ORIGINAL RESEARCH

Do older people with poor sleep quality have worse cardiac autonomic control?

Alaine S. L. Rocha, PhD[1,2,3], Vitória de Barros Siqueira, PhD[4], Paula A. Maduro, MSc[2,3], Laísla da Silva Paixão Batista, MSc[5], Victor R. Neves, PhD[3,6], Bruno B. Gambassi, PhD[3,7], Paulo A. Schwingel, PhD[2,3,6]

[1]Departamento de Fisioterapia, Universidade Federal do Ceará, Fortaleza; [2]Programa de Pós-Graduação em Ciências da Saúde, Universidade de Pernambuco, Recife; [3]Laboratório de Pesquisas em Desempenho Humano, Universidade de Pernambuco Campus Petrolina, Petrolina; [4]Colegiado de Enfermagem, Universidade Federal do Vale do São Francisco, Petrolina; [5]Colegiado de Fisioterapia, Faculdade UNIBRAS Juazeiro, Juazeiro; [6]Programa de Pós-Graduação em Reabilitação e Desempenho Funcional, Universidade de Pernambuco Campus Petrolina, Petrolina; [7]Programa de Mestrado em Gestão de Programas e Serviços de Saúde, Universidade Ceuma, São Luís, Brazil

https://doi.org/10.5770/cgj.26.658

ABSTRACT

Objective

To identify the differences in cardiac autonomic control between older people with good and poor sleep quality.

Material and Methods

This is a cross-sectional study with 40 older people aged ≥ 60 years, registered at a community health center in Petrolina, Pernambuco, Brazil. The sleep quality was assessed with the Pittsburgh Sleep Quality Index (PSQI). To assess heart rate variability (HRV), the RR intervals (RRI) were recorded for 10 min with a validated smartphone app and a wireless transmitter Polar H7 positioned on the patient's chest. The HRV parameters were calculated with Kubios HRV, and the data were analyzed in SPSS. Subjects with good and poor sleep quality (PSQI >5) were compared with the Mann-Whitney U test.

Results

A total of 31 older people were included in the final analysis, with 18 (58.1%) of them having poor sleep quality. Older people with good sleep quality have similar cardiac autonomic control to those with poor sleep quality. The medians of time (mean RRI, pNN50, SDNN, and RMSSD) and frequency-domain HRV parameters (LFms^2, LFnu, HFms^2, HFnu, and LF/HF ratio) were statistically similar ($p > .05$) in older people with good and poor sleep quality. According to the effect size, the HRV indicators were slightly better among those with good sleep quality.

Conclusion

There were no statistical differences in cardiac autonomic control between older people with good and poor sleep quality.

Key words: autonomic nervous system, heart rate, aged, health of the elderly, sleep

INTRODUCTION

Heart rate variability (HRV) is the variation in consecutive heartbeats (R–R interval [RRI]), which is a cardiac autonomic modulation marker,(1) and an early and sensitive health problem indicator.(2) Changes in HRV patterns may also point to physiological function impairments.(3) Besides being used to assess cardiovascular risk, HRV has been also approached to identify and understand autonomic components in various sleep disorders.(4)

Variations in sympathetic and parasympathetic activities are known to occur in the various stages of sleep. However, these changes are sharper in situations associated with autonomic disorders, mainly characterized by diminished HRV parameters.(4) In addition, there is a discussion about the possible relationship between cardiac autonomic function and sleep, mediated by underlying clinical conditions.(4) Irregular sleep can also interfere with the circadian rhythm and sleep–wake cycle(5) which, in turn, may affect cardiac autonomic control.

Sleep disorders are frequent in older people(6,7) because the aging process changes both the quantity and quality of this variable.(6) Data obtained in a previously published study—which assessed self-reported sleep complaints in a representative sample—reveal that 76% of the population had at least one sleep-related problem and that the number of complaints increased with age.(8)

Neurobiological events taking place during sleep are essential to preserving physical and cognitive health.(6,9)

Poor-quality sleep is associated with different health problems, including the risk of heart disease in older people.[10] Hence, there has been a recent interest in the relationship between cardiac vagal control and sleep[11] through HRV assessment.

