < 0.001**
Age (years)	38.5 ± 11.0	40.0 ± 11.5	30.3 ± 8.2	**<0.001**
Smoking				
Yes	42, 27.3%	12, 40.0%	32, 49.2%	χ^2 = 11.3
No	112, 72.7%	18, 60.0%	31, 50.8%	**p = 0.004**
Physical activity				
Yes	72, 46.8%	10, 33.3%	15, 23.8%	χ^2 = 10.4
No	82, 53.2%	20, 66.7%	48, 76.2%	**p = 0.006**

Observational Study > Nutrients. 2022 Feb 23;14(5):955. doi: 10.3390/nu14050955.

Chronotype: A Tool to Screen Eating Habits in Polycystic Ovary Syndrome?

Luigi Barrea [1 2], Ludovica Verde [2], Claudia Vetrani [3], Silvia Savastano [2 3], Annamaria Colao [2 3 4], Giovanna Muscogiuri [2 3 4]

N = 112 women with PCOS. Obesity was present in most of the enrolled subjects.

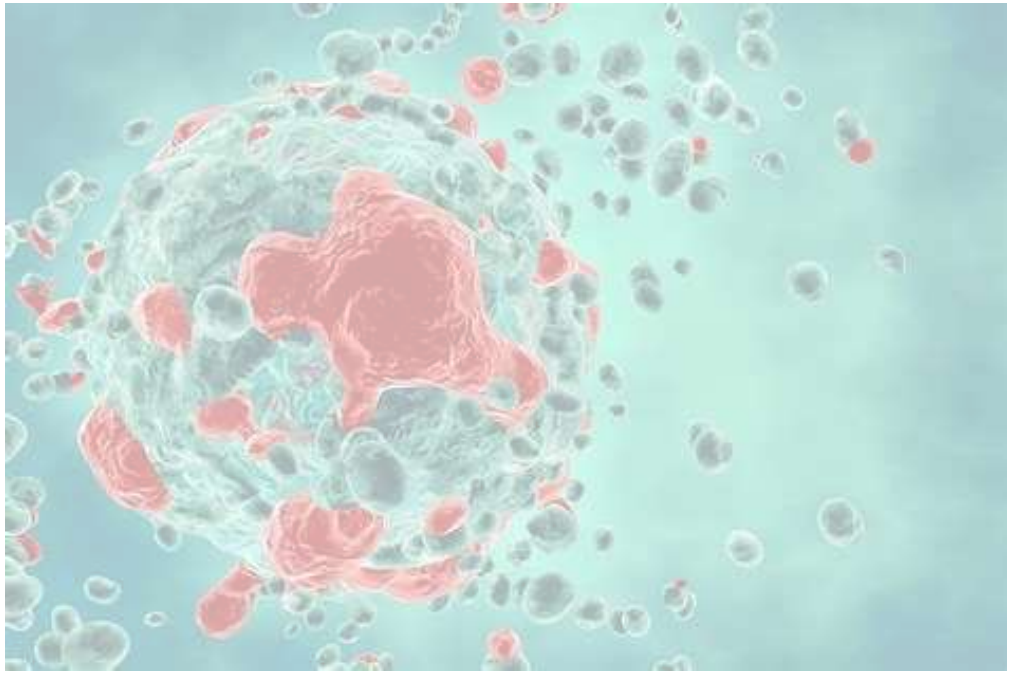
Parameters	Morning Chronotype *n* = 31, 27.7%		Neither Chronotype *n* = 33, 29.5%		Evening Chronotype *n* = 48, 42.9%		χ^2	*p*-Value
BMI categories								
Normal weight (*n*, %)	22	71.0	2	6.1	0	0	62.91	**<0.001**
Overweight (*n*, %)	4	12.9	18	54.5	7	14.6	20.04	**<0.001**
Grade I obesity (*n*, %)	1	3.2	6	18.2	17	35.4	11.89	**0.003**
Grade II obesity (*n*, %)	4	12.9	7	21.2	24	50.0	19.16	**0.001**
Physical activity								
YES (*n*, %)	20	64.5	13	39.4	3	6.3	30.45	**<0.001**
NO (*n*, %)	11	35.5	20	60.6	45	93.8		
Smoking								
YES (*n*, %)	2	6.5	2	6.1	25	52.1	30.03	**<0.001**
NO (*n*, %)	29	93.5	31	93.9	23	47.9		

J Transl Med. 2021 Jul 30;19(1):324. doi: 10.1186/s12967-021-03010-1.

Chronotype: what role in the context of gastroenteropancreatic neuroendocrine tumors?

