**KAPICA, Marcin, KOPACZ, Wojciech, GŁOGOWSKA, Karen, WOJTAS, Mikołaj, KRZYŻANOWSKA, Maria, NOWAK, Gabriela, ŻMIJEWSKA, Aleksandra, SZTYBÓR, Mateusz, MALESZEWSKA, Monika and PIĄTKIEWICZ, Julia. The Association Between Heart Rate Variability and Sleep Quality - a Narrative Review. Journal of Education, Health and Sport. 2024;65:73-85. eISSN 2391-8306. https://dx.doi.org/10.12775/JEHS.2024.65.005**
**https://apcz.umk.pl/JEHS/article/view/49843**
**https://zenodo.org/records/10963755**

**The journal has had 40 points in Minister of Science and Higher Education of Poland parametric evaluation. Annex to the announcement of the Minister of Education and Science of 05.01.2024 No. 32318. Has a Journal's Unique Identifier: 201159. Scientific disciplines assigned: Physical culture sciences (Field of medical and health sciences); Health Sciences (Field of medical and health sciences).**
**Punkty Ministerialne 40 punktów. Załącznik do komunikatu Ministra Nauki i Szkolnictwa Wyższego z dnia 05.01.2024 Lp. 32318. Posiada Unikatowy Identyfikator Czasopisma: 201159. Przypisane dyscypliny naukowe: Nauki o kulturze fizycznej (Dziedzina nauk medycznych i nauk o zdrowiu); Nauki o zdrowiu (Dziedzina nauk medycznych i nauk o zdrowiu).**
**The authors declare that there is no conflict of interests regarding the publication of this paper.**
**Received: 06.03.2024. Revised: 29.03.2024. Accepted: 10.04.2024. Published: 12.04.2024.**

# The Association Between Heart Rate Variability and Sleep Quality - a Narrative Review

1. Marcin Kapica, MD

Health Care Team of the District Hospital In Sochaczew, Batalionów Chłopskich 3/7, 96-500 Sochaczew, Poland https://orcid.org/0009-0005-2191-034X, marcin_kapica@icloud.com

2. Wojciech Kopacz, MD

Central Clinical Hospital in Warsaw, Banacha 1a, 02-097 Warsaw, Poland https://orcid.org/0000-0001-6188-5306, w.kopacz@icloud.com

3. Karen Głogowska, DMD

The University Dental Center Medical University of Warsaw, Binieckiego 6, 02-097 Warsaw, Poland https://orcid.org/0009-0004-9869-3374, karen.glogowska@gmail.com

4. Mikołaj Wojtas, MD

Health Care Team of the District Hospital In Sochaczew, Batalionów Chłopskich 3/7, 96-500 Sochaczew, Poland https://orcid.org/0009-0006-1092-3214, wojtas.m12@gmail.com

5. Maria Krzyżanowska, MD

Military Institute of Medicine - National Research Institute, Szaserów 128, 04-141 Warszawa, Poland

https://orcid.org/0009-0002-2148-4414, mariaannakrzyzanowska@gmail.com

6. Gabriela Nowak, MD

County Health Center in Otwock Sp. z o.o, Batorego 44, 05-400 Otwock, Poland

https://orcid.org/0009-0000-4942-9914, gabi098098098@gmail.com

7. Aleksandra Żmijewska, MD

Railway Hospital of dr. Włodzimierz Roefler in Pruszków, Warsztatowa 1, 05-800 Pruszków, Poland

https://orcid.org/0009-0002-6281-8943, zmijewskaleksandra@gmail.com

8. Mateusz Sztybór, MD

Provincial Polyclinical Hospital in Płock of Marcina Kacprzaka, Medyczna 19, 09–400 Płock, Poland

https://orcid.org/0009-0000-7511-3534, mateuszsztybor@onet.pl

9. Monika Maleszewska, MD

Dr Anna Gostynska Wolski Hospital, Independent Public Health Care Institution, Marcina Kasprzaka 17, 01-211 Warsaw, Poland https://orcid.org/0009-0006-4623-7742, monikamaleszewskaa@gmail.com