A study by Jackowska *et al*.[12] reported that sleep problems were not predictive of a decrease in nocturnal HRV. Nevertheless, its findings suggest that sleep disturbances may influence HRV at other times of the day, including at work. Evidence in the scientific literature suggests that greater parasympathetic activity at rest is associated with a higher objective and subjective quality of sleep.[11]

Therefore, people with poor sleep quality may have a lower HRV and less parasympathetic activity than those with good sleep quality, although data on this topic are still scarce in the scientific literature, particularly addressing the older population. Understanding this relationship is essential to identify such problems early, as these people have high rates of sleep disorders. Moreover, such disorders may negatively affect people's performance in various everyday and occupational activities. Hence, investigating and understanding the mechanisms and factors related to irregular sleep is important to public health.[8]

Thus, studies assessing the relationship between sleep quality and HRV in older people are justified, as their data may help develop preventive measures and improve these people's quality of life. Given the above, the objective of this study was to identify the differences in cardiac autonomic control in older people with good and poor sleep quality.

METHODS

This is a descriptive, analytical, cross-sectional study, conducted at a community health center within the urban area of Petrolina, Pernambuco, Brazil, between October and November 2018, when 1,601 older people were registered at the said center. The nonprobabilistic sample counted 40 volunteers aged 60 or more years (older people).

The inclusion criteria were as follows: being an older adult (age $\geq$ 60 years); being functionally active; having preserved cognitive function. Adequate functional activity (being functionally active) was defined in this study as the older person's ability to walk inside and outside their home with no difficulties or need for external help. Preserved cognitive function was defined as their capacity to verbally interact with the interviewer.[13]

The exclusion criteria were as follows: having functional limitations; having a self-reported history of angina, cardiopathy, myocardial infarction, invasive cardiovascular procedures; using insulin, beta-blockers,[13] sleep-inducing drugs (e.g., Zolpidem hemitartrate); obtaining a score lower than the cutoff per educational attainment in the Mini-Mental State Examination (MMSE), which indicates a poor cognitive function;[14] and not concluding all data collection stages.

The study was approved by the Research Ethics Committee of the School of Medical Sciences of Pernambuco (CEP-FCM/PE) under evaluation report number 2.753.501 and Certificate of Presentation for Ethical Appraisal (CAAE) number 88147918.9.000.5192. This research followed all requirements in Resolutions 466/2012 and 510/2016 of the National Health Council; all participants signed an informed consent form (ICF).

Procedures

Firstly, the research was presented at the community health center where the study was conducted, at senior centers in the same municipality, and on social media so patients would get acquainted with the project.

After publicizing it, explanatory letters with an ICF were handed to the older people who were interested in participating in the study. Then, the assessment date was scheduled. They were assessed in a separate room inside the community health center, always in the morning to avoid changes in the circadian rhythm.

On the day of data collection, the volunteers answered the questionnaire through an interview; the questionnaire contained questions on their perception of overall health status, comorbidities, medication use, and socioeconomic characteristics. Then, their cognitive status was assessed with the MMSE, and their sleep quality with a questionnaire. All questionnaires were administered in interviews by previously trained researchers in a separate room.

At the end of the assessment, each volunteer rested for 10 min before their arterial pressure and HRV were measured. On this occasion, their anthropometric data were also recorded.

Cognitive Status Assessment

The cognitive status was assessed with the MMSE, whose maximum score is 30 points, based on dichotomous items. The literature establishes a score equal to or lower than 23 points as indicative of cognitive decline.[15,16]

Due to the influence of educational attainment on the MMSE final score, this study used the following cutoffs: 20 points for nonliterate persons; 25 for people with one to four years of school attendance; 26.5 for those with five to eight years of school attendance; 28 for those with nine to 11 years of school attendance; and 29 for those with more than 11 years of school attendance.[14]

Socioeconomic & Overall Health Status Assessment

The socioeconomic assessment was based on a structured questionnaire on sociodemographic (age, marital status, religion, occupation, educational attainment) and economic data (monthly family income in minimum wages). Another structured questionnaire was used to assess the patient's self-perception of overall health status and conditions, comorbidities, and medication use.

