

Relationship Between Sleep and Hypertension: A Narrative Review

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The risk of cardiovascular disease increases at an alarming rate with the increase in an individual's blood pressure. Rise in systemic arterial blood pressure can be caused by factors such as unhealthy diet (excessive intake of salts, trans-fats and saturated fats), alcohol intake, inadequate sleep, smoking and decreased levels of physical activity. This narrative review aims at providing an overview of the existing studies on the relationship between duration of sleep as well as its quality and hypertension. The studies reported in this review were collected from the databases that include PubMed, Scienedirect, Hindawi, ResearchGate and AHA journals in the period of 2006-2022. The keywords used for searching in the databases included sleep, insomnia, hypertension and cardiovascular diseases. The two sociodemographic variables considered was age and gender. Literature review showed that individuals reporting shorter durations of sleep, disrupted sleep patterns and insomnia were shown to be suffering from hypertension as compared to individuals receiving adequate and quality sleep at night. Data from this review article can prove beneficial to the common population in the understanding of sleep being a modifiable risk factor of hypertension and encourage healthcare workers and patients to make the necessary changes in their sleeping patterns to prevent hypertension and associated cardiovascular events.

Keywords: Cardiovascular diseases; Hypertension; Insomnia; Sleep.

Hypertension or high arterial blood pressure increases the risk of cardiovascular-associated morbidity and mortality burden worldwide¹. Hypertension is the cause of about 7.6 million deaths per year across the world. About 47% of atherosclerotic arterial diseases is caused by chronically elevated blood pressure². As a result of issues associated to hypertension, men lose 9.31 years of their lifetime on average, and women lose 9.46 years³. There are several studies that prove the consistent positive association between hypertension and cardiovascular diseases^{1, 4, 5}.

Causes of Hypertension

There are several causes of increased blood pressure, such as unhealthy lifestyle, diet, idleness, sleep, smoking and alcohol consumption. Willis-Ekbom disease or restless leg syndrome, which is incontrollable movement of the leg due to uncomfortable sensations, is also known to increase the blood pressure⁶.

One of the major factors responsible for constant elevation of arterial pressure is trouble sleeping. Lack of sleep, inadequate sleep and poor quality of sleep results in high blood pressure

which in turn causes a greater likelihood of cardiac diseases⁷. In today's fast paced world, the duration of sleep achieved by an individual especially of the working age group is progressively reducing, along with a compromise in its quality owing to overwhelming stressful conditions in life. Statistical analysis show that around two-thirds of the American population sleep for less than 7 hours on a day-to-day basis⁸.

Mechanism of elevated blood pressure due to short sleep

The mechanism involved as demonstrated by various studies is that shorter sleep durations can interfere with the normal circadian or sleep wake cycle and autonomic balance control⁹. Parasympathetic nervous system prevails during night-time whereas sympathetic stimulation takes over during daytime. The low blood pressure seen at night is known as "nocturnal dipping".

Reduced nocturnal dipping is a risk factor for hypertension⁶. Alterations in sleep patterns or sleep disruptions cause an increase in the activity sympathetic nervous system. This increased sympathetic stimulation, hence raises heart rate and blood pressure¹⁰.

Evidence from the US show that shorter durations of sleep is associated with increased incidence of hypertension¹¹.

Risk factors

The risk factors associated with hypertension can be classified into modifiable and non-modifiable factors. Although non-modifiable factors such as age, gender, nationality and genetics aren't under one's control, the modifiable factors can be controlled to a large extent. Changes in one's lifestyle is not only the primary management strategy of hypertension, but is also very crucial in reducing the risk of any future cardiac complications. While lifestyle changes such as dietary modifications, cessation of alcohol intake, smoking and drug use has been widely propagated and practised, sleep amendments are given relatively less importance and thus less commonly adopted. Correction of sleep schedules or patterns is not only one of the preventive measures for hypertension but it has been proven to reduce blood pressure as well. Increasing the level of awareness among the population about the importance of adequate, timely and good quality sleep is vital to achieve an overall decrease in the

incidence of life-threatening complications and thus, also achieve a significant rise in the health outcome of the population.

This review also intends to encourage adults mainly of the middle-aged group to follow a healthy sleep schedule and seek medical or psychological help for the management of their sleep problems, which in turn would protect them from the risk of hypertension leading to serious heart diseases. Thus, this review overall aims to emphasize of the association between short sleep and increased risk of hypertension.

