



The Effect of Obesity on Nocturnal Blood Pressure Patterns

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Abnormal nocturnal blood pressure (BP) during sleep is considered an indication of many cardiovascular diseases.^[1] For healthy individuals, nocturnal BP drops 5-10% on ambulatory BP monitoring (ABPM). Individuals with abnormal nocturnal BP are classified in three distinct ways: (1) an absence of BP drop, (2) a lack of typical nocturnal dip (LND), or (3) a rise of BP at night (RBPN).^[3] In this study, we examine a potential correlation between obesity and abnormal nocturnal BP and the impact of weight loss on nocturnal BP patterns. For our study, we recruited 30 individuals with LND, 30 with RBPN, and 20 with normal nocturnal BP (control) and placed them all on a prescribed DASH diet previously demonstrated to improve daytime BP.^[9] Baseline ABPM readings and body mass index (BMI) measurements for each individual were compared before and after two months of dieting. After two months on the DASH diet, the control group had the lowest BMI followed by the LND group and the RBPN group. These results demonstrate a linear correlation between BMI and nocturnal BP. Individuals who lost less than 5% of their original weight experienced a 3% increase in BP at night. Those who lost more than 5% weight experienced a 8.5% decrease in BP nocturnally, effectively restoring their healthy nocturnal BP pattern. Thus, obesity may contribute to nocturnal BP abnormalities, and weight loss may improve this condition.

Une pression artérielle (PA) nocturne anormale durant le sommeil est considérée un indicateur de nombreuses maladies cardiovasculaires.^[1] Chez les personnes saines, la PA nocturne diminue de façon physiologique d'environ 5-10 % mesurée grâce au moniteur ambulatoire de pression artérielle (MAPA). Les personnes ayant une PA nocturne anormale sont classées de trois façons distinctes: 1) une absence d'une diminution de PA, 2) un manque de « dipping » nocturne typique (MDN), ou 3) une augmentation de la PA durant la nuit (APAN).^[3] Dans cette étude, nous examinons la possibilité d'une corrélation entre l'obésité et la PA nocturne anormale et l'impact d'une perte de poids sur les motifs de la PA nocturne. Pour notre étude, nous avons recruté 30 individus avec MDN, 30 avec APAN, et 20 individus avec une PA nocturne normale (groupes contrôle), et les avons mis sur le régime DASH qui a précédemment démontré une amélioration de PA durant la journée.^[9] Des mesures de base avec MAPA ainsi que des mesures d'indice de masse corporelle (IMC) furent prises pour chaque individu, et par la suite utilisées afin de les comparer avec les mesures de MAPA et d'IMC suites aux deux mois du régime. Après avoir suivi le régime DASH pendant une durée de deux mois, le groupe contrôle avait la plus faible IMC suivie par le groupe du MDN, et le groupe APAN eu le plus haut IMC global. Ces résultats démontrent une relation linéaire entre l'IMC et des anomalies de PA nocturnes. Les individus qui ont perdus <5 % de poids ont su voir une augmentation de PA d'un taux de 3 % la nuit. Ceux qui ont perdu ≥ 5 % de poids ont eu une diminution de leur PA de 8,5% la nuit ce qui rétablit un motif sains de PA nocturne. Par conséquent, conformément à cette étude on peut conclure que l'obésité contribue à des anomalies de la PA nocturne, et la perte de poids peut améliorer cette conditions.

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Introduction

In healthy individuals, sleep is associated with a drop in blood pressure (BP) known as nocturnal dip^[1]. A lack of nocturnal dip or an increase in BP at night are considered abnormal conditions. A lack of nocturnal dip occurs when the systolic BP fails to drop at least 5% between day and night, as assessed by 24 hour monitoring^[1, 2]. Individuals with abnormalities in nocturnal dip have a greater risk of stroke, renal failure, and heart failure^[2, 3, 5]. The absence of a nocturnal dip is also associated with an improper breathing condition during sleep known as sleep apnea^[4]. Strategies to treat sleep apnea, including nocturnal CPAP (positive pressure nasal masks), have been shown to improve nocturnal BP patterns^[4, 5].

On the other hand, many individuals with abnormal nighttime BP pattern do not have sleep apnea^[4, 5]. There are, at this moment, no effective or proven methods to treat such individuals^[5]. Weight loss lowers daytime BP and may decrease the risk of myocardial infarction, stroke, and renal and heart failure^[6]. However, no clear correlation has been established between weight loss and nocturnal BP pattern^[6]. This study attempts to define a relationship between obesity and abnormal nocturnal BP, taking into consideration the effect of weight loss strategies.