Sleep Quality

The sleep quality was assessed with the validated Brazilian version of the Pittsburgh Sleep Quality Index (PSQI),[9] which assesses this variable over the preceding month.

The following are the PSQI components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. The sum of the scores in each of these seven components is the overall score, which ranges from 0 to 21 points; higher scores show poorer sleep quality. A PSQI overall score higher than 5 indicates poor sleep quality.[9]

HRV and Arterial Pressure

The arterial pressure was measured with automatic equipment (HEM 742, manufactured by OMRON Healthcare, Inc., Lake Forest, USA) after the subjects had rested for 10 min. Three consecutive measures were taken (with 1-min intervals between them) on the nondominant arm, using adequate cuffs according to arm circumference. The analysis was made with the mean of the last two measures.

HRV assessment was based on RRI records collected with a free smartphone app (Elite HRV LLC, Asheville, NC, USA, release 4.0.2, 2018) for Android via Bluetooth 4.0, and a wireless transmitter Polar H7 (Polar Electro Oy, Kempele, Finland) positioned on the patient's chest.[17] The signals were transmitted to the computer for later analysis.

The volunteers were previously instructed to avoid alcoholic and/or stimulant beverages (sodas, coffee, chocolate milk, green tea, etc.), and extenuating physical activities on the day of data collection and the day before.[18] They were also instructed to avoid talking, moving, coughing, and sleeping during data collection.

All subjects rested for at least 10 min in the supine position. Then, the HRV was recorded for 10 min, while they were at rest in the supine position, breathing spontaneously. The HRV values obtained from short-term (≤ 10 min) recordings reflect the data obtained with long-term recordings, in addition to being more practical and having been used more.

All HRV records were collected in the morning, and the RRI were exported to the Kubios HRV program (Kubios Oy, Kuopio, Finland, version 2.2). They were analyzed through time-domain and frequency-domain analysis.

The following calculations were made: mean RRI, time parameters, the standard deviation of all RRI (SDNN), root mean square of successive differences between adjacent normal RRI (RMSSD), and percentage of adjacent RRI longer than 50 ms (pNN50).

Frequency parameters were also obtained. Those between 0.04 and 0.4 Hz were considered physiologically significant; the low-frequency component ranged from 0.04 to 0.15 Hz, and the high-frequency component, from 0.15 to 0.4 Hz. The power of each spectral component was calculated in normalized units (nu).[19] The normalized low-frequency (LF) and high-frequency (HF) bands were respectively considered the predominant cardiac sympathetic and parasympathetic modulations, and the LF/HF ratio was considered the cardiac sympathovagal balance.[19]

Anthropometric Assessment

The anthropometric assessment included the total body mass index and height, measured with a portable digital scale HBF-214 (OMRON Healthcare, Inc.) with a 0.1-kg precision and 150-kg maximum capacity, and a portable stadiometer (Sanny, São Bernardo do Campo, SP, Brazil) with a 0.1-cm precision and 2.20-m maximum height. The body mass index (BMI) was calculated by dividing the total body mass (kg) by the square of the height (m^2).

Data Analysis

The data were entered twice and analyzed with the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA, release 16.0.2). Firstly, the normality of continuous data was verified with the Shapiro-Wilk test. The descriptive analysis of the categorical variables included the distribution of the absolute and relative frequencies, while the continuous variables were presented in the median and first quartile (Q_1) and third quartile (Q_3). The Mann-Whitney U test was used in the inferential analysis to compare the time- and frequency-domain HRV parameter values between the subjects with good and poor sleep quality. Also, given the tendency to use modern robust statistical methods, the magnitude of the differences between the rankings was tested with the effect size,[20] using the interpretation proposed by Grissom.[21] P values and 95% confidence intervals (95%CI) were calculated and are exact. The 5% bilateral significance level was used in all analyses.

