Sleep-Disordered Breathing in Hypertensive Disorders of Pregnancy – A BMI-Matched Study

Shortened Title – SDB in HDP with BMI-Matching

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Author Contributorship

D. Wilson was involved in the study design, data collection, data analysis, interpretation of results and preparation of the manuscript.

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Summary

Sleep-disordered breathing (SDB) is more common in hypertensive disorders during pregnancy, however most studies have not adequately accounted for the potential confounding impact of obesity. This study evaluated the frequency of SDB in women with gestational hypertension and pre-eclampsia compared to BMI- and gestation-matched normotensive pregnant women. Women diagnosed with gestational hypertension or pre-eclampsia underwent polysomnography shortly after diagnosis. Normotensive controls BMI-matched within ±4kg/m^2 underwent PSG within ±4 weeks of gestational age of their matched case. The mean BMI and gestational age at polysomnography were successfully matched for 40 women with gestational hypertension/pre-eclampsia and 40 controls. The frequency of SDB in the cases was 52.5% compared to 37.5% in the control group (p=.18), and the RDI overall did not differ (p=.20). However, more severe SDB was more than twice as common in women with gestational hypertension or pre-eclampsia (35% vs 15%, p=.039). While more than half of women with a hypertensive disorder of pregnancy meet the clinical criteria for SDB, it is also very common in normotensive women of similar BMI. This underscores the importance of adjusting for obesity when exploring the relationship between SDB and hypertension in pregnancy. More severe degrees of SDB are significantly associated with gestational hypertension and pre-eclampsia, and SDB may plausibly play a role in the pathophysiology of pregnancy hypertension in these women. This suggests that more severe SDB is a potential therapeutic target for reducing the prevalence or severity of hypertensive disorders in pregnancy.

Keywords: Obstructive sleep apnoea, gestational hypertension, pre-eclampsia, obesity, polysomnography.

Hypertensive disorders of pregnancy (HDP) are the most common and serious medical disorders in pregnancy, affecting 3-8% of pregnant women and responsible for over 60,000 maternal deaths and far greater numbers of perinatal deaths worldwide every year (Redman and Sargent, 2005, Sibai et al., 2005). Gestational hypertension (GH) is characterised by the new onset of hypertension after 20 weeks gestation, whereas pre-eclampsia (PE) is diagnosed when GH is accompanied by multisystem organ dysfunction (Tranquilli et al.,

2014); most typically renal involvement manifesting as proteinuria. Once established, PE inexorably worsens until delivery. PE can have a range of life-threatening complications including maternal liver damage, renal failure and seizures, with increased risks of pre-term birth and fetal growth restriction (Sibai et al., 2005). There is no cure, and the mainstay of management is delivery of the fetus. Although GH alone is generally associated with a good prognosis, up to a quarter of women with GH will go on to develop PE and therefore close surveillance is required (Lowe et al., 2015). Because of the disease burden associated with HDP, contributors that have an effective treatment could have an important impact on the health of women and their offspring.

In the non-pregnant population, sleep-disordered breathing (SDB) confers a 3-fold increase in risk of hypertension independent of other risk factors (Chen and He, 2007). Perimenopausal women with SDB have a higher prevalence of hypertension and antihypertensive medication use (Pedrosa et al., 2014), while snoring and symptoms of SDB are commonly reported during pregnancy (Franklin et al., 2000). SDB during pregnancy appears to be linked to adverse outcomes for the mother and baby (Bourjeily et al., 2011, Fung et al., 2012) and in particular, was significantly associated with GH and PE in a recent large prospective cohort study (Facco et al., 2017). On the other hand, obesity is a risk factor for both increased blood pressure during pregnancy and PE (Gaillard et al., 2011). It is also a well-recognised risk factor for SDB (Young et al., 2005), and a determinant of developing SDB in pregnancy (Pien et al., 2014). Thus the relative contribution of SDB and obesity to HDP requires independent evaluation.

Several cross-sectional studies have identified an increased frequency of objectively-measured SDB in HDP, but many have not adjusted for the confounding effect of obesity. For example, Reid *et al.* (Reid et al., 2011) demonstrated that women with GH with or without proteinuria were at least four times more likely to have SDB compared to women with uncomplicated pregnancies. However, the women with GH had a substantially higher body mass index (BMI) on average (37.4kg/m^2 vs 28.7kg/m^2, p=.0001). Other studies have statistically accounted for BMI in multivariate tests (Champagne et al., 2009, Facco et al., 2017), but no studies to date have used a BMI-matched approach to assess the impact of HDP on SDB prevalence.

