UNIVERSIDADE ESTADUAL DE CAMPINAS
FACULDADE DE ODONTOLOGIA DE PIRACICABA

DORA ZULEMA ROMERO DIAZ

PADRÃO DE RITMO CIRCADIANO SONO-VIGÍLIA EM ADULTOS JOVENS POR ACTIGRAFIA

CIRCADIAN RHYTHM PATTERN SLEEP-WAKE IN YOUNG ADULTS BY ACTIGRAPHY

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Tese apresentada à Faculdade de Odontologia de Piracicaba da Universidade Estadual de Campinas como parte dos requisitos exigidos para a obtenção do título de Doutora em Biologia Buco-Dental, na Área de Anatomia.

Thesis presented to the Piracicaba Dental School of the University of Campinas in partial fulfillment of the requirements for the degree of Doctor in Oral Biology, in Anatomy area.

Orientadora: Profª. Drª. Maria Beatriz Duarte Gavião
Este exemplar corresponde à versão final da tese defendida pela aluna Dora Zulema Romero Diaz e orientada pela Profª. Drª. Maria Beatriz Duarte Gavião.

Piracicaba
2021

Ficha catalográfica
Universidade Estadual de Campinas
Biblioteca da Faculdade de Odontologia de Piracicaba
Marilene Girello - CRB 8/6159

Diaz, Dora Zulema Romero, 1987-
D543p Padrão de ritmo circadiano sono-vigília em adultos jovens por actigrafia / Dora Zulema Romero Diaz. – Piracicaba, SP : [s.n.], 2021.

Orientador: Maria Beatriz Duarte Gavião.
Tese (doutorado) – Universidade Estadual de Campinas, Faculdade deOdontologia de Piracicaba.

1. Actigrafia. 2. Ritmo circadiano. 3. Luz solar. 4. Isolamento social. 5. Obesidade. I. Gavião, Maria Beatriz Duarte, 1955-. II. Universidade Estadual deCampinas. Faculdade de Odontologia de Piracicaba. III. Título.

Informações para Biblioteca Digital

Título em outro idioma: Circadian rhythm pattern sleep-wake in young adults by actigraphy
Palavras-chave em inglês:
Actigraphy
Circadian rhythm
Sunlight
Social isolation
Obesity
Área de concentração: Anatomia
Titulação: Doutora em Biologia Buco-Dental
Banca examinadora:
Maria Beatriz Duarte Gavião [Orientador]
Mariana dos Santos Fernandes Lopes
Junia Maria Cheib Serra Negra
Paula Midori Castelo Ferrua
Alexandre Rodrigues Freire
Data de defesa: 28-07-2021
Programa de Pós-Graduação: Biologia Buco-Dental

Identificação e informações acadêmicas do(a) aluno(a)
- ORCID do autor: https://orcid.org/0000-0002-5594-2586
- Currículo Lattes do autor: http://lattes.cnpq.br/8142921520181103

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Faculdade de Odontologia de Piracicaba

A Comissão Julgadora dos trabalhos de Defesa de Tese de Doutorado, em sessão pública realizada em 28 de julho de 2021, considerou a candidata DORA ZULEMA ROMERO DIAZ aprovada.

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DEDICATÓRIA

Dedico este trabalho a:

DEUS, meu Pai, que foi minha fortaleza nos momentos mais difíceis, por NUNCA ter me deixado mesmo nas horas de angústia e grande solidão. Por ter me abençoado com a dádiva da vida, a coragem de aproveitar as oportunidades, pela felicidade de realizar aquilo que um dia foi um sonho, e por me abençoar com todas as pessoas maravilhosas que colocou na minha vida.

María Zulema Díaz, minha mãe, que mesmo não compreendendo a natureza do meus estudos sempre me apoiou de forma INCONDICIONAL, muito obrigada por compreender minha ausência e por tudo o que a senhora fez para que meu sonho se tornasse realidade.

A eles minha ETERNA GRATIDÃO!

AGRADECIMENTOS

Agradeço acima de tudo a DEUS, pela vida e pela benção concedida de terminar o meu doutorado.

O presente trabalho foi realizado com apoio do Coselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), processo nº 147405/2017-3.

À Universidade Estadual de Campinas, na pessoa do Magnifico Reitor Prof. Dr. Antonio José de Almeida Meirelles.

À Faculdade de Odontologia de Piracicaba, na pessoa do senhor Diretor, Prof. Dr. Francisco Haiter Neto.

À Coordenadoria de Pós-graduação, na pessoa da Senhora Coordenadora Profª. Drª. Karina Gonzales Silvério Ruiz.

Ao Programa de Pós-graduação em Biologia Buco-Dental, na pessoa do Coordenador Prof. Dr. Marcelo Rocha Marques.

A minha orientadora Profª. Drª. Maria Beatriz Duarte Gavião, por ter me ajudado e apoiado, agradeço imensamente pela participação ativa e direta neste passo gigantesco à caminho da construção de minha carreira profissional.

A todos os participantes pela sua adesão meticulosa ao protocolo de pesquisa, principalmente durante a pandemia pela COVID-19, por dispuserem do seu tempo e concedido a sua história clínica para o desenvolvimento científico deste trabalho.

À Condor Instruments® pelo seu apoio na fase de coleta de dados deste estudo, emprestando um dispositivo de actigrafia.

À Profª. Drª. Ana Claudia Rossi, pelos ensinamentos durante o programa de estagio docente os quais me permitiram desenvolver uma das minhas paixões, ensinar.

Ao Prof. Dr. Francesquini Junior, pela oportunidade de participar na sua equipe desenvolvendo os projetos com os alunos PIBICs, tempo no qual desenvolvi e adquiri habilidades que serão de grande ajuda na carreira profissional.

Ao Sr. Valdir Francisco de Brito e à Srª. Leni Aparecida Garcia de Brito, pelo apoio durante toda minha estadia em Piracicaba.

Ao Sr. Adelino Agusto Duarte e à Srª. Magali Célia Vieira da Costa Duarte, pelos momentos de alegria nos domingos à tarde, os senhores foram uma benção na minha vida.

Aos meus amigos Manuel Jara, Cinthia Vargas, Gabriel Nima, Juliana Pavan, Juana Salas, Cinthya Arias, Ándres Cáceres, María Choque, Carolina Garfias, Florence Cuadra e Paola Aristizabal, pelos momentos de alegria que passamos juntos, vocês fizeram minha estadia

mais leve e me apoiaram quando necessitei, sempre estarão na mente e no coração, mesmo que o tempo passe e a distancia seja grande.

Aos membros da Igreja Batista Jardim Monte Cristo e da Igreja Metodista Betânia, por me acolher com amor, pelas orações e pelos momentos de comunhão e alegria nos anos que frequentei o templo.

À minha mãe, María Zulema, e ao meu irmão, Sigfredo Antonio, por me acompanharem nesta jornada e pelo carinho, embora distantes, o amor de vocês sempre esteve comigo.

Muito Obrigada!

RESUMO

Os objetivos foram investigar, por meio da actigrafia do punho, o padrão atividade-repouso, estimar os parâmetros do sono noturno e quantificar a exposição à luz em indivíduos jovens. Foram realizados dois estudos, o primeiro durante o isolamento social devido à pandemia pela doença coronavirus 2019 e o segundo referente a uma série de casos de indivíduos com sobrepeso e obesidade. Em ambos estudos, os participantes usaram o actígrafo no punho não dominante por sete dias. A derivação dos parâmetros do sono noturno foi inferida a partir dos dados brutos do modo integral proporcional, agrupadas em estatísticas de sono, vigília, atividade e fragmentação. Variáveis circadianas também foram obtidas por actigrafia. No estudo 1, intitulado *Sleep/wake cycle and circadian rhythm pattern in young adults during social isolation using actigraphy*, avaliou-se o sono de 19 indivíduos com idade entre 19 e 33 anos. A análise de cluster hierárquica determinou a formação de dois clusters, o primeiro composto por indivíduos com tempo de sono normal (n = 13) e o segundo por indivíduos com tempo de sono curto (n = 6). Foram aplicados os testes de Mann-Whitney, t de *Student* independente, regressão linear *stepwise* e teste de Kendall, considerando $\alpha = 0,05$. Os indivíduos com tempo normal de sono apresentaram estatística de sono com valores normais. Os indivíduos com tempo de sono curto apresentaram valores menores nas estatísticas de sono e valores maiores nas estatísticas de vigília e fragmentação ($p < 0,001$). Não houve diferença entre os clusters na estatística de atividade. A hora de dormir e atividade noturna contribuíram para a variância no início e na quantidade da atividade diurna, respectivamente ($p < 0,001$). O ponto médio durante o tempo na cama foi o preditor mais significativo para o início do menor período de atividade à noite. Os indivíduos com tempo normal de sono apresentaram exposição significativamente maior à luz do dia ($p < 0,001$). No segundo estudo, intitulado *Sleep-wake patterns and circadian rhythm in adults with overweigh/obesity: a case series*, avaliou-se quatro adultos com idade entre 25 e 34 anos, que apresentaram sobrepeso (n = 2) e obesidade (n = 2). Medidas antropométricas e composição corporal foram obtidas pela avaliação clínica. Foram aplicados questionários para avaliação subjetiva dos parâmetros do sono e do bruxismo do sono e os Inventários de Ansiedade e Depressão de Beck, para avaliação dos sintomas de ansiedade e depressão, respectivamente. Nesta série de casos, os participantes apresentaram valores elevados do tempo acordado após início do sono, do número de despertares, da atividade durante o tempo na cama, além do tempo reduzido de sono. Os participantes que apresentavam sobrepeso e obesidade mostraram nível mínimo e moderado de ansiedade e depressão respectivamente. Três participantes relataram bruxismo do sono. Concluindo, a actigrafia inferiu que durante o isolamento social os indivíduos apresentaram ritmo circadiano irregular,

parâmetros de sono inconsistentes e diminuição da exposição à luz do dia durante a manhã. A série de casos mostrou que a variabilidade do ritmo atividade-repouso, gerou despertares e movimento durante o sono, comprometendo a qualidade do repouso.

Palavras chaves: Actigrafia; Ritmo circadiano; Luz solar; Isolamento social; Obesidade.

ABSTRACT

The objectives were to investigate, through wrist actigraphy, the activity-rest pattern, to estimate the parameters of nocturnal sleep and to quantify light exposure in young individuals. Two studies were carried out, the first during social isolation due to the coronavirus 2019 pandemic and the second referring to a series of cases of overweight and obese individuals. In both studies, participants wore the actigraph on their non-dominant wrist for seven days. The derivation of nocturnal sleep parameters was inferred from the raw data of the proportional integral mode, grouped into sleep, wakefulness, activity and fragmentation statistics. Circadian variables were also obtained by actigraphy. In study 1, entitled Sleep/wake cycle and circadian rhythm pattern in young adults during social isolation using actigraphy, the sleep of 19 individuals aged between 19 and 33 years-old was evaluated. Hierarchical cluster analysis determined the formation of two clusters, the first composed of individuals with normal sleep time (n = 13) and the second by individuals with short sleep time (n = 6). Mann-Whitney and independent Student t tests, stepwise linear regression and Kendall test were applied, considering $\alpha = 0.05$. Individuals with normal sleep time presented sleep statistics with normal values. Individuals with short sleep time had lower values for sleep statistics and higher values for wakefulness and fragmentation statistics ($p < 0.001$). There was no difference between clusters in activity statistics. Bedtime and nocturnal activity contributed to the variance in the onset and amount of daytime activity, respectively ($p<0.001$). The midpoint during time in bed was the most significant predictor for the beginning of the shortest period of activity at night. Individuals with normal sleep time had significantly greater exposure to daylight ($p<0.001$). In the second study, entitled Sleep-wake patterns and circadian rhythm in adults with overweigh/obesity: the case series, four adults aged between 25 and 34 years, who were overweight (n = 2) and obese (n = 2) were evaluated. Anthropometric measurements and body composition were obtained by clinical evaluation. Questionnaires were applied to subjectively assess sleep parameters, sleep bruxism, and the Beck Anxiety and Depression Inventories were used to assess symptoms of anxiety and depression, respectively. In this series of cases, the participants showed high values for time awake after sleep onset, number of awakenings, activity during time in bed, in addition to reduced sleep time. Participants who were overweight and obese showed minimal and moderate levels of anxiety and depression, respectively. Three participants reported sleep bruxism. In conclusion, the actigraphy inferred that during social isolation, individuals exhibited irregular circadian rhythms, inconsistent sleep parameters, and decreased exposure to daylight in the morning. The series of cases showed that the variability

of the activity-rest rhythm generated awakenings and movement during sleep, compromising the quality of rest.

Keywords: Actigraphy; Circadian rhythm; Daylight; Social isolation; Obesity.

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LISTA DE ABREVIATURAS E SIGLAS

L5	–	Activity counts for the least active 5 h period
M10	–	Activity counts for the most active 10 h period
ACTX	–	Activity index
ASD	–	Activity standard deviation during time in bed
BAI	–	Beck Anxiety Inventory
BDI	–	Beck Depression Inventory
BMI	–	Body Mass Index
BWR	–	Brief wake ratio
Covid-19	–	Coronavirus disease
CFI	–	Circadian function index
CNPq	–	Conselho Nacional de Desenvolvimento Científico e Tecnológico
ICC	–	Intraclass correlation coefficient
IS	–	Inter-daily stability
IV	–	Intra-daily variability
LPS	–	Latency to persistent sleep
LSEP	–	Long sleep episodes
LWEP	–	Long wake episodes
LGSEP	–	Longest sleep episode
LGWEP	–	Longest wake episode
AMEAN	–	Mean activity during time in bed
MSEP	–	Mean sleep episode
MWEP	–	Mean wake episode
PSLP	–	Percent sleep

PIM	–	Proportional Integration Mode
RA	–	Relative amplitude
SE	–	Sleep efficiency
SEP	–	Sleep episodes
SFX	–	Sleep fragmentation index
SMIN	–	Sleep minutes during time in bed
SOL	–	Sleep onset latency
SLP	–	Sleep period
NA	–	The number of awakenings during time in bed
TAT	–	Time Above Threshold
TIB	–	Time in bed
TSMIN	–	True sleep minutes
UNIFESP	–	Universidade Federal de São Paulo
WASO	–	Wake after sleep onset
WMIN	–	Wake minutes during time in bed
ZCM	–	Zero Crossing Mode

SUMÁRIO

1 INTRODUÇÃO

O sono é uma função corporal que tem sido motivo de inúmeras pesquisas, mas que ainda permanece pouco compreendida (Siegel, 2005). Com a finalidade de estudar os eventos que acontecem durante o sono noturno, técnicas têm sido desenvolvidas. O padrão ouro é a polissonografia, a qual fornece informações detalhadas sobre a arquitetura, duração e qualidade do sono. No entanto, a operacionalidade e o alto custo do exame polissonográfico restringe a coleta de dados, por ser realizado em ambiente laboratorial, o que pode dificultar a coleta de várias noites para a obtenção de dados fidedignos do padrão de sono (Van de Water, Holmes, & Hurley, 2011). Como alternativa a essas limitações surge a actigrafia, uma técnica que permite inferir os ciclos de sono/vigília com base na frequência, duração e intensidade do movimento (Ancoli et al., 2003); é realizada por meio de um actígrafo, dispositivo este utilizado preferencialmente no pulso não dominante, que permite gravar os ciclos vários dias consecutivos no ambiente familiar e com menos transtorno para os indivíduos. Além disso, o monitoramento dos ciclos de atividade-repouso possibilita avaliar indiretamente o padrão do ritmo circadiano e o seu acoplamento com o ciclo claro-escuro. Dessa forma, a actigrafia é considerada uma técnica que facilita a obtenção de parâmetros do sono noturno e de variáveis circadianas de forma simples, não invasiva e de baixo custo (Ortiz-Tudela et al., 2010; Fekedulegn et al., 2020).

Os resultados do monitoramento da atividade-repouso pela actigrafia têm sido validados (Ancoli-israel et al., 2003, Kanady et al., 2011; Guillodo et al., 2020) mostrando a capacidade do actígrafo em distinguir o sono da vigília com aceitável precisão (82,7 a 86,2%), sensibilidade (92,5 a 96,5%) e especificidade (40,1% a 66,7%), quando comparada com a polissonografia, apoiando o uso da técnica (Kanady et al., 2011). No entanto, os dados da actigrafia podem estar sujeitos a mascaramentos e artefatos, como a superestimativa do tempo do sono e a subestimativa do tempo de vigília. Sendo assim, sugere-se coleta dos dados por 7, 14, 21 dias ou mais, o que possibilita pontuação mais precisa do sono (Fekedulegn et al., 2020). Eventos importantes, como o momento de deitar-se para o sono noturno e de levantar-se pela manhã, podem ser registrados pelo próprio indivíduo ao acionar o botão marcador de eventos do actígrafo, auxiliando na precisão do registro dos dados (Fekedulegn et al., 2020). Pode haver desconforto no uso contínuo do actígrafo durante os dias de coleta, sendo necessários cuidados de higiene com a pele e com a pulseira do actígrafo para não haver irritação (Baek et al., 2020). O diário do sono, medida subjetiva por autorrelato, é um recurso útil que oferece informações importantes sobre o comportamento do indivíduo durante o período de amostragem (Baek et al., 2020). Indica-se preenchê-lo simultaneamente com os registros da actigrafia, pois eventos

não previstos durante as coletas, como impossibilidade de remoção do actígrafo quando necessário, cochilos, permanecer acordado na cama sem se movimentar por longos períodos, viagens de longa duração, podem ser controlados ao analisar os dados da actigrafia (Baek et al., 2020). Todos esses cuidados metodológicos contribuem para maior confiabilidade da técnica.

Estudos apoiam teorias que sugerem que o sono pode ser influenciado por inúmeros fatores, a saber: a exposição crônica à luz azul de baixa intensidade diretamente antes de se deitar (Tosini et al., 2016; Touitou et al., 2017), mudanças na temperatura do ambiente para dormir (Harding et al., 2019), exposição reduzida à luz do sol (Phillips et al., 2017), que podem dificultar o início e a manutenção do sono, refletindo em sérias implicações na fase circadiana. Assim, é necessário monitorar esses fatores, a fim de compreender os possíveis efeitos e orientar medidas de higiene do sono.

Ainda a composição corporal do indivíduo, como o sobrepeso e a obesidade, têm sido relatados como fatores influenciadores da qualidade no sono (Tan et al., 2015), mais significativamente a obesidade central relacionada à curta duração do sono, insônia e ronco habitual (Koo et al., 2016). A obesidade atingiu proporções epidêmicas no mundo. No Brasil a prevalência passou de 11,8% em 2006 para 20,3% em 2019. Ao considerar o excesso de peso, metade dos brasileiros encontra-se nesta situação (55,4%) (Vigitel 2019). O sobrepeso e a obesidade são considerados problemas de saúde pública que afetam praticamente todas as idades e grupos socioeconômicos. Portanto, torna-se importante observar o comportamento dos indivíduos durante o sono, a fim de orintar hábitos que melhorem o estilo de vida na tentativa de diminuir os problemas que possam influenciar negativamente a qualidade de vida, uma vez que o sono tem sido considerado um marcador de bem-estar e saúde (Salehinejad et al., 2020).

De igual forma, as alterações do estado psicológico do indivíduo, manifestadas em depressão e ansiedade, têm sido relatadas (Chellapa et al., 2007) como fatores que podem refletir na má percepção do sono (Varma et al., 2021). Apesar da necessidade de determinar a causalidade, é importante conhecer as experiências sentidas nas pessoas com essas caraterísticas para poder enriquecer a compreensão do sono e da saúde mental, ajudando a melhorar as estratégias de intervenção, uma vez que os fatores envolvidos são de natureza biopsicossocial (Barragán et al., 2021).

Além disso, em 2020, com a pandemia pela doença coronavírus de 2019, surge um novo fator influenciador do sono, o isolamento social/confinamento domiciliar obrigatório (Blume et al., 2020; Korman et al., 2020), implementado como medida de saúde pública para mitigar a infecção da população. Tal medida pode alterar a rotina dos indivíduos tirando-os de suas rotinas (Wilder-Smith et al., 2020) com efeitos adversos que, por sua vez, podem impactar

a vida cotidiana dos indivíduos. Nessa circunstância, foi observado maior frequência de distúrbios do sono em regiões com taxas de infecções mais altas (Blume et al., 2020; Korman et al., 2020). Dessa forma, se faz necessário investigar como essa nova situação social traz novos comportamentos ou hábitos que podem refletir em mudanças no sono noturno e no ciclo circadiano dos indivíduos.

Perante esse contexto, torna-se importante e necessário observar o comportamento de todos esses fatores e a possível influência no sono do indivíduo. Portanto, este estudo teve como objetivos (1) investigar, por meio da actigrafia do punho, o padrão atividade-repouso ao longo de um período de 24 horas, para determinar os parâmetros objetivos do sono noturno e quantificar a exposição à luz do dia e luz azul em indivíduos saudáveis que estavam em isolamento social durante a primeira onda da pandemia pela doença coronavírus de 2019, e (2) descrever, em uma série de casos, os dados objetivos do padrão do sono-vigília por actigrafia e os dados subjetivos do sono por autorrelato e os possíveis fatores envolvidos em adultos com sobrepeso e obesidade.

2 ARTIGOS

2.1 Sleep-wake circadian rhythm pattern in young adults during social isolation by actigraphy

Dora Zulema Romero Díaz, D.D.S., M.Sc.[1], Maria Beatriz Duarte Gavião, Ph.D.*[2]

[1]Department of Biosciences, Anatomy division, Piracicaba Dental School, University of Campinas, Piracicaba, Brazil. ORCID: 0000-0002-5594-2586

[2] PhD, Department of Health Sciences and Pediatric Dentistry, Piracicaba Dental School, University of Campinas, Piracicaba, Brazil. ORCID: 0000-0002-7546-5262

*Correspondence to:

Prof. Maria Beatriz Duarte Gavião

Faculdade de Odontologia de Piracicaba, Universidade Estadual de Campinas.

Address: Av. Limeira 901, Bairro Areião, CEP 13414-903, Piracicaba, SP, Brasil.

Telephone +55 19 2106-5200

E-mail: mbgaviao@unicamp.br

Artigo submetido ao periódico: Sleep Science.

