Jurnal Eduhealth
Volume 16, Number 03 2025 DOI 10.54209/eduhealth.v16i03
ESSN 2808-4608 (Online)
https://ejournal.seaninstitute.or.id/index.php/healt

The Association of Physical Activity and Sleep Quality with Baroreceptor-Mediated Blood Pressure Regulation in Healthy Adult Women

Bintang Tatius[1], Nabil Hajar [1], Herianto Sibuea[2]
[1]Departments of Biomedical Science, Faculty of Medicine Universitas Muhammadiyah Semarang, Jl. Kedungmundu No.18, Kec. Tembalang, Semarang, Indonesia. [2]Medical Doctor Professional Program, Faculty of Medicine, Universitas Muhammadiyah Semarang, Jl. Kedungmundu No.18, Kec. Tembalang, Semarang, Indonesia

Article Info

Keywords:
Baroreceptor,
Blood Pressure,
Orthostatic Response,
Physical Activity,
Sleep Quality

ABSTRACT

Baroreceptor-mediated blood pressure regulation is a vital autonomic mechanism influenced by various physiological factors, including physical activity and sleep quality. However, few studies have explored these relationships specifically in healthy adult women. This study aimed to examine the association between physical activity levels and sleep quality with baroreceptor function, measured through blood pressure changes from supine to standing positions. A cross-sectional analytical study was conducted involving 55 healthy adult women selected by purposive sampling from participants of community exercise programs at Klinik Pratama Unimus and Yayasan Al-Muqorrobin, Semarang. Participants completed the International Physical Activity Questionnaire (IPAQ) and Pittsburgh Sleep Quality Index (PSQI), followed by measurement of systolic, diastolic, and pulse pressure differences during the Schellong test. Baroreceptor response was operationalized as the difference in blood pressure and pulse rate from supine to erect positions. Data were analyzed using Spearman's rank correlation in SPSS version 25. A significant correlation was observed between physical activity levels and systolic blood pressure changes ($r = 0.272$, $p = 0.045$), as well as between sleep quality and diastolic blood pressure changes ($r = -0.336$, $p = 0.012$), indicating that higher physical activity and better sleep quality are associated with more stable baroreceptor responses. In conclusion, physical activity and sleep quality are significantly associated with baroreceptor-mediated blood pressure regulation in healthy adult women. Our findings suggest that lifestyle factors may play a role in maintaining autonomic cardiovascular function.

Corresponding Author:
Bintang Tatius
Universitas Muhammadiyah Semarang
Jl. Kedungmundu No.18, Kec. Tembalang, Semarang, Indonesia
bintangtatius@unimus.ac.id

INTRODUCTION

Health is a fundamental priority in life. In today's fast-paced world, people increasingly opting for sedentary lifestyle, leading to physical inactivity and sleep deprivation, even when these are detrimental to health (Damayanti, 2019). Cardiovascular disease (CVD), being caused by sedentary lifestyle, is one such condition that is frequently neglected. Globally, CVD remains a major threat. In 2017, cardiovascular diseases accounted for approximately 17.8 million deaths and led to 35.6 million people living with disability worldwide. The majority of these deaths occurred in low- and middle-income countries (Mensah et al., 2019).

A previous study conducted in Malang, Indonesia, from 2016 to 2017, involving adults aged 40 years and older, found that 6,455 (29.2%) of 22,093 participants had a high cardiovascular risk (Maharani et al., 2019). Adults who regularly engage in physical activity have a lower risk of heart disease compared to those with sedentary lifestyles and tend to achieve better overall quality of life (Tsao et al., 2022). However, to engage in physical activity optimally, individuals also need sufficient sleep. Adequate sleep is crucial for maintaining both physical and mental health. Poor sleep quality is equally harmful as neglecting cardiovascular health (Evbayekha et al., 2022). Previous research indicated that individuals who sleep less than six hours per night are more likely to develop heart disease than those who sleep for about seven hours (Gambardella et al., 2020).