Luigi Barrea [# 1 2 3], Giovanna Muscogiuri [# 4 5 6], Gabriella Pugliese [4 5], Roberta Modica [5], Daniela Laudisio [4 5], Sara Aprano [4 5], Antongiulio Faggiano [7], Annamaria Colao [4 5 6], Silvia Savastano [4 5]

N = 109 patients with GEP-NET



Parameters	Morning type n = 53, 48.6%	Neither type n = 19, 17.4%	Evening type n = 37, 33.9%	*p-value
Gender				
Males (n, %)	25, 47.2%	10, 52,6%	18, 48.6%	$\chi^2 = 0.17$,
Females (n, %)	28, 52.8%	9, 47.4%	19, 51.4%	$p = 0.919$
Age (years)	54.0 ± 16.6	62.4 ± 12.2	58.7 ± 16.1	0.110
Clinical characteristics				
Smoking (No)	40, 75.5%	14, 73.7%	18, 48.6%	$\chi^2 = 7.59$, $\mathbf{p = 0.023}$
Physical activity (No)	24, 45.3%	7, 36.8%	29, 78.4%	$\chi^2 = 12.73$, $\mathbf{p = 0.002}$

Sport Sci Health. 2023;19(1):309-319. doi: 10.1007/s11332-022-00963-8. Epub 2022 Jun 20.

Evening chronotype predicts dropout of physical exercise: a prospective analysis

Flávio Augustino Back [1 2], Adriano Akira Ferreira Hino [3], Wilynson Gomes Bojarski [1], João Manoel Gonçalves Aurélio [1], Cláudia Roberta de Castro Moreno [4], Fernando Mazzilli Louzada [1]

(N = 153 newly enrolled volunteers at three different gyms)

Results

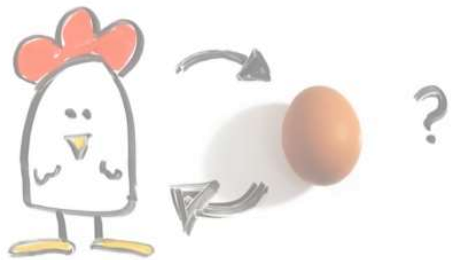
Even after adjusting for possible confounding variables, higher MEQ *(morningness)* score was associated with lower chance of dropping out from the program. When considering three chronotypes, multivariate model 2, evening chronotype had the highest dropout risk compared to morning chronotype.