ABSTRACT

Study Objectives: This study investigated, through wrist actigraphy, the activity–rest pattern, estimate nocturnal sleep parameters, and quantify the exposure of light (daylight and blue light) during social isolation due to coronavirus disease 2019. Methods: The participants (n = 19, aged 19 – 33 years-old) wore the actigraph in nondominant wrist for 7 days. Derivation of 25 nocturnal sleep parameters was inferred from proportional integration mode raw data including sleep, wake, activity, and fragmentation statistics. A hierarchical cluster analysis determined the participant's profiles. Mann–Whitney and independent Student t tests, linear stepwise regression and Kendall's test were applied. The significant level was $\alpha = 0.05$. Results: Two clusters were formed, normal sleepers (n = 13) and short sleepers (n = 6). The participants of both clusters went to sleep after midnight, spent approximately 1 h of being awake during time in bed, their latency to persistent sleep was normal, though true sleep minutes was less than 7 h, showed a normal sleep efficiency. Daytime activity was moderate, and a circadian rhythm was irregular. The regressions showed that bedtime and nocturnal activity contributed to the variance of daytime activity and the beginning of it ($p< 0.001$). The midpoint during the time in bed was the most significant predictor for the start of less period activity at night ($p< 0.001$). Conclusions: Actigraphy inferred that during social isolation the individuals presented, despite normal sleep latency and efficiency, inconsistent sleep parameters and irregular circadian rhythm. Moreover, decreased exposure to daylight during the morning was observed.

Keywords: Actigraphy; Circadian rhythm; Sleep; Chronotype; Blue light; Daylight; Social isolation

INTRODUCTION

The pandemic due to Coronavirus disease (Covid-19) is today, in Brazil, a phenomenon of great magnitude and extension, which has caused such great losses in terms of human lives, economy and quality of life of individuals.

The 17th of March 2020, the São Paulo Government implemented measures to prevent risks of direct transmission of COVID-19. The Brazilian population has been subjected to a substantial period of social isolation with a restriction of movements, cancellation of all events promoted by the Governments that generate crowds of people, such as events sporting, artistic, cultural, political, scientific, and commercial. Many people have been in home confinement situations; non-essential services adopted a non-face-to-face regime (e.g., education in every level), and were authorized to operate the services of urgent needs of the community (health, food, and security). These changes in lifestyle have negative consequences for well-being, which impact sleep quality that can be related to changes in the sleep/wake cycle and circadian rhythms (Brook et al., 2020; Rajkumar, 2020). Circadian rhythms are 24 h daily cycles that can be entrained or phase-shifted not only by our internal clock but also by external factors such as daily schedules, social rhythms, and daylight exposition (Grandin and Abramson, 2006). This is important because activity and behavior during wakefulness can influence the duration and quality of sleep and, conversely, the duration and quality of sleep can affect daytime function (Li et al., 2020).

Previous studies have been presented using online questionnaires, as the lifestyle changes during social isolation, (Casagrande et al., 2020; Di Renzo et al., 2020) not allowing the clinical evaluation of research participants. Nevertheless, studies are required to show objective data on the rhythmicity of the circadian cycle and sleep in healthy individuals during that time. In this sense, this study hypothesizes that social isolation can alter the sleep–wake pattern, generating irregular and less robust activity–rest patterns. Furthermore, during this period the daily exposure daylight may have decreased because people stayed at home, which may have led to increased exposure to blue light. Thus, this study aimed to investigate, through wrist actigraphy, the activity–rest pattern, estimate nocturnal sleep parameters, and quantify the exposure of light (daylight and blue light) in healthy individuals who were in social isolation during the COVID-19 pandemic.

MATERIALS AND METHODS

This study was approved by the Ethics Committee of the Piracicaba Dental School, University of Campinas (ethical approval CAAE 95764718.6.0000.5418). The participants provided their written informed consent to participate.

Participants

Adults aged 18 to 35 years were invited to participate through WhatsApp. The inclusion criteria were body mass index (BMI) of 18.5–24.9 kg/m^2, to sleep alone (to ensure that the activity records during bedtime were owned by the participant, avoiding false positives generated by the movements of a partner), to be in social isolation and living in Piracicaba city, São Paulo state, Brazil. Individuals who were self-reporting sleep disorders and respiratory diseases by a standardized questionnaire, for example, obstructive sleep apnea and asthma, and neurological disorders were excluded. Demographic data, such as age (years), sex, marital status, and education were obtained through questionnaires. To calculate the BMI, self-reported height and weight were obtained from which BMI was calculated as weight in kilograms (kg) divided by height in square meters (m^2).

Study design

In the framework of chronobiological study designs, longitudinal sampling corresponds to obtaining data on the same individual as a function of time (Cornelissen. 2014). In this study, 24 h periods were recorded for seven consecutive days; however, this study was cross-sectional and descriptive-observational.

The data were collected from March 16th to June 8th, 2020. The degree of social isolation began from March 17th in the State of São Paulo, Brazil, when the acquisition of actigraphy data began. Schools were closed, the home-office was encouraged and activities with many people were restricted. However, the measures adopted of social isolation were not so strict, which gave people relative freedom, i.e., they could decide to stay at home and go out only if necessary or go out to walk/run. Initially, the participants should receive the actigraph in the lab of the Dental School, but due to the closure of educational institutions, the device has just been delivered and removed at the participants' homes.

The actigraph used was the ActTrust® (model AT0503 Condor Instruments, Brazil) applied to evaluate the circadian rhythms and sleep parameters of the selected sample. This device was previously validated by Rodrigues and Eckeli (2018), showing excellent sensitivity (95.69%), good accuracy (80.24%), predictive value for the sleep of 81.52% and predictive

value for wakefulness of 68.93% in individuals with sleep-disordered breathing. All participants were instructed to use the device on the wrist of the non-dominant hand for 7 days (Fig. 1), starting and ending on Monday at midday (including weekends) and fill in the sleep diary simultaneously; and to maintain their normal lifestyle during the week of data collection.

Standardized procedures were performed on the device configuration (ActStudio® 1.013, Condor Instruments, Brazil) before handing it over to the participant, as follows:

- The device was programmed to record activity counts in the proportional integral mode (PIM), every 30 s, and added to generate a 1 min epoch; similarly, light was recorded every 30 s.
- The calculations of day length were based on the times of sunrise and sunset (corresponding with the start of the light and dark phase of the 24 h period, respectively) computed based on the local latitude, longitude, date, and geopolitical time zone.
- The information stored in the actigraph was transferred via a USB adapter (ActDock®, Condor Instruments, Brazil) to a computer using the software provided by the manufacturer (ActStudio 1.013, Condor Instruments, Brazil). All configurated were made on the same computer.
- The examiner (DZRD) was previously trained to handle actigraphy related to data acquisition and analysis. Five participants, aged 24.6 ± 4.16 years, properly instructed, used the device for four consecutive days. After 12 days, the data were acquired again in the same way allowing the determination of intra-examiner reliability using the intraclass correlation coefficient, which was 97-99, showing "good" reliability, according to Koo and Li (2016). These participants were not included in the final study.

Measures

The sleep parameters were calculated based on the Cole–Kripke algorithm (Cole et al., 1992) and are included in four statistics, namely, sleep, wake, activity, and fragmentation, providing a detailed analysis method to infer these parameters objectively, allowing a description of events during the periods (Fekedulegn et al., 2020). The derivation of each sleep parameter uses only the sleep scores. The complete definition of each parameter can be seen in the supplementary materials, as well as the normal values and ranges, so the studied variables were listed below:

A) Sleep statistics

i. Time in bed (TIB)
ii. Sleep period (SLP)
iii. Sleep minutes during TIB (SMIN)
iv. True sleep minutes (TSMIN)
v. Sleep onset latency (SOL)
vi. Latency to persistent sleep (LPS)
vii. Percent sleep (PSLP)
viii. Sleep efficiency (SE)
ix. Sleep episodes (SEP)
x. Mean sleep episode (MSEP)
xi. Long sleep episodes (LSEP)
xii. Longest sleep episode (LGSEP)

B) Wake statistics

i. Wake minutes during TIB (WMIN)
ii. Wake after sleep onset (WASO)
iii. Number of awakenings during TIB (NA)
iv. Mean wake episode (MWEP)
v. Long wake episodes (LWEP)
vi. Longest wake episode (LGWEP)

C) Activity statistics

i. Mean activity during TIB (AMEAN)
ii. Activity standard deviation during TIB (ASD)
iii. Activity index (ACTX)

D) Fragmentation statistics

i. Sleep fragmentation index (SFX)
ii. Brief wake ratio (BWR)

Circadian rhythm non-parametric variables

i. Activity counts for the most active 10 h period (M10) and Onset-M10
ii. Activity counts for the least active 5 h period (L5) and Onset-L5
iii. Inter-daily stability (IS)
iv. Intra-daily variability (IV)
v. Relative amplitude (RA)
vi. Circadian function index (CFI)

Complementary measures

i. Chronotype by SLP and TIB
ii. Exposure to daylight and blue light

Statistical analyses

For data statistical analyses, the Statistical Package for Social Sciences, version 21.0 (SPSS® Statistics Inc., Chicago, USA) was used. Descriptive statistics were performed for all variables and sample characterization expressed as mean, standard deviation, median, and quartile amplitude.

To study the participants' profiles, a cluster analysis was performed, which aims to organize a set of cases into homogeneous groups, in such a way that the individuals belonging to a group are similar to each other and different from the rest (Johnson and Wichern, 2007). The hierarchical cluster analysis was performed using the farthest neighbor method for calculating distances between clusters and obtain the dendrogram. The sleep parameters that contributed to the formation of clusters can be seen in Supplementary Table 1 (Johnson and Wichern, 2007). After analyzing the plot dendrogram, it was decided to inform *a priori* the number of clusters to be performed for identifying clusters of participants with similar sleep parameters. Thus, two clusters were chosen (clusters 1 and 2). The differences between clusters were assessed by the Mann–Whitney test for clustering validation.

Data distribution was assessed using the Shapiro–Wilk test and the quartile–quartile plot graphs, and the homogeneity Levene test. The sleep parameters and circadian rhythms (M10, L5, and RA) show data not normally distributed, whereas the circadian rhythms (IS, IV, and CFI) were normally distributed. To compare the differences between clusters and differences between weekdays and weekends, the Mann–Whitney test was applied. For the variables IV, IS, and CFI the differences between clusters, the independent Student t-test was applied.

Exploratory analyses were conducted to investigate potential relationships between circadian rhythm variables (M10 and L5) and sleep parameters predictors (i.e., Onset SLP and ASD, etc.). The relationships were tested using the linear stepwise regression model. The blue light and sunlight intensity were correlated with Onset SLP and Onset L5, using Kendall's test.

The level of significance was defined as alpha equal to 0.05.

RESULTS

Sample

The characteristics of the study population are shown in Table 1. Initially, 21 individuals were assessed for eligibility. However, two were excluded, because one did not sign the informed consent and the other returned to work during the week of participation. Finally, nineteen (male n = 9; female n = 10) adults were included in the final convenience sample. The participants lived in the same geographic area (urban region of residence).

Sleep patterns

Table 2 shows the values of sleep patterns. The cluster analysis generated two groups varying significantly according to the sleep parameters. Using the mean and median of the TIB and SLP, the clusters were being nominated as “normal sleepers” (cluster 1, n = 13, SLP > 7h) and “short sleepers” (cluster 2, n = 6, SLP < 5.5h). Despite the late sleep times, normal sleepers were characterized by better sleep parameters, such as a normal sleep duration with almost two more hours than short sleepers. The participants of both clusters went to sleep after midnight: normal sleepers at 01h33 ± 10.33 and short sleepers at 03h04 ± 7.03. Other parameters of sleep statistics, such as TSMIN, PSLP, SE, MSEP, and LGSEP were significantly higher also for normal sleepers than for short sleepers, which indicates better sleep. However, the parameter TSMIN for normal sleepers showed values slightly below normal, and for short sleepers, the values were even lower. The SOL and SE values were similar for both clusters but were within the normal range.

LWEP and SFX all parameters were significantly lower for normal sleepers. Nevertheless, the similar values of NA between clusters were above the normal range.

Although the other parameters were similar for both clusters, in the pre-selection, they were considered different as much as possible.

Differences between weekdays and weekend was only for SLP, since short sleepers had lower values, suggesting that they slept one hour and thirty minutes less during the weekend when compared with the normal sleepers ($p < 0.005$) (Supplementary Table S2 for differences between weekdays and weekends data).

Circadian rhythm variables derived from non-parametric approaches

The circadian rhythms variables (Table 3) derived from non-parametric approaches showed that the two clusters presented moderate patterns of activity for M10 indicating active

waking periods. Although Onset M10 started late in both clusters, normal sleepers started an hour and a half before than did short sleepers. L5 values were low, but significantly lower for normal sleepers than for short sleepers, indicating that the two clusters had less restful sleep (nocturnal activity). This finding is in accordance with the activity statistics in Table 2. In addition, L5 started very late for both clusters, accordingly to Onset-L5 time, but significantly earlier for normal sleepers. IV values suggested the occurrence of nocturnal awakenings in both clusters, with no significant differences; this finding is in accordance with the wake statistics in Table 2. The repetitiveness of the rhythm across consecutive days showed low synchronization, as IS mean and median values were below 0.5. There was a subtle but significant difference in RA between clusters, suggesting that the short sleepers showed more irregular circadian rhythm when compared with normal sleepers. The CFI in both clusters showed low values, indicating low circadian rhythmicity.

Figure 2 (A) shows the actogram data from a participant in the normal sleeper cluster and (B) from a participant in the short sleeper cluster, demonstrating minute-by-minute wrist movement values (activity counts) over 7 days. A double-plotted graph enables a clearer observation of the data.

Table 4 shows the significant models of stepwise multivariate regression considering the circadian rhythm (M10 and L5) as dependent variables and the respective sleep parameters as the predictors. M10 could be explained by 21% of the sleep parameters. ASD was also a significant predictor for M10. AMEAN per night influenced significantly L5, explaining 21% of the variability. Sleep parameters could predict the Onset L5 very well, explained 81% of the variability. The parameters were midpoint TIB, LGSEP, and TSMIN, with the latter two negatively influencing the models.

The other sleep parameters did not meet the presuppositions for linear regression.

Exposure to light during the light–dark cycle (i.e., 24 h period)

Figure 3 shows the mean light level. Figure 3A shows the exposure to daylight from 06h00 to 18h00, whereas Figure 3B shows the trajectory of the intensity of blue light from 18h00 in the afternoon to 05h00 in the morning. Both light levels were of the light–dark cycle. The normal sleepers (gray line) showed significantly higher exposure to daylight ($U = 37.00$; $p = 0.015$) than short sleepers (black line). However, there were no significant differences ($U = 61.00$; $p = 0.525$) in evening blue light exposure between clusters. The Supplementary Table S3 shows all values of daylight and blue light exposition, respectively. There was no significant

correlation between daylight and blue light with onset L5 or onset SLP (all rs < 0.36, p > 0.12) (Supplementary Table S4).

DISCUSSION

As the COVID-19 pandemic changed lifestyle during the first wave worldwide, mainly in terms of social isolation, this study aimed to assess sleep parameters in healthy individuals during this period and compare them with parameters established in the literature.

Bedtime can be considered delayed in the present study, probably due to isolation during the COVID-19 pandemic. This is an important observation, since later sleep timing has been associated with poor health results (Wong et al., 2015; Dong et al., 2019) and it can be altered by social isolation, as found in previous studies in which participants showed significantly delayed in time to go to bed during quarantine compared to pre-quarantine time (Salehinejad et al., 2020; Wright et al., 2020). The SLP in the short sleepers was much less than the recommended time of at least 7 h stated by the American Academy of Sleep Medicine and the Sleep Research Society, as well as the TSMIN, despite TIB has been about 7 h in this cluster. On the other hand, normal sleepers had SLP more than 7 h, but TSMIN was below 7 h on average. The low values for TSMIN can be related to awakenings episodes, as observed in pre-pandemic period by Cellini et al. (2020a) using actigraphy (Actiwatch-64). New sleep behaviors can be assumed during social isolation due to changes in daytime and night-time activities and routines can influence the parameters mentioned above (Liu et al., 2020; Altena et al., 2020). An interesting observation is the similarity between median values of Onset SLP (calculated) and the values of Onset L5 (the device's algorithm) mainly in the short sleepers. This finding shows the need for further studies that implement a methodological analysis for the derivation of the sleep parameters presented in this study to test whether the Onset SLP and the Onset L5 match.

Get up was nearly 9 a.m., without difference between weekdays and weekend. Recent studies have found that during social isolation, the sleep-wake time difference between weekdays and weekend days decreased (Wright et al., 2020; Korman et al., 2020) due to a delay in mid-sleep on workdays (Blume et al., 2020). One possibility is that social isolation increased flexibility regarding social schedules, determining the postponed time of awakening on workdays (Korman et al., 2020).

The SOL showed normal values (<20 min) in both clusters, despite the late bedtime, and was similar with other studies before Covid-19 pandemic (Vitale et al., 2015; Umemura et al., 2018; Saxvig et al., 2019; Cellini et al., 2020a). Conversely, Korman et al. (2020) observed a delay in sleep onset during social isolation that did not affect the sleep duration, due to the postponed wake-up time. The respective differences can be attributed to different measurements, since the study of Korman et al. (2020) used questionnaires in a large sample, whereas the others used actigraphy.

Moreover, the sleep parameters, WASO and SE, presented also normal values, suggesting that, although participants slept late and presented light activity during TIB, sleep quality was adequate, that is, greater than 90% in both clusters. These findings agree with previous studies using other devices (Vitale et al., 2015; Saxvig et al., 2019; Rupp et al., 2011; Kuo et al., 2017) but are in contrast with Cellini et al. (2020b) and Haghayegh et al. (2020), who showed that participants spent adequate TIB, but the sleep quality was not good enough, mainly because of a high amount of WASO, differing from the participants in the present study. Some studies during social isolation due to Covid19 pandemic agreed with Cellini et al. (2020b) showing a decrease in sleep quality in this time (Blume et al., 2020; Salehinejad et al., 2020). On the other hand, many people experienced increased flexibility regarding social schedules, leading to improve individual sleep–wake timing and overall, more sleep (Wright et al., 2020; Blume et al., 2020), that can be occurred in part with the participants of the present study.

The chronotype was estimated by midpoint of the TIB and SLP, as done also by Wright et al. (2020); circadian phase or questionnaire to estimate chronotype were not considered. There was significantly difference between clusters, with a later chronotype for the short sleepers, although no differences were found between clusters for sleep-wake-up time, considering TIB and SLP. This was an unexpected result, as late chronotypes prefer to wake up later in the morning and sleep later at night (Fekedulegn et al., 2020), but the condition of social isolation during the pandemic could be an influencing factor. Moreover, variations in chronotype can be associated with variations in the timing of numerous physiological and behavioral variables (Wright et al., 2020; Refinetti et al., 2019).

The activity pattern for M10 in this study did not differ between clusters, suggesting that the participants perform a moderate activity in the wake period during daytime, as seen also by Forner-Cordero et al. (2018). According to Pépin et al. (2020), the activity pattern did not appear to have a significant clinical impact on people's activity compared to the pre-pandemic period. M10 was in line with L5 values, indicating that participants presented slight

movement intensity during the time of less activity that usually occurs during the sleep period (Neikrug et al., 2020), agreeing with previous studies (Umemura et al., 2018; Forner-Cordero et al., 2018). Differences in circadian rhythm between clusters can be explained because during the social isolation the first one had a little bit to exposure to light during the early hours of the morning than the second one, which can lead to the delay of the biological clock, since sunlight has been considered as an important zeitgeberts (Phillips et al., 2017; Tsanas et al., 2020).

The stepwise regression models showed that both sleep parameters, M10 and L5, explained a significant amount of the variance in the level of day/night activity. Of the various factors that may influence M10, ASD contributed significantly to the variation of daytime activity, demonstrating that activity during the sleep period may have had the effect of decreasing the amount of daytime activity. This is an interesting result since activity at night can stabilize day-to-day habits, thus creating a more regular circadian rhythm (Atkinson et al., 2007). However, during the COVID-19 pandemic, the participants were kept in their homes, probably reducing the physical activity.

A relevant finding of the study was that the bedtime was a significant and negative contributor to the beginning of daytime activity because late bedtime overlaps sleep in the middle of the morning, consequently it will lead to a few hours of daytime activity. The lack of activity significantly increases the fragmentation of the activity–rest rhythm (Atkinson et al., 2007), which was observed in the present sample. WASO was other significant contributor, suggesting that fragmented nights by nocturnal activity can also contribute to Onset M10 delay. Moreover, AMEAN significantly influenced L5 due to nighttime activity during the least active period of the light–dark cycle. The preference time to sleep and wake up (Midpoint TIB) was the most significant predictor for the variation of the Onset-L5, because the participants of this study preferred to go to sleep late and wake up later. This sleep behavior produces a delay at the beginning of M10 during the light–dark cycle, and consequently, it makes L5 start later.

In normal sleepers, the daylight intensity increases at 09h00 exceeding the 200-lux threshold, which can indicate exposure to daylight at that time. However, in the short sleepers, the exposure to daylight remains low, suggesting that they have been indoor for a longer time. According to Korman et al. (2020), social restrictions lead to robust shifts in daily behavior and in exposure to daylight that can explain the present findings. Moreover, participants could be exposed to less daylight during social isolation, due to the characteristics of the house, such as small windows and no outside area (Altena et al., 2020). When analyzing the actograms, a degree of variability was evidenced during the 7 days (Figure 2), but a tendency toward

regularity at bedtime for normal sleepers was observed, whereas for short sleepers the sleep periods were irregular. In addition, the activity cycle showed out of sync with the light–dark cycle. This is according to a previous study (Phillips et al., 2017) that reported that the short sleepers who frequently change their sleep timing and consequently their pattern of light–dark exposure showed misalignment between the circadian system and the sleep/wake cycle. In both clusters, the activity cycle is not synchronized to the light–dark cycle, in a 24 h period, because wake up happens in mid-morning ranging from 09h00 to 10h00. The interesting finding of this work is that during social isolation, the wide variation in sleep parameters was characterized as irregular and free-running, and sleep–wake rhythm out of sync.