Baroreceptor response is a critical physiological mechanism that helps maintain blood pressure stability during postural changes. It reflects the autonomic nervous system's ability to regulate cardiovascular function, particularly through heart rate and vascular tone adjustments when transitioning from a supine to an erect position (Bintang et al., 2024). A blunted baroreceptor response is associated with an increased risk of syncope, falls, and cardiovascular morbidity, even in healthy individuals (Palamarchuk et al., 2021).

Both physical activity and sleep quality are known to modulate autonomic nervous system function and baroreflex sensitivity (Joyner & Masuki, 2008). Regular aerobic exercise enhances baroreceptor reflex function by improving vascular compliance and autonomic balance (Ramos et al., 2017). Conversely, poor sleep quality or insufficient sleep has been linked to impaired baroreflex sensitivity, which may result in dysregulated blood pressure upon standing (Grimaldi et al., 2014).

Previous studies have examined the relationship between physical activity, sleep quality, and cardiovascular risk, including orthostatic hypotension. For instance, Febriani (2015) reported a relationship between physical activity and orthostatic hypotension, while McHugh et al. and Hoevenaar-Blom et al. found an association between sleep quality and cardiac health. These findings emphasize the importance of lifestyle factors in cardiovascular regulation.

The current study expands upon these findings by shifting focus to the baroreceptor response, as assessed by measuring the change in systolic and diastolic blood pressure from a supine to an erect position. This study will specifically investigate this response in a population of healthy adult women, aiming to analyze the correlation between physical activity and sleep quality with baroreceptor response.

METHODS

This study employed an analytical observational design using a quantitative cross-sectional approach. The research was conducted in September 2023 at the Klinik Pratama of Universitas Muhammadiyah Semarang (UNIMUS) and the Al-Muqorrobin Foundation in Semarang. The population in this study consisted of healthy adult women who regularly participated in physical activity programs, such as group aerobic exercises, organized by both institutions. Participants were selected through purposive sampling based on predetermined eligibility criteria. A total of 55 women who met the inclusion criteria were included in the analysis.

Inclusion criteria consisted of adult women aged 20 to 60 years, with a generally healthy condition and no history of acute illness at the time of data collection. Participants were required to be physically able to perform positional changes independently, regularly engaged in community-based exercise, and willing to provide written informed consent. Exclusion criteria included a history of cardiovascular disease such as hypertension, arrhythmia, or heart failure; known neurological or autonomic disorders such as Parkinson's disease or diabetic neuropathy; pregnancy; the use of medications that could affect autonomic regulation such as beta-blockers or diuretics; and complaints of dizziness, vertigo, or fainting during posture changes. Individuals with orthopaedic impairments or conditions that could interfere with safe execution of the Schellong test were also excluded. These criteria were applied to ensure the participants' safety during orthostatic measurements and to control for confounding variables that could affect baroreceptor responses.

Data collection began with the distribution and explanation of informed consent forms, followed by completion of demographic data and two standardized questionnaires. Physical activity levels were measured using the International Physical Activity Questionnaire – Short Form (IPAQ-SF), which evaluates physical activity over the past seven days, including vigorous, moderate, and walking activities. The results are expressed in MET-minutes/week and categorized as low, moderate, or high activity levels based on international scoring standards. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), a validated instrument consisting of 19 items grouped into seven components that measure various aspects of sleep over the past month. The global score ranges from 0 to 21, with scores greater than 5 indicating poor sleep quality (Tobaldini et al., 2017).

To evaluate baroreceptor response, each participant underwent the *Schellong* test in a controlled and quiet room. Measurements of systolic blood pressure, diastolic blood pressure, and pulse rate were taken using an automatic digital blood pressure monitor Omron type HEM 7120, first after one minute in a supine (lying down) position, and again after one minute in an erect (standing) position. The changes in blood pressure and pulse were recorded to reflect baroreceptor response to orthostatic stress (Almeida et al., 2015).