MATERIALS AND METHODS

A comprehensive literature search was conducted in 2022 to extract published work on sleep and hypertension. Published articles on the topic were collected by searching various databases that include PubMed, Sciencedirect, Frontiers, Hindawi, ResearchGate and AHA journals in the period of 2006-2022. This time period showed an increase in the prevalence of chronic illnesses in the middle aged population. The keywords used for searching included "Sleep", "Hypertension", "Insomnia" and "Cardiovascular diseases".

Inclusion criteria

- All studies published on Sleep and Hypertension
- Articles published from 2006 to 2022
- Restricted to English language

Exclusion criteria

- Abstracts only
- Case reports and Case series

Methodology

Both authors participated in the review process. SK and JM reviewed articles on Sleep and hypertension. Studies explaining the association based on age and gender were chosen. The review was completed within a period of four months. During the initial search for articles in the databases, 75 studies were extracted. A total of 49 articles were finally used after adopting the exclusion criteria. The articles used for this narrative review consisted of various study patterns, such as review articles, systematic reviews, meta-analytic studies, cross-sectional studies, instrumental evaluation and experimental studies. The information obtained from each publication was abstracted.

Summary of Table 1

49 articles were downloaded from the

databases. Out of these, a majority (45) of the articles focus on the effect of shortened and poor sleep quality on blood pressure. Around four articles highlight the association of longer durations of sleep with the development of hypertension. Three articles identified insomnia to be an independent risk factor of hypertension. Five articles focus on the effect of or the relationship between hypertension and cardiovascular diseases. Although a majority of the articles emphasizes sleep characteristics as a modifiable risk factor of hypertension, a few also highlight the several other modifiable and non-modifiable risk factors. Majority of the articles highlight the association of short sleep and hypertension among adults, and not children and adolescents. However, one study confirmed the association among young children. In the cross-sectional studies that were conducted, individuals were grouped according to sleep durations they receive, and those falling in the category of sleep received less than 6 to 7 hours belonged to the highest risk group. Two studies reported the relationship to be associated with the population's Body Mass Index, which proves obesity to be a risk factor as well. Around six studies emphasize on this association to be more prevalent in the middle-aged group. Risk of hypertension following longer durations of sleep was also found to be more prevalent among the middle-aged population. Four studies concluded females to be at a greater risk of developing hypertension as a result of shortened sleep compared to males.

RESULTS

A total of 49 studies were included in this review. Assessments of the articles concluded that inadequate sleep, poor sleep quality and lack of sleep or insomnia was seen to be associated with increased risk of hypertension and cardiovascular diseases.

This review proves shortened sleep duration to be one of the risk factors of hypertension. Individuals receiving inadequate sleep (less than 5 hours) were at a higher risk of developing an elevated blood pressure. A majority of the studies used in this review concluded this association to be stronger among females, and those belonging to the middle-aged group. About 10% of the studies

used in this narrative review presented an opposite association outcome. These studies reported that not only short sleep, but longer durations of sleep also increased the incidence of hypertension, though there is no sufficient explanation for the association. Insomnia was also seen to be an independent predictor of hypertension. The review also concluded that sufficient sleep at night (6-8 hours) significantly reduces the risk of hypertension.

DISCUSSION

Prior literature presents the various risk factors associated with hypertension. Sleep-related effects on hypertension is one of the modifiable sectors with addition to changes in lifestyle. Recent research has shown that sleep deprivation has direct significant effects on hypertension and coronary artery diseases¹². A study has shown that during normal night's sleep, blood pressure is lower as compared to daytime during alertness⁶. Through a thorough literature search, the current review concluded a strong association between sleep duration and prevalence of hypertension. It was found that shortened duration of sleep and insomnia were risk factors for the development of hypertension.