The intensity of the blue light at 22h30 of the night was few, 1.7 lux (Vandewalle et al., 2007), which is possibly the result of the ambient light at home. The blue light intensity decreases at midnight, and both clusters showed low values at 03h00 of the night, indicating darkness during SLP. No significant correlation was observed between low evening blue light levels before Onset L5 or Onset SLP. One hypothesis to explain this fact is the light sensor was outside the emission ratio of the blue light source and that, sequentially, can explain the low levels of light registered. This finding contrasts with the related literature (Wahl et al., 2019; Janků et al., 2020) in which chronic exposure to low-intensity blue light directly before bedtime may have serious implications on the circadian phase, resulting in lower subjectively perceived sleep quality. In fact, the influence of blue light on sleep parameters has been a controversial issue, due to the different methodologies including self-reported or objective assessments. In this context, the findings of the present study are in line with others that evaluated objectively sleep parameters related to blue light exposure. In randomized controlled trials in individuals having insomnia, the use of blue light blocking, and behavioral therapy improved self-reported measures of sleep quality, but there was no improvement in total sleep time using actigraphy (Janků et al., 2020). Thus, it is possible to infer that blue light did not affect the sleep parameters measured objectively, such as the actigraphy, but other clinical trials must be addressed incorporating other measurements, such as melatonin and polysomnography (Bigalke et al., 2021) to allow a more precise diagnosis.

The findings should be interpreted considering the limitations of the study that include (i) the lack of PSG data to validate findings (the gold standard of sleep assessment). However, the adopted methodology provided a clear and detailed protocol for scoring sleep. Moreover, Rodrigues and Eckelli (2018) observed that the ActTrust® actigraph presented excellent sensitivity and good accuracy. Another limitation is that (ii) data acquisition was in a

small convenience sample of healthy adults of different ages, determining that the results cannot be extrapolated to other populations. Further, (iii) the fact that most studies use methodologies and devices different from the present study determine that the respective comparisons should be interpreted with caution. Moreover, (iv) no measures of daily sleepiness and nap were collected, as well as data prior to the period of social isolation; therefore, any strong assumptions about sleep disorders cannot be made. Finally, (v) the cross-sectional design of the study does not allow for the determination of a causal effect of circadian rhythm on sleep parameters.

In conclusion, actigraphy inferred that during social isolation the individuals presented, despite normal sleep latency and efficiency, inconsistent sleep parameters and irregular circadian rhythm. Moreover, decreased exposure to daylight during the morning was observed.

Acknowledgments

The authors are grateful to all study participants for their meticulous adherence to the research protocol during the COVID-19 pandemic.

The authors are grateful to CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico, Brazil) for the scholarship for the first author (process number 147405/2017-3).

Author contributions

DZRD and MBDG developed the study concept. DZRD wrote the study protocol, ethics application, recruitment of the participants, collected and analyzed the actigraphy data, entered self-report data (BMI), performed statistical analysis, contributed to the interpretation of the reported results and the production of figures, and wrote the first draft of the manuscript. All authors interpreted the data, critically reviewed, commented on the text, and gave final approval for submission of this manuscript for publication.

Conflicts of interest

The authors declare no potential conflict of interest concerning the authorship and/or publication of this article.

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Table 1 - Characteristics of the study population

Age (years)[a]	25.4 ± 4.3
Sex (N, %)	n = 19
Male	9 (47%)
Female	10 (53%)
BMI (kg/m^2)[a]	21.8 ± 3.07
Education (N, %)	
High school graduate	2 (11%)
College	8 (42%)
Postgraduate	9 (47%)
School type (N)	
Private	5 (26%)
Public	14 (74%)

[a]No difference in age between sexes

Table 2 – Comparison of the sleep parameters by clusters

Sleep parameters	Normal sleepers (n = 13)	Short sleepers (n = 6)	U (*p*)
A. Sleep statistics			
Bedtime (hh:mm)	02:40 (00:30 – 03:33)	02:45 (01:19 – 04:40)	1800.00 (0.823)
Get up time (hh:mm)	09:00 (08:05 – 10:30)	09:00 (08:14 – 10:39)	1733.00 (0.578)
TIB (h)	8.18 (7.31 – 8.50)	7.40 (6.42 – 8.29)	702.00 (<0.001)[a]
SLP (h)	7.19 (6.44 –7.48)	6.38 (5.24 – 7.36)	665.00 (<0.001)[a]
Onset SLP (hh:mm)	02:18 (01:51 – 03:52)	03:09 (02:54 – 04:48)	1613.00 (0.249)
Offset SLP (hh:mm)	08:45 (08:04 – 10:10)	08:55 (07:44 – 10:32)	1693.50 (0.452)
SMIN (h)	7.15 (6.42 – 7.51)	5.46 (5.21 – 7.23)	494.50 (<0.001)[a]
TSMIN (h)	6.52 (6.16 – 7.18)	5.07 (4.38 – 6.56)	498.00 (<0.001)[a]
SOL (min)	9.50 (5.75 – 16.25)	12.00 (5.50 – 18.50)	1665.00 (0.370)
LPS (min)	34.00 (27.00 – 56.25)	38.00 (29.50 – 62.50)	1645.00 (0.320)
PSLP (%)	83.04 (78.15 – 88.20)	78.28 (70.24 – 83.23)	1138.50 (<0.001)[a]
SE (%)	94.34 (89.72 – 96.97)	91.01 (87.75 – 94.23)	1241.00 (0.003)[a]
SEP (#)	9.50 (7.00 – 15.00)	11.00 (9.50 – 14.00)	1533.50 (0.121)
MSEP (min)	43.02 (28.80 – 65.26)	30.17 (19.87 – 39.35)	1059.00 (<0.001)[a]
LSEP (#)	8.00 (6.00 – 11.00)	9.00 (7.00 – 12.00)	1589.50 (0.203)
LGSEP (min)	124.00 (94.75 – 184.25)	89.00 (65.50 – 124.00)	1058.50 (<0.001)[a]
B. Wake statistics			
WMIN (min)	58.50 (36.00 – 75.00)	57.00 (40.00 – 89.00)	1755.50 (0.657)
WASO (min)	23.00 (12.75 – 45.25)	30.00 (18.50 – 39.00)	1566.50 (0.167)
NA (#)	7.00 (4.00 – 11.00)	8.00 (5.50 – 10.50)	1645.00 (0.320)
MWEP (min)	4.85 (3.83 – 7.53)	5.36 (4.09 – 7.51)	1722.50 (0.543)
LWEP (#)	3.50 (2.00 – 5.00)	4.00 (3.00 – 6.50)	1443.00 (0.043)[a]
LGWEP (min)	15.00 (11.00 – 30.25)	14.00 (11.00 – 22.50)	1786.00 (0.769)
C. Activity statistics			
AMEAN (counts)	198.89 (149.31 – 250.26)	245.30 (196.20 – 337.47)	20.00 (0.096)
ASD (counts)	751.26 (595.94 – 927.05)	925.15 (672.10 – 1113.66)	20.00 (0.096)
ACTX (%)	22.93 (18.44 – 29.28)	24.73 (20.56 – 28.75)	1390.50 (0.599)
D. Fragmentation statistics			
SFX (%)	1.50 (0.94 – 2.69)	2.35 (1.79 – 3.39)	1237.50 (0.003)[a]
BWR (A1′/NA)	0.10 (0.00 – 0.18)	0.11 (0.04 – 0.17)	1726.50 (0.551)
Complimentary measures			
Chronotype			
Midpoint of the TIB (hh:mm)	04:47 (04:16 – 05:40)	05:11 (04:28 – 07:26)	1338.50 (0.012)[a]
Midpoint of the SLP (hh:mm)	04:58 (04:03 – 05:58)	05:55 (04:40 – 07:59)	1252.00 (0.003)[a]

Data are presented as median and quartile [Md [(25th – 75th)]; TIB = time in bed; SLP = sleep period; NA = number of awakenings; A1′ = awakenings lasting only 1 min..

[a]Significantly different ($p < 0.05$) between clusters in the Mann–Whitney test.

Table 3 – Circadian rhythms variables derived from non-parametric approaches by cluster

Circadian rhythms variables (PIM)	Normal sleepers (n = 13)		Short sleepers (n = 6)		*p-value*
	Me ± SD	Md (Q1 – Q3)	Me ± SD	Md (Q1 – Q3)	
M10 (count)	3463.42 ± 1863.35	3129.22 (2397.77 – 3816.21)	3405.40 ± 2250.41	2658.42 (2047.82 – 4133.92)	1994.00 (0.306)[a]
Onset M10 (hh:mm)	09:41 ± 3.17	09:43 (08:25 – 11:57)	10:00 ± 4.31	11:18 (09:47 – 12:47)	1807.50 (0.067)[a]
L5 (count)	312.61 ± 589.63	107.06 (71.88 – 167.58)	380.40 ± 613.50	159.34 (109.64 – 292.13)	1510.00 (0.002)[a]
Onset L5 (hh:mm)	03:43 ± 5.09	01:39 (00:43 – 03:38)	04:54 ± 4.91	03:18 (02:09 – 05:09)	1449.00 (<0.001)[a]
IS (A.U. 0–1)	0.42 ± 0.09	0.40 (0.34 – 0.47)	0.33 ± 0.11	0.32 (0.23 – 0.49)	−1.89 (0.075)[b]
IV (A.U. 0–2)	0.77 ± 0.19	0.74 (0.65 – 0.92)	0.79 ± 0.16	0.74 (0.68 – 0.87)	0.20 (0.842)[b]
RA (A.U. 0–1)	0.84 ± 0.23	0.93 (0.87 – 0.96)	0.80 ± 0.21	0.90 (0.77 – 0.93)	1677.00 (0.017)[a]
CFI (A.U. 0–1)	0.44 ± 0.08	0.44 (0.39 – 0.53)	0.43 ± 0.08	0.44 (0.34 – 0.49)	−0.49 (0.627)[b]

Data are presented as mean and standard deviation (Me ± SD) and median and quartile [Md [(25th – 75th)]; PIM: Proportional Integration Mode; IS: Inter-daily stability; IV: Intra-daily variability; RA: relative amplitude; CFI: Circadian function index; ♦Indicates when the activity count begin; A.U. = arbitrary units.
[a]$p < 0.05$ in the Mann–Whitney test
[b]$P < 0.05$ in the independent Student t-test.

Table 4 – Model comparison and results of the linear stepwise regression models predicting circadian rhythm variables

Dependent variable	Predictor	Coefficient statistics Coeff.† (SE)	β‡	CI	t (*p*)
M10-PIM: [F(1,17) = 4.78; p = 0.043; R^2 =0.46]					
	ASD	4.88 (2.23)	0.46	[0.17 – 9.59]	2.18 (0.043)
Onset-M10-PIM: [F(2;16) = 10.10;p = 0.001; R^2 = 0.55]					
	Bedtime	-0.08(0.02)	-0.49	[-0.42 - 0.02]	-2.85 (0.012)
	WASO	0.03(0.01)	0.45	[0.006 - 0.58]	2.63 (0.018)
L5—PIM: [F(1,17) = 5.85; p = 0.027; R^2 = 0.50]					
	AMED	0.82 (0.343)	0.50	[0.10 - 1.55]	2.42 (0.027)
Onset-L5—PIM: [F(2, 16) = 34.12; p < 0.001; R^2 = 0.81]					
	Midpoint of the TIB	0.67(0.09)	0.76	[0.46 - -0.88]	6.89 (<0.001)
	LGSEP	-0.008(0.003)	-0.35	[-0.01 - -0.003]	-3.15 (0.006)

Equation: [(degrees of freedom, regression − residual) F-value; p-value; R^2]; †unstandardized regression coefficient (SE: standard error); ‡standardized regression coefficient; CI = 95% confidence intervals obtained using stepwise method.
[a]Spearman's correlation (p-value) between independent variables.
Limits of variable: collinearity statistics [tolerance: 0.17–1.00; VIF: 1.00–5.74]; residual statistics [std. predictive: −0.98, −3.47; std. residual: −2.06, 2.13].

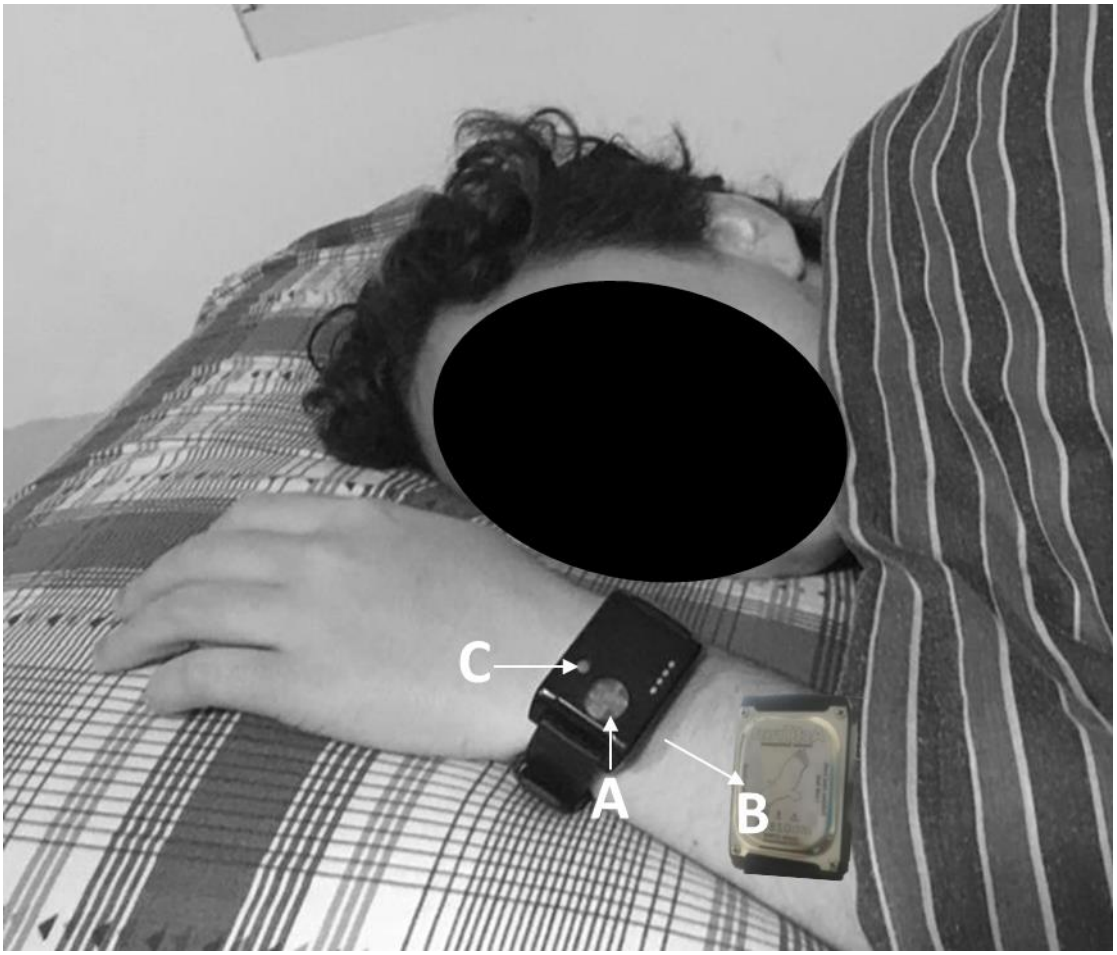

Figure 1 – The circadian monitoring device, composed of an accelerometer (internal, not shown in the figure), luxometer (A), a temperature sensor (B) and event-marker button (C).

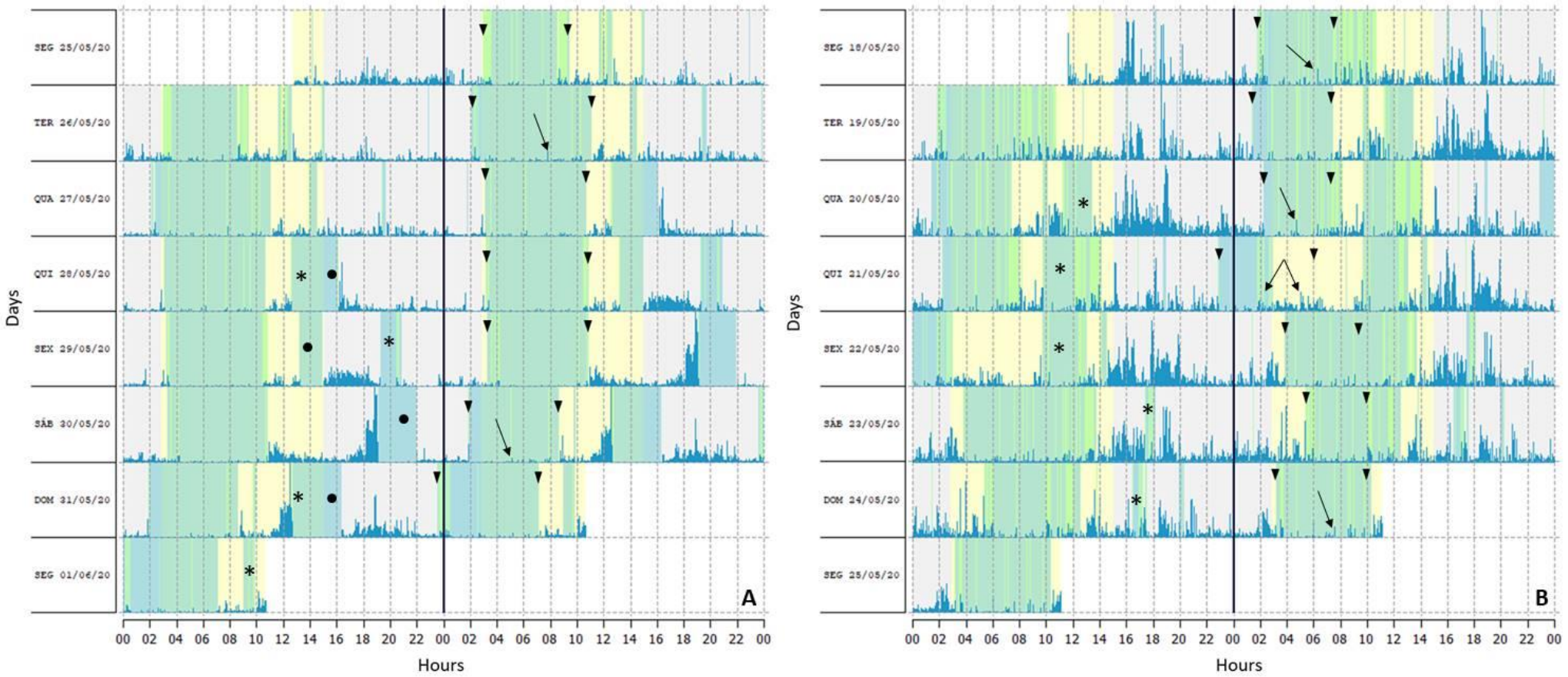

Figure 2 – The actograms of the wrist actigraphy. A degree of variability was evidenced during the 7 days. (A) Actogram of one participant of the normal sleeper cluster. The almost vertical arrangement of the arrows indicates a tendency toward regularity at bedtime. (B) Actogram of one participant of the short sleeper cluster

The vertical alignment of the ▼ shows an irregular pattern, indicating that sleep periods did not happen at the same time during night.

✱ moments when the actigraph was off the wrist; ▼ ▼ time in bed; ● moments of silence awake in bed

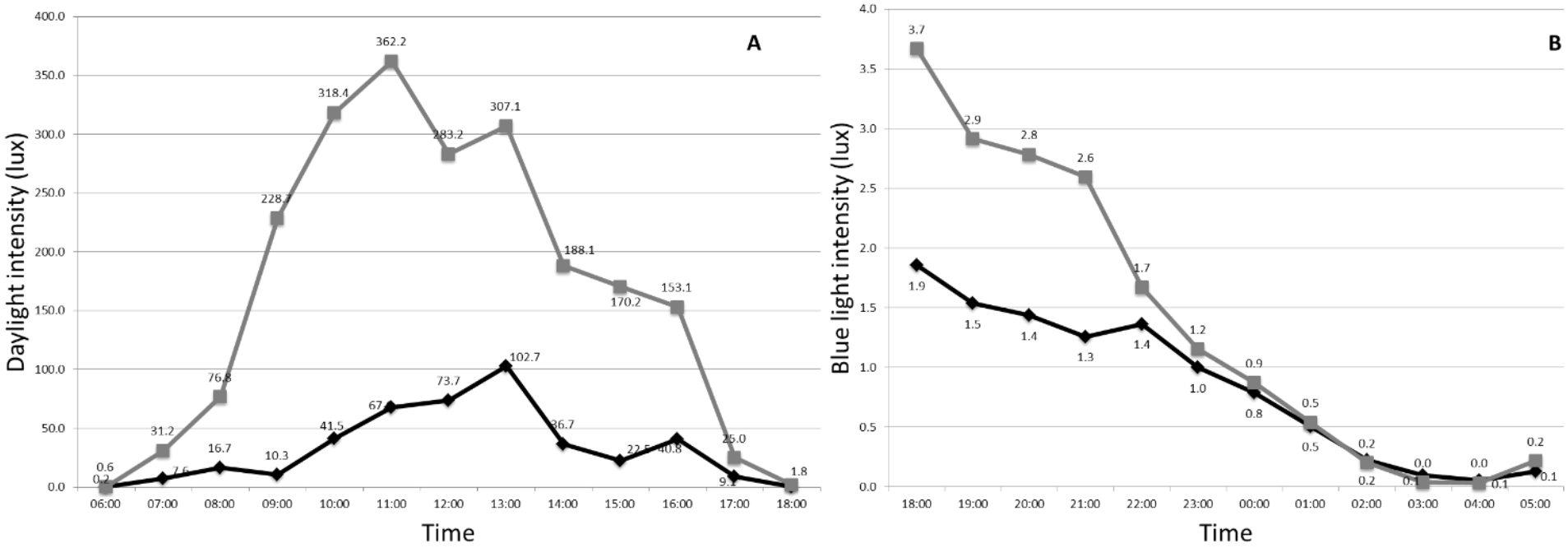

Figure 3 - Intensity of light during the 24-hour period. A) The exposure to daylight. B) The trajectory of the intensity of blue light. Gray line representing normal sleepers and black line representing short sleepers.