All data were processed using IBM SPSS Statistics version 25. Descriptive statistics were used to describe participants' characteristics, sleep quality, physical activity, and baroreceptor responses. As the data were not normally distributed and suited for non-parametric statistical analysis, the Spearman Rank correlation test with p-value <0.05 indicates statistical significance was performed to examine the relationship between physical activity and sleep quality with the baroreceptor response. This research has obtained ethical clearance from the Ethics Committee of the Faculty of Medicine, Universitas Muhammadiyah Semarang, with the official approval number 049/EC/KEPK-FK/UNIMUS/2023.

RESULTS AND DISCUSSION

Characteristic of Research Subjects

Based on Table 1, the research subjects were mostly young adult individuals (25 - 44 years old), with 43 subjects (78.2%). In terms of occupation, the majority of the research subjects were housewives, totaling 40 subjects (76.4%). Table 2 shows the mean physical activity score was 6408.42 ± 5305.230, the mean sleep quality score was 7.89 ± 2.192, the mean difference in systolic blood pressure was 1.51 ± 12.389 mmHg, the mean difference in diastolic blood pressure was -6.65 ± 9.722 mmHg, and the mean pulse difference was -6.04 ± 7.909 beats per minute. The data distribution was analyzed as abnormal distribution according to Kolmogorov Smirnov test.

Correlation Between Physical Activity, Sleep Quality, and Baroreceptor Reflex

Table 3 indicates that the Spearman Rank correlation test showed a significant relationship between physical activity and the difference in systolic blood pressure ($p = 0.045$), and between sleep quality and the difference in diastolic blood pressure ($p = 0.012$). This indicates that greater physical activity is associated with lower systolic pressure changes ($r=0.272$), while poor sleep quality is associated with increased diastolic pressure differences ($r=-0.336$). However, there were no significant correlations between physical activity and differences in diastolic blood pressure ($p = 0.138$) or pulse ($p = 0.398$), and no significant correlations between sleep quality and systolic blood pressure difference ($p = 0.118$) or pulse difference ($p = 0.512$).

Table 1. Demographic characteristics of research respondents

Characteristics	Amount (n=40)	Percentage (%)
Age group		
Young Adult (25-44 y.o.)	43	78.2%
Middle Aged (≥45-59 y.o.)	12	21.8%
Occupation		
Housewife	42	76.4%
Private sector	9	16.4%
Therapist	1	1.8%
Tailor	1	1.8%
Entrepreneur	2	3.6%

Table 2. Respondents' characteristics by variable

Variable	Mean ± SD
Physical activity score	6408.42 ± 5305.230
Sleep quality score	7.89 ± 2.192
Systolic blood pressure difference	1.51 ± 12.389 mmHg
Diastolic blood pressure difference	-6.65 ± 9.722 mmHg
Pulse difference	-6.04 ± 7.909 beats/minute

Table 3. Correlation of physical activity and sleep quality with systolic, diastolic blood pressure and pulse differences

Variable	Systolic BP diff	Diastolic BP diff	Pulse diff
Physical activity	r=0.272, p=0.045*	r=0.202, p=0.138	r=-0.116, p=0.398
Sleep quality	r=-0.213, p=0.118	r=-0.336, p=0.012*	r=-0.090, p=0.512

* indicates statistical significance (p<0.05)

Discussion

This study found a significant association between physical activity and variations in systolic blood pressure, with a moderate inverse correlation pattern, indicating that higher levels of physical activity were associated with smaller differences in systolic blood pressure when transitioning from a supine to an erect position. This finding aligns with previous studies, which reported that continuous high-intensity physical activity can induce orthostatic hypotension (Hidayati et al., 2019). During intense physical exertion, sympathetic nerve activity increases and blood flow is redistributed to the active muscles. This can lead to a reduction in central blood volume, which may persist after physical activity ends. Our previous study also found correlation between muscle mass and baroreceptor reflex (Nasrullah, 2024). The subsequent decline in preload and cardiac output contributes to a decrease in blood pressure. In addition, heavy exercise stimulates the release of vasodilatory substances such as nitric oxide and prostaglandins, which induce peripheral vasodilation and lower systemic vascular resistance, thus contributing to a drop in blood pressure. However, the interplay of these mechanisms is complex and may differ between individuals (Sonkodi et al., 2023).

