

RESEARCH ARTICLE



OPEN ACCESS

Received: 29.11.2021

Accepted: 08.01.2022

Published: 05.03.2022

Citation: Lele CD (2022) The Physical Activity and Sleep Quality - A Correlation Analysis of Young Adults in India. Indian Journal of Science and Technology 15(9): 357-363. <https://doi.org/10.17485/IJST/v15i9.2222>

* **Corresponding author.**

deeptigadre@gmail.com

Funding: None

Competing Interests: None

Copyright: © 2022 Lele. This is an open access article distributed under the terms of the [Creative Commons Attribution License](https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Published By Indian Society for Education and Environment ([iSee](https://www.indjst.org/))

ISSN

Print: 0974-6846

Electronic: 0974-5645

The Physical Activity and Sleep Quality - A Correlation Analysis of Young Adults in India

Chaitanya Deepti Lele^{1*}

¹ Assistant Professor, Krupanidhi College of Physiotherapy, Bangalore, Karnataka, India

Abstract

Introduction: An adequate and undisturbed sleep is a necessity for physical and mental wellbeing. Lack of sleep will have an impact on growth, mental, biological functioning and immunity. Studies on young adults suggest, there is an evident increase in sedentary life style and change in physical activity status over the last decade. **Objectives:** The purpose of this study is to understand the relationship and effects of physical activity on sleep in young adults in India. Also, to determine the change in the sleep parameters according to gender and physical activity. **Methods:** Study includes 215 (n=215) young healthy adults between age 18-35years. Males and females 87 and 128 respectively. Informed consent and anthropometric measurements were taken. Participants were interviewed and guided for self-report of Pittsburgh Sleep Quality Index (PSQI) for recording sleep and Global Physical Activity Questionnaire (GPAQ) for recording physical activity status in past 7days. **Inclusion criteria:** Healthy young adults between 18-35 years of age, willing to participate in the survey. **Exclusion criteria:** Participants suffering from infections, history of illness in past three months, participants with the history of ongoing chronic disease. **Findings:** 178 participants were in the age group of 18-22years. Weak negative correlation is seen in physical activity and sleep. Participants with low intensity physical activity reported affected sleep, with disturbed sleep ($r = -0.186$), difficulty in breathing at night ($r = -0.135$), Sleep disturbances due to bad dreams ($r = -0.131$) were seen in very few participants with moderate level activities. **Conclusion:** Weak negative correlation is found in physical activity and sleep. Vigorous to moderate intensity physical activity has good effect on quality of sleep. Women and young adults have better sleep parameters and physical activity intensity. Most of the subjects were found to have low to moderate levels of physical activity and were unaware about the necessary levels of physical activity. **Novelty:** The studies are focusing on young Indian population, who have a very busy lifestyle. There are studies focusing of sleep with higher mental function and effect of the physical activity on memory and mental health. However, the current study aims at understanding the correlation between the physical activity and sleep.

Keywords: Physical Activity; Sleep Quality; Young Adults; Sleep Patterns; Sleep Habits; Physical Inactivity; Sedentary Lifestyle

1 Introduction

India has a good demographic profile being 65% of population under the age of 35 years⁽¹⁾. Lack of sleep has negative impact on normal growth, mental functioning and, biological functioning and immunity⁽²⁾. An adequate and undisturbed sleep is a need for physical and mental wellbeing. Sleep quality is a strong determining factor for various mental illnesses like anxiety and depression and other non-communicable diseases viz. -cancer, diabetes⁽³⁾. As per WHO's recommendation for an individual in age group of 18-35 years necessitates 7-8 hours of sleep and 150mins/week of physical activity⁽⁴⁾, Sleep quality and quantity are both essential when term 'sleep' is used. NSF recommends indicators like time taken to fall asleep (sleep latency), sleep disturbances (number of awakenings>5 mins) and sleep efficiency along with number of hours of sleep and wake after sleep onset for good quality of sleep⁽⁵⁾.