Materials and Methods

Materials

The materials that were used in this study included 13 Spacelabs ABPM: model # 90207-30, Dell Inspiron 620 S computer with Windows 8 and Microsoft Office 2007, and GraphPad InStat 3.10 statistical analysis software (GraphPad inc. , 2009).

Recruitment of study participants

This study protocol and informed consent forms were reviewed by Dr. Susan Sykes from the University of Waterloo Human Research Ethics Board. 20 consecutive, random patients with a normal drop in nocturnal BP , 30 consecutive, random patients with no nocturnal dip and 30 consecutive, random patients with a rise in nocturnal BP were approached to participate in this study. All patients were given the opportunity to consider the study, and the commitments necessary to participate in this study. All patients were given ample time and opportunity to have any questions answered. No study procedures were conducted until the informed consent document was signed.

Dash Diet

The dietary approaches to stop hypertension (DASH) diet has been well validated as an effective strategy of reducing daytime blood pressure in hypertensive patients^[9]. In short, It is a low salt, high fiber diet that incorporates low fat dairy, and high fish intake. It also incorporates approach to nuts, vegetables and plant protein. The DASH diet was prescribed to individuals as previously described.^[10]

Study Procedure

Participants completed a baseline survey of demographics and had their height and weight measured. Individuals who had a rise of BP nocturnally or whose BP that did not fall at night were prescribed the DASH diet and lifestyle program for two months. After 2 months of adherence to the DASH lifestyle intervention, individuals returned for a repeat height, weight, Body Mass Index measurement and a repeat 24 hour BP monitor to assess the efficacy of this intervention. Individuals were instructed to neither change their medication regimen nor the timing of medications during the 2 months of lifestyle intervention of this study.

Statistical Analysis

Statistical analysis was performed using GraphPad InStat 3.10. Student's T-test was used for comparisons of two variables. ANOVA with Bonferroni correction was used for all comparisons with two or more variables with multiple comparisons. A p value of $p=0.05$ was considered statistically significant.

Results

Correlation between BMI and Nocturnal Blood Pressure (Figure 1)

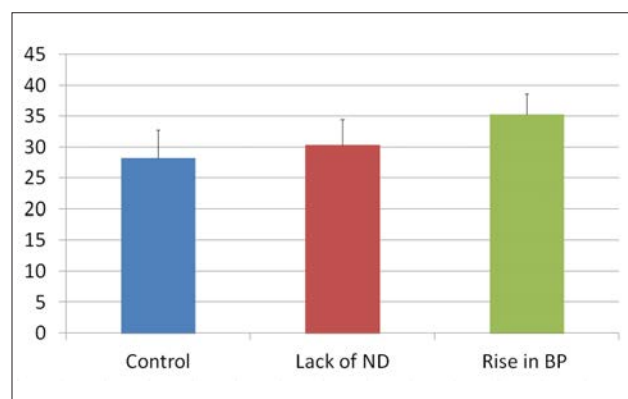


Figure 1. Average Body Mass Index of participants with standard deviation (kg/m²).



80 individuals were recruited to participate in this study (see study procedure). There was a correlation made between the BMI, and their nocturnal Blood Pressure Patterns. Control individuals (those who had BP that dropped at night) had an average BMI of 28.2 kg/m², which is considered to be normal/slightly overweight. Those who had a lack of nocturnal dip had an average BMI of 30.3 kg/m², which is considered to be overweight. The individuals who had a rise in BP at night had an average BMI of 35.3 kg/m², which is considered to be obese (p<0.0001).

The effect of the weight loss intervention (2 month readings) on nocturnal BP patterns. (Figure 2)

When weight loss of 5% or more was achieved by individuals who previously experienced abnormalities in nocturnal dip, blood pressure dropped by an average of 8.4% nocturnally, restoring the healthy pattern. Those who lost less than 5% of their original weight and those who gained weight had blood pressures that rose by 3.2% at night on average (p < 0.0001).