Supplementary material

Sleep Parameters

A) Sleep statistics: refers to the moments of asleep the participant had during time in bed.

i. Time in bed (TIB) is defined as the time that the participant lies in bed after turning off the lights until the time to physically get out of bed.
ii. Sleep period (SLP): interval from sleep onset to sleep offset (O–O interval).
iii. Sleep minutes during TIB (SMIN): the total number of minutes during TIB.
iv. True sleep minutes (TSMIN): the total number of minutes during SLP. The recommended normal for adults is 7–9 h of sleep per night (Hirshkowitz et al., 2015).
v. Sleep onset latency (SOL): the number of minutes between lying down in bed and actually falling asleep. The normal limit for adults is less than 20 min.
vi. Latency to persistent sleep (LPS): the start of persistent sleep at least 20 min.
vii. Percent sleep (PSLP): the minutes of asleep during TIB; the normal for adults is ≥80%.
viii. Sleep efficiency (SE): the percentage of time spent asleep during the sleep period; the normal limit for adults is ≥80%.
ix. Sleep episodes (SEP): the count of instances when the participant was asleep for one or more minutes.
x. Mean sleep episode (MSEP): the average number of minutes the participant was asleep per sleep episode.
xi. Long sleep episodes (LSEP): the total number of instances when the participant was asleep for at least 5 min during TIB (considered long if it lasts at least 5 min).
xii. Longest sleep episode (LGSEP): the duration (in minutes) of the longest sleep episode during TIB.

B) Wake statistics: refers to the moments of awake the participant had during time in bed (the minute-by-minute wrist movement values).

i. Wake minutes during time in bed (WMIN).
ii. Wake after sleep onset (WASO): the number of minutes that the participant was awake between sleep onset and sleep offset, considering only the TSMIN; the normal value in adults is <10% of total sleep minutes.
iii. The number of awakenings during TIB (NA) for one or more minutes; normal values in adults range from 2 to 6 awakenings per night.
iv. Mean wake episode (MWEP): awakening minutes during time in bed.

v. Long wake episodes (LWEP): awakening episode for at least 5 min.
vi. Longest wake episode (LGWEP): the duration of the longest wake episode during time in bed (min).

C) Activity statistics: refers to the activity the participant had during time in bed.

i. Mean activity during TIB (AMEAN): frequency of wrist movement (PIM) per minute during time in bed.
ii. Activity standard deviation during TIB (ASD): the variability in the activity score.
iii. Activity index (ACTX): minutes during TIB where the activity score was greater than zero (0).

D) Fragmentation statistics: are indicators of restlessness or nocturnal movement during time in bed.

i. Sleep fragmentation index (SFX): the ratio of the NA to the total sleep time in minutes.
ii. Brief wake ratio (BWR): the ratio of the NA lasting only 1 min to the total NA during TIB.

Circadian rhythm non-parametric variables

Non-parametric analysis was used to calculate the following phase markers (Neikrug et al., 2020; Rodriguez-Morilla et al., 2019; Mitchell et al., 2017; Ortiz-Tudela et al., 2010; Van Someren et al., 1999).

i. Activity counts for the most active 10 h period (M10) and start of M10 (Onset-M10): reflects how active the wake periods are.
ii. Activity counts for the least active 5 h period (L5) and start of L5 (Onset-L5): activity levels during the night. Thus, the patterns of activity can be classified into intensity levels (Freedson et al., 1998) as follows: light $\leq$ 1951 counts/min, moderate = 1952–5724 counts/min, hard = 5725–9498 counts/min, and very hard $\geq$ 9499 counts/min.
iii. Inter-daily stability (IS): the repetitiveness of the rhythm across consecutive days (i.e., synchronization of the 24 h activity–rest rhythm to the 24 h light–dark cycle). IS ranges from 0 to 1. A high value indicates good synchronization to light and other environmental cues that regulate the biological clock.
iv. Intra-daily variability (IV): fragmentation estimate of the 24 h resting activity rhythm (IV $\approx$ 0 for a perfect sine wave, IV $\approx$ 2 for Gaussian noise). A healthy adult has an IV of less than 1.

v. Relative amplitude (RA): the difference between M10 and L5 in the 24 h period. High RA indicates a more robust 24 h rest–activity rhythm. Values near 0 indicate null contrast between wakefulness and sleep, whereas values near 1 express maximal contrast.
vi. Circadian function index (CFI) characterizes the robustness of the rhythm, ranging from 0 to 1.

Complimentary measures

i. Actigraphy also allows the assessment of the chronotype, classifying the participants as early risers versus night owls (Natale et al., 2014). Chronotype was quantified by calculating the midpoint between the start and end of SLP (Simpkin et al., 2014; de Souza et al., 2015; Santisteban et al., 2018) and midpoint of TIB (Urbanek et al., 2018).
ii. The exposure to sunlight and blue light during the 24 h periods was also quantified. For this, the infrared light record was used to indirectly infer the sunlight, because infrared radiation is 30% to 54% of solar energy (Schroeder et al., 2007). A threshold of 200 lux was used because this is the average illuminance of indoor lighting (at home), and exposure to greater light implies time spent outdoors (Refinetti et al., 2019).

    The following scale was used to quantify the levels of blue light intensity: (i) moderate ≥16 lux, (ii) low ≤8 lux, (iii) few <5 lux, and (iv) dark ≤0.01 lux (Harvard Health Publishing, 2020; Vandewalle et al., 2007).

Table S1 - Variables that contributed to the formation of clusters

Variable	Cluster 1 (n = 6)	Cluster 2 (n = 13)	F (*p*)
Time in bed (TIB)	6.76	8.25	24.80 (<0.001)
Sleep period (SLP)	5.67	7.30	33.15 (<0.001)
Sleep duration during TIB (SMIN)	333.55	434.51	40.29 (<0.001)
Sleep duration during SLP (TSMIN)	304.12	408.53	44.93 (<0.001)
Percent sleep (PSLP)	75.10	82.61	8.29 (0.010)

F = ANOVA, $p < 0.05$ significantly different
gl= degrees of freedom (1 – 17)

Table S2—Differences between weekdays and weekends by clusters

Sleep parameters	Normal sleepers (n = 13)	U (*p*)	Short sleepers (n = 6)	U (*p*)
Bedtime (hh:mm)				
Weekdays	02:40 (00:52 – 23:00)	76.00 (0.663)	02:20 (01:45 – 03:55)	16.00 (0.749)
Weekend	02:40 (00:44 – 23:12)		03:30 (01:45 – 03:18)	
Get up time (hh:mm)				
Weekdays	09:00 (07:37 – 09:50)	83.00 (0.939)	08:01 (07:21 – 10:30)	13.00 (0.423)
Weekend	09:00 (07:34 – 09:49)		09:27 (07:34 – 10:11)	
TIB (h)				
Weekdays	8.16 (7.42 – 8.53)	68.50 (0.418)	7.16 (5.55 – 7.54)	7.00 (0.078)
Weekend	7.40 (7.29 – 8.55)		6.10 (5.10 – 7.00)	
SLP (h)				
Weekdays	7.25 (6.46 – 7.52)	76.00 (0.663)	5.45 (4.56 – 6.55)	5.00 (0.037)[a]
Weekend	6.58 (6.14 – 8.04)		5.22 (3.31 – 6.25)	
Onset SLP (hh:mm)				
Weekdays	02:12 (02:12 – 02:45)	72.00 (0.522)	02:53 (02:06 – 04:21)	9.00 (0.150)
Weekend	02:49 (00:50 – 02:20)		05:02 (03:00 – 06:00)	
Offset SLP (hh:mm)				
Weekdays	08:45 (08:45 – 09:36)	84.00 (0.980)	08:00 (07:10 – 10:11)	12.00 (0.337)
Weekend	08:43 (07:24 – 09:40)		09:12 (07:25 – 10:00)	
Chronotype				
Midpoint of the TIB (hh:mm)				
Weekdays	04:44 (04:00 – 05:42)	84.00 (0.980)	05:02 (04:06 – 06:38)	11.00 (0.262)
Weekend	04:49 (03:54 – 05:35)		05:55 (04:56 – 06:22)	
Midpoint of the SLP (hh:mm)				
Weekdays	04:55 (03:51 – 05:48)	83.00 (0.939)	05:27 (04:25 – 07:09)	11.00 (0.262)
Weekend	04:58 (03:59 – 05:58)		06:48 (05:10 – 07:41)	

Data are presented as median and quartile [Md [(25th – 75th)]; TIB = Time in bed; SLP = sleep period; NA = number of awakenings; A1′ = awakenings lasting only 1 min.
U(p) = the Mann–Whitney test value for differences between weekdays and weekends
[a]Significantly different ($p < 0.05$) between groups in the Mann–Whitney test.

Table S3—Light level

Time	Normal sleepers (n = 13)	Short sleepers (n = 6)	U (*p*)
Daylight (lux)			
06:00	0.24 (0.10 – 0.31)	0.14 (0.05 – 1.06)	37.00 (0.015)[a]
07:00	27.21 (7.99 – 54.82)	6.48 (0.79 – 12.21)	
08:00	50.19 (33.87 – 134.40)	10.03 (6.67 – 18.60)	
09:00	261.75 (123.13 – 314.10)	10.44 (6.06 –11.60)	
10:00	279.14 (202.08 – 494.74)	21.76 (18.75 – 49.55)	
11:00	390.58 (195.86 – 517.60)	25.34 (17.72 – 56.00)	
12:00	185.83 (171.34 – 392.65)	48.14 (39.07 – 59.29)	
13:00	250.81 (222.22 – 441.29)	48.79 (25.35 –260.25)	
14:00	181.95 (80.00 – 226.52)	16.77 (10.64 – 40.24)	
15:00	153.54 (76.67 – 308.58)	21.57 (11.34 – 23.91)	
16:00	153.37 (110.06 – 177.36)	43.90 (12.25 – 62.24)	
17:00	21.98 (14.61 – 30.69)	6.66 (2.50 – 18.58)	
18:00	1.57 (1.44 – 2.29)	0.51 (0.29 – 0.53)	
Blue light (lux)			
18:00	2.45 (2.04 – 3.75)	1.45 (1.21 – 2.14)	61.00 (0.525)
19:00	3.19 (1.95 – 3.37)	1.27 (0.97 – 1.99)	
20:00	2.45 (2.19 – 3.22)	1.21 (1.05 – 2.09)	
21:00	2.73 (2.12 – 2.88)	1.31 (1.10 – 1.52)	
22:00	1.80 (1.25 – 2.01)	1.17 (1.08 – 1.92)	
23:00	1.11 (0.93 – 1.32)	0.99 (0.71 – 1.18)	
00:00	0.94 (0.66 – 1.01)	0.89 (0.67 – 1.01)	
01:00	0.59 (0.33 – 0.71)	0.43 (0.22 – 0.76)	
02:00	0.16 (0.10 – 0.32)	0.21 (0.01 – 0.36)	
03:00	0.02 (0.01 – 0.06)	0.02 (0.01 – 0.17)	
04:00	0.02 (0.01 – 0.06)	0.02 (0.01 – 0.07)	
05:00	0.11 (0.02 – 0.49)	0.05 (0.02 – 0.25)	

Data are presented as median and quartile [Md [(25th – 75th)].
[a]$p < 0.05$ in the Mann–Whitney test (U).

Table S4—Correlations of light exposure with sleep parameters

Variables	Correlation
Daylight exposure with sleep parameters	τ (*p*)
Sunlight × onset L5-PIM	−0.32 (0.054)
Sunlight × Onset SLP	−0.07 (0.649)
Blue light exposure with sleep parameters	
Blue light × onset L5-PIM	0.01 (0.972)
Blue light × onset SLP	−0.17 (0.310)

[a]p < 0.05 in Kendall's test

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2.2 Sleep-wake patterns and circadian rhythm in adults with overweigh/obesity: a case series

Dora Zulema Romero Díaz, D.D.S., M.Sc.[1], Júnia Maria Cheib Serra Negra, Ph.D,[2] Maria Beatriz Duarte Gavião, Ph.D.*[3]

[1]Department of Biosciences, Anatomy division, Piracicaba Dental School, University of Campinas, Piracicaba, Brazil. ORCID: 0000-0002-5594-2586

[2]Ph.D, Department of Pediatric Dentistry, Federal University of Minas Gerais, Minas Gerais, Brazil. ORCID: 0000-0001-6098-3027

[3]PhD, Department of Health Sciences and Pediatric Dentistry, Piracicaba Dental School, University of Campinas, Piracicaba, Brazil. ORCID: 0000-0002-7546-5262

*Correspondence to:

Prof. Maria Beatriz Duarte Gavião

Faculdade de Odontologia de Piracicaba, Universidade Estadual de Campinas.

Address: Av. Limeira 901, Bairro Areião, CEP 13414-903, Piracicaba, SP, Brasil.

Telephone +55 19 2106-5200

E-mail: mbgaviao@unicamp.br

ABSTRACT

This case series provided detailed self-reported and illustrations of the actigraphy recording to recognize some of the sleep complaints (subjective) and measures of sleep-wake patterns (objective) in men with overweight (n = 2) and obesity (n = 2) with a mean age of 29.5 ± 3.20 years. Sleep-wake patterns and circadian rhythms were studied through non-dominant wrist actigraphy for seven consecutive days and, simultaneous, by sleep diary, from February to March 2020. A clinical evaluation was carried out to obtain anthropometric measurements (weight, height, body mass index and waist circumference) and body composition (fat percentage). The Sleep Questionnaire and sleep bruxism were applied. In addition, anxiety and depression symptoms were assessed with the Beck Anxiety Inventory and the Beck Depression Inventory respectively. The Wilcoxon test was used to assess the difference between subjective (sleep diary) and objective (actigraphy) sleep parameters, and the difference between sleep parameters on weekdays and weekends. The results shown that obese participants present moderate scores for anxiety and depression and the two overweight, minimal scores. The two obese participants and one overweight reported sleep bruxism. Visual analysis of the seven days recorded, and the actogram suggested that these participants showed a non-24-hour rhythm and not synchronized with the light dark cycle. The analysis of sleep-wake patterns revealed bedtime after midnight, short duration sleep, high number of nocturnal awakenings, and large amount of wake-time after sleep onset. In conclusion, this case series allowed us to observe the importance of objective sleep parameters using actigraphy summed to subjective sleep reports, highlighting the importance to take into account the anthropometric and emotional variables, considering their influence on the sleep-obesity relationship.

Keywords: Obesity; Sleep; Actigraphy; Circadian rhythm.

INTRODUCTION

Sleep is a complex physiological function for the body (Anafi et al., 2019), prompting growing interest in the relationship between sleep patterns and health (Zuraikat et al., 2020). The day-to-day variability in sleep patterns can contribute to circadian misalignment and can cause dysregulation in metabolic and endocrine functions, as these functions oscillate in a circadian fashion (Phillips et al., 2017; Zuraikat et al., 2020). In this context, there is growing evidence on the role of sleep in cardiometabolic health, including the risk of obesity (Barragán et al., 2021). Obesity is a health conditions that affect all races, ethnicities, and ages; approximately 40.0% young adults aged 20 to 39 years have obesity, which in turn can lead to the other health complications, such as heart disease, stroke, type 2 diabetes, among others, that can worsen the quality of life of individuals (Ogilvie and Patel, 2017; WHO, 2020).

In turn, the prevalence of inadequate sleep duration and disturbances has been increased, probably due to aspects of lifestyle, for example, reduced exposure to daylight, demanding work schedules and spending more time on technology devices (blue light) (Division of Sleep Medicine H, 2020; Huang et al., 2020; Zuraikat et al., 2020). It has been observed high variability in sleep patterns that can influence the regularity of sleep behaviors (Huang et al., 2020). Sleep variability may be indicatives of insufficient sleep on some nights of workdays due to social commitments and its compensation on other nights during free days (Baron et al., 2011; Ogilvie and Patel, 2017). The daytime napping and nocturnal awakenings (more than 6 per night) may reflect an irregular sleep schedule and fragmented nocturnal sleep, respectively (Ohayon, 2008; Wang et al., 2020). These changes can negatively influence rest time during the night and are important because the duration and quality of sleep can affect activity and behavior during the day and converse (Li et al., 2020).

Zuraikat et al. (2020) considered that there is consistent evidence of associations between sleep variability and increased risk of adiposity, as well as glucose dysregulation, type II diabetes, and metabolic syndrome, despite the need to determine causality. Furthermore, insufficient sleep and sleep quality have been associated with obesity and diabetes (Anothaisintawee et al., 2015; Reutrakul and Van Cauter, 2018).

In addition, obesity was strongly correlated with psychosocial conditions especially with depression and weaker for anxiety disorders (Rajan et al., 2017), suggesting that the sleep disorders are one of the main symptoms in individuals with depressive disorder. Moreover, the regulation of food intake is influenced by cognitive, emotional, and behavioral factors (Quick

et al., 2014), inferring that the sleep-obesity relationship has biopsychosocial features (Barragán et al., 2021).

Subjective measures of sleep pattern can lead to study limitations, thus objective measures are required (Barragán et al., 2021), such as the actigraphy, which is a validated method for recording rest–activity patterns that apply a non-invasive measurement of wrist movement (Ancoli-Israel et al., 2003; Van De Water et al., 2011; Kusmakar et al., 2021). This method is considered convenient and economical for objective sleeping monitoring over days or weeks (Sadeh, 2011).

The purpose of the following case-based descriptions was to provide detailed self-reported and illustrations of the actigraphy recording to recognize some of the measures of sleep-wake patterns (objective) and sleep complaints (subjective) in overweight and obesity adults.

METHODS

This study was approved by the Ethics Committee of the Piracicaba Dental School, University of Campinas, Piracicaba, São Paulo, Brazil. Written informed consent was obtained from all participants.

The cases included were selected from individuals of the Dental School.

The methods employed were precisely detailed in Supplementary Material. Briefly, demographic characteristics, lifestyle, and health status were obtained using structured questionnaire. Some questions of the UNIFESP Sleep Questionnaire were applied, and sleep bruxism was informed using a specific questionnaire. Moreover, symptoms of anxiety and depression were evaluated using the Beck Anxiety Inventory (BAI) and Beck Depression Inventory (BDI), respectively. Anthropometry and body composition measures were obtained to determine whether individuals met inclusion criteria for overweight/obesity, which parameters were in accordance with World Health Organization (2011). Actigraphy data were obtained using ActTrust® (model AT0503 Condor Instruments, Brazil) for seven days, scored in 30-seconds epochs. The sleep parameters measured were: time in bed (TIB), sleep period (SLP), sleep onset latency (SOL), sleep efficiency (SE), wake after sleep onset (WASO), number of awakening (NA), mean activity during TIB (AMEAN), sleep fragmentation index (SFX), midpoint of the SLP (chronotype). The sleep diary was simultaneously completed

during the period of use of the actigraph to obtain subjective information related to sleep and activity.

Circadian variables were also obtained by actigraphy: activity counts for the most active 10 h period (M10), activity counts for the least active 5 h period (L5), inter-daily stability (IS), intra-daily variability (IV), relative amplitude (RA) and circadian function index (CFI).

Data are presented as the mean value and standard deviation (Me±Sd) or the median value and quartile [Md [(25^{th} – 75^{th})]. The Wilcoxon test was used to assess the difference between subjective sleep (sleep diary) and objective parameters (actigraphy), and difference between weekdays and weekend sleep parameters.

According to the case-series design, the data of three graduate students and one school employee were individually examined, described, and graphed. Data collection took place from January to March 2020.

Case 1

A 31-year-old man, full-time graduate student, presented BMI of 35.83 kg/m^2, thus classified as obese. The waist circumference was 118 cm, indicating abdominal obesity and body fat was 34.89%.

The BDI score was 16 points, meaning mild depression, whereas BAI score was 24 points, indicating moderate anxiety. He did not present symptoms of cardiovascular disease or diabetes, neither use of recreational drugs, alcohol, and did not smoke. He took one tablet of Zyloric® per day, vitamin D one day per week, and Citoneurin® when there was neuralgic pain. He did not practice any sport.

Based on the sleep questionnaire, the participant reported difficulty falling asleep over the last five years and did not consult the doctor for this sleep problem. In addition, in the last thirty days, other events during sleep occurred, with some frequency, such as feeling of suffocation, heartburn and talking while sleeping. He denied symptoms of other sleep disorders—parasomnia or movement disturbances. When the participant was asked why he had not consulted the doctor for his sleep problems, he replied: "lack of urgency to improve the quality of my sleep".

In the bruxism questionnaire he reported teeth grinding during sleep and had been wearing occlusal splints for two years.

The seven days actigraphy data showed that bedtime was characterized by a later mid-sleep time (after midnight), which pointed to sleep onset difficulties. Get up time was later, about 10:00 a.m., and the midpoint of the SLP was at 06:06 a.m. He slept less than 7h in average (SLP) with a large mean activity and a high sleep fragmentation index (Table 1), indicating nocturnal movement, respectively, although a good sleep efficiency during this period was observed.

The sleep latency by actigraphy was about 24 min greater than by sleep diary, although no statistical significance difference was achieved, probably due the large variability among days (graphically represented in figure 2). The participant reported a little tiredness when waking up on six mornings of the data collection period (Table 2) and reported not waking up at night. But according to actigraphy record, he spent 45 min awake after sleep onset and had several awakenings per night, showing a significant difference between self-perception of sleep and the respective objective parameter (Supplementary Table 1). He did not consume food or drinks before going to bed and did not report any naps. The variables did not show significant differences between weekdays and weekends during the sampling period (Supplementary Table 2).

The stability (IS = 0.42) indicated that during the sampling period the participant presented low coupling with external zeitgebers (e.g., 24 h cycle) maybe because the participant got up in the middle of the morning (see Figure 2 and Table 1).