Physical activity is defined as any movement of body that requires energy expenditure⁽⁶⁾. It can be playing, working household chores, recreational activity, walking or daily commute. Lack of physical activity is a leading cause of non-communicable, lifestyle diseases like diabetes and IHD. According to a study published in 36.9% of total Indian population is reported to be physically inactive⁽⁷⁾. Physical activity is classified into three main subcategories – high /vigorous (more than 6.0 METs /more than 7kcal/min) intensity, moderate intensity 3.0–6.0 exercise metabolic rates (METs/3.5–7 kcal/min)⁽⁸⁾.

There is wide literature available on sleep studies and physical activity. There are studies correlating sleep with various psychological⁽⁹⁾⁽¹⁰⁾⁽¹¹⁾, developmental disorders like autism⁽¹²⁾ and lifestyle diseases like diabetes, obesity⁽¹³⁾ and cancer survivors⁽¹⁴⁾ respectively. Literature generally has focused on very young or geriatric age group for the studies and mostly Caucasians.

This study includes qualitative assessment and correlation of physical activity and sleep of the young adults in age 18-35, in Indian young adults. As this age group mainly includes students, job seekers and working population. They generally have a busy lifestyle.

2 Methodology

This is a survey correlation study. An informed consent was taken from the participants. Participants were selected on the basis of random sampling method. Name, age, gender, height, weight, and anthropometric data was collected from all the subjects. History of existing diagnosed medical conditions was taken.

Data was collected from Krupanidhi Group of Institutions. Participants included both males and females between ages 18-35years were included in the study. The duration of the study was November 2019- December 2019. IEC number is EC - FAC /19 /PHY/ 21.

Participants suffering from active infections (Cold /viral), diagnosed and on treatment for other associated physical and psychological illnesses were excluded from the study.

Total participation was 257 out of which 215 (n=215) were included in the data. A few of them had an incomplete form or were excluded as they had history of illness in the past one month. As per the data analysis, 128 females and 87 males participated in the survey. As per the age distribution, three groups were made which classified them into students and working groups. Three groups were 18-22 years, 23 to 30 years and 31 to 35 years.

Two self-reported questionnaires on physical activity –(IPAQ) International physical activity questionnaire⁽⁹⁻¹¹⁾ and Pittsburgh sleep quality Index (PSQI);^(15,16) were given to participants post explanation of each questionnaire and guidelines of how to score.

2.1 International physical activity questionnaire

IPAQ can be used from age 15-69 yrs. It consists of 4 sets of questionnaires targeting various domains of high to low level physical activities one can perform during the day including commute and type of work. It includes total sitting, travelling, household chores etc. for the past 7 days. Based on these activities are the categories in physical activity fall into vigorous, moderate and low levels.

2.2 Pittsburgh sleep quality Index

PSQI is also a self-reported questionnaire, overlooking at sleep quality and parameters for past one month⁽¹⁷⁾. Various parameters like latency, duration of sleep, disturbances due to various reasons like use of washroom, body temperature changes, nightmares, etc. are scored from 0 being the best score and 5 as the worst score. Lesser score indicates better sleep.

3 Data analysis and results

3.1 Demographic data

Data was collected and analysed using Microsoft excel and SPSS software. Table 1 represents the demographic data, total number of subjects (n=215), 128 female subjects and 87 male subjects. As per these groups there were 176 participants in age 18-22, 31 participants in age 23 to 30 and 8 were in 31 to 35 years. From the data in Table 1, there were 109 females and 67 males in age group 18-22years. There were 17 females and 14 males in age group 23 to 30 years and 2 females and 6 males in the age group 31 to 35 years

Table 1. Demographic data
Gender * Age Cross tabulation

			Age			Total
			18-22	23-30	31-35	
Gender	Female	Count	109	17	2	128
		% within Gender	85.2%	13.3%	1.6%	100.0%
	Male	Count	67	14	6	87
		% within Gender	77.0%	16.1%	6.9%	100.0%
Total	Count		176	31	8	215
	% within Gender		81.9%	14.4%	3.7%	100.0%

3.2 Analysis of Physical Activity

Table 2 represents physical activity in various age groups. As per international physical activity questionnaire, various activities subdivided into given into categorise as low, moderate and vigorous physical activity. As per the data analysis 96% of participants are doing moderate physical activities.

