Nutrire (2020) 45: 25
https://doi.org/10.1186/s41110-020-00128-y

REVIEW

The effects of COVID-19 quarantine on eating and sleeping behaviors

Flavia Rodrigues da Silva [1] · Antonio Herbert Lancha Junior [2] · Valdênio Martins Brant [1] · Ingrid Ludimila Bastos Lôbo [1] · Luciana Oquendo Pereira Lancha [2,3] · Andressa Silva [1] · Marco Túlio de Mello [1]

Received: 14 July 2020 / Accepted: 17 September 2020 / Published online: 29 September 2020

Abstract
Since the beginning of the pandemic, the population has been exposed to a substantial period of social isolation, which leads to anxiety, fear, and metabolic and immune impairments.
Purpose Considering that sleep restriction influences eating behavior, we highlight that changes in it may occur during the COVID-19 quarantine. Alterations in feeding time can uncouple the body clocks, leading to circadian misalignment and consequently to a disruption in homeostasis and disturbances in many metabolic functions.
Method Narrative review.
Results Do not apply.
Conclusion The increase of body weight is related to increased food intake in response to mental stress and more time spent at home, increased opportunity to feed, and increased visual and olfactory stimulation to eat, which represents a potential risk of overfeeding nowadays. In this article, we postulate that the unusual lifestyle imposed by the COVID-19 quarantine may induce a circadian misalignment, which is capable to induce alterations on eating and sleep behaviors.

Keywords COVID-19 quarantine · Sleep behavior · Sleep quality · Eating behavior · Circadian misalignment

Introduction

Sleep is a physiological and behavioral state which plays an essential role in the homeostasis, energy metabolism, and cognitive function [1]. Circadian rhythms coordinate most biological processes [2], requiring endogenous and peripheral clocks [3], which regulate the rhythm of physiological functions such as heart rate, gastrointestinal motility, hormonal secretion, macronutrient metabolism, energy metabolism [4], and gastrointestinal functions [5].

Since the beginning of the pandemic, the population has been exposed to a substantial period of social isolation, also called self-quarantine [6]. Quarantine requires people to stay at home [7], changing their lifestyles [8], and inducing people to work at home, which becomes a stressor, considering that it does not have a vaccine and can only be treated symptomatically at present [9]. People lifestyles were changed since the COVID-19 pandemic started, especially sleep, nutrition, and physical activity habits, and during confinement, it could become difficult to shop for fresh groceries, and besides that, shortages of certain food products might happen, causing disruptions in food chains around the world [10]. Sleep restriction has been associated with negative consequences on health and mental wellbeing [11], and it has been demonstrated a relationship between biological rhythms, sleep, and the COVID-19 pandemic [12], and although during the isolation period the public life came to a standstill, some people experienced greater time flexibility regarding social schedules due to home office, leading to an improved individual sleep-wake timing, while others are experiencing sleep restriction and circadian misalignment [11]. Among the main consequences of confinement are changes in chronobiological rhythms and perceptions, feelings of anxiety and fear, and, very importantly, functional and metabolic impairments dictated by a sedentary lifestyle [9]. Changes in the neuroendocrine and immune setting produce adaptive and compensatory responses which

✉ Flavia Rodrigues da Silva
dra.flaviarodrigues@hotmail.com

✉ Marco Túlio de Mello
tmello@demello.net.br

[1] Departamento de Esportes, Universidade Federal de Minas Gerais, Av. Presidente Antônio Carlos, 6627, Pampulha, Belo Horizonte, MG 31270-901, Brazil

[2] Escola de Educação Física e Esporte (EEFE), Universidade de São Paulo, São Paulo, Brazil

[3] Instituto de Bem Estar e Saúde, IBES, São Paulo, Brazil

effects could last for months, and even for generations (epigenetics changes generated through major nutritional and lifestyle challenges have been evoked as the cause behind the association with a higher incidence of chronic diseases, such as diabetes and cardiovascular diseases, through two or more generations), which require healthy habits to restore the metabolic processes that have been dysregulated [13].

Sleep duration influences the length of time of the day available for eating [14]. Importantly, environmental and behavioral factors induce sleep restriction [15]. Besides that, prolonged wakefulness may induce alterations on digestion, absorption, and nutrient metabolism [16]. These changes in eating and sleeping behaviors may occur during the COVID-19 pandemic and their effects are expected to translate into physical and psychological consequences that will last for a long time after the pandemic period [9]. In this sense, we aimed to summarize the effects of the COVID-19-induced confinement with habit modifications on sleep and nutrition. Moreover, we highlight the possible factors which could be related to sleep disturbances development during the quarantine.