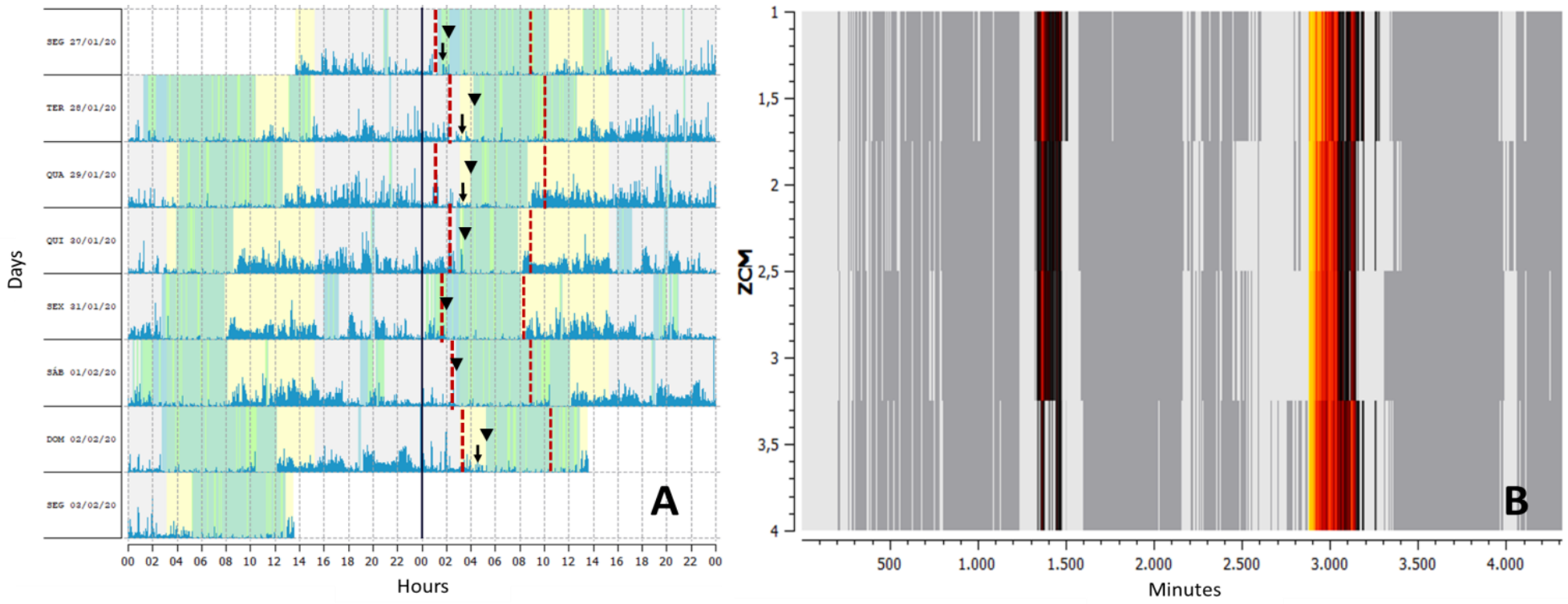

Figure 1 – Double plotted actogram of participant 1, whose rest-activity patterns reveal extremely delayed rest onsets. On panel A: the most relevant were the values of sleep onset latency (area between dashed line and arrow down), remarkably prolonged time, suggesting that he was trying to fall asleep; and is possible to see the activity during time in bed (vertical lines in cyan area). On panel B: The sleep spectrogram shows the high variability in the spectral content at different time stamps. Note the areas with frequency peaks (in yellow/orange colors), suggesting a single spectral pattern that is repeated every 3000 minutes.

Case 2

A 34-year-old man, graduate student, also working in a dental office during the day presented BMI of 30.08 kg/m^2, thus classified as obesity. The waist circumference was 107 cm, indicating abdominal obesity; body fat was 44.73%.

His BAI score was 18 points, indicating low anxiety, and BDI score was 28 points, indicating moderate depression. He also denied the use of recreational drugs, did not smoke, and drank alcohol beverages socially. He reported a previous diagnosis of chronic osteoarticular disease, and for this, he took one tablet of Chondroitin Glucosamine® per day. He went to the gym three times a week, spending an hour and a half a day doing weight training and cycling.

Based on the Sleep Questionnaire, he reported some events during sleep in the last two years, such as waking up too early and not being able to sleep quickly, and sleepiness that impaired daytime activities. He also reported in last thirty days some events that happen during nocturnal sleep, such as difficulty falling asleep, tachycardia, sleepwalking, feeling suffocated, waking up in a panic crying, heartburn, sleep paralysis, waking up because of a headache, waking up anxious after a nightmare, snoring, sleep myoclonus, and talking in his sleep. The participant reported not consulting the doctor for these sleep problems, he said "because I believe that moments of insomnia are due to anxiety, and I don't want to take strong drugs to control". He also reported napping at least two hours on Saturday afternoon.

In the bruxism questionnaire the participant reported teeth grinding, however, he has not been using the occlusal splints (Table 2).

In the sleep diary, he reported a little tiredness after waking up in five mornings (Table 2). In fact, according to the actigraphy record, sleep efficiency was considered low (Table 1). He also reported a few awakenings during sleep on the seven nights of assessment. However, the actigraphy showed more than normal awakenings, determining differences between the participant's perception and this objective sleep parameter (supplementary table 1). The participant also reported that his sleep was disturbed by noise and lights from the street, although the lights were not controlled in this study, suggesting that the bedroom did not offer adequate sleeping conditions. He did not consume food or drink before going to bed.

The nine-day actigraphy records showed that, on average, bedtime was later, starting at 1:00 am, although a normal latency time for falling asleep had passed, there was great variability between days.

The actigraphy records of nine days showed that, on average, the bedtime was later, after at 01:00 a.m., although he had spent a normal latency time to fall asleep but with great variability among days. Therefore, the get up time was at 10:05 a.m., presenting a sleep period of approximately 7 h per day along the week with a later midpoint of the SLP about 06:25 a.m. In addition, the participant had a great WASO value, which varied greatly during the evaluation nights, suggesting difficulty in maintaining a lees restful sleep. In line with these cited parameters, he had a high mean activity and high sleep fragmentation index (table 1), indicating difficult to sleep and nocturnal movement during time in bed, respectively, as shown in figure 3. No significant differences were found between weekdays and weekends (Supplementary Table 2). No naps were observed in the sleep diary or in the actigraphy record during the sampling period (Figure 3).

The participant had high L5 value, also indicating a less restful sleep, confirmed by a low sleep efficiency, less than normal. The fragmentation, represented by IV, was close to one indicating occurrence of nocturnal awakenings, confirmed by more than 6 awakening per night, in addition, the stability indicated that during the sampling period the participant not presented synchronization with external zeitgebers (e.g., 24 h cycle) maybe because get up was at 10 am (see Figure 2 and Table 1).

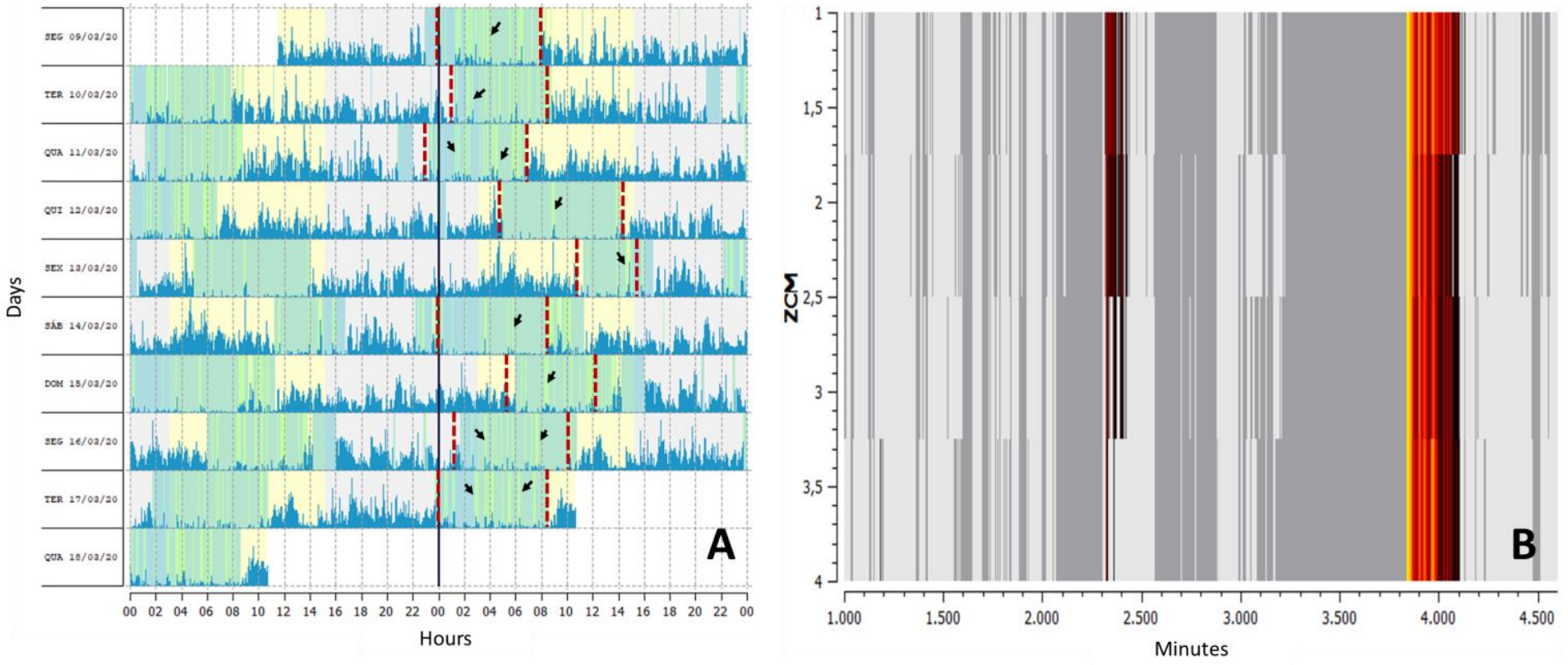

Figure 2 – Double plotted actogram of participant 2 (A) note the extreme irregularity of vertical dashed lines, which indicate the bedtime and get up time. Also note the extremely amount the activity during sleep period in this individual (cyan areas with the vertical lines that represent the activity count; examples shown with black arrows). (B) The sleep spectrogram shows the areas in yellow/orange colors, suggesting a single spectral pattern that is repeated every 3900 minutes.

Case 3

A 30-year-old man, graduate student, presented BMI of 29.36 kg/m2, thus classified as overweight. The waist circumference was 110 cm indicating abdominal obesity and body fat was 29.88%. He denied cardiovascular disease, diabetes, or another metabolic disease.

His BAI and BDI scores were 1 point, which is interpreted as a minimum level of anxiety and depression, respectively. He went to the gym every week and spent two hours per day working out to lose weight on his own, as well as taking walks outdoors.

Based on the Sleep Questionnaire, he reported waking up a lot during the night in the last five years and reported also other events during the night in the last month, for example, waking up because of a headache, talking while sleeping. The participant reported not seeing the doctor for these sleep problems. He did not nap on weekdays and on the weekend or after school hours.

According to the bruxism questionnaire, the participant reported not grinding their teeth during sleep.

Based in seven days of actigraphy, the records shown that, on average, the bedtime was before midnight, he had a normal time to fall asleep, both varying among nights. The get up time was early, around 08:00 a.m., indicating a sleep duration (SLP) of 7h approximately. Although WASO values were slightly higher than normal, he presented adequate sleep parameters.

The values of activity and sleep fragmentation index (Table 1) suggest restlessness while in bed. It was not observed daytime sleep. No significant differences were found between weekdays and weekend (Supplementary Table 2) in the actigraphy records.

In the sleep diary, he reported feeling rested upon waking up five mornings (Table 2). According the actigraphy record he presented good sleep efficiency during six nights. He also reported not waking up at night during the sampling period. However, according to actigraphy, he had high numbers of awakenings per night, showing significant differences between his perception and the correspondent objective sleep parameters (Supplementary Table 1), as well as with the Sleep Questionnaire, as he informed waking up a lot during the night. He does not consume food or drinks before going to bed. There was no record of naps in the sleep diary during the sampling period.

The stability suggested that during the sampling period the participant presented low coupling with rest-activity rhythm. Moreover, according to L5 values he presented relative activity during 5 h period, that usually occurs during sleep, in line with mean activity and WASO (Table 1). The fragmentation indicated the occurrence of nocturnal awakenings, corresponding to high number of awakenings (Table 1).

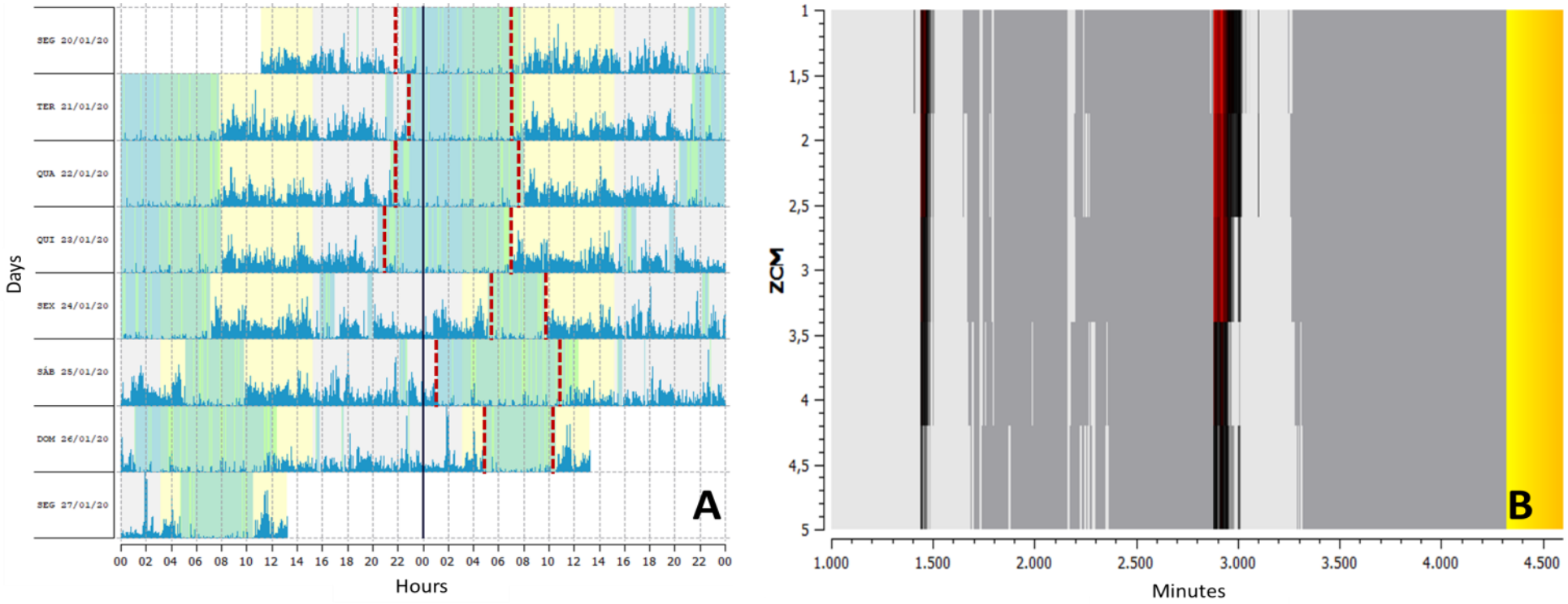

Figure 3 - Double plotted actogram of participant 3. (A) The actogram shows that bedtime was regular from Monday to Thursday, however, during weekend (from Friday to Sunday) the bedtime was profoundly later (based on the sleep diary, he reported going out to parties during this period), also note the activity during sleep (cyan areas with the vertical lines). (B) The sleep spectrogram shows the areas in yellow color, suggesting a single spectral pattern that is repeated every 4300 minutes.

Case 4

A 25-year-old man, who worked 5 days a week as a warehouse assistant., presented BMI of 27.46, thus classified as overweight. The waist circumference was 90 cm, indicating abdominal obesity and body fat was 38.44%.

He used Alenia® every day for asthma; he denied symptoms of other metabolic disease. His scores on the BAI and BDI were 4 points, meaning a "minimal" level of anxiety and depression, respectively. He went to the gym three times a week and spent forty minutes doing weight training, as well as taking outdoor walks and soccer.

Based on the Sleep Questionnaire, he reported difficulty falling asleep daily, however, actigraphy show normal values of sleep onset latency. He also reported drowsiness that impaired his activities once a week. In addition, other events occurred during the night in the last month, as heartburn, waking up anxious after nightmare, snoring and sleep myoclonus. The participant reported not seeing the doctor because of these sleep problems, as he said: “I don't usually go to the doctor very often”. He did not take a nap during the week and the weekend.

In the bruxism questionnaire the participant reported teeth grinding during the night, however, he did not use the occlusal splints.

In the sleep diary, he reported a little tiredness when waking up five mornings (Table 2), but he had particularly good sleep efficiency by actigraphy during the sampling period. He also reported not waking up at night, nevertheless, the actigraphy record showed few awakenings per night, although this difference was not significant (Supplementary Table 1). Thus, self-perception of awakening was different from this objective sleep parameter. He drank soda before going to bed four days during the sampling period.

Seven-day actigraphy measurements found that, on average, bedtime was late, around 2:00 a.m., with great variability among nights. However, the get up time was around 08:00 a.m., determining a short sleep period (SLP <6 h) with a midpoint at 05:14 a.m. He spent a normal time to wake after sleep onset, reflecting a high WASO value in this case, as the SLP was short (see figure 4). Nevertheless, sleep fragmentation index was low (Table 1). There were not naps and no significant differences between weekdays and weekend in the actigraphy records during the sampling period (Supplementary Table 2).

The stability suggested that during the sampling period the participant presented low coupling with rest-activity rhythm, according to short SLP value (Table 1).

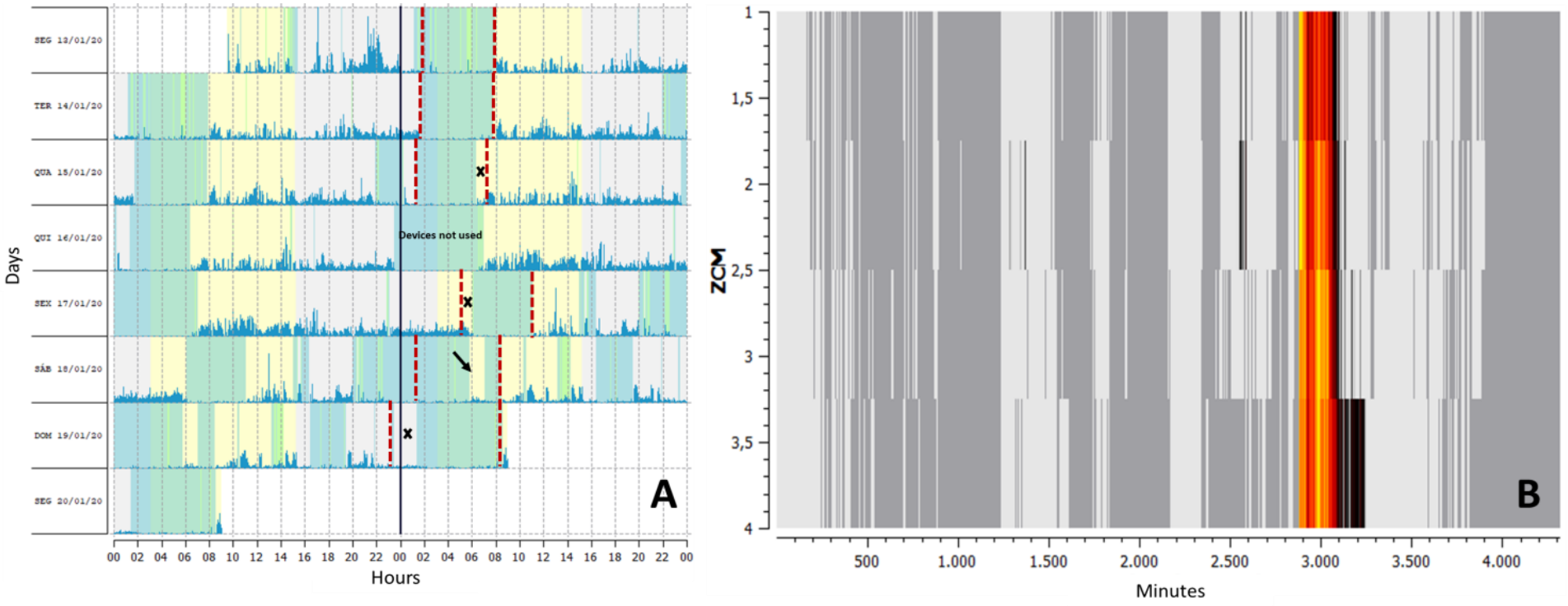

Figure 4 – Double plotted actogram of participant 4. On panel A: he showed long period awake minute during TIB (black crosses). Note activity period within TIB (black arrow), suggesting that he woke up, did some activity, and went back to sleep, only on that day. Participant did not wear the actigraphy on 1 night of the recording period. On panel B: The sleep spectrogram shown that the cycles are repeated at the same time in the sampling period, ranging 1900 and 3100 minutes, suggesting a unique rhythm.

DISCUSSION

In this study, a case-based approach was used to illustrate the objective and subjective sleep parameters taking into account emotional aspects in overweight/obese male adults, since sleep variability can be associated with risk of adiposity (Zuraikat et al., 2020) and possibly influenced by biopsychosocial factors (Barragán et al., 2021). The respective approaches were verified in four males, two with obesity and two overweight.

In fact, a pattern of association between sleep duration and increased weight has been considered (Hasler et al., 2004; Theorell-Haglöw et al., 2016), despite the need to determine causality (Zuraikat et al., 2020). However, there is controversy regarding this association (Theorell-Haglöw et al., 2016; Hanson et al., 2020), since a direct inverse relationship has been observed, meaning short sleep duration in obesity (Anic et al., 2010; Gildner et al., 2014), as well as a U-shaped relationship, meaning both short and long sleep duration in obesity (Chaput et al., 2008; Logue et al., 2014; Hanson et al., 2020). Different measurements of sleep, such as self-reported duration or objective measures such as actigraphy or polyssonography, cross-sectional or longitudinal studies explain the different results. Considering the context cited above on sleep duration and anthropometric parameters, in this case series, the participants with obesity (Cases 1 and 2) and one overweight (Case 3) presented sleep duration nearly to 7 hours, whereas the other overweight participant (Case 4) presented short sleep duration (< 6 hours). An interesting finding was in relation to the bedtime and get up time, since the two obese participants went to bed late and woke up in the middle of morning, with correspondent values for onset- and offset-SLP, differently from the overweight ones, as the participant 3 went to bed earlier and woke up two hours earlier, while participant 4 went to bed later and woke up also two hours earlier. It should be considered that, during the sampling period, the participants were on vacation, a period that may have provided greater flexibility for bedtime and get up time, explaining the large variability of these times during data collection.