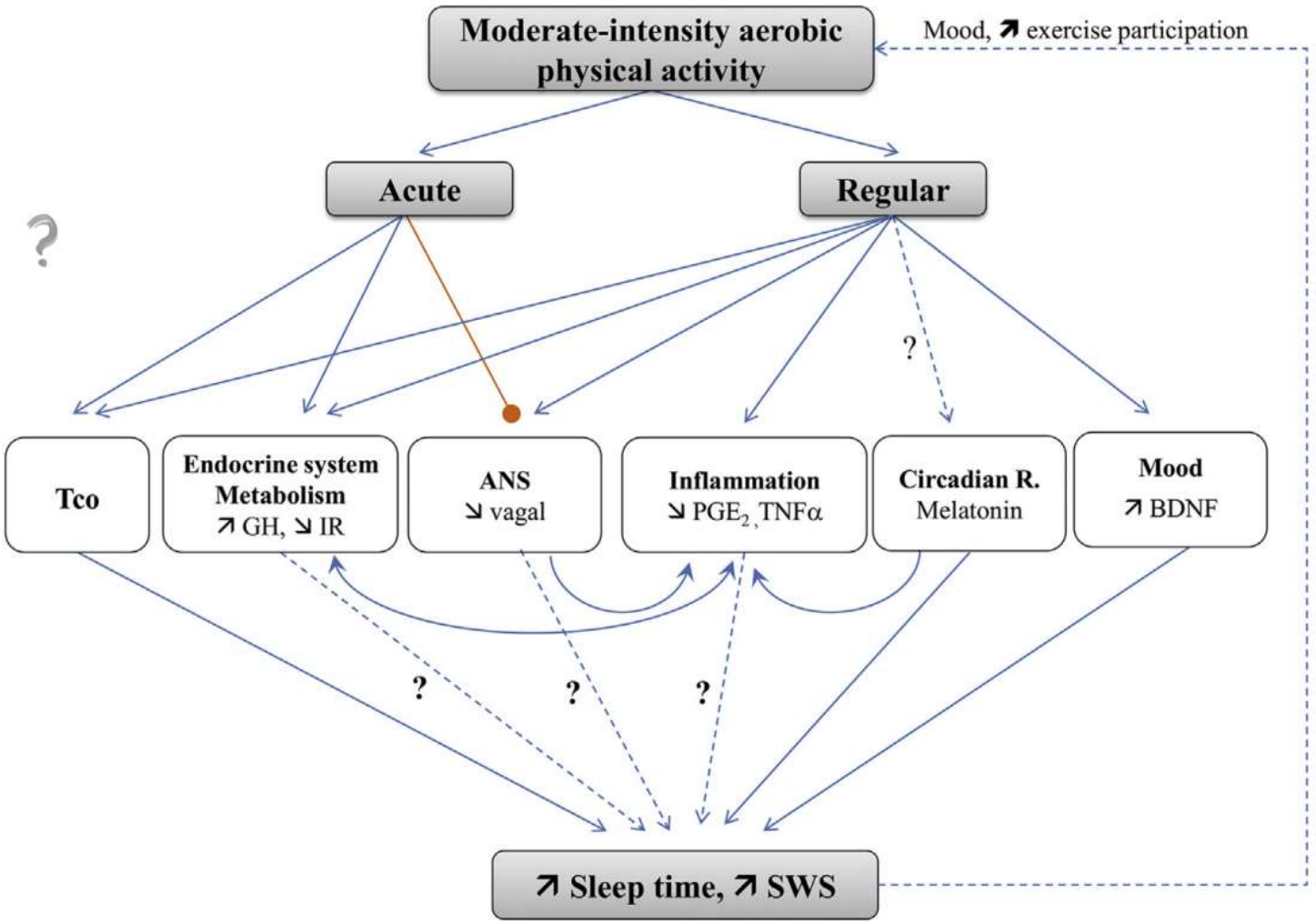
Variables	Model 1			Model 2		
	HR	CI95%	*p*	HR	CI95%	*p*
Age (years)	0.99	(0.96–1.01)	0.37	0.99	(0.96–1.01)	0.35
Educational level						
Up to high school degree	1.75	(0.89–3.45)	0.11	1.73	(0.87–3.43)	0.12
Bachelor's degree	1.28	(0.64–2.55)	0.49	1.20	(0.60–2.43)	0.60
Complete graduate school (MSc/PhD)	1.00			1.00		
Civil status						
Single	0.79	(0.47–1.35)	0.39	0.77	(0.46–1.31)	0.34
Married/stable Union	1.00			1.00		
Duration of membership plan						
1 month	2.37	(1.33–4.24)	**< 0.001**	2.36	(1.32–4.24)	**< 0.001**
3 months to 6 months	1.66	(0.88–3.13)	0.12	1.72	(0.91–3.26)	0.10
Annual	1.00			1.00		
Frequency on week 1	0.70	(0.58–0.85)	**< 0.001**	0.70	(0.57–0.85)	**< 0.001**
Chronotype (MEQ score)	0.98	(0.95–1.00)	**0.046**			
Chronotypes						
E-types				2.22	(1.09–4.52)	**0.027**
N-types				1.19	(0.67–2.1)	0.05
M-types				1.00		

Review > Sleep Med Rev. 2015 Apr;20:59-72. doi: 10.1016/j.smrv.2014.06.008. Epub 2014 Jun 30.

Sleep and exercise: a reciprocal issue?