There are several studies assessing the association of sleep and hypertension among middle-aged and elderly adults. However there is very few literature available that depicts the association among children and young adults owing to the rarity of occurrence¹³. One study conducted among Chinese children and adolescents showed shortened sleep duration caused an elevated blood pressure¹⁴. Short sleep duration was shown to be an independent risk factor for hypertension¹⁵. In a sleep heart health study that was conducted, individuals receiving less than or equal to 6 hours of sleep per week had a greater prevalence of hypertension.¹⁶

Analysis of results conducted among participants of the National Health and Nutrition Examination Survey, showed that shorter duration, sleeping troubles and any kind of sleep disorder was associated with increased risk of hypertension¹⁷. About two-thirds of the American population likely suffer from chronic sleep deprivation, which has shown to be causing an increased prevalence of

Table 1. Summary of articles included in the narrative review

No	Authors	Country	Year published	Database accessed from
1	Oparil S, Acelejado C.M, Bakris G.L, et.al.	USA	2018	PubMed
2	Arima H, Barzi F and Chalmers J.	Australia	2011	PubMed
3	Mirahmadizadeh A, Vali M, Hassanzadeh J, et.al.	Iran	2022	Hindawi
4	Wu C, Hu Y, Chou Y, et.al.	China	2015	PMC
5	Poznyak A.V, Sadykhov N.K, Kartuesov A.G, et.al.	Russia	2022	
6	Calhoun D.A and Harding S.M.	USA	2010	PMC
7	-	-	2021	Internet
8	Mansukhani M.P, Covassin N and Somers V.K.	USA	2019	AHA journal
9	Han B, Chen W.Z, Li Y.C, et al.	China	2020	Frontiers
10	Gangwisch J.E.	USA	2014	PMC
11	Gangwisch J.E, Heymsfield S.B, Boden-Albala B, et al.	USA	2006	Pubmed
12	Nagai M, Hoshide S and Kario K	Japan	2010	PMC
13	Fobian A.D, Elliott L and Louie T.	USA	2018	PMC
14	Guo X, Zheng L, Li Y, et.al.	China	2011	PMC
15	Wang L, Hu Y, Wang X, et.al.	China	2021	PubMed
16	Gottlieb D.J, Redline S, Nieto F.J, et.al.	USA	2006	Researchgate
17	Li C and Shang S	China	2021	PubMed
18	Okunowo O, Orimoloye H.T, Bakre S.A, et.al.	USA	2019	Sciencedirect
19	Alebiosu O.C, Ogunsemi O.O, Familoni O.B, et.al.	Nigeria	2015	PubMed
20	Altman N.G, Izci-Balserak B, Schopfer E, et.al.	USA	2012	Sciencedirect
21	Guo X, Zheng L, Wang J, et.al.	China	2013	Sciencedirect
22	Shittu R.O, Issa B.A, Olanrewaju G.T, et.al.	Nigeria	2014	Researchgate
23	Faraut B, Touchette E, Gamble H, et.al.	France	2012	PubMed
24	Meng L, Zheng Y and Hui R.	China	2013	Researchgate
25	Li M, Yan S, Jiang S, et al.	China	2019	PubMed
26	Lu K, Chen J, Wu S, et.al.	China	2015	PubMed
27	Liu R.Q, Qian Z, Trevathan E, et al.	China	2016	PubMed
28	Kario K, Hoshide S, Nagai M, et.al.	Japan	2021	PubMed
29	Yang F, Zhang Y, Qiu R, et.al.	China	2021	PubMed
30	Lu K, Chen J, Wang L, Wang C, et al.	China	2017	Researchgate
31	Wang D, Zhou Y, Guo Y, et.al.	China	2017	Sciencedirect
32	Zhao J, Wang W, Wei S, et.al.	China	2021	PMC
33	Hwang H.R, Lee J.G, Lee S, et al.	Korea	2015	PubMed
34	Vgontzas A.N, Liao D, Bixler E.O, et.al.	USA	2009	PubMed
35	Zhao H, Gui W, Huang H. et al.	China	2020	PubMed
36	Buxton O.M and Marcelli E.	USA	2010	PubMed
37	Pepin J.L, Borel A.L, Tamisier R, et.al.	France	2014	Sciencedirect
38	Sforza E, Martin M.S, Barthelemy J.C, et.al.	France	2014	PMC
39	Feng X, Liu Q, Li Y, et.al.	China	2019	Sciencedirect
40	Gangwisch J.E, Malaspina D, Posner K, et.al.	USA	2010	PubMed
41	Eguchi K, Pickering TG, Schwartz JE, et al.	Japan	2008	PubMed
42	Erden I, Erden E.C, Ozhan H, et.al.	Turkey	2010	PubMed
43	Bock J.M, Vungarala S, Covassin N, et.al.	USA	2022	PubMed
44	Stranges S, Dorn J, Cappuccio F, et.al.	UK	2010	PubMed
45	Thomas S.J and Calhoun D.	USA	2017	Sciencedirect
46	Bathgate C.J and Fernandez-Mendoza J.	USA	2018	PubMed
47	Palagani L, Rosa M.B, Angelo G, et.al.	Italy	2013	PubMed
48	Wu L, He Y, Jiang B, et.al.	China	2016	Sciencedirect
49	Cappuccio F.P, D'Elia L, Strazzullo P, et.al.	UK	2010	PMC

hypertension⁸. US adults with short sleep reported a greater occurrence of hypertension. However this association was dependent on age and Body Mass Index since blood pressure varies with age and obesity is one of an independent risk factor by itself¹⁸.