10. Julia Piątkiewicz, MD

The Infant Jesus Teaching Hospital, Lindleya 4 02-005 Warszawa, Poland https://orcid.org/0009-0005-1969-3593, julia.piatkiewicz@onet.pl

Corresponding author: Marcin Kapica, MD, marcin_kapica@icloud.com

**ABSTRACT**

**Introduction**

Heart rate variability (HRV) serves as a non-invasive marker to assess autonomic nervous system (ANS) modulation on cardiac rhythm. Its link with sleep quality, particularly in the context of insomnia, posits HRV as a potential indicator of autonomic state variations during sleep disturbances. The prevalence of insomnia, affecting up to 20% of the general population, emphasizes the need to understand its extensive impact.

**Material and Methods**

For this review - 41 relevant titles from 1985 to 2024 were selected

**Analysis of the Literature:**

Recent studies highlight a bidirectional relationship between insomnia and ANS function, with increased sympathetic activity indicated by physiological and subjective measures in individuals with insomnia. The role of medications like beta-blockers in disrupting ANS and leading to sleep deprivation further connects measurable and perceived aspects of sleep quality, impacting health negatively. Moreover, HRV's application has expanded beyond professional athletics to daily activity and sleep quality monitoring by the general population, emphasizing its potential in evaluating stress and training intensity.

**Conclusion:** The complex interplay between HRV, insomnia, and health outcomes necessitates further research. However, integrating HRV measurements into clinical and everyday monitoring may offer a promising avenue for improving sleep disorder management and enhancing quality of life.

**Keywords**: Heart Rate Variability; Sleep quality; Insomnia; Cardiovascular risk; Sympathetic nervous system

## Introduction

Heart rate variability (HRV) characterizes the fluctuations between successive electrocardiogram R-R intervals[1]. It is a non-intrusive approach employed to assess the modulation of the autonomic nervous system (ANS) on the cardiac rhytm[2-5]. In normal and pathological conditions, the ANS plays an essential role in regulating physiological processes

in the human body[3]. In contemporary times, HRV has become significant as a method for investigating the ANS, which plays a crucial role in preserving homeostasis. Increased HRV indices commonly signify efficient autonomic mechanisms indicative of a person's good health, whereas decreased or low HRV may signal dysfunction in the ANS, potentially indicating compromised health[3]. HRV has experienced a substantial increase in popularity for research purposes in recent decades[6]. HRV presents itself as a compelling choice and a prospective clinical instrument for assessing and recognizing health impairment owing to its extensive applications, cost-effectiveness in implementing the technique, and the simplicity of data acquisition[1].

Some researchers have explored the link between HRV and sleep quality, yet this topic remains insufficiently investigated[7]. Beyond expressing complaints about sleep, there are limited physiological metrics that consistently distinguish individuals with insomnia or poor sleep quality from those experiencing normal sleep[8]. The idea that stress reaction processes "play a key role in the pathophysiology of primary insomnia" makes it logically intriguing that HRV could potentially detect variations in the underlying autonomic state during insomnia[9]. In view of the significant prevalence of insomnia and sleep disorders, which affect up to 20% of the general population [10], it is crucial to comprehend the extensive impact of this condition. Insomnia is characterized by difficulties in initiating and maintaining sleep, often leading to frequent awakenings or struggles to return to sleep for a duration of at least three months[11]. Furthermore, insomnia and sleep disorders are correlated with a diminished quality of life (QoL)[12] and increased mortality[13]. Sleep disorders may also be connected to sudden cardiac death, potentially associated with ventricular arrhythmias[14].

## Aim

This narrative review offers an in-depth examination of the relationship between HRV and sleep quality, highlighting the clinical importance, epidemiological context, and management strategies of this bidirectional association.