The relationship between sleep, eating habits, and COVID-19 pandemic

The circadian modulation may occur by different stimuli [17]. The regularity of the sleep-wake cycle is important for optimizing health, as well as the function of the circadian system and biological clock. Our organism is governed by rhythmic oscillations that have a periodicity of approximately 24 h, for example, body temperature, cortisol, melatonin, and the sleep-wake cycle [18]. The factors that regulate and synchronize these rhythms are called "zeitgebers," or time givers. The main synchronizer of circadian rhythms is light, but food [5] and regular sleep times also influence circadian rhythms. Also, the mood exhibits circadian rhythmicity, showing peaks in the late afternoon and early evening [10], as well as the gastrointestinal tract motility, the production of gastric acid by the stomach, and the absorption of nutrients occur during the daytime [19, 20], and may fluctuate in situations of sleep restriction, influencing the transport of amino acids [21] and carbohydrates, which favors the increased risk of metabolic syndrome. Concentrations of fatty acids in terms of lipid absorption also vary during the day, and situations that lead to disturbance of the circadian rhythm also increase the risk of dyslipidemias [22]. The suprachiasmatic nucleus is the body's central clock [18] which controls the organism using these peripheral clocks. The time of meals is an important "zeitgeber" (particularly those in the liver and adipose tissue), and alterations in feeding time can uncouple the central and peripheral clocks, leading to circadian misalignment and consequently to a disruption in homeostasis and disturbances in many metabolic functions [23].

There are environmental and internal cues related to food intake that are important for the synchronization of feeding and the involvement of pathways that conduct information on food availability for brain structures responsible for the expression of variables synchronized to the feeding schedule. This signaling may be related to responses during the cephalic phase of digestion, or postprandial signs, occurring through neural and/or humoral signs modified by the presence of food in the digestive system; and also for information about the availability of food, which is transmitted to the central nervous system before and during ingestion, for example, through olfactory and/or taste signs [24].

There are multiple humoral signs in controlling food intake [25], which vary over the 24 h of the day, such as ghrelin and leptin hormones, which adjust to the feeding schedule during the fasting period [26, 27]. Both are humoral feedback signals from the periphery to the hypothalamic neuronal network regulating energy homeostasis [27]. Ghrelin promotes deposition of fat [28], whereas leptin stimulates energy expenditure [29]. Importantly, ghrelin and leptin are in part related to sleep because sleep deprivation alters plasma concentrations of these hormones [30], or sleep restriction, which is followed by shifts in hormone secretions [31]. The increase of body weight is related to increased food intake in response to mental stress and more time spent at home, increased opportunity to feed, and increased visual and olfactory stimulation to eat [6]. In this sense, it represents a potential risk of overfeeding nowadays [32]. Sleep restriction is considered to be predictors of weight gain [7], because the rhythmicity in brain areas is therefore a sensitive feeding schedule, increasing the time frame of daily feeding, and may promote fluctuation in body weight, metabolism, and parameters of cardiovascular diseases in humans [33].

In the current scenario caused by the pandemic of the COVID-19, there is growing evidence of a relationship between reduced sleep quality, increased anxiety and mental stress, increased weight, and reduced physical activity due to the COVID-19 and physical isolation, which may also cause physiological alterations, and even result in circadian rhythm disturbances and sleep disorders (e.g., insomnia). Considering that any misalignment in circadian rhythms can, therefore, disrupt a range of biological processes, people who sleep less than they need to feel refreshed consume more calories from fats or refined carbohydrates [34, 35] and have more irregular meal patterns characterized by a predominance of snacks over main meals [14, 36, 37], and lower fruit and vegetable intake [38–40]. Highlighting, this period of less healthy food intake is rising as a food habit, because short sleep duration may affect the motivation to eat a healthy diet [41] as well as decrease the desire to eat healthier foods in comparison with energy-dense foods [42] and also represent a trigger to raise the high-fat food intake [43].

As such, the food consumption at night may decrease the energy expenditure during the COVID-19 pandemic and increase energy intake as a consequence of the disruption in the patterns of secretion of the leptin and ghrelin [44]. This disruption may be more expressive among sleep restriction, increasing ghrelin, as well as decreasing leptin hormones [45, 46]. It emerges as an urgent problem of public health, considering that people are developing unhealthy eating habits, rising as a key factor for sleep and mental disorder development during the quarantine period.