RESULTS

Of the 40 older people assessed, 31 were included in the final data analysis. Nine volunteers were excluded—three for having a history of invasive cardiovascular procedures, two for having a history of angina or myocardial infarctions, two for being diagnosed with cardiopathies, and two for not agreeing to undergo all data collection procedures.

The volunteers' ages ranged from 61 to 92 yrs, with a median (Q_1– Q_3) of 69.0 (66.0–73.0) yrs. The distribution of the subjects' sociodemographic and economic characteristics is shown in Table 1.

Concerning the anthropometric variables, the median (Q_1–Q_3) total body mass was 68.3 (59.5–77.0) kg, height was 1.54 (1.51–1.65) m, and BMI was 27.4 (24.1–30.6) kg/m^2. The median (Q_1–Q_3) of systolic arterial pressure was 130.6 (120.0–140.0) mmHg, and diastolic arterial pressure was 73.0 (66.3–79.3) mmHg. Of those assessed, 74.2% (n = 23; 95%CI: 56.7–86.3) reported having some chronic disease. The sample characterization regarding self-perceived overall health status, comorbidities, nutritional status, and medication use are presented in Table 2.

None of the subjects obtained an MMSE overall score lower than the cutoff per educational attainment. The median (Q_1 – Q_3) of the sample was 24.0 (20.0–27.0) points. The variables related to the sample's sleep quality are shown in Table 3.

The comparison of the HRV time and frequency parameters in older people with good and poor sleep quality is presented in Table 4. The medians of the HRV time (mean RRI, pNN50, SDNN, and RMSSD) and frequency parameters (LFms^2, LFnu, HFms^2, HFnu, and LF/HF ratio)

TABLE 1.
Sociodemographic and economic characteristics of assessed older adults (n = 31), Petrolina, Pernambuco, Brazil, 2018

Variables	*n (%)*
Sex	
Females	22 (71.0)
Males	9 (29.0)
Occupation	
Retired	24 (77.4)
Working	4 (12.9)
Home activities	3 (9.7)
Religion	
Catholic	27 (87.1)
Evangelical	4 (12.9)
Marital status	
Single	3 (9.7)
Married or cohabiting	13 (41.9)
Widow(er)	6 (19.4)
Other	9 (29.0)
Educational attainment	
Illiterate or middle school, not completed	13 (41.9)
Middle school, completed	7 (22.6)
High school, not completed	1 (3.2)
High school graduate or higher education, not completed	5 (16.1)
Higher education degree	5 (16.1)
Monthly family income in minimum wages (MW)[a]	
Less than 1 MW	5 (16.1)
1 to 2 MW	22 (70.1)
> 2 MW	4 (12.9)

[a]The minimum wage was R$ 954.00.

TABLE 2.
Characterization of the older people regarding their self-perception of the overall health status, comorbidities, nutritional status, and medication use (n = 31), Petrolina, Pernambuco, Brazil, 2018

Variables	*n (%)*	*95% CI*
Perception of the overall health status		
Very good or good	11 (35.5)	21.1 – 53.1
Moderate	18 (58.1)	40.8 – 73.6
Poor or very poor	2 (6.4)	1.8 – 20.7
Systemic arterial hypertension		
Yes	19 (61.3)	43.8 – 76.3
No	12 (38.7)	23.7 – 56.2
Diabetes Mellitus		
Yes	10 (32.3)	18.5 – 49.9
No	21 (67.7)	50.1 – 81.4
Nutritional Status		
Low weight	-	-
Well-nourished	11 (35.5)	21.1 – 53.1
Overweight	7 (22.6)	11.4 – 39.8
Obese	13 (41.9)	26.4 – 59.2
Medication use		
Yes	25 (80.6)	63.7 – 90.8
No	6 (19.4)	9.2 – 36.6

were statistically similar ($p > .05$) between those with good and poor sleep quality. Also, the effect size of the comparisons demonstrated a small difference between the two sleep quality conditions regarding the analyzed variables (values ranging from 0.34 to 0.49).