## Material and methods

Databases such as Pubmed, Medline, Google Scholar, and Europe PMC were used for the literature review with the keywords: “heart rate variability”, “sleep quality”, “insomnia”, “quality of life”, “autonomic nervous system”, 765 Articles were found from the period of 1970 until 2024.

The majority of articles contained weak-quality research, or did not directly relate to the topic of this review. Finally, 41 titles that described the association between heart rate variability, insomnia and related topics were selected from 1985 until 2024 - mainly from the last seven years.

## Analysis of the literature

Recent investigations have illuminated a bidirectional relationship between insomnia and autonomic nervous system (ANS) function[15]. Symptoms such as increased cortisol, heart rate or body temperature may indicate increased sympathetic activity in people with insomnia[16]. In addition to objective measures, subjective measures of sleep quality, such as the Pittsburgh Sleep Quality Index (PSQI), correlate with increased autonomic activation[17]. On the other hand, some drugs, like beta-blockers, may disrupt ANS and lead to sleep deprivation[18]. The disruption of autonomic activity could serve as a connecting factor between the measurable and perceived aspects of sleep quality in older individuals experiencing insomnia, potentially playing a role in negative health consequences[17].

HRV is a nonintrusive approach used to assess the modulation of the autonomic nervous system (ANS) on the heart rhythm[2-5]. Furthermore, Jiang et al. demonstrated attenuated HRV responses to postural changes in primary insomnia subjects, pointing towards potential autonomic dysregulation in this population. However, prospective studies are needed to underscore the further exploration of HRV dynamics in different insomnia subtypes[19].

Nowadays, many people cannot deal with insufficient sleeping time. The prevalence of short sleep (<7h) varies between 24,3% to 48,5% of the adult population in the United States[20]. Smartwatches have become increasingly popular in recent years[21]. People started recording all daily activities[22], including sleep quality[23], which is crucial in post-workout regeneration[24]. Presently, HRV is used not only by professional athletes to measure awareness for training[25], but also by beginners[26]. That allows us to measure the stress of organisms and then determine how hard training the athlete should perform[26].

Insomnia emerges as a potential risk factor for cardiovascular anomalies, with altered HRV serving as a mediator[27]. One of the most valuable HRV parameters used in monitoring fatigue status is the square root of the mean of the sum of the squares of differences between adjacent normal R-R intervals (RMSSD)[28]. Additionally, another potential stress mediator is the ratio of differences exceeding 50 ms to the total number of differences (pNN50)[29]. Its decrease indicates increased stress[30] and is better for short-time evaluation[29]. Both RMSSD and pNN50 are connected with parasympathetic activity[31]. Insomnia patients have reduced parasympathetic activity as indicated by reduced high frequency power of HRV, as well as RMSSD and pNN50 values[27]. Moreover, short sleep duration links these alterations to increased cardiovascular morbidity and mortality rates[27]. Some results suggest that improvements in sleep following cognitive behavioural therapy for insomnia (CBT-I) were

associated with reduced parasympathetic activation and increased sympathovagal balance, contrary to expectations[32]. Therefore, we believe that the topic should be much more extensively researched, as the results of small clinical studies may distort our understanding of the correlation between HRV and insomnia.

Examining the relationship between HRV, insomnia, and acute well-being in terminally ill patients sheds light on the potential role of autonomic dysfunction and sleep disturbances in influencing the end-of-life experience. Warth et al. found a significant correlation between patients' acute well-being (AWB) Insomnia and SDNN[33]. Additionally, certain cardiovascular conditions, such as heart failure, may be associated with insomnia. Furthermore, medications used to treat heart failure can also contribute to sleep disturbances, a topic we have previously explored[34]. Patients with clinically significant arrhythmias like frequent premature ventricular complexes (PVCs) exhibit impaired HRV[35]. Additionally, a reduced HRV is associated with a higher risk of severe ventricular arrhythmia[36], which can lead to sudden cardiac death[14]. An increased number of night-time PVCs was accompanied by enhanced cardiac sympathetic activity[37]. PVCs can be diminished by pharmacological treatment[38] or with invasive methods[39]. After successful treatment of PVCs - both cardiac parasympathetic and sympathetic nervous activity declines[37].