Table 2. Distribution of moderate physical activity

Categories of IPAQ for moderate physical activity	Light	Moderate	Vigorous
Moderate Household Activity (eg: Sweeping outdoors, etc.)	94%	2%	4%
Sports Activities (eg: Swimming)	97%	1%	2%

Table 3 represents vigorous physical activity at work and non-work related vigorous activities. Those who did not satisfy the criteria on moderate and vigorous physical activities were categories into low physical activity.

From Table 2 and Table 3, Physical activity was more in age 18-22 and then 23-30 and declines drastically from 31-35. As per data analysis, it was observed that only 2% and 4% of moderate and vigorous physical activity seen as per activities included in

Table 3. Distribution of Vigorous physical activity analysis

Categories of IPAQ for vigorous physical activity	Light	Vigorous
Work Related Activity (eg: walking at work, lifting weights at work, etc.)	96%	4%
Vigorous Household Activity (Gardening, washing car, window cleaning etc.)	97%	3%
Bicycling (moderate)	100%	0%

vigorous intensity activities. From the above tables, it has been seen that 94% perform those activities but the duration or/and frequency was inadequate to include it as moderate or vigorous physical activity.

3.3 Sleep analysis

Table 4 represents Pittsburgh sleep quality index includes questions about duration of sleep, latency for sleep, disturbances at night, and various reason analysis for sleep disturbances, etc.

Table 4. Sleep Analysis

Sleep patterns with Gender and age				
Duration in hours	7 or >7hrs	6-7hrs	5-6hrs	<5hrs
Females	62%	52%	50%	69%
Males	38%	48%	50%	31%
Total	100%	100%	100%	100%
Age 18-22	83%	81%	50%	83%
Age 23-30	15%	15%	0	11%
Age 30-35	2%	4%	50%	6%
Total	100%	100%	100%	100%

Duration of sleep is considered normal if it's above 7 hours for adults. As per data analysis, 62% females sleep for longer duration as compared to males. As per age distribution sleep duration is maximum in 18-22 years of age and starts declining as age advances.[Table 4]

Pearson's correlation coefficient was used to study the correlation in physical activity and sleep. As per the data analysis, very weak negative correlation was seen. Participants with light to very light physical activity found to have difficulty in falling asleep in less than 15min (.049), sleep disturbances due to hot flushes at night or frequent waking up (.006) for using bathroom or bad dreams (.087) and difficulty in breathing (.054). They also found to have lack of enthusiasm in participating at social events.

Pearson's chi square test value was 0.022, strongly indicating that moderate to vigorous physical activity helps in getting better quality sleep. Sleep disturbances for moderate to high intensity exercises observed to be almost negligible. Though some disturbances due to bad dreams and reduced social enthusiasm were observed. Wherein, vigorous physical activities and sports related vigorous physical activities there were no sleep disturbances. Whereas subjects with work related vigorous physical activity were observed to experience sleep disturbances due to pain and body aches (0.069) (Table 5)

Cross tabulation of good sleep- poor sleep with moderate and low physical activity results are shown in Table-6. The odd's ratio for poor sleeping pattern to good sleeping patterns with low (leisure) and moderate physical activity is 0.365. The risk ratio between poor sleep to good sleep is 0.365, indicating towards a better quality of sleep for most of the participants. In this study, 2.282 is the risk value for good sleep and moderate-vigorous physical activity, which indicates that most of the participants had satisfactory sleep quality despite of inadequate levels of moderate to vigorous physical activity. The risk value of 0.832 associated between poor/good sleep and low levels of physical activity directs towards issues with sleep due to poor physical activity.

4 Discussion

The current study was designed to analyses the correlation between physical activity and sleep in the young adults in India, also to study the change in sleep parameters and physical activity as per gender and age.