Although the sleep duration of Cases 1, 2 and 3 was approximately as recommended, they reported sleep problems, as did Case 4, with short sleep duration and report of impaired sleep. Thus, the perception of sleep quality was poor for all of them. Accordingly, high WASO and awakenings, activity counts during the SLP, and high sleep fragmentation were observed for Case 1 and 2, agreeing with previous study about these high values in individuals with high BMI (Theorell-Haglöw et al., 2016). The first overweight participant (Case 3) had WASO values slightly higher than normal, but other objective sleep parameters

were adequate, while the Case 4, also overweight, had high WASO and activity counts during SLP. On the other hand, the sleep efficiency of all participants was good, over 80%, meaning that the subjective and objective impaired parameters happened along less than 20% of the SLP, with high values for Case 4, followed by Case 3, Case 1, and Case 2, respectively. In this sense, participants with obesity showed lesser sleep efficiency, agreeing with previous studies (Anothaisintawee et al., 2015; Reutrakul and Van Cauter, 2018; Zuraikat et al., 2020).

A previous study (Lederman et al. 2019) have suggested that sleep quality has an influence on well-being and mental health, highlighting the relationship between high levels of depression and moderate levels of anxiety with perceived poor sleep quality (Varma et al., 2021). Furthermore, considering the possible association between sleep variability and increased risk of adiposity, the factors involved in this relationship are of a biopsychosocial nature (Barragán et al., 2021), as mentioned before. In line with the comments above, it was observed that the two obese participants had moderate or low anxiety and mild and moderate depression (Case 1 and 2, respectively). On the other hand, the two overweight participants (Cases 3 and 4) had a lack or minimal level of anxiety and depression. Although the respective BAI and BDI scores for Cases 1 and 2 can be considered not so severe, they perceived poor sleep quality and some objective parameters indicated impaired sleep during SLP, confirming a tendency for the relationship between sleep, obesity, and emotional factors (Quick et al., 2014; Barragán et al., 2021), The same happened with overweight participant of case 4, whose scores were very low. Conversely, Case 3 showed no anxiety or depression and better subjective and objective sleep parameters, inferring that emotional factor could have a role on sleep parameters, as observed by Lederman et al. (2019). One possible explanation for low level of anxiety and depression could be due to the participants were on vacation, mitigating the emotional stresses derived from their academic/work requirements (Vgontzas et al., 2014). In addition, it is known that physical activity facilitates sleep (Hanson et al., 2020) and diminish stress, and with exception of participant 1, the others performed regular physical activity, despite the short sleep duration of participant 4.

In general, the participants showed higher RA values (close to one) indicating a robust 24 h rhythm, reflecting higher activity during the day and relatively lower activity during the night. However, analyzing stability and fragmentation parameters, i.e., IS and IV respectively, values less than one suggested low coupling of rest-activity rhythm, which means more awakenings and movements during the sleep phase, compromising the quality of rest. Interestingly Forner-Cordero et al. (2018), found similar circadian rhythm in a healthy sample,

suggesting the need to establish a routine to align the internal biological clock with the light-dark cycle of the 24-hour period to improve the quality of rest.

Given the findings of the reported cases, it is possible to observe the emotional factor and sleep disturbance as mediating factors in the relationship between sleep parameters and obesity, agreeing with Theorell-Haglöw and Lindberg (2014), thus requiring detection and management them to improve well-being. However, the management strategies should align with complexity of each individual case, taking into account the causality (Hanson et al., 2020). Febbraio (2017), reviewing the literature, noted the importance of the molecular mechanisms underlying the protective effects of exercise against a myriad of disease, including metabolic ones.

A possible relationship of SB with several issues related to sleep characteristics and quality, as well as the presence of comorbidities has been emerging (Segù et al., 2020), although sleep bruxism is considered a sleep behavior rather than sleep disorder (Lobbezoo et al., 2018; Manfredini et al. (2019). In this case series, the participants 1, 2, and 4 reported sleep bruxism and had a good sleep efficiency, above 82%, agreeing with Palinkas et al. (2017) who observed that individuals with sleep bruxism presented higher percentage values. Moreover, those authors found that the latency period in individuals with sleep bruxism were higher when compared to ones without sleep bruxism. In the present case series, it was observed that latency period was greater for participant 1, who used an occlusal splint for sleep, suggesting a more severe bruxism than the other participants. SB has been associated with arousal activity over sleep period (Huynh et al., 2006). Perhaps, the sleep bruxism episodes can be related to awakening findings in the three participants. Nevertheless, sleep bruxism was evaluated in this case series by a presence/absence dichotomous approach, and according to Manfredini and Lobbezoo (2021), as SB is a multifaceted motor behavior, it must be evaluated within a broader construct, that is, as a spectrum of different muscle activities. In addition, more specific studies should be carried out to verify the possible association between SB and civilization diseases, such as obesity and diabetes, as suggested by Michalek-Zrabkowska et al. (2021).

Concluding, this case series allowed us to observe the importance of objective sleep parameters using actigraphy summed to subjective sleep reports, highlighting the importance to take into account the anthropometric and emotional variables, considering their influence on the sleep-obesity relationship.

Acknowledgments

The authors are grateful to CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico, Brazil) for the scholarship for the first author (process number 147405/2017-3). The authors are grateful to all study participants for their adherence to the research protocol.

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

Participants consent

The participants provided written permission for publication of this case reports

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Table 1 – Body variables, sleep parameters and circadian variables by actigraphy

Characteristic	Case 1	Case 2	Case 3	Case 4
Body composition				
BMI (kg/m^2)	35.83	30.08	29.36	27.46
Body fat (%)	34.89	44.73	29.88	38.44
Waist circumference (cm)	118	107	110	90
Sleep parameters				
Bedtime	02:10 ± 0.58	01:10 ± 7.41	11:23 ± 10.11	02:24 ± 8.43
Get up time	10:02 ± 1.52	10:05 ± 2.51	08:18 ± 1.37	08:22 ± 1.26
TIB (min)	472.86 ± 103.98	449.89 ± 108.89	468.57 ± 107.48	388.00 ± 73.54
Onset-SLP	03:47 ± 1.08	03:31 ± 3.47	00:01 ± 10.22	02:49 ± 1.53
Offset-SLP	09:52 ± 2.01	09:58 ± 2.43	08:14 ± 1.35	08:16 ± 1.32
Midpoint of the SLP (Chronotype)	06:06 ± 1.12	06:25 ± 3.12	05:21 ± 1.16	05:14 ± 1.28
SLP (min)	366.43 ± 94.32	388.78 ± 105.20	417.42 ± 117.51	327.83 ± 57.37
Sleep onset latency (min)	63.43 ± 63.06	21.33 ± 25.15	22.85 ± 14.85	35.00 ± 46.39
Sleep efficiency (%)	87.98 ±3.39	81.78 ± 12.53	89.77 ± 3.98	94.23 ± 8.58
WASO (min)	45.00 ± 20.36	71.22 ± 50.13	43.28 ± 23.82	20.83 ± 33.70
Number of awakenings (#)	11.29 ± 5.68	11.33 ± 5.50	11.14 ± 4.22	2.17 ± 2.56
Sleep fragmentation index (%)	3.10 ± 1.07	3.44 ± 1.74	2.84 ± 0.85	0.72 ± 0.99
Mean activity during SLP (counts/min)	197.71± 36.15	293.11± 153.52	194.05 ± 58.75	121.30± 88.24
Circadian variables				
M10 (count)	3761.01 (1350.5)	3535.11 (894.59)	3862.65 (1044.92)	3072.21 (1193.94)
L5 (count)	187.35 (40.42)	277.26 (115.72)	181.06 (78.36)	97.15 (79.87)
RA (A.U. 0–1)	0.88 (0.05)	0.83 (0.11)	0.89 (0.04)	0.73 (0.36)
IV (A.U. 0–2)	0.69	0.84	0.88	0.86
IS (A.U. 0–1)	0.42	0.15	0.37	0.26
ICF (A.U. 0–1)	0.42	0.28	0.42	0.44

Data are presented as mean and standard deviation (Me±SD); TIB = Time in bed; SLP = Sleep period.
The hours are displayed in 12-hour system (a.m / p.m; hh:mm).
RA: Relative amplitude; IV: Intra-daily variability; IS: Inter-daily stability; ICF: Circadian function index; A.U. = arbitrary units

Table 2 – Individual reported characteristics

	Case 1	Case 2	Case 3	Case 4
Age (years)	31	34	30	25
Education (N)				
High school graduate				✓
Post-graduation degree	✓	✓	✓	
Smoking stated (N)	Non-smoker	10 years ago	Non-smoker	Non-smoker
Baseline alcohol-related variables				
Number of days that consumed alcohol (past 7 nights)[b]	Never	3 (Friday and weekend)	1 (Sunday)	2 (Tuesday and Friday)
Disturbed sleep by external factors (N, %)[c]				
≤ 3 nights	1 (14.28%)	3 (33.33%)	1 (14.28%)	1 (14.28%)
Not disturbed	6 (85.71%)	6 (85.71%)	6 (85.71%)	6 (85.71%)
Feeling when waking up in the morning {Perceived sleep quality} (N)[d]				
Rested		4 (44.44%)	5 (71.42%)	1 (14.28%)
A little tired	6 (85.71%)	5 (55.55%)	2 (28.57%)	5 (71.42%)
Tired	1 (14.28%)			1 (14.28%)
Sleep diary				
Teeth grind, tighten or make noise during sleep	Yes	Yes	No	Yes
Use of occlusal splints	Yes	No	No	No

[a]Participants were considered smokers if they reported smoking 100+ lifetime cigarettes.
[b]A binge drinking night was considered 5+ drinks in a day for males and 4+ drinks in a day for females (in this study the participants consumed alcoholic beverages during weekend).
[c]External factors mainly cell, nightmares, cold.
[d]Were considered more than 3 mornings.

Supplementary material

Material and Methods

Study area and design

This was a cross-sectional and observational study, which shows a series cases.

Eligibility criteria included age ≥ 18 years-old and BMI ≥ 25 kg/m2, attendance at the ultrasound laboratory of the Pediatric Dentistry of Piracicaba Dental School. Psychotic, debilitated, pregnant or handicapped individuals in any form to the point that obtaining anthropometric measurement would be difficult were excluded from the study.

This study was conducted between January to March 2020. A convenience sampling method was utilized. The cases included were selected from individuals of the Dental School.

Anthropometry and body composition measures

Anthropometric measurements followed the standard anthropometric methods of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones et al., 2006). Body weight was measured in light clothes to the nearest 0.01 kg in the standing position using an electronic scale (G-TECH®), and height was measured to the nearest 0.1 m by stadiometer (SANNY®) in standing position with closed feet, without shoes, these metrics were used to calculate the body mass index (BMI, kg/m2), as weight in kilograms (kg) divided by height in square meters (m^2). Based on World Health Organization, overweight and obesity were defined as 25–29.9 kg/m2 and ≥ 30 kg/m^2, respectively.

Body fat was measured using the Sanny® adipometer digital, through the sum the thickness of seven skin folds (subscapular, triceps, pectoral, bicep, abdominal, supra-iliac and middle thigh) the percentage of body fat was obtained. Overweight corresponded to 31-39% (mean 35%) body fat in females and 18-27% (mean 22%) body fat in males; obesity is characterized in young adults as body fat >25% in males and >35% in females (WHO 2004).

Waist circumference (WC) was measured using a tape-measure (SANNY®) at the level of the narrowest point between the lower costal border and the iliac crest at the end of a normal exhalation with the arms relaxed at the sides and was categorized in accordance with WHO as WC ≥ 94 cm for men and ≥ 80 cm for women (WHO 2008).

All measurements were taken by a trained research (DZRD; ICC 0.80) to ensure uniformity.

Demographic data – clinical data including age, gender, ethnicity, education level (college/graduate or lower education level), marital status (married/living together/single/divorced/widowed), social classification (high or lower level), smoking status (never, past, and current), alcohol intake, and physical activity per week, all current medications (prescription, over-the-counter, or vitamins), menstrual period, employment status were collected using a standardized data form.

Participants were considered to have clinical comorbidity if they reported a previous physician diagnosis of one of the following: hypertension, diabetes, chronic osteoarticular disease, chronic pulmonary disease, cardiovascular diseases, heart failure, and others. The number of clinical comorbidities was categorized into a comorbidity index: 0, 1, or ≥2 (Owolabi et al., 2017).

Sleep history – some questions of the UNIFESP Sleep Questionnaire was applied, specifically questions 1.14, 1.24. 1.24A, 1.46, 1.51a, 1.51b, 1.52, and 1.54, which allows a subjective assessment of sleep by obtaining general characteristics of sleep quality, such as naps (frequency, day of the week and time of day), conditions of the place where the individual sleeps, sleep problems (frequency), use of sleeping medications, events during sleep, and visits to the doctor for sleep problems. Chronic insomnia complaint was included and defined as the report of regular insomnia symptoms (difficulties initiating/maintaining sleep and early morning awakenings, occurring at least three times a week, during at least 3 months) (Sateia et al., 2014).

Sleep bruxism – was also registered using a specific questionnaire to verify grinding or tighten teeth during sleep. For this purpose, the following two questions were asked: (a) did you have grind, clenching or make noise with his teeth during sleep? and (b) do you use the occlusal splints? Regarding this question, the participants could only answer yes/no/I don't know; additional questions regarding frequency of the occlusal splints use were asked.

Anxiety and Depression – the characteristic attitudes and symptoms of anxiety and depression were evaluated by the Beck Anxiety Inventory (BAI) and Beck Depression Inventory (BDI) respectively, to get the score level.

Sleep measures and definitions

Nocturnal sleep parameters were objectively evaluated by ActTrust® (model AT0503 Condor Instruments, Brazil). The device measures wrist movement time series using the digital

integration method, and was configured to collect data in 30 s, epochs-by-epoch, being scored as either sleep or wake based on whether the accumulation of activity count is below (e.g., sleep) or above the set threshold (e.g., wake).

All participants were invited to wear the devices on the non-dominant wrist for 7 to 10 consecutive days.

The data was downloaded using ActDock® software (Condor Instruments, Brazil) and exported to Microsoft Excel (version 10) for analysis. Collected data applied the proportional integral mode (PIM), in 1 minute epoch (de Souza et al., 2003).

The raw data of PIM were considered for the analysis of the respective parameters. The periods of inactivity indicating device removal were not included in the analysis.

One trained examiner (D.Z.R.D.; ICC 0.97) analyzed the data.

Sleep parameters (Fekedulegn et al., 2020):

1) Time in bed (TIB) is based on the 'event-marker' button on the actigraph and sleep diary, calculated by subtracting the time the participant went to bed (bedtime) from the time to get up (get up time).

2) Sleep period (SLP) was defined from sleep onset (the starting time point of the first continuous block of at least 20 min of sleep with no more than 1 min of interruption) to sleep offset (the last minute the participant was scored asleep before getting out of bed). Objective short sleep duration was defined as averaged nocturnal sleep duration measured by actigraphy <6 hr (Piovezan et al., 2019).

3) Sleep onset latency (SOL) was calculated as the number of minutes from bedtime to the time the participant was scored as asleep for the first time by the algorithm. Normal limits of SOL for adults are <20 min.

4) Sleep efficiency (SE) was defined as the percentage of time spent asleep during the SLP (between onset of persistent sleep and sleep offset). Normal limit for adults is ≥80%.

5) Wake after sleep onset (WASO) refers to the number of minutes a participant was awake between sleep onset and sleep offset. The value considered normal in adults is <10% of total sleep minutes.

6) Number of awakening (NA) is the count of instances when the participant woke up (for 1 or more minutes) during sleep onset and sleep offset. On average, normal values in adults range from 2 to 6 awakenings per night.

7) Mean activity during TIB (AMEAN) was derived by summing the minute-by-minute activity scores during TIB and dividing the sum by duration of TIB in minutes.

8) Sleep fragmentation index (SFX) was defined to the ratio of the number of awakenings to the total sleep time in minutes, during TIB.

9) Chronotype was quantified by calculating the midpoint between the start and end of the SLP.

The sleep diary was simultaneously completed during the period of use of the actigraph to obtain subjective information related to sleep and activity, including bedtime and got up times, time spent sleeping, number of awakenings at night, how did it feel to wake up in the morning, factors that disturbed sleep (noise, light, cell phone, etc.), perceived sleep quality (rested or tired), and time of day that removed the device. If diary entries were unclear or incomplete, clarification of responses was sought and an agreed upon response was entered.

Circadian variables

Non-parametric analysis was used to calculate the following phase markers (Ortiz-Tudela et al., 2010):

i. Activity counts for the most active 10 h period (M10) and start of M10 (Onset-M10): reflects how active the wake periods are.

ii. Activity counts for the least active 5 h period (L5) and start of L5 (Onset-L5): activity levels during the night. Thus, the patterns of activity can be classified into intensity levels7 as follows: light $\leq$ 1951 counts/min, moderate = 1952–5724 counts/min, hard = 5725–9498 counts/min, and very hard $\geq$ 9499 counts/min.

iii. Inter-daily stability (IS): the repetitiveness of the rhythm across consecutive days (i.e., synchronization of the 24 h activity–rest rhythm to the 24 h light–dark cycle). IS ranges from 0 to 1. A high value indicates good synchronization to light and other environmental cues that regulate the biological clock.

iv. Intra-daily variability (IV): fragmentation estimate of the 24 h resting activity rhythm (IV ≈ 0 for a perfect sine wave, IV ≈ 2 for Gaussian noise). A healthy adult has an IV of less than 1.

v. Relative amplitude (RA): the difference between M10 and L5 in the 24 h period. High RA indicates a more robust 24 h rest–activity rhythm. Values near 0 indicate null contrast between wakefulness and sleep, whereas values near 1 express maximal contrast.

vi. Circadian function index (CFI) characterizes the robustness of the rhythm, ranging from 0 to 1.

Complimentary measures

i. Actigraphy also allows the assessment of the chronotype, classifying the participants as early risers versus night owls. Chronotype was quantified by calculating the midpoint between the start and end of SLP and midpoint of TIB (Fekedulegn et al., 2020).

Statistical analysis

Data are presented as the mean value and standard deviation (Me±Sd) or the median value and quartile [Md [(25th – 75th)]. The Wilcoxon test was used to assess the difference between sleep parameters subjective (sleep diary) and objective (actigraphy), and difference between weekdays and weekend sleep parameters. For the analysis, $p < 0.05$ was considered to be statistically significant. Statistical analysis was conducted with SPSS® software, version 21.0 (Chicago, USA).

Supplementary table 1 - Difference between subjective and objective sleep parameters

	Latency (min)			Awakenings (#)		
	Sleep diary	Actigraphy	Z(*p*)	Sleep diary	Actigraphy	Z(*p*)
Case 1	39.29 ± 22.44 [40.00(15.00 – 60.00)]	63.43±63.06 [19.00(16.00 – 127.00)]	-1.183(0.237)	0.29±0.76 [0.00(00.00)]	11.29±5.68 [10.00(5.00 – 15.00)]	-2.375(0.018)[a]
Case 2	10.00 ± 4.63 [10.00(5.00 – 15.00)]	21.33 ± 25.15 [13.00(11.00 – 46.00)]	-1.682(0.092)	4.87±2.30 [4.50(4.00 – 5.00)]	11.33 ± 5.50 [14.00(9.75 – 16.00)]	-2.527(0.012)[a]
Case 3	28.57 ± 17.73 [30.00 (10.00 – 40.00)]	22.86±14.85 [22.00(11.00 – 39.00)]	-0.593(0.553)	0.57±1.51 [0.00(00.00)]	11.14±4.22 [11.00(8.00 – 13.00)]	-2.366(0.018)[a]
Case 4	10.00 ± 3.16 [10.00(8.75 – 11.25)]	35.00±46.39 [10.50(4.50 – 79.75)]	-0.841(0.400)	0.17±0.41 [0.00(0.00 – 0.25)]	2.17±2.56 [2.00(0.00 – 3.25)]	-1.890(0.059)

Data are presented as mean and standard deviation (Me±Sd) and median and quartile [Md [(25th – 75th)].
[a]Significantly different ($p<0.05$) by Wilcoxon test.