A prospective study conducted among the semi-urban Nigerian population showed that majority of the participants with hypertension reported poor sleep and thus poor quality of life. This study also concluded that poorer quality of sleep worsens hypertension and eventually lead to other heart conditions¹⁹.

An analysis showed a significant relationship between insufficient sleep and high blood pressure²⁰. US citizens belonging to 32-59 years age group who sleep for 5 hours or less reported greater risk of hypertension¹¹. A systematic review performed showed congruent results²¹. Nigerian adults having poor sleep also showed a greater risk for hypertension²².

A study conducted in France showed that shorter sleep was a major cause of hypertension for adults greater than 40 years of age²³.

The greater prevalence of this association among the middle aged group can be explained by considering this section of the population to be more exposed to stress from work and family which will eventually lead to an unhealthy lifestyle. However, this association is less prominent among the older age groups because of the physiological increase in blood pressure and other parameters with age.

Numerous studies conducted in China showed congruent results. A cross-sectional study in China concluded that middle aged adults (belonging to the age group of 18-44) sleeping for less than 7 hours per day had a greater risk of hypertension as compared to individuals who got more than 7 hours of sleep²⁵. Another study conducted among Chinese males concluded that individuals with poor sleep quality and sleep for less than 6 hours showed greater risk for hypertension²⁶.

A study conducted in north-eastern China showed that shorter sleep duration, increased latency of sleep, sleep disruptions and poor sleep quality was related to increased risk of hypertension²⁷. Short sleep duration was also associated with increases incidence of atherosclerotic cardiovascular disease (ASCVD)²⁸.

A study conducted in Xinjiang, China showed that inadequate and poor sleep was positively associated with hypertension²⁹. People having shorter sleep durations showed greater prevalence of hypertension than people with normal sleep durations and patterns³⁰.

Another Chinese study concluded similar results³¹. A greater prevalence of hypertension was observed in middle-aged and old adults with fragmented or disrupted sleep patterns³². In an analytic study conducted in Korea, it was found that in individuals having sleep of 5 hours or less, there was a significant increase in the pharmacological management for hypertension³³. In contrast, from a study conducted among non-insomniac elderly subjects, it was found that sleep quality and duration had no association with prevalence of hypertension. It identified Body Mass Index to have a stronger correlation with hypertension³⁸. This difference could be attributed to the age-related blood pressure changes that is commonly found among the elderly.

A cross sectional study conducted in Pennsylvania suggested that the risk of hypertension was greater among individuals with less than 5 hours of sleep. However, it was shown to be of a lesser magnitude³⁴.

While most of the studies included in the current review highlighted short sleep to cause elevated blood pressure, an analysis showed that excess or longer duration of sleep increased the risk of hypertension²⁴. A systematic review that was conducted to analyse the correlation between short or long duration of sleep showed that a U-shaped relationship between the variables was established⁴⁹.

Similarly, meta-analytic study for finding the association between sleep and hypertension showed that, not only shorter durations, but also longer durations of sleep was associated with increased risk of high blood pressure⁹. A study conducted among Chinese adults showed that both shorter and longer duration of sleep can increase the risk of hypertension among the greater than 45 years age group. This study also demonstrated a preventive pattern of napping during the day³⁵. Similar results were derived from a study conducted in the US³⁶. Another report arrived at similar conclusions³⁷. Adequate research data is not available to explain this association. The possible

explanation for this could be that excessive sleep elevates blood sugar levels, which in turn can cause a rise in blood pressure.

In contrast, a longitudinal study conducted in China showed only shorter duration of sleep, to have a significant effect on blood pressure³⁹. It was found that treatment of sleep problems in middle-aged adults could significantly reduce the development of hypertension⁴⁰. A study conducted among hypertensive patients in Japan showed that reduced sleep was an important risk factor⁴¹. In a study conducted among 131 patients with Stage 1 hypertension, it was found that poor sleep was a major factor for the development stage 1 hypertension⁴².