Females have a higher risk of insomnia (Risk ratio = 1.41) versus males[40]. Chae et al. revealed the link between sleep quality, emotional labor, and HRV in the emotional laborers womens. The group of poor sleepers had a significantly lower difference in the root mean square of successive differences (RMSSD), the percentage of successive normal-to-normal intervals differing by more than 50 ms (pNN50) and the natural logarithm of high frequency (LnHF) when they were working compared to when they were resting, compared to the group of good sleepers[41].

## Conclusion

In summary, the multifaceted relationships between HRV, insomnia, and various health outcomes underscore the need for continued research in this domain. Further investigations, particularly prospective studies exploring HRV dynamics in different insomnia subtypes, will enhance our understanding of the complex interactions between autonomic function, sleep quality, and overall health. The integration of HRV measurements into clinical practice and daily monitoring tools holds promise for improving the assessment and management of sleep-related disorders, contributing to enhanced well-being and quality of life.

## Declarations

**Funding -** This Research received no external funding.

**Author contributions**

Conceptualization: M.K., W.K.; Methodology: A.Ż., M.S.; Formal analysis: M.K., M.M.; Investigation: J.P., G.N.; Writing - rough preparation: M.W., K.G.; Writing - review and editing: M.K., W.K.; Supervision: W.K., M.K.

**Conflicts of interest -** The authors declare no conflict of interest.

**Data availability -** Not applicable.

**Ethics approval -** Not applicable.

## References

1. Catai AM, Pastre CM, Godoy MF, Silva ED, Takahashi ACM, Vanderlei LCM. Heart rate variability: are you using it properly? Standardisation checklist of procedures. *Braz J Phys Ther*. Mar-Apr 2020;24(2):91-102. doi:10.1016/j.bjpt.2019.02.006

2. 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*. Mar 1996;17(3):354-81.

3. Vanderlei LC, Pastre CM, Hoshi RA, Carvalho TD, Godoy MF. Basic notions of heart rate variability and its clinical applicability. *Rev Bras Cir Cardiovasc*. Apr-Jun 2009;24(2):205-17. doi:10.1590/s0102-76382009000200018

4. Sassi R, Cerutti S, Lombardi F, et al. Advances in heart rate variability signal analysis: joint position statement by the e-Cardiology ESC Working Group and the European Heart Rhythm Association co-endorsed by the Asia Pacific Heart Rhythm Society. *Europace*. Sep 2015;17(9):1341-53. doi:10.1093/europace/euv015

5. Shaffer F, Ginsberg JP. An Overview of Heart Rate Variability Metrics and Norms. *Front Public Health*. 2017;5:258. doi:10.3389/fpubh.2017.00258

6. Pham T, Lau ZJ, Chen SHA, Makowski D. Heart Rate Variability in Psychology: A Review of HRV Indices and an Analysis Tutorial. *Sensors (Basel)*. Jun 9 2021;21(12)doi:10.3390/s21123998

7. Stein PK, Pu Y. Heart rate variability, sleep and sleep disorders. *Sleep Med Rev*. Feb 2012;16(1):47-66. doi:10.1016/j.smrv.2011.02.005

8. Parrino L, Ferrillo F, Smerieri A, et al. Is insomnia a neurophysiological disorder? The role of sleep EEG microstructure. *Brain Res Bull*. Jun 30 2004;63(5):377-83. doi:10.1016/j.brainresbull.2003.12.010

9. Bonnet MH, Arand DL. Heart rate variability in insomniacs and matched normal sleepers. *Psychosom Med*. Sep-Oct 1998;60(5):610-5. doi:10.1097/00006842-199809000-00017

10. Morin CM, Vezina-Im LA, Ivers H, et al. Prevalent, incident, and persistent insomnia in a population-based cohort tested before (2018) and during the first-wave of COVID-19 pandemic (2020). *Sleep*. Jan 11 2022;45(1)doi:10.1093/sleep/zsab258