Results are suggestive of weak negative correlation in sleep and physical activity. From the data and results it can be said that, most of the participants were involved in some type of physical activity which was low to moderate level of physical activity. When compared with the sleep, very few sleep issues were faced by them. But, it is also found that moderate and vigorous physical activity has better quality of sleep as compared to the rest. This finding is supported by Meta analytic review on the

Table 5. Correlation of Physical activity with Sleep

Control ables	Vari- ables	TFS	CNT- Slp	WKU- PMN	Use- Bathr	CNT- Breath	Cough- Snore	Feel- Cold	Feel- Hot	Bad- Dreams	Have- pain	Medi- cine	Enga- ging	ENT- HU	Sleeping Rat- ing
VGSL	Correlation	.048	- .068	-.042	.072	-.068	-.020	.047	-.021	.055	- .125	- .037	- .044	.023	-.027
	Significance (2-tailed)	.489	.325	.547	.296	.322	.767	.496	.756	.425	.069	.593	.527	.738	.696
LSL	Correlation	- .025	.037	.095	-.186	.132	-.044	.039	-.002	.007	-.050	- .029	- .001	- .003	.089
	Signifi- cance (2-tailed)	.719	.587	.168	.006	.054	.519	.572	.975	.921	.468	.674	.993	.966	.197
LSL1	Correlation	- .026	- .013	-.019	-.005	-.039	-.054	- .109	-.053	-.046	.021	- .028	- .020	.042	-.058
	Significance (2-tailed)	.703	.848	.780	.939	.568	.437	.114	.445	.501	.763	.683	.770	.545	.396
MSL	Correlation	.023	.052	-.014	.061	-.028	-.038	- .077	-.037	-.001	.083	- .020	.019	.120	.007
	Significance (2-tailed)	.741	.451	.844	.373	.688	.584	.266	.590	.994	.228	.773	.787	.082	.915
LSL2	Correlation	- .043	- .045	-.059	-.104	- .129	-.060	- .026	-.063	-.093	.014	- .084	- .067	- .183	-.031
	Significance (2-tailed)	.531	.512	.388	.132	.061	.381	.711	.359	.177	.842	.221	.329	.007	.649
VGSL1	Correlation	- .031	.023	-.106	.034	-.050	-.032	- .025	.000	.024	-.008	- .050	.024	.089	.015
	Significance (2-tailed)	.653	.738	.124	.620	.467	.640	.714	.996	.730	.913	.464	.725	.198	.827
MSL1	Correlation	- .055	- .011	-.037	.057	-.013	-.064	- .043	-.099	-.131	.058	- .102	- .012	.016	-.094
	Significance (2-tailed)	.422	.872	.590	.408	.846	.355	.528	.150	.055	.397	.139	.860	.818	.171
LTSL	Correlation	.026	.044	-.046	-.133	.001	-.008	- .045	.003	.018	.029	.028	.023	.091	.025
	Significance (2-tailed)	.702	.522	.503	.052	.988	.909	.516	.964	.793	.676	.689	.740	.187	.717
LTSL1	Correlation	- .135	.007	.107	-.008	-.063	-.085	- .068	-.084	-.118	.002	.094	- .017	.026	.017
	Significance (2-tailed)	.049	.923	.121	.904	.363	.215	.324	.223	.087	.973	.171	.803	.709	.810
VLTSL	Correlation	- .019	.062	.064	-.070	-.071	-.051	- .034	-.095	-.046	.053	- .051	.078	.012	-.026
	Significance (2-tailed)	.788	.371	.351	.309	.303	.457	.626	.167	.502	.438	.461	.255	.858	.701

Table 6. Cross tabulation and odd's ratio for sleep and physical activity

Sleep : Physical activity	Value	95% Confidence Interval	
		Lower	Upper
Odds Ratio for SLEEPING RATING (poor Sleep / Good Sleep)	0.365	0.150	0.885
For cohort Activity Status = Leisure	0.832	0.675	1.025
For cohort Activity Status = Moderate and Vigorous	2.282	1.145	4.547
N of Valid Cases	215		

effect of physical activity on sleep by Kredlow et al. in the journal of behavioral medicine, 2015⁽¹⁸⁾. The systematic review by Wang F and Boros S, 2021 supports the findings of the current study. They found sleep quality is better with moderate physical activity than vigorous or low intensity exercises.⁽¹⁹⁾ From the reviews it can be safely concluded that, acute exercises shown to have small effect on the parameters of sleep like efficiency of the sleep and onset latency of sleep. Moderate exercises have effect on other parameters like disturbances post onset of sleep, overall quality of the sleep.