Several studies have shown that this association is stronger among women than in men^{6, 8, 42, 44}. This can be attributed to the fact that women, especially of the middle aged group, bear the burden of household responsibilities along with work which provides them with minimal amount of sleep and rest. Women tend to be more stressed and anxious due to the overwhelming number of duties they are expected to fulfil. A study conducted among white men and women showed that less than 6 hours of sleep was significantly associated with increased risk of hypertension only in females and not in males. It was also seen to be stronger in pre-menopausal women⁴⁴.

Insomnia that is considered to be chronic showed present with symptoms at least 3 times a week for three months⁴⁵. Patients suffering from chronic insomnia showed a greater association with both stage 1 and stage 2 of hypertension. The study concluded that insomnia should be considered as a predictor during evaluation of hypertension⁴⁷. Elevated blood pressure associated with insomnia can be explained by the increased sympathetic activity as well as increased action of hypothalamic-pituitary system on the adrenal glands, which increases the levels of cortisol⁴³.

There is a concurrent existence of insomnia and hypertension⁴⁷. Insomnia has also been identified as a predisposition factor for the development of hypertension⁶. A higher prevalence of hypertension was seen among people suffering from insomnia as compared to the people not suffering from any kind of sleep disruption⁸.

A study conducted among the rural population in China suggested that having 6-8

hours of sleep at night and a one hour nap during daytime shows a significant reduction in the risk of hypertension⁴⁸.

CONCLUSION

Hypertension is one of the prime chronic condition that commonly prevails among the adults, especially in this new age and time of unhealthy and poor lifestyle. Hypertension is a salient risk factor for the development of heart diseases^[4], and ultimately leads to fatal consequences if turned a blind eye to. According to this review, a significant association between sleep and hypertension was found from various literature sources. Furthermore, the risk of hypertension following poor and inadequate sleep was found to be more prominent among females and individuals belonging to the middle-aged group. Insomnia was also found to be an independent predictor for development of hypertension. Systematic changes to the sleep schedule, disciplining of sleep habits and seeking professional help for sleep-related problems will prove to be pivotal in reducing the population's risk of developing not only hypertension but also other associated chronic illnesses such as diabetes, obesity and depression.

The review recommends the healthcare practitioners to advice disciplined sleep cycle patterns to their patients along with other lifestyle changes, which will aid in the overall augmentation of protection against hypertension.

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Conflict of Interest

There are no conflict of interests in association with the material presented in this paper.