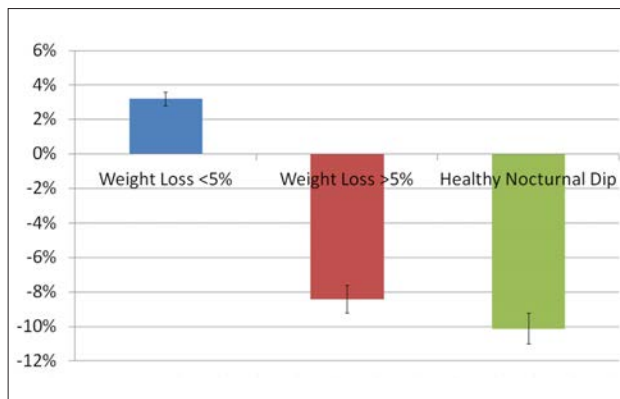


Figure 2. Nocturnal dip of individuals who previously had a lack of nocturnal dip or rise of BP at night after intervention (percent).

The difference in average systolic nighttime blood pressure before and after the study. (Figure 3)

When a 5% weight loss or more was achieved by individuals in the study, their systolic blood pressure dropped by an average of 26.2 mm Hg, which is considered to be very substantial. On the other hand, those who lost less than 5% only experienced a 1.9 mm Hg drop in systolic blood pressure, which is considered to be near-insignificant (p< 0.0001).

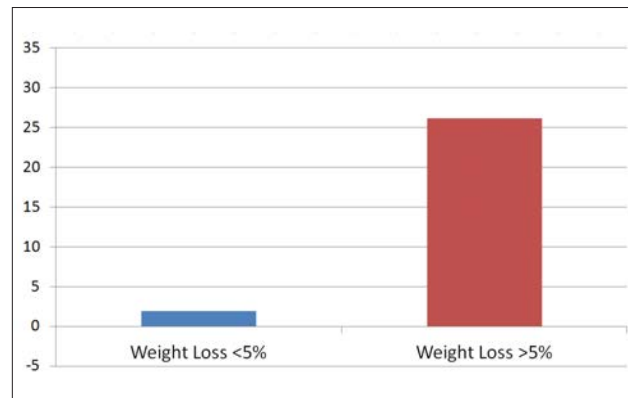


Figure 3. Average change in nighttime BP with weight loss intervention (Pre-intervention - Post-intervention BP) (mm Hg).

Discussion

This study involved participants with abnormal nocturnal BP patterns in the DASH diet as well as counselling for increased physical activity with the goal of reducing weight by 5-15% over 2 months^[9]. The effects of this weight loss on nocturnal BP patterns were assessed. All individuals with abnormal nocturnal BP patterns underwent an assessment of BMI and 24 hour ambulatory BP, before and after the two month intervention. Individuals who lost less than 5% weight had BP that increased by 3% at night, while individuals who lost 5% or more had BP that decreased by 8.5% at night, restoring a healthy nocturnal dip of 5-10% (Figure 2).

The DASH diet was chosen for this study because it has been shown to reduce daytime BP^[9]. However, its effects on nighttime BP have not been tested. As the DASH diet is effective at treating day-time BP patterns, and hypertension, it was used in this study to determine whether it could have an effect on nighttime BP^[9]. In this study, a direct correlation was observed between the BMI of participants and their abnormalities in nocturnal BP pattern. The control group had the lowest average BMI, followed by the group that lacked the nocturnal dip and the group that experienced a rise in BP by night (Figure 1). A possible explanation for this result is that higher BMI is associated with sodium retention, which in turn raises BP.^[7] Obesity is also associated with the development of poor sleep patterns such as insomnia and nocturia.^[4,8] Sleeping improperly or waking prematurely to use the bathroom can prevent BP from dropping appropriately at night. Finally, obese individuals are also more prone to developing diabetes, which is associated with hypertension^[6].



Future Directions

This study involved a small group of individuals from a select cardiovascular practice. Further research is required to examine the impact of weight on nocturnal blood pressure in larger and more diverse patient populations. This study used the DASH diet for weight loss. The impact of other diets on nocturnal blood pressure patterns may differ and requires further evaluation. The potential mechanisms by which weight may impact nocturnal BP that were suggested in the discussion should also be explored in subsequent studies.

Acknowledgments

I would like to thank my science teacher, Mr. Vissler, for inspiring me to conduct this study, and for his assistance and guidance. I would like to thank Dr. Jolly, hypertension specialist, for his useful discussions and for his assistance in designing the protocol. I would also like to thank Dr. Shankar, statistician at the University of Waterloo, for assistance in study design and statistical analysis; Sandee Clarus, cardiac nurse, Katie Fleet, and Jennifer Rich, cardiovascular technicians for assistance in patient recruitment, conducting the blood pressure readings and counselling patients on the DASH diet for this study. Most importantly, I would like to thank the 80 volunteers who participated in this study.