It is also found that women participated in the study have better sleep quality and total duration in hours of sleep as compared to male participants independent of socio-economic status, BMI, marital status and lifestyle etc. This finding is contradictory to the study published by Yaqoot Fatima et al in Clinical medicine and research 2016. According to this study, women in mean age 21, independent of their socio-economic status, lifestyle and marital status etc., were found to have sleep disturbances more than men.⁽²⁰⁾ But this study was done on Caucasian population unlike current study which is on Asian population. Effect of lifestyle and impact of socioeconomic status on sleep and on physical activity was not considered in the current study. Most of the female participants in the current study were in the age group of 18-22 years and were in the academic age group. The overview of the current study points that despite of low -moderate levels of physical activity in most of the participants, sleep remained unaffected. Physical activity and sleep, both are significantly affected after age of 30 years. Incidentally, the participants in age 30-35 yrs were few. The variability in the current study could be attributed to the fact that two components, the physical activity and the sleep are compared independently with each other without categorizing them into various parameters which are known to affect them e.g. Socio-economic status, personal history of smoking alcoholism, BMI etc. Despite of that, the results are indicative of physical activity improves quality of the sleep.

Correlation between how physical activity affects sleep is explained with reference to circadian rhythm. All our day to day activities which require energy expenditure are regulated by a circadian rhythm, which is responsible of maintaining all physiological systems and their functions. It is regulated by two important components. The central clock is located in suprachiasmatic nucleus. This regulates photic and non-photoc environmental cues like feeding, sleep-wake cycle, activity levels and hormonal levels. The peripheral clock is located in almost all tissues and organ systems in the body. Skeletal muscles are major organ systems regulating peripheral clocks and empower growth and development.^(21,22) Several factors influence the rhythmicity of circadian clocks like exercises, temperature, time of intake of food etc. Increased wakefulness at night, disturbed sleep, daytime sleepiness are the symptoms of distorted circadian rhythm⁽²³⁾. It has proven that exercises/physical activity via skeletal muscles helps in restoring the rhythm. Regular exercise bouts led to drastic changes in hormonal regulation as a result of stimulating the neuroendocrine system. Exercise promotes the production and release of melatonin and commonly results in improved sleep quality. Quality and duration of sleep are higher in individuals who regularly engage in physical activity than those who do not.⁽²⁴⁾

5 Conclusion

Participants reported to have moderate to high level of physical activity (96%) and reported to have satisfactory sleep. However, poor sleep quality was reported by participants with light and vigorous levels of physical activity. In Participants with work and/or sports related vigorous physical activity, sleep was affected due to body aches and pains. There is severe lack of awareness in understanding the adequate level of physical activity in individual and hence physiotherapist can help by guiding, educating and designing a schedule which will include the job requirement of physical activity and what additional is needed for regular practice. Guided Physical activity can help in improving quality of life by improving quality of sleep.

Scope of study: Age distribution and gender distribution in the current study was unequal. Further study recommendation with correlation of BMR and specific age group of the participants and with equal age and gender distribution. Correlation of BMR with sleep patterns and impact of BMR was not considered in the current stud. Questionnaire consider only a short time period for assessment, studying individuals for longer duration would help to understand the sleep patterns better.