Furthermore, physical activity has been shown to improve baroreceptor sensitivity through pressure-lowering responses (Gomes et al., 2017). This supports the current study's findings, which are consistent with prior research reporting a significant relationship between physical activity and the occurrence of orthostatic hypotension (Febriani, 2015). The link is further supported by evidence suggesting that individuals who engage in regular physical activity tend to have enhanced baroreceptor response mechanisms (Climie et al., 2019). During physical activity, the body demands more oxygen and nutrients for the working muscles. To meet this demand, the heart pumps more forcefully and at a faster rate, activating the sympathetic nervous system and inducing vasoconstriction. As blood pressure rises, baroreceptors detect the increase and transmit signals to the central nervous system, which in turn triggers endothelial cells to release nitric oxide. Nitric oxide plays a critical role in blood pressure regulation by promoting vasodilation. The dilation of blood vessels decreases blood flow resistance, thereby helping normalize blood pressure. This baroreflex mechanism continues to operate after the cessation of physical activity, maintaining cardiovascular homeostasis (Gambardella et al., 2020; Sonkodi et al., 2023).

In this study, a statistically significant relationship was also observed between sleep quality and diastolic blood pressure variation, with a moderate positive correlation. These findings are supported by previous research showing that poor sleep quality is associated with elevated blood pressure and a greater risk of orthostatic hypotension (Saraswati et al., 2020). During the transition from light sleep (NREM N1) to deeper stages, parasympathetic tone increases while sympathetic tone gradually decreases. These autonomic changes result in reduced arterial pressure and decreased peripheral vascular resistance. Consequently, the cardiac workload is diminished, and autonomic balance is enhanced. This autonomic shift during sleep highlights the crucial role of sleep in modulating baroreceptor responses via the autonomic nervous system. (Tobaldini et al., 2017) Conversely, poor sleep quality triggers stress responses, activating the sympathetic nervous system and promoting the release of stress hormones such as adrenaline and cortisol. This stimulation also enhances the renin-angiotensin system, leading to increased blood pressure (Luthfi et al., 2017). Repeated poor sleep episodes may result in baroreceptor response dysregulation due to sustained sympathetic activation (Robillard et al., 2011).

Our prior study also suggests that poor sleep quality activates the hypothalamus and the sympathetic-adrenal-medullary axis, as well as the hypothalamic-pituitary-adrenal (HPA) axis. In these conditions, the adrenal medulla secretes norepinephrine and epinephrine, which act directly on the vasculature and heart, causing vasoconstriction and increased peripheral resistance. In addition to stimulating sympathetic activity, inadequate sleep also elevates both physical and psychosocial stress, thereby affects cardiovascular fitness and exacerbating blood pressure elevations (Bintang et al., 2024).

This study has several limitations that should be acknowledged. First, the cross-sectional design limits the ability to draw causal inferences between physical activity, sleep quality, and baroreceptor response. The relationships observed only represent associations at a single point in time, not the direction or long-term impact of the variables. Second, the assessment of baroreceptor response was indirectly measured using the difference in systolic and diastolic blood pressure between supine and standing positions. While this orthostatic change is a widely accepted proxy for baroreflex function, it is less precise than direct measurements such as heart rate variability or baroreflex sensitivity index. Third, the use of self-reported questionnaires such as the IPAQ and PSQI may be subject to recall bias or social desirability bias, possibly leading to misclassification of physical activity levels or sleep quality. Furthermore, potential confounders such as caffeine consumption, hydration status, recent physical activity before measurement, or underlying undiagnosed autonomic dysfunction were not controlled for in this study. Finally, the generalizability of the findings may be limited to similar populations and settings, as the sample may not represent the broader demographic or clinical variability.