Conclusion

There is a direct relationship between sleep and eating behaviors, and both are related to the impacts of physical isolation. There is an influence of eating disorders on the sleeping quality, and the pandemic can predispose to eating disorders and sleeping disturbance due to more free time, more stress, and anxiety on the individual. These factors can negatively affect sleep, which in turn impacts eating habits, inducing stress, which becomes a feedback cycle, contributing to sleep disorders.

Acknowledgments CEPE (Centro de Estudos em Psicobiologia e Exercício); CEMSA (Centro Multidisciplinar em Sonolência e Acidentes); CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico); FAPEMIG (Fundação de Amparo à Pesquisa do Estado de Minas Gerais); CAPES (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior); UFMG (Universidade Federal de Minas Gerais); and FEPE-UFMG (Fundação de Apoio ao Ensino Pesquisa e Extensão-UFMG).

Authors' contributions M.T.M. and A.H.L.J. made the conception and design of the study and revised it critically for important intellectual content; M.T.M. coordinated the study and made final approval of the version to be submitted; the article was written by F.R.S. A.S., I.L.B.L., and V.M.B. contributed with important intellectual content. All authors revised and discussed the manuscript.

Data availability The datasets and/or files used during the current study are available from the corresponding author on reasonable request.

Code availability Not applicable.

Compliance with ethical standards

Conflict of interest Not applicable.

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent to publication Not applicable.

Abbreviations *COVID-19,* new coronavirus 2019 disease

References

1. Krueger JM, Frank MG, Wisor JP, Roy S. Sleep function: toward elucidating an enigma. Sleep Med Rev. 2016;28:46–54. https://doi.org/10.1016/j.smrv.2015.08.005.
2. Majde JA, Krueger JM. Links between the innate immune system and sleep. J Allergy Clin Immunol. 2005;116(6):1188–98. https://doi.org/10.1016/j.jaci.2005.08.005.
3. Everson CA. Sustained sleep deprivation impairs host defense. Am J Phys. 1993;265(5 Pt 2):R1148–54. https://doi.org/10.1152/ajpregu.1993.265.5.R1148.
4. Patton AP, Hastings MH. The suprachiasmatic nucleus. Curr Biol: CB. 2018;28(15):R816–22. https://doi.org/10.1016/j.cub.2018.06.052.
5. Pan X, Hussain MM. Clock is important for food and circadian regulation of macronutrient absorption in mice. J Lipid Res. 2009;50(9):1800–13. https://doi.org/10.1194/jlr.M900085-JLR200.
6. Zachary Z, Brianna F, Brianna L, Garrett P, Jade W, Alyssa D, et al. Self-quarantine and weight gain related risk factors during the COVID-19 pandemic. Obes Res Clin Pract. 2020;14(3):210–6. https://doi.org/10.1016/j.orcp.2020.05.004.
7. Parmet WE, Sinha MS. Covid-19 - the law and limits of quarantine. N Engl J Med. 2020;382(15):e28. https://doi.org/10.1056/NEJMp2004211.
8. Jansen EC, Prather A, Leung CW. Associations between sleep duration and dietary quality: results from a nationally-representative survey of US adults. Appetite. 2020;153:104748. https://doi.org/10.1016/j.appet.2020.104748.
9. Galli F, Reglero G, Bartolini D, Visioli F. Better prepare for the next one. Lifestyle lessons from the COVID-19 pandemic. Pharm Nutr. 2020;12:100193. https://doi.org/10.1016/j.phanu.2020.100193.
10. Calder PC, Carr AC, Gombart AF, Eggersdorfer M. Optimal nutritional status for a well-functioning immune system is an important factor to protect against viral infections. Nutrients. 2020;12(4). https://doi.org/10.3390/nu12041181.
11. Blume CS, Schmidt MH, Cajochen C. Effects of the COVID-19 lockdown on human sleep and rest-activity rhythms. Curr Biol. 2020;30:R795–7. https://doi.org/10.1016/j.cub.2020.06.021.
12. Silva FRD, Guerreiro RC, Andrade HA, Stieler E, Silva A, de Mello MT. Does the compromised sleep and circadian disruption of night and shiftworkers make them highly vulnerable to 2019 coronavirus disease (COVID-19)? Chronobiol Int. 2020;37:607–17. 1–11. https://doi.org/10.1080/07420528.2020.1756841.
13. Maggini S, Pierre A, Calder PC. Immune function and micronutrient requirements change over the life course. Nutrients. 2018;10(10). https://doi.org/10.3390/nu10101531.
14. Kim S, DeRoo LA, Sandler DP. Eating patterns and nutritional characteristics associated with sleep duration. Public Health Nutr. 2011;14(5):889–95. https://doi.org/10.1017/S136898001000296X.
15. Potter GD, Cade JE, Grant PJ, Hardie LJ. Nutrition and the circadian system. Br J Nutr. 2016;116(3):434–42. https://doi.org/10.1017/S0007114516002117.
16. Almoosawi S, Vingeliene S, Karagounis LG, Pot GK. Chrono-nutrition: a review of current evidence from observational studies on global trends in time-of-day of energy intake and its association with obesity. Proc Nutr Soc. 2016;75(4):487–500. https://doi.org/10.1017/S0029665116000306.
17. Irwin M, McClintick J, Costlow C, Fortner M, White J, Gillin JC. Partial night sleep deprivation reduces natural killer and cellular immune responses in humans. FASEB J : official publication of the Federation of American Societies for Experimental Biology. 1996;10(5):643–53. https://doi.org/10.1096/fasebj.10.5.8621064.