6 Acknowledgement

The author would like to thank The Management, Krupanidhi Group of Institutions for supporting the work through Krupanidhi Research Incubator Center (K-RIC). The author also appreciates the productive discussions and guidance from Dr. Sudhakar Subramaniam, Professor and Research Head Krupanidhi College of Physiotherapy. The author would also would like to thank Dr. Milan Anand, Principal, Krupanidhi College of Physiotherapy along with, Dr. Sudhan SG, Professor and research mentor, Krupanidhi College of Physiotherapy for extending their guidance, help, support and knowledge for this study.

References

- 1) Zhang C, Zhang H, Zhao M, Li Z, Cook CE, Buysse DJ, et al. Reliability, Validity, and Factor Structure of Pittsburgh Sleep Quality Index in Community-Based Centenarians. *Frontiers in Psychiatry*. 2020;11:886–886. Available from: <https://dx.doi.org/10.3389/fpsy.2020.573530>.
- 2) Rao N, Bhadra K, Wyss N, Bhan N, Raj A. Parental Violence Against Unmarried Adolescents Aged 10-19 Years in Uttar Pradesh, India. Center on Gender Equity and Health. University of San Diego School of Medicine. For International Day of Sport for Development and Peace. 2019. Available from: https://gehweb.ucsd.edu/wp-content/uploads/2019/05/final-up-physical-punishment_apr-26-2019_may-09-nr.pdf.
- 3) Warburton DER, Bredin SSD. Health benefits of physical activity. *Current Opinion in Cardiology*. 2017;32:541–556. Available from: <https://dx.doi.org/10.1097/hco.0000000000000437>.
- 4) Ohayon M, Wickwire EM, Hirshkowitz M, Albert SM, Avidan A, Daly FJ, et al. National Sleep Foundation's sleep quality recommendations: first report. *Sleep Health*. 2017;3(1):6–19. Available from: <https://dx.doi.org/10.1016/j.sleh.2016.11.006>.
- 5) Mehta RA, Rathod IR, Jagad K. A Study to Determine the Factors Affecting the Level of Physical Fitness in Normal College Going Students. . Available from: https://ijshr.com/IJSHR_Vol.5_Issue.3_July2020/IJSHR_Abstract.0078.html.
- 6) Physical Activity Fact sheet by WHO. . Available from: <https://www.who.int/news-room/fact-sheets/detail/physical-activity>.
- 7) Nethan S, Sinha D, Mehrotra R. Non communicable disease risk factors and their trends in India. *Asian Pacific journal of cancer prevention: APJCP*. 2017;18(7). doi:10.22034/APJCP.2017.18.7.2005.
- 8) Pandit-Agrawal D, Khadilkar A, Chipplonkar S, Khadilkar V. Knowledge of nutrition and physical activity in apparently healthy Indian adults. *Public Health Nutrition*. 2018;21(9):1743–1752. Available from: <https://dx.doi.org/10.1017/s1368980017004268>.
- 9) Herring MP, Kline CE, O'Connor PJ. Effects of exercise on sleep among young women with Generalized Anxiety Disorder. *Mental Health and Physical Activity*. 2015;9:59–66. Available from: <https://dx.doi.org/10.1016/j.mhpa.2015.09.002>.
- 10) Cahuas A, He Z, Zhang Z, Chen W. Relationship of physical activity and sleep with depression in college students. *Journal of American College Health*. 2020;68(5):557–564. Available from: <https://dx.doi.org/10.1080/07448481.2019.1583653>.
- 11) Bartfay E, Stewart P, Bartfay W, Papaconstantinou E. Is There an Association between Physical Activity and Sleep in Community-Dwelling Persons with Dementia: An Exploratory Study Using Self-Reported Measures? *Healthcare*. 2019;7(1):6–6. Available from: <https://dx.doi.org/10.3390/healthcare7010006>.
- 12) Tse CYA, Lee HP, Chan KSK, Edgar VB, Wilkinson-Smith A, Lai WHE. Examining the impact of physical activity on sleep quality and executive functions in children with autism spectrum disorder: A randomized controlled trial. *Autism*. 2019;23(7):1699–1710. Available from: <https://dx.doi.org/10.1177/1362361318823910>.