CONCLUSION

This study found significant associations between physical activity and systolic blood pressure changes, and between sleep quality and diastolic blood pressure changes during postural transition. individuals with higher levels of physical activity exhibited a smaller reduction in systolic blood pressure when moving from a supine to a standing position, potentially indicating better baroreceptor responsiveness. Maintaining regular physical activity and good sleep hygiene is important in preserving baroreceptor response stability. Future research with longitudinal designs and more direct assessments of baroreflex function is needed to further elucidate the mechanisms underlying these associations.

REFERENCE

Almeida, F. A., Sill, S. C., Smith-Ray, R. L., Estabrooks, P. A., & Glasgow, R. E. (2015). Evaluation of a lay health educator physical activity program for older adults: Translation to practice. *Health Education & Behavior*, *42*(3), 381–388. https://doi.org/10.1177/1090198114557129

Bintang, T., Hajar, N., Tursinawati, Y., Romadhoni, Baihaqi, M. H., Muhammad, K., Akmal, M. I., & Ja'far, I. M. (2024). Factors affecting cardiorespiratory fitness among medical students: A cross-sectional study. *Universal Journal of Public Health*, *12*(5), 820–827. https://doi.org/10.13189/ujph.2024.120504

Climie, R. E., van Sloten, T. T., Bruno, R. M., Tafflet, M., Bureau, J. M., Thomas, F., & Boutouyrie, P. (2019). Association between occupational, sport, and leisure-related physical activity and baroreflex sensitivity: The Paris prospective study III. *Hypertension*, *74*(6), 1476–1483. https://doi.org/10.1161/HYPERTENSIONAHA.119.13461

Evbayekha, E. O., Adelakun, F. E., & Alabi, O. O. (2022). Sleep deprivation is associated with increased risk for hypertensive heart disease: A nationwide population-based cohort study. *Cureus*, *14*(12), e33005. https://doi.org/10.7759/cureus.33005

Febriani, R. R. (2015). *Hubungan antara aktivitas fisik dengan hipotensi ortostatik pada lanjut usia di Panti Sasana Tresna Wreda Raden Rainy Febriani*.

Gambardella, J., Lombardi, A., Trimarco, B., & Santulli, G. (2020). Pathophysiological mechanisms underlying the beneficial effects of physical activity in hypertension. *Journal of Clinical Hypertension*, *22*(2), 291–295. https://doi.org/https://doi.org/10.1111/jch.13804

Gomes, M. F. P., Santos, F., & Barreto, M. (2017). The effect of physical resistance training on baroreflex sensitivity of hypertensive rats. *Arquivos Brasileiros de Cardiologia*, *108*(6), 539–545. https://doi.org/https://doi.org/10.5935/abc.20170065

Grimaldi, D., Carter, J. R., Van Cauter, E., & Leproult, R. (2014). Adverse impact of sleep restriction and circadian misalignment on autonomic function in healthy young adults. *Hypertension*, *64*(5), 993–998. https://doi.org/https://doi.org/10.1161/HYPERTENSIONAHA.114.03537

Hidayati, N., Paryono, & Wibowo, S. (2019). Hipotensi ortostatik pada pasien dengan diabetes: Strategi pengobatan secara komprehensif. *Berkala Neurosains*, *18*(2), 63–70.

Hoevenaar-Blom, M. P., Spijkerman, A. M., Kromhout, D., van den Berg, J. F., & Verschuren, W. M. (2011). Sleep duration and sleep quality in relation to 12-year cardiovascular disease incidence: The MORGEN study. *Sleep*, *34*(11), 1487–1492. https://doi.org/https://doi.org/10.5665/sleep.1382

Joyner, M. J., & Masuki, S. (2008). Pushing the limit: Exercise and the physiology of cardiovascular regulation. *Comprehensive Physiology*, 589–635. https://doi.org/https://doi.org/10.1152/physrev.00004.2008