Supplementary Table 2 – Difference between weekdays and weekend sleep parameters

Sleep parameters	Case 1	Case 2	Case 3	Case 4
Bedtime				
Weekdays	01:45±0.38 [01:46(01:13 – 02:22)]	01:31±1.54 [00:50(00:08 – 01:22)]	22:21±0.37 [22:28(21:30 – 23:30)]	02:40±1.43 [02:16(01:27 – 04:49)]
Weekend	03:13±0.55 (03:13)	02:31±3.15 (02:31)	02:50±1.53 (02:50)	00:25±12.25 (00:25)
Get up time				
Weekdays	09:46±1.49 [08:56(08:25 – 11:33)]	10:01±3.07 [08:40(07:34 – 11:09)]	07:30±1.00 [07:20(07:30 – 09:10)]	8:26±1.50 [07:54(07:50 – 08:00)]
Weekend	10:41±2.32 (10.41)	10:20±2.35 (10:20)	10:20±0.28 (10:20)	08:15±0.21 (08:15)
TIB (hrs)				
Weekdays	482.60±116.00 [(462.00(375.00 - 600.50)]	444.29±59.00 [478.50(436.50 – 551.50)]	475.60±110.05 [516.00(391.00 – 540.00)]	346.50±32.52 [353.50(312.50 – 373.50)]
Weekend	448.50±96.87 (448.50)	469.50±40.31 (469.50)	451.00±141.42 (451.00)	471.00±56.57 (471.00)
SLP – Onset				
Weekdays	03:33±0.58 [03:46(02:31 – 04:27)]	03:30±4.04 [01:53(00:28 – 05:22)]	23:09±0.22 [22:55(22:16 – 23:37)]	03:23±2.09 [02:42(01:46 – 05:40)]
Weekend	04:23±1.44 (04:23)	03:32±3.59 (03:32)	03:29±2.20 (03:29)	01:42±0.02 (01:42)
SLP – Offset				
Weekdays	09:33±2.00 [08:39(08:00 – 11:56)]	09:57±2.52 [08:35(07:49 – 10:06)]	07:27±1.00 [07:08(06:16 – 07:30)]	08:18±1.59 [07:51(06:43 – 10:18)]
Weekend	10:41±2.32 (10.41)	10:04±2.17 (10:04)	10:14±0.28 (10:14)	08:13±0.21
SLP (hrs)				
Weekdays	361.40±112.50 [344.00(254.00 – 477.50)]	387.57±52.79 [416.00(376.50 – 480.50)]	422.20±116.07 [462.00(334.00 – 490.50)]	295.5±33.16 [281.00(276.00 – 329.50)]
Weekend	379.00±48.08 (379.00)	393.00±101.82 (393.00)	405.50±169.00 (405.50)	392.50±24.75 (392.50)
Midpoint of the SLP				
Weekdays	05:27±0.97 [05:37(05:03 – 06:56)]	06:25±2.10 [04:40(03:53 – 06:28)]	04:52±1.11 [04:28(04:13 – 05:40)]	05:33±1.76 [05:08(04:18 – 07:23)]
Weekend	06:57±1.74 (06:57)	06:25±2.93 (06:6.25)	06:35±0.71 (06:51)	04:35±0.47 (04:35)
Sleep onset latency (min)				
Weekdays	68.60±72.47 [19.00(15.50 – 146.50)]	15.57±18.95 [13.00(8.25 – 26.00)]	24.20±11.52 [22.00(15.00 – 34.50)]	23.75±29.60 [10.50(6.75 – 54.00)]
Weekend	50.50±48.79 (50.50)	41.50±43.13 (41.50)	19.50±27.58 (19.50)	57.50±81.32 (57.50)
Sleep efficiency (%)				

Weekdays	87.51±2.95 [86.92(84.88 – 90.44)]	80.33±12.50 [74.94(66.63 – 90.26)]	90.35±2.47 [90.53(88.47 – 92.13)]	96.73±5.62 [99.28(90.91 – 100.00)]
Weekend	89.14±5.52 (89.14)	86.88±10.96 (86.88)	88.36±8.05 (88.36)	89.23±14.09 (89.23)
WASO (min)				
Weekdays	46.00±21.13 [45.00(29.50 – 63.00)]	78.43±47.88 [100.00(46.25 – 128.00)]	39.00±9.30 [43.00(29.00 – 47.00)]	9.25±15.35 [2.50(0.00 – 25.25)]
Weekend	42.50±26.16 (42.50)	46.00±29.68 (46.00)	54.00±52.33 (54.00)	44.00±57.98 (44.00)
Number of awakenings (#)				
Weekdays	10.80±6.65 [10.00(5.00 – 17.00)]	11.57±5.08 [15.00(11.25 – 16.00)]	10.60±2.07 [11.00(8.50 – 12.50)]	2.25±3.30 [1.00(0.00 – 5.75)]
Weekend	12.50±3.54 (12.50)	10.50±2.12 (10.50)	12.50±9.19 (12.50)	2.00±00.00(2.00)
Mean activity (counts/min)				
Weekdays	205.55 ± 39.35 [209.29(170.16 – 239.07)]	295.40 ± 167.80 [324.71 (139.45 – 414.28)]	179.68 ± 24.89 [164.06(161.10 - 206.07)]	106.37 ± 100.14 [65.68 (44.29 – 209.14)]
Weekend	178.13 ± 23.94 (178.13)	285.10 ± 139.45 (285.10)	229.97±120.9 (229.97)	151.17 ± 78.58 (151.17)
Sleep fragmentation index (%)				
Weekdays	2.95±1.21 [2.80(1.96 – 4.02)]	3.52±1.72 [4.59(2.86 – 4.93)]	2.73±0.68 [2.57(2.21 – 3.31)]	0.80±1.27 [0.28(0.00 – 2.14)]
Weekend	3.48±0.78 (3.48)	3.15±1.69(3.15)	3.13±1.49 (3.13)	0.54±0.050.54)
Z(*p*)	-0.345 (0.730)	-0.345 (0.730)	-1.099 (0.272)	-0.471 (0.638)

Data are presented as mean and standard deviation (Me±Sd) and median and quartile [Md [(25th – 75th)]; TIB = Time in bed; SLP = Sleep period.
The hours are displayed in 24-hour system (hh:mm).
[a]Significantly different ($p<0.05$) by Wilcoxon test.

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3 DISCUSSÃO

Neste estudo a actigrafia foi utilizada como um método alternativo à polissonografia, a qual é considerada padrão ouro para avaliação do sono, por causa das múltiplas vantagens amplamente documentadas na literatura (Ancoli-israel et al., 2003, Kanady et al., 2011; van Hees et al., 2018; Guillodo et al., 2020). A actigrafia é considerada menos invasiva, de menor custo, mais confortável para o indivíduo, e permite a coleta por vários dias para estimar os parâmetros do sono; além disso, o dispositivo utilizado neste trabalho permitiu a obtenção de diversas porções dos espectros de luz para inferir indiretamente o ritmo circadiano.

Embora o estudo careça de dados prévios ao isolamento social pela Covid 19, os resultados objetivos mostraram três dimensões dos comportamentos do sono significativamente alterados durante esse período que foram similares às avaliações subjetivas realizadas em estudos prévios (Blume et al., 2020; Wright et al., 2020). Observou-se a duração do sono suficiente (>7h) ou insuficiente (≤6h), irregularidade na hora de ir dormir (sendo caracterizada como tardio, isto é, após meia noite) e um desalinhamento entre o tempo de sono-vigília externo (social) e interno (biológico), que provavelmente se deveu ao aumento da flexibilidade dos horários sociais dos participantes. Tais comportamentos do sono foram considerados inadequados.

A análise do padrão circadiano baseado na actigrafia de punho permitiu observar em ambos os estudos o início de L5 após meia noite, o que provavelmente influiu no início tardio de M10 (no meio da manhã, entre às 9h e 10h). Esses achados sugerem desalinhamento com o ciclo claro-escuro, sem relações entre o pôr-do-sol e a hora de dormir, e o nascer do sol e a hora de vigília. Esse comportamento foi agravado durante o período de isolamento social como relatado em estudo anterior (Wright et al., 2020). Nos participantes da série de casos essa característica pode estar justificada pela participação no estudo durante o período de férias, o que pode ter determinado um comportamento diferente aos dias rotineiros de estudo ou trabalho, o que por sua vez, poderia justificar os baixos a moderados escores de ansiedade e depressão. Considerando as características antropométricas destes participantes, tais resultados são contrários aos relatados na literatura que mostraram altos níveis de ansiedade e depressão em indivíduos com obesidade (Quick et al., 2014; Barragán et al., 2021).

Embora na literatura seja relatada uma relação controversa entre duração insuficiente do sono e obesidade (Hasler et al., 2004; Theorell-Haglöw et al., 2016; Zuraikat et

al., 2020), os participantes da série de casos, com obesidade e sobrepeso (Caso 3) apresentaram duração do sono relativamente normal (7 horas), enquanto o participante Caso 4 (sobrepeso) apresentou curta duração do sono (<6 horas). No entanto, em todos os participantes observou-se parâmetros que indicam um sono inconsistente, como alto número de despertares (≥6 por noite) e mais do 10% de WASO, sendo considerados fatores de risco para o desenvolvimento de alterações metabólicas em indivíduos jovens na sociedade atual (Broussard e Van Cauter, 2016; Martinez Aguirre-Betolaza et al., 2019; Blume et al., 2020), concordando com estudo anterior (Fatima et al., 2016) no qual, apenas a duração do sono pode não ajudar a desemaranhar a associação sono-obesidade.

Os resultados de ambos os estudos sugerem que, por tratar-se maioritariamente de estudantes universitários, é importante a manutenção de um esquema de sono mais consistente, com horários regulares de sono em ambiente adequado e específico para tal, uso com parcimônia de equipamentos eletrônicos em horários adequados, evitar bebidas estimulantes antes de deitar e evitar luminosidade durante o sono. Esses cuidados e/ou hábitos podem contribuir para mitigar as alterações do sono reportadas no presente trabalho (Veeramachaneni et al., 2019).

Considera-se que o uso de 7 dias de actigrafia e diários de sono podem ser suficientes para atingir confiabilidade aceitável para o estudo do sono. Embora tenha sido sugerido mais dias de avaliação, poderia haver comprometimento da adesão de participantes à pesquisa pelos detalhes metodológicos que uso do actígrafo requer, além do preenchimento do diário do sono, ações estas que embora simples, requerem disciplina (Veeramachaneni et al., 2019). A metodologia adotada forneceu um protocolo claro e detalhado da pontuação do sono e a sensibilidade e a acurácia do actígrafo utilizado foram previamente verificadas (Rodrigues e Eckelli, 2018), mas considera-se que a polissonografia é o padrão ouro. Deve-se considerar que a aquisição dos dados se deu em uma amostra pequena de adultos de diferentes idades e perfis corporais, tornando os resultados intrínsecos à referida amostra. Embora os dados da série de casos tenham mostrado a importância de se fazer um elo entre os dados objetivos, como os obtidos pela actigrafia, e a percepção da qualidade do sono, na tentativa de compreender melhor os aspectos envolvidos, como por exemplo as características psicoemocionais e antropométricas, estabelecer a relação causal depende da abordagem precisa dos aspectos multifatoriais envolvidos (Fatima et al., 2016).

4 CONCLUSÃO

(1) A actigrafia permitiu inferir que durante o isolamento social os indivíduos apresentavam ritmo circadiano irregular, parâmetros de sono inconsistentes e diminuição da exposição à luz do dia durante a manhã.

(2) A série de casos mostrou que um baixo acoplamento do ritmo repouso-atividade, pode gerar mais despertares noturnos e movimentos durante a fase de sono, comprometendo a qualidade do repouso de indivíduos com sobrepeso e obesidade.

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*De acordo com as normas da UNICAMP/FOP, baseadas na padronização do International Committee of Medical Journal Editors – Vancouver Group. Abreviatura dos periódicos em conformidade com o PubMed.

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APÊNDICES

APÊNDICE 1 – Informações técnicas do actígrafo

O actígrafo ActTrust® é um dispositivo que contém diversos sensores que detectam e registram simultaneamente variáveis como o movimento, a temperatura e a luz. Além disso o aparelho possui o botão marcador de evento. Todos esses recursos permitem melhorar a estimativa da pontuação do sono e oferecem informações importantes sobre o comportamento do indivíduo durante o período de 24h, por tanto, eles serão descritos brevemente, como segue:

O acelerômetro é um sensor para detecção do movimento (localizado no interior do dispositivo, não visível) e quando este ocorre, o dispositivo produz um sinal elétrico contínuo (voltagem) que é transduzido em uma forma elétrica analógica, por exemplo, na taxa de 10 hertz (10 Hz) – ou seja, 10 amostras por segundo. Os sinais são processados de três modos diferentes, a saber:

a) Modo de cruzamento zero (Zero Crossing Mode, ZCM) refere-se à contagem do número de vezes por minuto que o sinal do transdutor cruza um limite de referência predefinido que geralmente é um valor definido próximo de zero (Figura 1). Por exemplo, este modo registra com facilidade movimentos frequentes que podem ser um sinal de vigília, enquanto o movimento infrequente pode ser uma ocorrência normal durante sono (Haghayegh et al., 2020).

b) Modo tempo acima do limiar (Time Above Threshold, TAT) refere-se à quantidade de tempo, em décimos de segundo, gasto acima do limite de sensibilidade que é acumulado durante um minuto. O TAT é uma medida de tempo gasto em movimento – ou seja duração do movimento (Figura 1), por exemplo, a longa duração dos movimentos durante o período de sono pode ser associada a luzes acesas, que podem ser usadas para monitorar despertares noturnos, por exemplo, idas ao banheiro (Tsanas et al. 2020).

c) Modo de integração proporcional (Proportional Integration Mode, PIM) é a medição de alta resolução da área sob o sinal do transdutor, e, em seguida, é calculada a área sob a curva para cada minuto (Figura 1). O PIM é uma medida do nível de atividade ou vigor do movimento ou intensidade do movimento, por exemplo, este modo pode distinguir entre movimento intenso, que pode ser um sinal de vigília; e movimento muito fraco, que normalmente pode ocorrer durante o sono noturno (Kosmadopoulos et al., 2014; Fekedulegn et al., 2020).

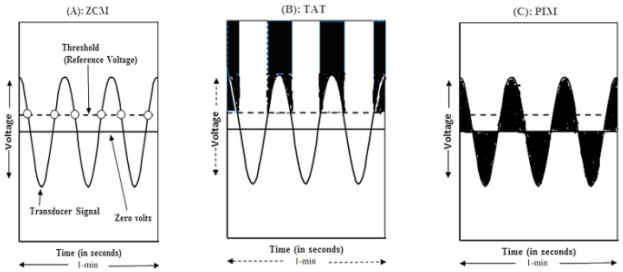


Figura 1 – Representação esquemática dos três modos em que os dados de movimento do pulso são digitalizados pelo actígrafo Motionlogger Sleep Watch®. Painel A, o modo de cruzamento zero (ZCM). Painel B, o modo tempo acima do limiar (TAT). Painel C, o modo de integração proporcional (PIM). Figura de Fekedulegn et al. (2020) que foi adaptada de Jean-Louis et al. (2001).

O sensor de temperatura fica localizado na parte posterior do dispositivo (Figura 2), para aferição da temperatura distal da pele, em graus centigrados. A superfície posterior do actígrafo deve permanecer em contato com a pele do punho não dominante durante o período de amostragem.

Figura 2 – Sensores do actigrafo: temperatura (A), luxímetro (B) e botão marcador de evento (C).

O sensor de luz detecta e grava o espectro de luz (Figura 2); o dispositivo registra luz ambiente, luz vermelha, luz verde, luz azul, e luz infravermelha separadamente. A exposição à luz é medida em luxes [lux].

O botão marcador de evento localiza-se na parte anterior do dispositivo (círculo azul, Figura 2). É um recurso que permite identificar eventos importantes como o momento de se deitar na cama pela primeira vez, quando as luzes estão apagadas e ao se levantar pela manhã. Nesses momentos os participantes devem apertar o botão até escrutar o sinal sonoro.

APÊNDICE 2 – Ficha de avaliação clínica e antropométrica

Data da avaliação: _____/ _____/ _____.

Nome Completo: _____. Idade:_____

anos Data de nascimento: _____ Sexo: F ( ) M ( )

Número de celular (wsp): ___/_____ Endereço: _____ N°___

Bairro:_____ Cidade:_____ Estado:_____.

Horários Disponíveis:_____. Profissão: _____.

1. Anamnese

Fuma: Sim ( ) Não ( ) há quantos tempo: _____ frequência: _____
Etilismo: Sim ( ) Não ( ) há quanto tempo: _____frequência_____
Usa medicamentos: Sim ( ) não ( ) qual _____ frequência_____
Doenças: Diabetes Sim ( ) Não ( ) tipo (1) (2) medicamento: _____
Cardiovascular: Sim ( ) Não ( ) Pressão arterial _____mm/Mg
Medicamentos: _____
Período menstrual regular ( ) irregular ( )
Você está nos 5 dias antes do seu período menstrual Sim ( ) Não ( )
Você está nos 5 dias após do seu período menstrual Sim ( ) Não ( )
Você pratica atividade física: Sim ( ) Não ( )
Qual atividade física: _____
Com que frequência você a pratica:
1 dia por semana ( ) 3 dias por semana ( ) todos os dias da semana ( ) só final de semana ( )
Quanto tempo você faz essa atividade (min/h): 20 ( ) 30 ( ) 40 ( ) 1h ( ) 1h30 ( ) 2h ( )

2. Histórico Familiar (Câncer, doença cardiovascular, etc) _____

1ª avaliação antropométrica

Dados antropométricos: Peso: _____Kg Altura: _____m IMC: _____Kg/m^2

Dobras cutâneas

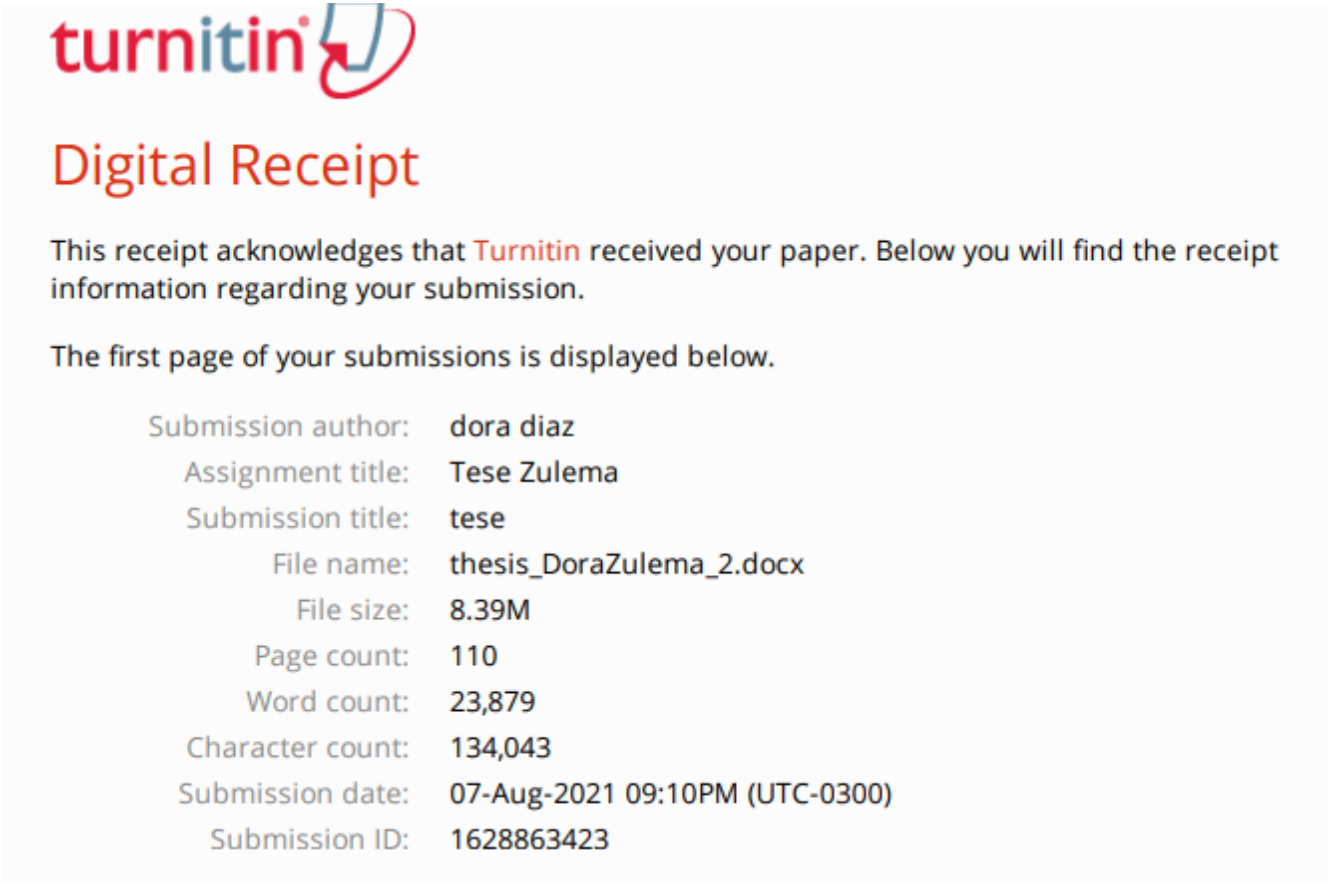
1. Subescapular _____ mm
2. Tríceps _____mm
3. Pectoral _____mm
4. Bíceps _____ mm
5. Axilar média _____ mm
6. Supra ilíaco _____ mm
7. 1 Abd. vertical _____ mm
7. 2 Abd. horizontal _____ mm
8. Coxa média _____ mm

Perímetros corporais

1. Cervical _____mm
2. Tórax _____mm
3. Braço (bíceps) _____ mm
4. Cintura _____ mm
5. Abdominal _____ mm
6. Quadril _____ mm
7. Coxa média _____ mm

ANEXO 1 – Verificação de originalidade e prevenção do plágio

PADRÃO DE RITMO CIRCADIANO SONO-VIGÍLIA EM ADULTOS OVENS POR ACTIGRAFIA



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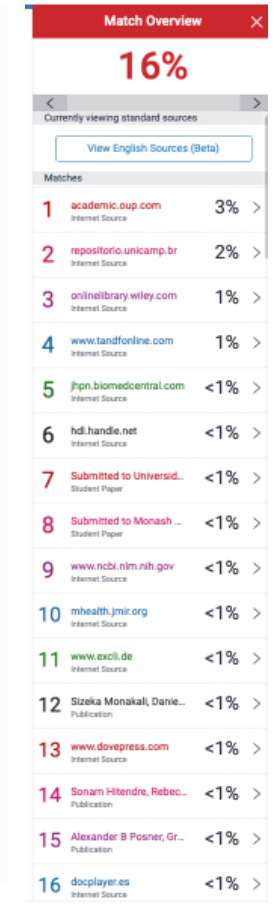

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ANEXO 2 – Aprovação do comitê de ética

COMITÊ DE ÉTICA EM PESQUISA
FACULDADE DE ODONTOLOGIA DE PIRACICABA
UNIVERSIDADE ESTADUAL DE CAMPINAS

CERTIFICADO

O Comitê de Ética em Pesquisa da FOP-UNICAMP certifica que o projeto de pesquisa "Relação entre bruxismo, qualidade do sono e variáveis corporais", CAAE 95764718.6.0000.5418, dos pesquisadores Dora Zulema Romero Díaz e Maria Beatriz Duarte Gavião, satisfaz as exigências das resoluções específicas sobre ética em pesquisa com seres humanos do Conselho Nacional de Saúde – Ministério da Saúde e foi aprovado por este comitê em 01/10/2018.

The Research Ethics Committee of the Piracicaba Dental School of the University of Campinas (FOP-UNICAMP) certifies that research project "Relationship between bruxism, sleep quality and body variables", CAAE 95764718.6.0000.5418, of the researcher's Dora Zulema Romero Díaz and Maria Beatriz Duarte Gavião, meets the requirements of the specific resolutions on ethics in research with human beings of the National Health Council - Ministry of Health, and was approved by this committee on October, 101 2018.

Profa. Fernanda Miori Pascon

Vice Coordenador
CEP/FOP/UNICAMP

Prof. Jacks Jorge Junior

Coordenador
CEP/FOP/UNICAMP

Nota: O título do protocolo e a lista de autores aparecem como fornecidos pelos pesquisadores, sem qualquer edição.
Notice: The title and the list of researchers of the project appears as provided by the authors, without editing.