- 13) Sakamoto R, Yamakawa T, Takahashi K, Suzuki J, Shinoda MM, Sakamaki K, et al. Association of usual sleep quality and glycemic control in type 2 diabetes in Japanese: A cross sectional study. Sleep and Food Registry in Kanagawa (SOREKA). *PLOS ONE*. 2018;13(1):e0191771–e0191771. Available from: <https://dx.doi.org/10.1371/journal.pone.0191771>.
- 14) Nguyen NH, Vallance JK, Buman MP, Moore MM, Reeves MM, Rosenberg DE, et al. Effects of a wearable technology-based physical activity intervention on sleep quality in breast cancer survivors: the ACTIVATE Trial. *Journal of Cancer Survivorship*. 2021;15(2):273–280. Available from: <https://dx.doi.org/10.1007/s11764-020-00930-7>.
- 15) Ryan DJ, Wullems JA, Stebbings GK, Morse CI, Stewart CE, Onambele-Pearson GL. Reliability and validity of the international physical activity questionnaire compared to calibrated accelerometer cut-off points in the quantification of sedentary behaviour and physical activity in older adults. *PLOS ONE*. 2018;13(4):e0195712–e0195712. Available from: <https://dx.doi.org/10.1371/journal.pone.0195712>.
- 16) Cleland C, Ferguson S, Ellis G, Hunter RF. Validity of the International Physical Activity Questionnaire (IPAQ) for assessing moderate-to-vigorous physical activity and sedentary behaviour of older adults in the United Kingdom. *BMC Medical Research Methodology*. 2018;18(1):1–2. Available from: <https://dx.doi.org/10.1186/s12874-018-0642-3>.
- 17) Fontes F, Gonçalves M, Maia S, Pereira S, Severo M, Lunet N. Reliability and validity of the Pittsburgh Sleep Quality Index in breast cancer patients. *Supportive Care in Cancer*. 2017;25(10):3059–3066. Available from: <https://dx.doi.org/10.1007/s00520-017-3713-9>.
- 18) Kredlow MA, Capozzoli MC, Hearon BA, Calkins AW, Otto MW. The effects of physical activity on sleep: a meta-analytic review. *Journal of Behavioral Medicine*. 2015;38(3):427–449. Available from: <https://dx.doi.org/10.1007/s10865-015-9617-6>.
- 19) Wang F, Boros S. The effect of physical activity on sleep quality: a systematic review. *European Journal of Physiotherapy*. 2021;23(1):11–18.
- 20) Fatima Y, Doi SAR, Najman JM, Mamun AA. Exploring Gender Difference in Sleep Quality of Young Adults: Findings from a Large Population Study. *Clinical Medicine & Research*. 2016;14(3-4):138–144. Available from: <https://dx.doi.org/10.3121/cmr.2016.1338>. doi:10.3121/cmr.2016.1338.
- 21) Mayeuf-Louchart A, Staels B, Duez H. Skeletal muscle functions around the clock. *Diabetes, Obesity and Metabolism*. 2015;17:39–46. Available from: <https://dx.doi.org/10.1111/dom.12517>.
- 22) Hower IM, Harper SA, Buford TW. Circadian Rhythms, Exercise, and Cardiovascular Health. *Journal of Circadian Rhythms*. 2018;16(1). Available from: <https://dx.doi.org/10.5334/jcr.164>. doi:10.5334/jcr.164.
- 23) Harfmann BD, Schroder EA, Esser KA. Circadian Rhythms, the Molecular Clock, and Skeletal Muscle. *Journal of Biological Rhythms*. 2015;30(2):84–94. Available from: <https://dx.doi.org/10.1177/0748730414561638>.
- 24) Tortosa-Martínez J, Clow A, Caus-Perdagaz N, González-Caballero G, Abellán-Mirallas I, Saenz MJ. Exercise Increases the Dynamics of Diurnal Cortisol Secretion and Executive Function in People With Amnesic Mild Cognitive Impairment. *Journal of Aging and Physical Activity*. 2015;23(4):550–558. Available from: <https://dx.doi.org/10.1123/japa.2014-0006>.