Luthfi, B. M., Azmi, S., & Erkadius, E. (2017). Hubungan kualitas tidur dengan tekanan darah pada pelajar kelas 2 SMA Negeri 10 Padang. *Jurnal Kesehatan Andalas*, *6*(2), 318. https://doi.org/https://doi.org/10.25077/jka.v6i2.698

Maharani, A., Tampubolon, G., Rahardjo, T. B., & Dewi, F. S. T. (2019). Cardiovascular disease risk factor prevalence and estimated 10-year cardiovascular risk scores in Indonesia: The SMARThealth Extend study. *PLOS ONE*, *14*(4), e0215219. https://doi.org/https://doi.org/10.1371/journal.pone.0215219

McHugh, J. E., Taylor, A. H., & Morrison, V. (2012). Orthostatic hypotension and subjective sleep quality in older people. *Aging and Mental Health*, *16*(8), 958–963. https://doi.org/https://doi.org/10.1080/13607863.2012.684665

Mensah, G. A., Roth, G. A., & Fuster, V. (2019). The global burden of cardiovascular diseases and risk factors: 2020. *Journal of the American College of Cardiology*, *74*(20), 2529–2532. https://doi.org/https://doi.org/10.1016/j.jacc.2019.10.009

Nasrullah, B. T. (2024). Korelasi Massa Otot Dan Massa Lemak Total Dengan Respon Baroreseptor : Studi Cross Sectional Pada Komunitas Senam Wanita. *Jurnal Medika Malahayati*, *8*(2), 366–374. https://doi.org/10.33024/jmm.v8i2.14005

Palamarchuk, I., Furmanek, M. P., Pham, T., & Smith, M. L. (2021). Baroreflex dysfunction and its clinical implications: A review. *Autonomic Neuroscience*, *235*, 102867. https://doi.org/https://doi.org/10.1016/j.autneu.2021.102867

Ramos, J. S., Dalleck, L. C., Tjonna, A. E., Beetham, K. S., & Coombes, J. S. (2017). The impact of high-intensity interval training versus moderate-intensity continuous training on vascular function: A systematic review and meta-analysis. *Sports Medicine*, *47*(4), 713–731. https://doi.org/https://doi.org/10.1007/s40279-016-0626-5

Robillard, R., Prince, F., Filipini, D., & Carrier, J. (2011). Sleep deprivation increases blood pressure in healthy normotensive elderly and attenuates the blood pressure response to orthostatic challenge. *Sleep*, *34*(3), 335–339. https://doi.org/https://doi.org/10.1093/sleep/34.3.335

Saraswati, M. A. P., Saraswati, P. A. S., Adiatmika, I. P. G., & S., L. P. R. (2020). Hubungan kualitas tidur terhadap tekanan darah pada wanita lansia di Denpasar Timur. *Jurnal Universitas Udayana*, *8*(1), 42–46.

Sonkodi, B., Radovits, T., Csulak, E., Kopper, B., Sydó, N., & Merkely, B. (2023). Orthostasis is impaired due to fatiguing intensive acute concentric exercise succeeded by isometric weight-loaded wall-sit in delayed-onset muscle soreness: A pilot study. *Sports*, *11*(11), 209. https://doi.org/https://doi.org/10.3390/sports11110209

Tobaldini, E., Costantino, G., Solbiati, M., Cogliati, C., Kara, T., Nobili, L., & Montano, N. (2017). Sleep, sleep deprivation, autonomic nervous system and cardiovascular diseases. *Neuroscience & Biobehavioral Reviews*, *74*, 321–329. https://doi.org/https://doi.org/10.1016/j.neubiorev.2016.07.004

Tsao, C. W., Aday, A. W., Almarzooq, Z. I., Anderson, C. A. M., Arora, P., Avery, C. L., & Virani, S. S. (2022). Heart disease and stroke statistics—2022 update: A report from the American Heart Association. *Circulation*, *145*(8), e153–e639. https://doi.org/https://doi.org/10.1161/CIR.0000000000001052