DISCUSSION

This study did not identify statistical differences in the HRV parameters between subjects with good and poor sleep quality. It was verified, though, that an important part of the sample had poor sleep quality and that the HRV indicators were slightly better in the good sleep quality group than in the poor sleep quality one.

There was a high frequency of poor sleep quality among the assessed older people. Changes in sleep patterns and poorer sleep quality are common in this population.[(7,22)] The results of this study are similar to those observed in other pieces of research. In the study by da Silva *et al.*,[(23)] which also used the PSQI to assess sleep quality in older people, approximately 46.7% of them had poor sleep quality. In a multicentric study with older people, 68.5% of the subjects had a sleep disorder.[(24)] In another study, also assessing the older population, 44.6% of participants reported sleep problems.[(22)]

Given the high rates of sleep changes among older people, different sleep components must be assessed to better understand this variable. The present study used a validated questionnaire[(9)] whose self-reported results had good agreement with the objective sleep quality measures.[(10)] On the other hand, studies that compared objective sleep measures

TABLE 3.
Variables regarding the sleep quality of assessed older people (n = 31), Petrolina, Pernambuco, Brazil, 2018

Characteristics	*n (%)*	*95% CI*
Subjective sleep quality		
Very good	4 (12.9)	5.1 – 28.8
Good	19 (61.3)	43.8 – 76.3
Poor	5 (16.1)	7.1 – 32.6
Very poor	3 (9.7)	5.1 – 28.8
Sleep duration		
≤ 7 hours	16 (51.1)	34.8 – 68.0
> 7 hours	15 (48.9)	31.9 – 65.2
Sleep efficiency		
> 85%	22 (70.1)	53.4 – 83.9
75–84%	2 (6.4)	1.8 – 20.7
65–74%	2 (6.4)	1.8 – 20.7
< 65%	5 (16.1)	7.1 – 32.6
Sleep quality[a]		
Good sleep quality	13 (41.9)	26.4 – 59.2
Poor sleep quality	18 (58.1)	40.8 – 73.6
Sleep duration per night (hours)[b]	7.0 (5.0 – 8.0)	
PSQI final score[†]	7.0 (3.0 – 10.0)	
Sleep onset time (minutes)[†]	30.0 (10.0 – 60.0)	

[a]Classification based on the Pittsburgh Sleep Quality Index (PSQI).
[b]Variables presented in median (first quartile – third quartile).

TABLE 4.
Comparison of time- and frequency-domain heart rate variability parameters and effect size among older people with good and poor sleep quality (n = 31), Petrolina, Pernambuco, Brazil, 2018

Parameters	*Good Sleep Quality (n = 13)*	*Poor Sleep Quality (n = 18)*	*Total (N = 31)*	*p*	*Magnitude of the Difference*	
	Median (Q_1 – Q_3)	*Median (Q_1 – Q_3)*	*Median (Q_1 – Q_3)*		*ES*	*ES Interpretation*
Time Domain						
Mean RRI	879.0 (769.0 – 1019.0)	860.5 (787.3 – 930.3)	861.0 (778.0 – 942.0)	.92	0.49	Small
SDNN (ms)	16.3 (12.1 – 25.8)	15.4 (11.5 – 33.8)	15.7 (12.0 – 26.7)	.92	0.49	Small
RMSSD (ms)	20.8 (9.7 – 26.4)	19.6 (11.4 – 35.8)	20.8 (11.3 – 27.1)	.57	0.44	Small
pNN50 (%)	0.9 (0.0 – 3.3)	1.5 (0.0 – 15.5)	1.03 (0.0 – 3.4)	.65	0.45	Small
Frequency Domain						
LF (ms^2)	110.0 (69.0 – 195.0)	100.5 (52.0 – 200.0)	110.0 (59.0 – 192.0)	.62	0.45	Small
HF (ms^2)	69.2 (27.5 – 105.5)	94.0 (39.2 – 452.3)	71.0 (32.0 – 210.0)	.19	0.36	Small
LF (nu)	63.1 (46.8 – 83.2)	54.2 (28.6 – 67.4)	56.9 (34.3 – 72.2)	.16	0.35	Small
HF (nu)	36.8 (23.5 – 53.1)	48.8 (32.2 – 71.3)	44.9 (29.5 – 65.5)	.15	0.34	Small
LF/HF (%)	1.7 (0.9 – 3.3)	1.0 (0.4 – 2.1)	1.30 (0.5 – 2.4)	.15	0.34	Small