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REFERENCES

1. Oparil S, Acelejado C.M, Bakris G.L, et.al. Hypertension. *Nat. Rev. Dis. Primers.*, 2018;4(18014).

2. Arima H, Barzi F and Chalmers J. Mortality patterns in hypertension. *J. hypertens.*, 2011;29(1):S3-7.
3. Mirahmadizadeh A, Vali M, Hassanzadeh J, et.al. Mortality Rate and Years of Life Lost due to Hypertension in the South of Iran between 2004 and 2019: A Population-Based Study. *Int. J. Hypertens.*, 2022;(7759699):7.
4. Wu C, Hu Y, Chou Y, et.al. High Blood Pressure and All-Cause and Cardiovascular Disease Mortalities in Community-Dwelling Older Adults. *Medicine(Baltimore)*, 2015; 94(47): e2160.
5. Poznyak A.V, Sadykhov N.K, Kartuesov A.G, et.al. Hypertension as a risk factor for atherosclerosis: Cardiovascular risk assessment. *Front. Cardiovasc. Med.*, 2022;9:959285.
6. Calhoun D.A and Harding S.M. Sleep and hypertension. *Chest.*, 2010;138(2):434-43.
7. Author, Year: N/A. How Does Sleep Affect Your Heart Health? [Internet]. Centres for disease control and prevention. (2021).
8. Mansukhani M.P, Covassin N and Somers V.K. Apneic Sleep, Insufficient Sleep, and Hypertension. *Hypertension.*, 2019;73(4):744–756.
9. Han B, Chen W.Z, Li Y.C, et al. Sleep and hypertension. *Sleep Breath.*, 2020;(24):351–356.
10. Gangwisch J.E. A Review of Evidence for the Link Between Sleep Duration and Hypertension. *Am. J. Hypertens.*, 2014;27(10):1235–1242.
11. Gangwisch J.E, Heymsfield S.B, Boden-Albala B, et al. Short sleep duration as a risk factor for hypertension: analyses of the first National Health and Nutrition Examination Survey. *Hypertension.*, 2006;47(16585410):833-9.
12. Nagai M, Hoshide S and Kario K. Sleep Duration as a Risk Factor for Cardiovascular Disease- a Review of the Recent Literature. *Curr. Cardiol. Rev.*, 2010;6(1):54-61.
13. Fobian A.D, Elliott L and Louie T. A Systematic Review of Sleep, Hypertension, and Cardiovascular Risk in Children and Adolescents. *Curr. Hypertens. Rep.*, 2018;20(42).
14. Guo X, Zheng L, Li Y, et.al. Association Between Sleep Duration and Hypertension Among Chinese Children and Adolescents. *Clin. Cardiol.*, 2011;34(12):774-781.
15. Wang L, Hu Y, Wang X, et.al. The association between sleep duration and hypertension: a meta and study sequential analysis. *J Hum Hypertens.*, 2021; 35:621-626.
16. Gottlieb D.J, Redline S, Nieto F.J, et.al. Association of Usual Sleep Duration With Hypertension: The Sleep Heart Health Study. *Sleep.*, 2006;29(8):1009-1014.
17. Li C and Shang S. Relationship between Sleep and Hypertension: Findings from the NHANES (2007-2014). *Int. J. Environ. Res. Public Health.*, 2021;18(15):7867.
18. Okunowo O, Orimoloye H.T, Bakre S.A, et.al. Age- and body weight-dependent association between sleep duration and hypertension in US adults: findings from the 2014-2017 National Health Interview Survey. *Sleep Health.*, 2019; 5(5):509-513.
19. Alebiosu O.C, Ogunsemi O.O, Familoni O.B, et.al. Quality of Sleep among Hypertensive Patients in a Semi-Urban Nigerian Community: A Prospective Study. *Postgrad. Med.*, 2015;121(1):166-172.
20. Altman N.G, Izci-Balsarak B, Schopfer E, et.al. Sleep duration versus sleep insufficiency as predictors of cardiometabolic health outcomes. *Sleep Med.*, 2012;13(10):1261-1270.
21. Guo X, Zheng L, Wang J, et.al. Epidemiological evidence for the link between sleep duration and high blood pressure: A systematic review and meta-analysis. *Sleep Med.*, 2013;14(4):324-332.
22. Shittu R.O, Issa B.A, Olanrewaju G.T, et.al. Association between Subjective Sleep Quality, Hypertension, Depression and Body Mass Index in a Nigerian Family Practice Setting. *J. sleep disord. ther.*, 2014;3(2):1000157.
23. Faraut B, Touchette E, Gamble H, et.al. Short sleep duration and increased risk of hypertension: a primary care medicine investigation. *J Hypertens.*, 2012;30(7):1354-1363.
24. Meng L, Zheng Y and Hui R. The relationship of sleep duration and insomnia to risk of hypertension incidence: a meta-analysis of prospective cohort studies. *Hypertens Res.*, 2013;36: 985–995.
25. Li M, Yan S, Jiang S, et al. Relationship between sleep duration and hypertension in northeast China: a cross-sectional study. *BMJ Open.*, 2019;9(1):e023916.
26. Lu K, Chen J, Wu S, et.al. Interaction of Sleep Duration and Sleep Quality on Hypertension Prevalence in Adult Chinese Males. *J Epidemiol.*, 2015;25(6):415-422.
27. Liu R.Q, Qian Z, Trevathan E, et al. Poor sleep quality associated with high risk of hypertension and elevated blood pressure in China: results from a large population-based study. *Hypertens Res.*, 2016;39: 54–59.
28. Kario K, Hoshide S, Nagai M, et.al. Sleep and cardiovascular outcomes in relation to nocturnal hypertension: the J-HOP Nocturnal Blood Pressure Study. *Hypertens Res.*, 2021;44:1589-1596.