11. Sateia MJ. International classification of sleep disorders-third edition: highlights and modifications. *Chest*. Nov 2014;146(5):1387-1394. doi:10.1378/chest.14-0970

12. Leger D, Morin CM, Uchiyama M, Hakimi Z, Cure S, Walsh JK. Chronic insomnia, quality-of-life, and utility scores: comparison with good sleepers in a cross-sectional international survey. *Sleep Med*. Jan 2012;13(1):43-51. doi:10.1016/j.sleep.2011.03.020

13. Vgontzas AN, Liao D, Pejovic S, et al. Insomnia with short sleep duration and mortality: the Penn State cohort. *Sleep*. Sep 2010;33(9):1159-64. doi:10.1093/sleep/33.9.1159

14. Sulej L, Momot K, Zarębiński M, Wojciechowska M. Reperfusion arrhythmias – Underestimated cause of sudden cardiac death? *Medical Hypotheses*. 2023;174. doi:10.1016/j.mehy.2023.111060

15. Jiang XL, Zhang ZG, Ye CP, et al. Attenuated or absent HRV response to postural change in subjects with primary insomnia. *Physiol Behav*. Mar 1 2015;140:127-31. doi:10.1016/j.physbeh.2014.12.018

16. Grimaldi D, Goldstein MR, Carter JR. Insomnia and cardiovascular autonomic control. *Auton Neurosci*. Sep 2019;220:102551. doi:10.1016/j.autneu.2019.05.003

17. Grimaldi D, Reid KJ, Papalambros NA, et al. Autonomic dysregulation and sleep homeostasis in insomnia. *Sleep*. Jun 11 2021;44(6)doi:10.1093/sleep/zsaa274

18. Dahlof C, Dimenas E. Side effects of beta-blocker treatments as related to the central nervous system. *Am J Med Sci*. Apr 1990;299(4):236-44. doi:10.1097/00000441-199004000-00004

19. Zhao W, Jiang B. Heart rate variability in patients with insomnia disorder: a systematic review and meta-analysis. *Sleep Breath*. Aug 2023;27(4):1309-1313. doi:10.1007/s11325-022-02720-0

20. CDC Behavioral Risk Factor Surveillance System (BRFSS), 2020.

Short sleep duration based on response to the question:

"On average, how many hours of sleep do you get in a 24-hour period?".

21. Massoomi MR, Handberg EM. Increasing and Evolving Role of Smart Devices in Modern Medicine. *Eur Cardiol*. Dec 2019;14(3):181-186. doi:10.15420/ecr.2019.02

22. Degroote L, De Bourdeaudhuij I, Verloigne M, Poppe L, Crombez G. The Accuracy of Smart Devices for Measuring Physical Activity in Daily Life: Validation Study. *JMIR Mhealth Uhealth*. Dec 13 2018;6(12):e10972. doi:10.2196/10972

23. Chang L, Lu J, Wang J, et al. SleepGuard: Capturing Rich Sleep Information Using Smartwatch Sensing Data. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*. 09/18 2018;2:1-34. doi:10.1145/3264908

24. Meyer T, Wegmann M, Poppendieck W, Fullagar HHK. Regenerative interventions in professional football. *Sport-Orthopädie - Sport-Traumatologie - Sports Orthopaedics and Traumatology*. 2014/05/01/ 2014;30(2):112-118. doi:10.1016/j.orthtr.2014.04.009

25. Rave G, Fortrat JO. Heart rate variability in the standing position reflects training adaptation in professional soccer players. *Eur J Appl Physiol*. Aug 2016;116(8):1575-82. doi:10.1007/s00421-016-3416-9

26. da Silva DF, Ferraro ZM, Adamo KB, Machado FA. Endurance Running Training Individually Guided by HRV in Untrained Women. *J Strength Cond Res*. Mar 2019;33(3):736-746. doi:10.1519/JSC.0000000000002001