ES = effect size; RRI = inter-beat intervals between all successive heartbeats; SDNN = standard deviation of NN intervals; RMSSD = root mean square of successive interval differences; pNN50 = percentage of adjacent NN intervals that differ from each other by more than 50 ms; LF = relative power of the low-frequency band (0.04–0.15 Hz); HF = relative power of the high-frequency band (0.15–0.4 Hz); LF/HF = ratio of LF-to-HF power; nu = normalized units.

(e.g., polysomnography and actigraphy) with subjective measures still have unclear results regarding the agreement between these approaches.[25,26]

There was no statistical difference in the medians of the HRV time and frequency parameters between older people with good and poor sleep quality. The effect size was also calculated to estimate the magnitude of the difference, resulting in a small effect size for all HRV parameters assessed. Thus, it is inferred that the relationship between these variables in this sample had limited clinical importance. A difference was expected between these groups because irregular sleep changes the circadian rhythm and sleep-wake cycle, which may also affect the heart rate.[5]

These findings agree with the data by Jackowska *et al*.[12] in whose study sleep problems were not predictive of reduced HRV. However, they verified this regarding nocturnal HRV in working women. That study also suggests that sleep disturbances may influence HRV at other times of the day.

No other studies were found in the scientific literature assessing differences in cardiac autonomic control between older people with good and poor sleep quality. This limits the comparison possibilities regarding the results found in the present study.

The similarities in HRV parameters between older people with good and poor sleep quality found in this research may be explained by this sample's specific characteristics. The older people included in it were functionally active, with preserved cognitive function and access to primary health care.

The analysis of the HRV indices also showed that the values obtained by the older people, both in general and categorized into subjects with good and poor sleep quality, are within the reference percentages for healthy 65-to-74-year-olds.[2] Based on this information, it can be inferred that the older people who participated in this study had a good overall health status. This characteristic may explain the similar HRV parameters between people with good and poor sleep quality, as the relationship between sleep and cardiac autonomic control may be mediated by the person's health status.[4]

The present study approaches topics that require attention and are important to public health. The high occurrence of poor sleep quality raises concern because the overall sleep quality may be related to different factors, such as the risk of falls, moods, and cognition.[23] Furthermore, changes in sleep patterns may affect the immune system, performance, behavioral response, and adaptation ability.[24]

Therefore, sleep disorders are considered markers of various overall medical conditions.[6] It is important to know older people's sleep quality because this variable is relevant to better understanding this population's health needs.[23] Mechanisms are needed to consolidate the health-care model for older people and solve the demands that arise from the aging process,[27] in both assessment and interventions, especially in the Unified Health System (SUS, in Portuguese).

Nonetheless, the results in this study must be carefully analyzed because its limitations prevent extrapolating its findings to other older people groups. The limitations identified in the present research include the sample size and characteristics, memory bias (as the instrument that assessed sleep quality was based on self-reported questions),[23] and factors such as stress, mood, fatigue, and level of physical activity (which may influence the HRV but were not assessed in this study).[28]

Despite limitations and not presenting statistically significant differences between the evaluated groups, the present study is an innovative and unprecedented work because the hypothesis tested had not been previously evaluated in an elderly population. In addition, the methods and instruments used are accurate, validated, and inexpensive, which may encourage further studies with larger samples, and thus corroborate the use of these instruments in clinical practice. The topic studied is relevant to the quality of life and functionality of the elderly population and extremely relevant to public health.