Mounir Chennaoui [1], Pierrick J Arnal [2], Fabien Sauvet [3], Damien Lége

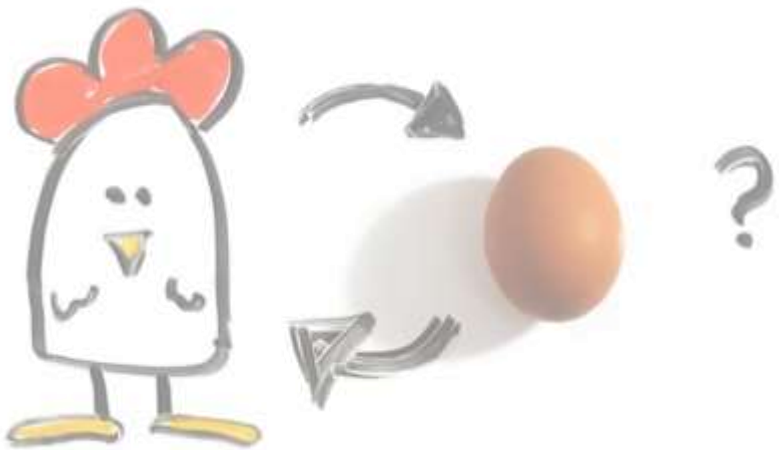


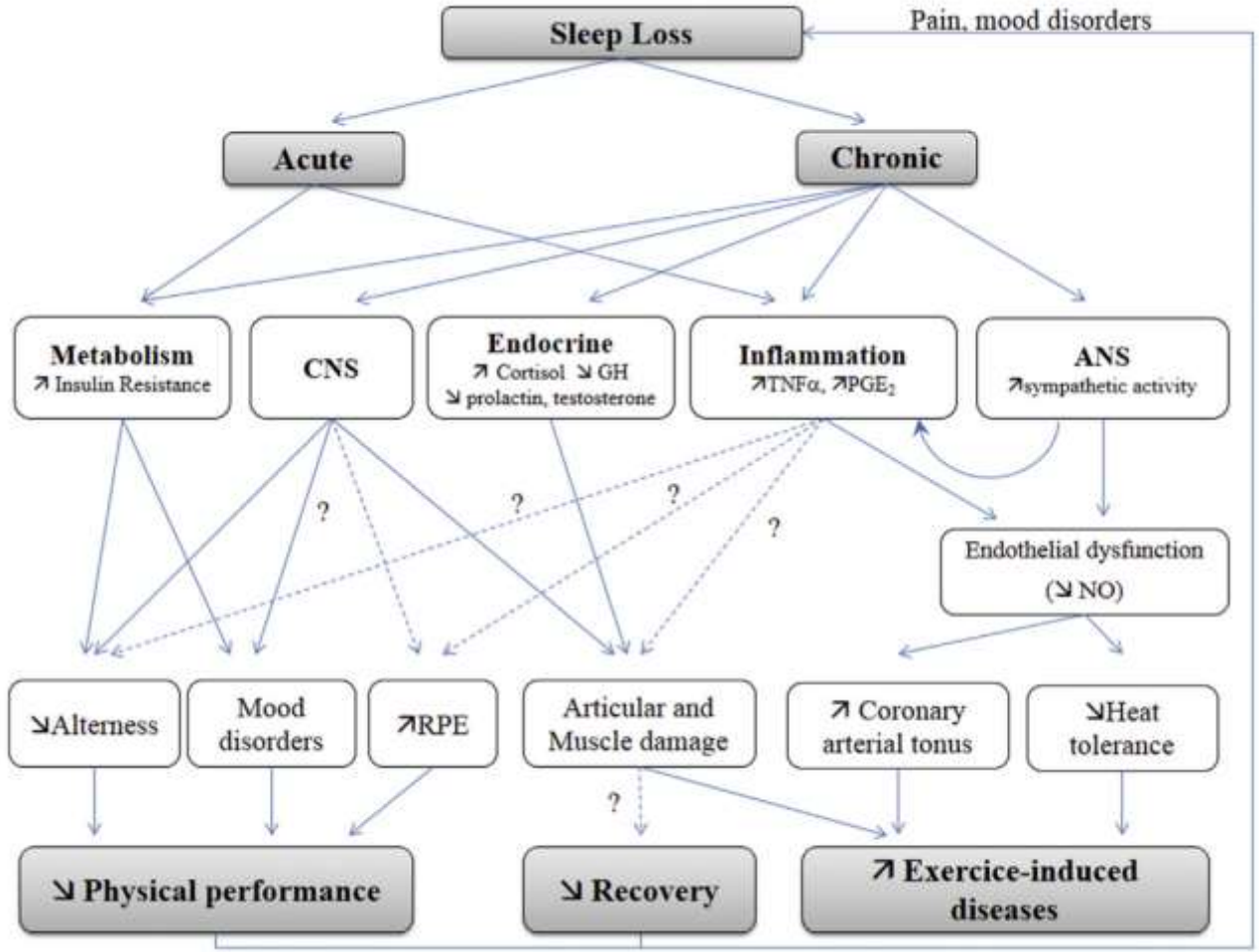


Review > Sleep Med Rev. 2015 Apr;20:59-72. doi: 10.1016/j.smrv.2014.06.008. Epub 2014 Jun 30.

Sleep and exercise: a reciprocal issue?