27. Spiegelhalder K, Fuchs L, Ladwig J, et al. Heart rate and heart rate variability in subjectively reported insomnia. *J Sleep Res*. Mar 2011;20(1 Pt 2):137-45. doi:10.1111/j.1365-2869.2010.00863.x

28. Buchheit M. Monitoring training status with HR measures: do all roads lead to Rome? *Front Physiol*. 2014;5:73. doi:10.3389/fphys.2014.00073

29. Jobbágy Á, Majnár M, Toth L, Nagy PB. HRV-based Stress Level Assessment Using Very Short Recordings. *Period Polytech Electr Eng Comput Sci*. 2017;61:238-245.

30. Corino VDA, Mainardi LT, Husser D, Bollmann A. Autonomic Modulation of Ventricular Response by Exercise and Antiarrhythmic Drugs during Atrial Fibrillation. Springer Berlin Heidelberg; 2007:82-85.

31. Otzenberger H, Gronfier C, Simon C, et al. Dynamic heart rate variability: a tool for exploring sympathovagal balance continuously during sleep in men. *Am J Physiol*. Sep 1998;275(3):H946-50. doi:10.1152/ajpheart.1998.275.3.H946

32. Jarrin DC, Chen IY, Ivers H, Lamy M, Vallieres A, Morin CM. Nocturnal heart rate variability in patients treated with cognitive-behavioral therapy for insomnia. *Health Psychol*. Jun 2016;35(6):638-41. doi:10.1037/hea0000347

33. Warth M, Kessler J, Bardenheuer HJ. Insomnia and Autonomic Function Predict Well-Being in Patients Receiving Palliative Care. *J Palliat Med*. Dec 2017;20(12):1395-1399. doi:10.1089/jpm.2017.0032

34. Kapica M, Momot, K., Żmijewska, A., Sztybór, M., Krzyżanowska, M., Maleszewska, M., Piątkiewicz, J., Nowak, G., Wojtas, M., & Głogowska, K. . Connecting the Dots: Heart Failure and Insomnia. *Journal of Education, Health and Sport*. 2024;62:199-216. doi:10.12775/JEHS.2024.62.013

35. Zhang B, Yu J, Wu Y, et al. The significance of heart rate variability in patients with frequent premature ventricular complex originating from the ventricular outflow tract. *Clin Cardiol*. Jan 2024;47(1):e24174. doi:10.1002/clc.24174

36. Sessa F, Anna V, Messina G, et al. Heart rate variability as predictive factor for sudden cardiac death. *Aging (Albany NY)*. Feb 23 2018;10(2):166-177. doi:10.18632/aging.101386

37. Yu Q, Wang J, Dai M, et al. Night-Time Premature Ventricular Complex Positively Correlates With Cardiac Sympathetic Activity in Patients Undergoing Radiofrequency Catheter Ablation. *Heart Lung Circ*. Aug 2020;29(8):1152-1163. doi:10.1016/j.hlc.2019.11.009

38. Kojic D, Radunovic A, Bukumiric Z, et al. Idiopathic premature ventricular complexes treatment: Comparison of flecainide, propafenone, and sotalol. *Clin Cardiol*. Oct 2023;46(10):1220-1226. doi:10.1002/clc.24090

39. Rodkiewicz D, Kozluk E, Momot K, et al. Efficacy of Catheter Ablation Using the Electroanatomical System without the Use of Fluoroscopy in Patients with Ventricular Extrasystolic Beats. *J Clin Med*. Jul 24 2023;12(14)doi:10.3390/jcm12144851

40. Zhang B, Wing YK. Sex differences in insomnia: a meta-analysis. *Sleep*. Jan 2006;29(1):85-93. doi:10.1093/sleep/29.1.85

41. Chae B, Kang J, Shin C, Ko YH, Yoon HK. Insomnia in Emotional Labor: Its Role in Autonomic Nervous System Regulation. *Psychiatry Investig*. Sep 2021;18(9):889-894. doi:10.30773/pi.2021.0117