Given the above, further studies should approach the relationship between cardiac autonomic control and sleep quality in older people, assess population samples, and use objective measures to assess sleep quality. Studies also assessing other variables (e.g., stress, depression, mood, and level of physical activity) are needed to better understand this issue.

CONCLUSION

No statistical differences were identified in the cardiac autonomic control between older people with good and poor sleep quality. In opposition, the high frequency of older people with poor sleep quality among those assessed further reinforces the importance of studies on this issue. Knowing the relationship between sleep quality and cardiac autonomic control is useful in developing preventive measures and interventions to improve this population's sleep quality.

ACKNOWLEDGEMENTS

Gratitude is extended to the older people who participated in this study.

CONFLICT OF INTEREST DISCLOSURES

We have read and understood the Canadian Geriatrics Journal's policy on conflicts of interest disclosure and declare there are no conflicts of interest.

FUNDING

This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—Brazil (CAPES) [under Finance Code 001] and was supported by Fundação de Amparo à Ciência e Tecnologia do Estado de Pernambuco (FACEPE) [APQ-0246-4.06/14]. Alaine Souza Lima Rocha was granted a doctorate scholarship by FACEPE [IBPG-0393-4.01/17].

REFERENCES

1. Rajendra Acharya U, Paul Joseph K, Kannathal N, Lim CM, Suri JS. Heart rate variability: a review. *Med Biol Eng Comput*. 2006 Dec;44(12):1031–51.
2. Dantas EM, Kemp AH, Andreão RV, *et al*. Reference values for short-term resting-state heart rate variability in healthy adults: results from the Brazilian Longitudinal Study of Adult Health—ELSA-Brasil study. *Psychophysiology*. 2018 June; 55(6):e13052.
3. Vanderlei LCM, Pastre CM, Hoshi RA, Carvalho TD, Godoy MF. Noções básicas de variabilidade da frequência cardíaca e sua aplicabilidade clínica. *Braz J Cardiovasc Surg*. 2009;24(2):205–17.
4. Stein PK, Pu Y. Heart rate variability, sleep and sleep disorders. *Sleep Med Rev*. 2012 Feb 1;16(1):47–66.
5. Phillips AJ, Clerx WM, O'Brien CS, *et al*. Irregular sleep/wake patterns are associated with poorer academic performance and delayed circadian and sleep/wake timing. *Sci Rep*. 2017 Jun 12; 7(1):1–13.
6. Nóbrega PV, Maciel ÁC, de Almeida Holanda CM, Oliveira Guerra R, Araújo JF. Sleep and frailty syndrome in elderly residents of long-stay institutions: a cross-sectional study. *Geriatr Gerontol Int*. 2014 Jul;14(3):605–12.
7. Zhu X, Hu Z, Nie Y, *et al*. The prevalence of poor sleep quality and associated risk factors among Chinese elderly adults in nursing homes: a cross-sectional study. *PLoS One*. 2020 May 15;15(5):1–16.
8. Hirotsu C, Bittencourt L, Garbuio S, Andersen ML, Tufik S. Sleep complaints in the Brazilian population: impact of socioeconomic factors. *Sleep Sci*. 2014 Sep 1;7(3):135–42.
9. Bertolazi AN, Fagondes SC, Hoff LS, *et al*. Validation of the Brazilian Portuguese version of the Pittsburgh Sleep Quality Index. *Sleep Med*. 2011 Jan 1;12(1):70–5.
10. Lao XQ, Liu X, Deng HB, *et al*. Sleep quality, sleep duration, and the risk of coronary heart disease: a prospective cohort study with 60,586 adults. *J Clin Sleep Med*. 2018 Jan 15;14(1):109–17.
11. Werner GG, Ford BQ, Mauss IB, Schabus M, Blechert J, Wilhelm FH. High cardiac vagal control is related to better subjective and objective sleep quality. *Biol Psychol*. 2015 Mar 1;106:79–85.
12. Jackowska M, Dockray S, EndrighI R, Hendrickx H, Steptoe A. Sleep problems and heart rate variability over the working day. *J Sleep Res*. 2012 Aug;21(4):434–40.
13. Almeida-Santos MA, Barreto-Filho JA, Oliveira JLM, Reis FP, da Cunha Oliveira CC, Sousa ACS. Aging, heart rate variability and patterns of autonomic regulation of the heart. *Arch Gerontol Geriatr*. 2016 Mar 1;63:1–8.
14. Brucki SMD, Nitrin R, Caramelli P, Bertolucci PHF, Okamoto IH. Sugestões para o uso do mini-exame do estado mental no Brasil. *Arq Neuropsiquiatr*. 2003;61(3 B):777–81.
15. Melo DM, Barbosa AJ. O uso do Mini-Exame do Estado Mental em pesquisas com idosos no Brasil: uma revisão sistemática. *Cien Saude Colet*. 2015;20(12):3865–76.
16. Mahinrad S, Jukema JW, van Heemst D, *et al*. 10-Second heart rate variability and cognitive function in old age. *Neurology*. 2016 Mar 22;86(12):1120–27.
17. Gambassi BB, Neves VR, Brito EZA, *et al*. A validation study of a smartphone application for heart rate variability assessment in asymptomatic adults. *Am J Cardiovasc Dis*. 2020;10(3):219–29.
18. Neves VR, Takahashi AC, do Santos-Hiss MD, *et al*. Linear and nonlinear analysis of heart rate variability in coronary disease. *Clin Auton Res*. 2012 Aug;22(4):175–83.
19. Malik M, Bigger JT, Camm AJ, *et al*. Heart rate variability: standards of measurement, physiological interpretation, and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. *Eur Heart J*. 1996 Mar 1;17(3):354–81.
20. Erceg-Hurn DM, Mirosevich VM. Modern robust statistical methods: an easy way to maximize the accuracy and power of your research. *Am Psychol*. 2008 Oct;63(7):591–601.
21. Grissom RJ. Probability of the superior outcome of one treatment over another. *J Appl Psychol*. 1994 Apr;79(2):314–16.