ANEXO 3 – Comprovante de submissão ao periódico

Original Articles

Sleep-wake circadian rhythm pattern in young adults during social isolation by actigraphy

Dora Zulema Romero Díaz

zulema.romero@hotmail.com

Affiliation(s): 1 University of Campinas, Piracicaba Dental School, Department of Biosciences - Piracicaba - São Paulo - Brazil

Maria Beatriz Gavião

mbgaviao@unicamp.br

Affiliation(s): 2 University of Campinas, Piracicaba Dental School, Department of Health Sciences and Pediatric Dentistry - Piracicaba - São Paulo - Brazil

Total: 2 Authors

ABSTRACT

Study Objectives: This study investigated, through wrist actigraphy, the activity-rest pattern, estimate nocturnal sleep parameters, and quantify the exposure of light (daylight and blue light) during social isolation due to COVID-19. **Methods**: The participants (n = 19, aged 19 - 33 years-old) wore the actigraph in nondominant wrist for 7 days. Derivation of 25 nocturnal sleep parameters was inferred from PIM mode raw data including sleep, wake, activity, and fragmentation statistics. A hierarchical cluster analysis determined the participants profiles. Mann-Whitney and independent Student t tests, linear stepwise regression and Kendalls test were applied. The significant level was a = 0.05. **Results**: Two clusters were formed, normal sleepers (n = 13) and short sleepers (n = 6). The participants of both clusters went to sleep after midnight, spent approximately 1 h of being awake during time in bed, their latency to persistent sleep was normal, though true sleep minutes was less than 7 h, showed a normal sleep efficiency. Daytime activity was moderate, and a circadian rhythm was irregular. The regressions showed that bedtime and nocturnal activity contributed to the variance of daytime activity and the beginning of it ($p < 0.001$). The midpoint during the time in bed was the most significant predictor for the start of less period activity at night ($p < 0.001$). **Conclusions**: Actigraphy inferred that during social isolation the individuals presented, despite normal sleep latency and efficiency, inconsistent sleep parameters and irregular circadian rhythm. Moreover, decreased exposure to daylight during the morning was observed.

HEADINGS: Actigraphy. Circadian rhythm. Social isolation

Funding source: Conselho Nacional de Desenvolvimento Científico e Tecnológico, Brazil (CNPq) - scholarship for the first author (process number 147405/2017-3.

Conflict of interest: No

Clinical Trials? No

Ethics committee number: 95764718.6.0000.5418

Submission date: Saturday, July 24, 2021

ANEXO 4 – Inventário de Ansiedade de Beck

Este questionário contém 21 sintomas. Eu vou ler cada sintoma em voz alta, um por um. Depois de cada sintoma que eu ler, quero que o(a) Sr.(a) me diga se o(a) Sr.(a) não se incomodou absolutamente, se incomodou levemente, moderadamente ou gravemente por causa deste sintoma, durante a última semana, incluindo hoje. Isso inclui agora.

"Levemente" significa que o sintoma não o incomodou muito; "moderadamente" significa que o(a) Sr.(a) ficou muito incomodado por causa do sintoma; e "gravemente" significa que o(a) Sr.(a) dificilmente podia suportar.

	Absolutamente não (0)	**Levemente (1)** Não me incomodou muito	**Moderadamente (2)** Foi desagradável mas pude suportar	**Gravemente (3)** Dificilmente pude suportar
.1-Dormência ou formigamento	☐	☐	☐	☐
.2-Sensação de Calor	☐	☐	☐	☐
.3-Tremores nas pernas	☐	☐	☐	☐
.4-Incapaz de relaxar	☐	☐	☐	☐
.5-Medo que aconteça o pior	☐	☐	☐	☐
.6-Atordoado(a) ou tonto(a)	☐	☐	☐	☐
.7-Palpitação ou aceleração do coração	☐	☐	☐	☐
.8-Sem equilíbrio	☐	☐	☐	☐
.9-Aterrorizado(a)	☐	☐	☐	☐
.10-Nervoso(a)	☐	☐	☐	☐
.11-Sensação de sufocação	☐	☐	☐	☐
.12-Tremores nas mãos	☐	☐	☐	☐
.13-Trêmulo(a)	☐	☐	☐	☐
.14-Medo de perder o controle	☐	☐	☐	☐
.15-Dificuldade de respirar	☐	☐	☐	☐
.16-Medo de morrer	☐	☐	☐	☐
.17-Assustado(a)	☐	☐	☐	☐
.18-Indigestão ou desconforto no abdômen	☐	☐	☐	☐
.19-Sensação de desmaio	☐	☐	☐	☐
.20-Rosto afogueado	☐	☐	☐	☐
.21-Suor (não devido ao calor)	☐	☐	☐	☐

Data da avaliação _____

ANEXO 5 – Inventário de depressão de Beck

Data: ____/____/____
dia mês ano

INSTRUÇÕES:

Leia, por favor, todas as frases expostas a seguir e escolha, em cada grupo, aquela que descreve ou constitui a descrição mais aproximada da maneira como tem vindo a sentir:

A Não me sinto triste..... ( )
Ando "neura" ou triste..... ( )
Sinto-me "neura" ou triste todo o tempo e não consigo evitá-lo..... ( )
Estou tão triste ou infeliz todo o tempo e não consigo evitá-lo..... ( )
Sinto-me tão triste ou infeliz que não consigo suportar mais este estado..... ( )

B Não estou demasiado pessimista nem me sinto desencorajado em relação ao futuro..... ( )
Sinto-me com medo do futuro..... ( )
Sinto que não tenho nada a esperar do que surja no futuro..... ( )
Creio que nunca conseguirei resolver os meus problemas..... ( )
Não tenho qualquer esperança no futuro e penso que a minha situação não pode melhorar..... ( )

C Não tenho a sensação de ter fracassado..... ( )
Sinto que tive mais fracassos que a maioria das pessoas..... ( )
Sinto que realizei muito pouca coisa que tivesse valor ou significado..... ( )
Quando analiso a minha vida passada, tudo o que noto são uma quantidade de fracassos..... ( )
Sinto-me completamente falhado como pessoa (pai, mãe, marido, mulher) ..... ( )

D Não me sinto descontente com nada em especial..... ( )
Sinto-me aborrecido a maior parte do tempo..... ( )
Não tenho satisfação com as coisas que me alegravam antigamente..... ( )
Nunca mais consigo obter satisfação seja com o que for..... ( )
Sinto-me descontente com tudo..... ( )

E Não me sinto culpado de nada em particular..... ( )
Sinto-me bastante culpado..... ( )
Agora, sinto permanentemente que sou mau e não valho absolutamente nada..... ( )
Considero que sou mau e não valho absolutamente nada..... ( )

F Não sinto que esteja a ser vítima de algum castigo..... ( )
Tenho o pressentimento de que me pode acontecer alguma coisa de mal..... ( )
Sinto que estou a ser castigado ou que em breve serei castigado..... ( )
Sinto que mereço ser castigado..... ( )
Quero ser castigado..... ( )

G Não me sinto descontente comigo..... ( )
Estou desiludido comigo..... ( )
Não gosto de mim..... ( )
Estou bastante desgostoso comigo..... ( )
Odeio-me..... ( )

H Não sinto que seja pior do que qualquer outra pessoa..... ( )
Critico-me a mim mesmo pelas minhas fraquezas ou erros..... ( )
Culpo-me das minhas próprias faltas..... ( )
Acuso-me por tudo de mal que acontece..... ( )

I	Não tenho quaisquer ideias de fazer mal a mim mesmo……	( )
	Tenho ideias de pôr termo à vida, mas não sou capaz de as concretizar……...	( )
	Sinto que seria melhor morrer……....	( )
	Creio que seria melhor para a minha família se eu morresse…….	( )
	Tenho planos concretos sobre a forma como hei-de por termo à vida…….....	( )
	.	
	Matar-me-ia se tivesse oportunidade……....	( )
J	Actualmente não choro mais do que o costume……...	( )
	Choro mais agora do que costumava…….....	( )
	Actualmente passo o tempo a chorar e não consigo parar de fazê-lo…….....	( )
	Costumava ser capaz de chorar, mas agora nem sequer consigo, mesmo quando tenho vontade.....	( )
K	Não fico agora mais irritado do que ficava……...	( )
	Fico aborrecido ou irritado mais facilmente do que ficava……..	( )
	Sinto-me permanentemente irritado……....	( )
	Já não consigo ficar irritado por coisas que me irritavam anteriormente……..	( )
L	Não perdi o interesse que tinha por outras pessoas……	( )
	Actualmente sinto menos interesse pelos outros do que costumava ter…….....	( )
	Perdi quase todo o interesse pelas outras pessoas, sentindo pouca simpatia por elas……...	( )
	Perdi por completo o interesse pelas outras pessoas, não me importando absolutamente com nada a seu respeito…….	( )
M	Sou capaz de tomar decisões tão bem como antigamente…….	( )
	Actualmente sinto-me menos seguro de mim mesmo e procuro evitar tomar decisões…….....	( )
	Não sou capaz de tomar decisões sem a ajuda de outras pessoas…….....	( )
	Sinto-me completamente incapaz de tomar qualquer decisão……...	( )
N	Não acho que tenho pior aspecto do que costumava…….	( )
	Estou aborrecido porque pareço velho e pouco atraente……...	( )
	Sinto que se deram modificações permanentes na minha aparência que me tornaram pouco atraente…….....	( )
	Sinto que sou feio ou que tenho um aspecto repulsivo……...	( )
O	Sou capaz de trabalhar tão bem como antigamente……...	( )
	Agora preciso de um esforço maior do que antes para começar a trabalhar…….....	( )
	Não consigo trabalhar tão bem como de costume……...	( )
	Tenho que despender um grande esforço para fazer seja o que for…….....	( )
	Sinto-me incapaz de realizar qualquer trabalho por mais pequeno que seja…….....	( )
P	Consigo dormir tão bem como antes…….....	( )
	Acordo mais cansado de manhã do que o habitual……	( )
	Acordo cerca de 1 a 2 horas mais cedo do que o costume e custa-me voltar a adormecer…….....	( )
	Acordo todos os dias mais cedo do que o costume e não durmo mais do que 5 horas…….....	( )
Q	Não me sinto mais cansado que o habitual……...	( )
	Fico cansado com mais facilidade do que antigamente…….	( )
	Fico cansado quando faço seja o que for…….....	( )
	Sinto-me tão cansado que sou incapaz de fazer o que quer que seja…….....	( )

R O meu apetite é o mesmo de sempre..... ( )
O meu apetite não é tão bom como costumava ser..... ( )
Actualmente o meu apetite está muito pior do que anteriormente..... ( )
Perdi por completo todo o apetite que tinha..... ( )

S Não tenho perdido muito peso, se é que perdi algum, ultimamente..... ( )
Perdi mais de 2,5 quilos de peso..... ( )
Perdi mais de 5 quilos de peso..... ( )
Perdi mais de 7,5 quilos de peso..... ( )

T A minha saúde não me preocupa mais do que o habitual..... ( )
Sinto-me preocupado com dores e sofrimentos,com má disposição do estômago ou prisão de ventre ou ainda outras sensações físicas desagradáveis..... ( )
Estou tão preocupado com a maneira como me sinto ou com aquilo que sinto, que se torna difícil pensar noutra coisa..... ( )
Encontro-me totalmente preocupado com a maneira como me sinto..... ( )

U Não notei qualquer mudança recente no meu interesse pela vida sexual..... ( )
Encontro-me menos interessado na vida sexual do que costumava estar..... ( )
Actualmente sinto-me muito menos interessado pela vida sexual..... ( )
Perdi completamente o interesse que tinha pela vida sexual..... ( )

ANEXO 6 – Questionário do Sono – UNIFESP

Endereço de acesso: http://repositorio.unifesp.br/handle/11600/10000

1.14-O(A) Sr.(a) costuma dormir durante o dia, mesmo que só em algum ou alguns dos 7 dias da semana, fora do seu horário normal de sono? ☐ Não (PPP 1.19) ☐ Sim ☐ Outro: _____

1.15-Em que dia da semana ou feriado o(a) Sr.(a) dorme durante o dia fora do horário normal de sono? **(ESPONTÂNEA E MÚLTIPLA)**

☐ 2ª a 5ª feira	☐ 6ª feira	☐ Sábado	☐ Domingo	☐ Feriado	☐ Irregular/ não tem dia certo

1.16- E nesses dias em que o(a) Sr.(a) dorme durante o dia, quantas horas costuma dormir?

2ª a 5ª feira	:	hh: mm
6ª feira	:	hh: mm
Sábado	:	hh: mm
Domingo	:	hh: mm
Feriados	:	hh: mm
Irregular/ não tem dia certo	:	hh: mm

1.17-Qual foi o último dia que o(a) Sr.(a) dormiu durante o dia? ☐ Não lembra ☐ Lembra / / dd / mm / aa

1.18-Quantas horas o(a) Sr(a) dormiu neste dia? ☐ Não lembra ☐ Lembra : hh: mm

1.19-O Sr(a) gostaria ou precisaria mudar alguma coisa no seu horário de dormir ou no tempo de sono?

1.24- Agora eu vou ler 5 problemas de sono e gostaria que o(a) Sr.(a) me dissesse se tem cada um deles.
(LEIA UM POR UM E REGISTRE A FREQÜÊNCIA NO QUADRO II) **(SE NÃO POSSUI NENHUM PROBLEMA PPP 1.29)**

1.24 A- **(APRESENTAR CARTÃO DE FREQÜÊNCIA)** Com que freqüência você costuma:

(RODÍZIO)	**P. 1. 24**		Freqüência	**P. 1. 24 A**				
	Não	Sim	Diária	3-6 x/sem	1-2 x/sem	2-3 x/mês	1 x/mês	Menos de 1 x/mês
A-Dificuldade para dormir ou para pegar no sono	☐	☐	☐	☐	☐	☐	☐	☐
B-Acorda muito durante a noite	☐	☐	☐	☐	☐	☐	☐	☐
C-Acorda antes da hora e não consegue dormir outra vez rapidamente	☐	☐	☐	☐	☐	☐	☐	☐
D-Ataques de sono incontroláveis, chegando a dormir repentinamente.	☐	☐	☐	☐	☐	☐	☐	☐
E-Muita sonolência durante o dia, chegando a prejudicar suas atividades.	☐	☐	☐	☐	☐	☐	☐	☐

1.46- Existem algumas coisas que podem acontecer durante o sono. Às vezes a gente só percebe quando acorda, exatamente porque acorda por isso.
(APRESENTAR CARTÃO DE FREQÜÊNCIA) Eu vou ler uma lista dessas coisas e gostaria que o (a) Sr.(a) me dissesse se costumam acontecer com o (a) Sr.(a) e com que freqüência?

(RODÍZIO)	**SIM**						**NÃO**
	Diária	3-6x/sem	1-2x/sem	2-3x/mês	1x/mês	Menos de 1x/mês	Não /Nunca
F) Sentar-se ou levantar-se e andar dormindo	☐	☐	☐	☐	☐	☐	☐
G) Ranger os dentes	☐	☐	☐	☐	☐	☐	☐
H) Engolir e sentir-se sufocado	☐	☐	☐	☐	☐	☐	☐
I) Crises epilépticas ou ataques	☐	☐	☐	☐	☐	☐	☐
J) Crises de asma	☐	☐	☐	☐	☐	☐	☐
K) Acordar em pânico chorando e gemendo	☐	☐	☐	☐	☐	☐	☐
L) Taquicardia ou batedeira no coração	☐	☐	☐	☐	☐	☐	☐
M) Azia ou queimação no estômago	☐	☐	☐	☐	☐	☐	☐
N) Sentir-se paralisado, sem poder se mexer, alguns momentos antes de adormecer ou imediatamente após acordar	☐	☐	☐	☐	☐	☐	☐

O) Acordar por causa de uma dor de cabeça	☐	☐	☐	☐	☐	☐	☐
P) Acordar ansioso após pesadelo	☐	☐	☐	☐	☐	☐	☐
Q) Roncar	☐	☐	☐	☐	☐	☐	☐
R) Ter câimbras	☐	☐	☐	☐	☐	☐	☐
S) Falar dormindo	☐	☐	☐	☐	☐	☐	☐
T) Chutar ou movimentar bruscamente as pernas	☐	☐	☐	☐	☐	☐	☐
U) Chupar o dedo dormindo	☐	☐	☐	☐	☐	☐	☐
V) Urinar na cama, dormindo	☐	☐	☐	☐	☐	☐	☐

(SE NUNCA EM TODAS AS ALTERNATIVAS, PPP 1.50)

1.51a)- O(a) Sr.(a) já consultou um médico por causa de problemas de sono? ☐ Não ☐ Sim

1.51b)- Por que consultou ou não consultou um médico?

1.52-O(A) Sr.(a) faz algum tipo de atividade física regularmente? **(SE SIM)** Qual? **(MÚLTIPLA)**

☐ Não (PPP 1.56) ☐ Sim Qual tipo? **(ANOTE)**

1.54-Com que freqüência o(a) Sr.(a) faz atividade física? **(ESTIMULADA)**

☐ Diariamente ☐ 3-6 vezes/semana ☐ 1-2 vezes/semana ☐ Menos de 1 vez/semana

1.55-O(A) Sr.(a)tem alguma pessoa que o(a) orienta na atividade física? ☐ Não ☐ Sim

Anexo 7 – Questionário sobre Bruxismo do sono

6.1-Nos últimos 6 meses o(a) Sr.(a) teve mais de uma vez:

	Não	Sim
Dor de cabeça?	☐	☐
Dor no rosto?	☐	☐
Dor de dente?	☐	☐
Queimação na língua ou na boca?	☐ **(SE NÃO EM TODAS P.P.P. 6.3)**	☐

6.2- Se teve dor, de 1 a 10, qual foi a média dessa dor? (1 é fraca, 10 é muito forte) ☐

6.3-Nos últimos 6 meses o(a) Sr.(a) acordou mais de uma vez com:

	Não	Sim
Dor de cabeça?	☐	☐
Dor no rosto?	☐	☐
Dor nos dentes?	☐	☐
Rosto cansado?	☐	☐
Dificuldade de abrir a boca?	☐	☐

6.4-O(a) Sr(a) já rangeu, apertou, bateu ou fez barulho com os dentes durante o sono mais de uma vez em sua vida?

☐ Não **(P.P.P. 6.6)** ☐ Sim ☐ Não sei **(P.P.P. 6.6)**

6.5- Quem lhe disse que rangeu, apertou, bateu ou fez barulho com os dentes durante o sono?

☐ Mãe/Pai	☐ Esposo(a)/Namorado(a)	☐ Dentista
☐ Irmão(a)	☐ Amigo(a)	☐ Outro

6.6- Especifique qual dos sintomas relacionados ao sono está presente na sua família de origem:

☐ Insônia	☐ Apnéia	☐ Sonambulismo	☐ Nenhum
☐ Ronco	☐ Pesadelo	☐ Bruxismo	☐ Outro

6.7- Relate abaixo outro(s) comportamento(s) estranho(s) durante seu sono que julgue importante:

Data de avaliação _____

Anexo 8 – Diário do sono (Cedido pela Profa. Dra. Júnia Maria Cheib Serra Negra)

MEU DIÁRIO DO SONO: preencher durante sete dias. Por favor, não deixe nenhuma resposta em branco!

Dias da semana	Hora de deitar 	Hora de levantar 	Tempo para adormecer	Quantas vezes acordou durante a noite. Se você não acordou, escreva "zero".	Como sentiu-se ao acordar de manhã	O sono foi perturbado (nos diga fatores como frio, barulho, dores, ronco de parceiro de quarto, luzes, ficou no computador, video game, celular)	Consumiu antes de dormir (pode marcar mais de uma opção)	Alguém te disse que você rangeu os dentes enquanto dormia	Você percebeu que apertou os dentes quando acordado sem estar comendo
2ª feira	__h__min	__h__min	------min		( )descansado ( )um pouco cansado ( )cansado	( )não ( )sim: Porque_____	( )leite puro ( )leite com chocolate ( )café ( )chá ( )energética ( )bebida alcoólica ( )refrigerantes: qual_____ ( )medicamento: Qual----------	( )não ( )sim	( )Nunca ( )poucas vezes ( )muitas vezes
3ª feira	__h__min	__h__min	------min		( )descansado ( )um pouco cansado ( )cansado	( )não ( )sim: Porque_____	( )leite puro ( )leite com chocolate ( )café ( )chá ( )energética ( )bebida alcoólica ( )refrigerantes: qual_____ ( )medicamento: Qual----------	( )não ( )sim	( )Nunca ( )poucas vezes ( )muitas vezes
4ª feira	__h__min	__h__min	------min		( )descansado ( )um pouco cansado ( )cansado	( )não ( )sim: Porque_____	( )leite puro ( )leite com chocolate ( )café ( )chá: ( )energética ( )bebida alcoólica ( )refrigerantes: qual_____ ( )medicamento: Qual----------	( )não ( )sim	( )Nunca ( )poucas vezes ( )muitas vezes
5ª feira	__h__min	__h__min	------min		( )descansado ( )um pouco cansado ( )cansado	( )não ( )sim: Porque_____	( )leite puro ( )leite com chocolate ( )café ( )chá ( )energética ( )bebida alcoólica ( )refrigerantes: qual_____ ( )medicamento: Qual----------	( )não ( )sim	( )Nunca ( )poucas vezes ( )muitas vezes
6ª feira	__h__min	__h__min	------min		( )descansado ( )um pouco cansado ( )cansado	( )não ( )sim: Porque_____	( )leite puro ( )leite com chocolate ( )café ( )chá ( )energética ( )bebida alcoólica ( )refrigerantes: qual_____ ( )medicamento: Qual----------	( )não ( )sim	( )Nunca ( )poucas vezes ( )muitas vezes
Sábado	__h__min	__h__min	------min		( )descansado ( )um pouco cansado ( )cansado	( )não ( )sim: Porque_____	( )leite puro ( )leite com chocolate ( )café ( )chá ( )energética ( )bebida alcoólica ( )refrigerantes: qual_____ ( )medicamento: Qual----------	( )não ( )sim	( )Nunca ( )poucas vezes ( )muitas vezes
Domingo	__h__min	__h__min	------min		( )descansado ( )um pouco cansado ( )cansado	( )não ( )sim: Porque_____	( )leite puro ( )leite com chocolate ( )café ( )cha () energética ( )bebida alcoólica ( )refrigerantes: qual_____ ( )medicamento: Qual----------	( )não ( )sim	( )Nunca ( )poucas vezes ( )muitas vezes