29. Yang F, Zhang Y, Qiu R, et.al. Association of sleep duration and sleep quality with hypertension in oil workers in Xinjiang. *PeerJ.*, 2021;9:e11318.
30. Lu K, Chen J, Wang L, Wang C, et.al. Association of Sleep Duration, Sleep Quality and Shift-Work Schedule in Relation to Hypertension Prevalence in Chinese Adult Males: A Cross-Sectional Survey. *Int. J. Environ. Res. Public Health.*, 2017;14(2):210.
31. Wang D, Zhou Y, Guo Y, et.al. The effect of sleep duration and sleep quality on hypertension in middle-aged and older Chinese: the Dongfeng-Tongji Cohort Study. *Sleep Med.*, 2017;40:78-83.
32. Zhao J, Wang W, Wei S, et.al. Fragmented Sleep and the Prevalence of Hypertension in Middle-Aged and Older Individuals. *Nat Sci Sleep.*, 2021;13:2273-2280.
33. Hwang H.R, Lee J.G, Lee S, et al. The relationship between hypertension and sleep duration: an analysis of the fifth Korea National Health and Nutrition Examination Survey (KNHANES V-3). *Clin Hypertens.*, 2015;21(8).
34. Vgontzas A.N, Liao D, Bixler E.O, et.al. Insomnia with Objective Short Sleep Duration is Associated with a High Risk for Hypertension. *Sleep.*, 2009;32(4):491-497.
35. Zhao H, Gui W, Huang H. et al. Association of long-term sleep habits and hypertension: a cross-sectional study in Chinese adults. *J. Hum. Hypertens.* 2020;34:378–387.
36. Buxton O.M and Marcelli E. Short and long sleep are positively associated with obesity, diabetes, hypertension, and cardiovascular disease among adults in the United States. *Soc. Sci. Med.*, 2010;71(5):1027-1036.
37. Pepin J.L, Borel A.L, Tamisier R, et.al. Hypertension and sleep: Overview of a tight relationship. *Sleep Med. Rev.*, 2014;18(6):509-519. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S1087079214000240>
38. Sforza E, Martin M.S, Barthelemy J.C, et.al. Association of Self-Reported Sleep and Hypertension in Non-Insomniac Elderly Subjects. *JCSM.*, 2014;10(9):1550-9389.
39. Feng X, Liu Q, Li Y, et.al. Longitudinal study of the relationship between sleep duration and hypertension in Chinese adult residents (CHNS 2004–2011). *Sleep Med.*, 2019;58:88-92. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S1389945718308530>
40. Gangwisch J.E, Malaspina D, Posner K, et.al. Insomnia and Sleep Duration as Mediators of the Relationship Between Depression and Hypertension Incidence. *Am. J. Hypertens.*, 2010;23(1):62-69.
41. Eguchi K, Pickering TG, Schwartz JE, et al. Short Sleep Duration as an Independent Predictor of Cardiovascular Events in Japanese Patients With Hypertension. *Arch Intern Med.*, 2008;168(20):2225–2231.
42. Erden I, Erden E.C, Ozhan H, et.al. Poor-quality sleep score is an independent predictor of nondipping hypertension. *Blood Press Monit.*, 2010;15(4):184-187.
43. Bock J.M, Vungarala S, Covassin N, et.al. Sleep Duration and Hypertension: Epidemiological Evidence and Underlying Mechanisms. *Am. J. Hypertens.*, 2022;(1): 3–11.
44. Stranges S, Dorn J, Cappuccio F, et.al. A population-based study of reduced sleep duration and hypertension: the strongest association may be in premenopausal women. *J Hyperten.*, 2010;28(5):896-902.
45. Thomas S.J and Calhoun D. Sleep, insomnia, and hypertension: current findings and future directions. *J. Am. Soc. Hypertens.*, 2017;11(2):122-129.
46. Bathgate C.J and Fernandez-Mendoza J. Insomnia, Short Sleep Duration, and High Blood Pressure: Recent Evidence and Future Directions for the Prevention and Management of Hypertension. *Curr Hypertens Rep.*, 2018;20(52).
47. Palagani L, Rosa M.B, Angelo G, et.al. Sleep loss and hypertension: A systematic review. *Curr. Pharm. Des.*, 2013;19(13):2409-2419.
48. Wu L, He Y, Jiang B, et.al. Association between sleep duration and the prevalence of hypertension in an elderly rural population of China. *Sleep Med.*, 2016;27-28:92-96.
49. Cappuccio F.P, D’Elia L, Strazzullo P, et.al. Sleep duration and all-cause mortality: a systematic review and meta-analysis of prospective studies. *Sleep.*, 2010;33(5):585-592.