22. Costa SV, Ceolim MF, Neri AL. Sleep problems and social support: frailty in a Brazilian Elderly Multicenter Study. *Rev Lat Am Enfermagem*. 2011;19(4):920–27.
23. da Silva RV, Soares NM, Pereira GM, da Silva Júnior EG, do Carmo Eulálio M. Sleep quality features and their association with mood symptoms and cognitive factors in a non-clinical sample of older Brazilian adults. *Psychogeriatrics*. 2020 Sep;20(5):673–80.
24. Santos AA, Mansano-Schlosser TC, Ceolim MF, Pavarini SC. Sono, fragilidade e cognição: estudo multicêntrico com idosos brasileiros. *Rev Bras Enferm*. 2013;66(3):351–57.
25. Lauderdale DS, Knutson KL, Yan LL, Liu K, Rathouz PJ. Self-reported and measured sleep duration: How similar are they? *Epidemiology*. 2008 Nov 1;19(6):838–45.
26. Silva GE, Goodwin JL, Sherrill DL, *et al*. Relationship Between Reported and Measured Sleep Times: the sleep heart health study (SHHS). *J Clin Sleep Med*. 2007 Oct 15;3(6):622–30.
27. Miranda D, Morais G, da Cruz Gouveia A, da Silva AL. O envelhecimento populacional brasileiro : desafios e consequências sociais atuais e futuras. *Rev Bras Geriatr e Gerontol*. 2016 May;19(3):507–19.
28. Sekiguchi Y, Adams WM, Benjamin CL, Curtis RM, Giersch GEW, Casa DJ. Relationships between resting heart rate, heart rate variability and sleep characteristics among female collegiate cross-country athletes. *J Sleep Res*. 2019 Dec;28(6):e12836.

Correspondence to: Alaine Souza Lima Rocha, PhD, Departamento de Fisioterapia, Universidade Federal do Ceará (UFC), Rua Major Weyne, 1440 - Rodolfo Teófilo, Fortaleza – CE, Brazil CEP 60430-450
E-mail: alaine.rocha@ufc.br