Abbreviations

BP Blood Pressure
BMI Body Mass Index
DASH Dietary Approaches to Stop Hypertension
ABPM Ambulatory Blood Pressure Monitor

Keywords

Blood pressure; Weight Loss; Lifestyle Intervention; Lack of Nocturnal Dip; Hypertension

References

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Review of *The Effect of Obesity on Nocturnal Blood Pressure Patterns*

The author is to be applauded for his effort and hard work toward this interesting investigation. It is a great pleasure to see a secondary student show such enthusiasm towards medical research, a field in which he undoubtedly has a bright future in.

The potential complications of hypertension have a large impact on individuals and on society. Targeting the phenomenon of abnormal nocturnal blood pressure is a promising strategy.

Overall, the manuscript is very good. The results section is missing important information on the baseline characteristics and post-intervention findings of the study subjects. There are some aspects that require further development and specific details are outlined below.

Obesity is defined as having a BMI of $> 30 \text{ kg/m}^2$. There appears to be some confusion in the manuscript between BMI as a measured value, elevated BMI, and obesity. It is unclear how obesity was defined in this study. Is this assessing the correlation between obesity and abnormal nocturnal BP, or BMI and abnormal nocturnal BP? The author should make this connection much more clear to the readership. For example, the title would be more appropriate as “The Effect of Body Mass Index on Nocturnal Blood Pressure Patterns” or “The Effect of Body Mass Index and Weight Loss on Nocturnal Blood Pressure Patterns”.

Abstract

I suggest changing “Abnormal nocturnal blood pressure (BP) during sleep is considered an indication of many cardiovascular diseases” to “Abnormal nocturnal blood pressure (BP) during sleep is associated with many cardiovascular diseases” in the abstract. Abnormal nocturnal blood pressure may be a risk factor, a risk marker, a result of, or correlated with cardiovascular diseases, and “indication of” is too specific of a term to be used in this context. To state that obesity contributes (causes in part) to nocturnal BP abnormalities may be too strong of an assertion. Using “correlation” or “association” is more accurate.

Methods

Recruitment of study participants

What were the inclusion and exclusion criteria for the study? Example: Did the inclusion criteria specify minimum BMI? What were the required nocturnal blood pressures to be enrolled in the study? Essential hypertension only rather than secondary hypertension? Did the study exclude pregnant patients? Were patients with sleep apnea included or excluded? It is potentially a confounding variable. Patients cannot be both consecutive and random. The two are mutually exclusive, which one were they?

It is important to define blood pressure drop more clearly in the methods section.

Intervention and data collection

How was this DASH diet intervention provided? Were meals given to patients? Were they instructed about how to follow the DASH diet? The physical activity counselling needs to be described in more detail. What was done to ensure compliance with the DASH diet?

How was the nocturnal BP defined and measured? An ambulatory BP monitor was used, but at what times of day were the measures taken? Were they a mean of several readings on one night?

Results

The author would need to provide a written description and a table of the baseline characteristics of the study subjects. This allows readers to know more about the individuals in the study, and if the findings apply to their own patients. What other medical conditions or co-morbidities did they have? Were the patients using anti-hypertensive medications? (Report the number of medications and type - if available).



For results reported in Figure 1, it is unclear which statistical measure was used to demonstrate a linear relationship between BMI and abnormalities of nocturnal BP. Would suggest the author be explicit about this measure. Were these results before or after the intervention? Rather than “average”, please state if the measure of central tendency is a mean (and include a standard deviation) or a median (and include an interquartile range).

In reporting Figure 2 results, “those who lost less than 5%, or gained weight” technically does not include individuals whose weight remained unchanged. Instead, use “did not lose 5% or more in weight” as it would better describe this group. What were the results in the various groups (LND, RBPN, controls)? Additionally, was the follow-up rate in the study 100%, or did some patients drop out?

Discussion

In the discussion, please discuss the impact of sleep apnea on your study population. In patients with weight loss, their sleep apnea may improve, and as a result, as may their nocturnal BP. Along with your excellent discussion of diabetes, please expand the discussion to include “metabolic syndrome”. Metabolic syndrome would tie together elevated BMI, hypertension, and diabetes.

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