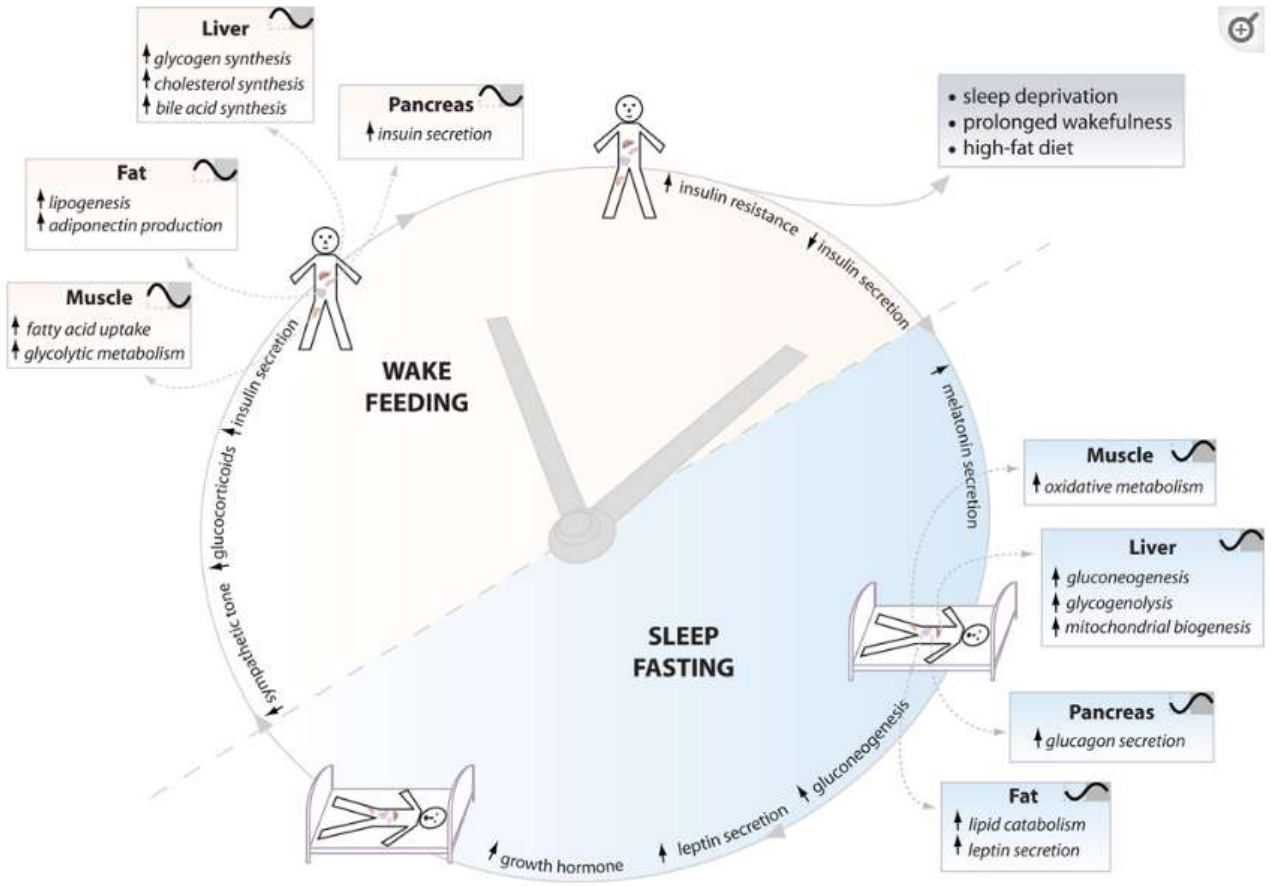
Mounir Chennaoui [1], Pierrick J Arnal [2], Fabien Sauvet [3], Damien Léger [4]





What can we do if we are faced with an owl?

Time for food: when to eat?



Review > Minerva Med. 2022 Feb;113(1):172-188. doi: 10.23736/S0026-4806.21.07207-4. Epub 2021 Apr 29.

The clock diet: a practical nutritional guide to manage obesity through chrononutrition

Luigi Barrea [1 2], Evelyn Frias-Toral [3 4], Sara Aprano [5 6], Bianca Castellucci [5 6], Gabriella Pugliese [5 6], Dolores Rodriguez-Veintimilla [7], Giovanni Vitale [8 9], Davide Gentilini [10 11], Annamaria Colao [5 6 12], Silvia Savastano [5 6], Giovanna Muscogiuri [5 6 12]

- **Do not skip breakfast**
- **Prefer a balanced breakfast and lunch, composed of carbohydrates, fiber, proteins and the right amount of fat**
- **Take an adequate protein intake, especially preferring whey proteins**
- **Take most of the daily carbohydrates intake in the first half of the day**
- **Reduce calorie intake and especially carbohydrates intake in the evening**

Bass J et al, Science. 2010

Take home messages

- Evening chronotype promotes sleep disorders and low physical activity.

- Chronotype, sleep quality and physical activity levels are interconnected in favouring the development of obesity.

- New chrono-approaches could improve lifestyle habits (sleep quality and physical activity) and ultimately improve the treatment of obesity.

Thank you!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