18. Borbely AA, Daan S, Wirz-Justice A, Deboer T. The two-process model of sleep regulation: a reappraisal. J Sleep Res. 2016;25(2):131–43. https://doi.org/10.1111/jsr.12371.
19. Hoogerwerf WA. Biologic clocks and the gut. Curr Gastroenterol Rep. 2006;8(5):353–9. https://doi.org/10.1007/s11894-006-0019-3.
20. Scheving LA. Biological clocks and the digestive system. Gastroenterology. 2000;119(2):536–49. https://doi.org/10.1053/gast.2000.9305.
21. Okamura A, Koyanagi S, Dilxiat A, Kusunose N, Chen JJ, Matsunaga N, et al. Bile acid-regulated peroxisome proliferator-activated receptor-alpha (PPARalpha) activity underlies circadian expression of intestinal peptide absorption transporter PepT1/Slc15a1. J Biol Chem. 2014;289(36):25296–305. https://doi.org/10.1074/jbc.M114.577023.
22. Wong PM, Hasler BP, Kamarck TW, Muldoon MF, Manuck SB. Social jetlag, chronotype, and cardiometabolic risk. J Clin Endocrinol Metab. 2015;100(12):4612–20. https://doi.org/10.1210/jc.2015-2923.
23. Hutchison AT, Heilbronn LK. Metabolic impacts of altering meal frequency and timing - does when we eat matter? Biochimie. 2016;124:187–97. https://doi.org/10.1016/j.biochi.2015.07.025.
24. Carneiro BTSL-MM, Fontenele-Araujo J. Relógio Alimentar: Mecanismos da Sincronização Circadiana por Alimento. Revista da Biologia. 2019;19(1):7–18. https://doi.org/10.7594/revbio.19.01.02.
25. Coll AP, Farooqi IS, O'Rahilly S. The hormonal control of food intake. Cell. 2007;129(2):251–62. https://doi.org/10.1016/j.cell.2007.04.001.
26. Drazen DL, Vahl TP, D'Alessio DA, Seeley RJ, Woods SC. Effects of a fixed meal pattern on ghrelin secretion: evidence for a learned response independent of nutrient status. Endocrinology. 2006;147(1):23–30. https://doi.org/10.1210/en.2005-0973.
27. Bodosi B, Gardi J, Hajdu I, Szentirmai E, Obal F Jr, Krueger JM. Rhythms of ghrelin, leptin, and sleep in rats: effects of the normal diurnal cycle, restricted feeding, and sleep deprivation. Am J Physiol Regul Integr Comp Physiol. 2004;287(5):R1071–9. https://doi.org/10.1152/ajpregu.00294.2004.
28. Tschop M, Smiley DL, Heiman ML. Ghrelin induces adiposity in rodents. Nature. 2000;407(6806):908–13. https://doi.org/10.1038/35038090.
29. Hwa JJ, Ghibaudi L, Compton D, Fawzi AB, Strader CD. Intracerebroventricular injection of leptin increases thermogenesis and mobilizes fat metabolism in ob/ob mice. Hormone Metab Res = Hormon- und Stoffwechselforschung = Hormones et metabolisme. 1996;28(12):659–63. https://doi.org/10.1055/s-2007-979873.
30. Mullington JM, Chan JL, Van Dongen HP, Szuba MP, Samaras J, Price NJ, et al. Sleep loss reduces diurnal rhythm amplitude of leptin in healthy men. J Neuroendocrinol. 2003;15(9):851–4. https://doi.org/10.1046/j.1365-2826.2003.01069.x.
31. Simon C, Gronfier C, Schlienger JL, Brandenberger G. Circadian and ultradian variations of leptin in normal man under continuous enteral nutrition: relationship to sleep and body temperature. J Clin Endocrinol Metab. 1998;83(6):1893–9. https://doi.org/10.1210/jcem.83.6.4864.
32. Grippo RM, Tang Q, Zhang Q, Chadwick SR, Gao Y, Altherr EB, et al. Dopamine signaling in the suprachiasmatic nucleus enables weight gain associated with hedonic feeding. Curr Biol : CB. 2020;30(2):196–208 e198. https://doi.org/10.1016/j.cub.2019.11.029.
33. Melkani GC, Panda S. Time-restricted feeding for prevention and treatment of cardiometabolic disorders. J Physiol. 2017;595(12):3691–700. https://doi.org/10.1113/JP273094.
34. Shi Z, McEvoy M, Luu J, Attia J. Dietary fat and sleep duration in Chinese men and women. Int J Obes. 2008;32(12):1835–40. https://doi.org/10.1038/ijo.2008.191.
35. Grandner MA, Kripke DF, Naidoo N, Langer RD. Relationships among dietary nutrients and subjective sleep, objective sleep, and napping in women. Sleep Med. 2010;11(2):180–4. https://doi.org/10.1016/j.sleep.2009.07.014.
36. Nedeltcheva AV, Kilkus JM, Imperial J, Kasza K, Schoeller DA, Penev PD. Sleep curtailment is accompanied by increased intake of calories from snacks. Am J Clin Nutr. 2009;89(1):126–33. https://doi.org/10.3945/ajcn.2008.26574.
37. Kant AK, Graubard BI. Association of self-reported sleep duration with eating behaviors of American adults: NHANES 2005-2010. Am J Clin Nutr. 2014;100(3):938–47. https://doi.org/10.3945/ajcn.114.085191.
38. Almoosawi S, Palla L, Walshe I, Vingeliene S, Ellis JG. Long sleep duration and social jetlag are associated inversely with a healthy dietary pattern in adults: results from the UK National Diet and Nutrition Survey Rolling Programme Y1(-)4. Nutrients. 2018;10(9). https://doi.org/10.3390/nu10091131.
39. Noorwali EA, Cade JE, Burley VJ, Hardie LJ. The relationship between sleep duration and fruit/vegetable intakes in UK adults: a cross-sectional study from the National Diet and Nutrition Survey. BMJ Open. 2018;8(4):e020810. https://doi.org/10.1136/bmjopen-2017-020810.
40. Haghighatdoost F, Karimi G, Esmaillzadeh A, Azadbakht L. Sleep deprivation is associated with lower diet quality indices and higher rate of general and central obesity among young female students in Iran. Nutrition. 2012;28(11–12):1146–50. https://doi.org/10.1016/j.nut.2012.04.015.
41. Chaput JP. Short sleep duration promoting overconsumption of food: a reward-driven eating behavior? Sleep. 2010;33(9):1135–6. https://doi.org/10.1093/sleep/33.9.1135.
42. Morselli L, Leproult R, Balbo M, Spiegel K. Role of sleep duration in the regulation of glucose metabolism and appetite. Best Pract Res Clin Endocrinol Metab. 2010;24(5):687–702. https://doi.org/10.1016/j.beem.2010.07.005.
43. Scott CJ, A M (2012) Eur J Obes. 5 (2). https://doi.org/10.1159/000338970
44. Scheer FA, Hilton MF, Mantzoros CS, Shea SA. Adverse metabolic and cardiovascular consequences of circadian misalignment. Proc Natl Acad Sci U S A. 2009;106(11):4453–8. https://doi.org/10.1073/pnas.0808180106.
45. Spiegel K, Leproult R, L'Hermite-Baleriaux M, Copinschi G, Penev PD, Van Cauter E. Leptin levels are dependent on sleep duration: relationships with sympathovagal balance, carbohydrate regulation, cortisol, and thyrotropin. J Clin Endocrinol Metab. 2004;89(11):5762–71. https://doi.org/10.1210/jc.2004-1003.
46. Taheri S, Lin L, Austin D, Young T, Mignot E. Short sleep duration is associated with reduced leptin, elevated ghrelin, and increased body mass index. PLoS Med. 2004;1(3):e62. https://doi.org/10.1371/journal.pmed.0010062.