This study aims to address this gap in the literature, by exploring the relationship between HDP and SDB (assessed with full polysomnography), using a closely matched design to control for the effect of obesity. We hypothesised that pregnant women with HDP (both GH and PE) will have a higher rate of SDB compared to BMI- and gestation-matched normotensive pregnant women.

Method

Study Participants

This was a single-centre cross-sectional study conducted between October 2012 and October 2015, comparing the prevalence of SDB in late pregnancy among women with a hypertensive disorder of pregnancy to women with uncomplicated pregnancies. The Human Research Ethics Committees at Austin Health, Mercy Hospital for Women and University of Melbourne approved the study and written informed consent was obtained from all participants.

Cases included women with a singleton pregnancy diagnosed with GH or PE not requiring immediate delivery between 26 and 37 weeks gestation and were recruited from the Pregnancy Day Assessment Centre or were inpatients at Mercy Hospital for Women. Hypertension in pregnancy was defined as systolic blood pressure greater than or equal to 140mmHg and/or diastolic blood pressure greater than or equal to 90mmHg, confirmed by a minimum of two readings over several hours. GH was defined as the new onset of hypertension after 20 weeks of gestation (Tranquilli et al., 2014). We used the most recent International Society for the Study of Hypertension in Pregnancy (ISSHP) definition of PE: new hypertension after 20 weeks gestation and one or more of the following new-onset conditions: i) proteinuria, ii) other maternal organ dysfunction (renal insufficiency, liver involvement or neurological complications), and iii) uteroplacental dysfunction – fetal growth restriction (Tranquilli et al., 2014). Women with chronic hypertension who developed superimposed PE (diagnosed when one or more systemic features of PE occur after 20 weeks gestation in addition to pre-existing hypertension) were also considered eligible cases.

Control participants were normotensive pregnant women one-to-one matched by BMI (within ±4kg/m^2, measured at the first antenatal appointment) to each of the cases, and were recruited from the antenatal outpatient clinic. Control participants had otherwise uncomplicated pregnancies and were confirmed to have an appropriately grown fetus (estimated fetal weight >10^{th} centile with normal fetoplacental Doppler studies) prior to inclusion. All potentially eligible women were screened by medical record review. Exclusion criteria included <18 years of age, multiple gestation, fetal abnormality or other maternal/fetal condition likely to mandate early or imminent delivery, and previous diagnosis of a sleep disorder.

Investigational Measures

Polysomnography (PSG)

Attended overnight PSG was conducted in the Austin Health sleep laboratory using the Compumedics E series (Abbotsford, Victoria, Australia), or unattended in the participant's home with the Somté (Compumedics) portable sleep-monitoring device. Participants who were inpatients were also studied using the portable device. Signals recorded both in-

laboratory and portably included electroencephalogram (EEG; with recommended derivations of F4, C4 and O2 referenced to M1), electrooculogram (EOG), electromyogram (EMG), electrocardiogram (ECG), arterial oxygen saturation, thoracic and abdominal respiratory effort via inductance plethysmography, nasal airflow measured via nasal cannula, oronasal thermistor, leg movements, snoring and body position. Recordings were sleep-staged and respiratory-scored by a single experienced sleep technologist who was blinded to maternal hypertensive status. As per the AASM criteria (Berry et al., 2016), respiratory events were categorised as apnoeas, hypopnoeas, and respiratory event-related arousals (RERAs). The number of apnoeas and/or hypopnoeas per hour of sleep was calculated as the Apnoea/Hypopnoea Index (AHI). The addition of RERAs per hour to the AHI was expressed as the respiratory disturbance index (RDI). The oxygen desaturation index (ODI≥3%) was defined as the number of arterial oxygen desaturations of ≥3% from baseline, per hour of sleep (Berry et al., 2016).

All participants diagnosed with SDB at an RDI ≥ 5 were offered clinical follow up with a sleep physician, whereas those diagnosed at an RDI ≥ 15 or with clinically significant symptoms (i.e. falling asleep while driving) were given urgent follow up within 2 weeks of the PSG.

SDB Questionnaire

The Berlin Questionnaire (Netzer et al., 1999) assesses pre-test probability of obstructive sleep apnea (OSA). Predetermination of high risk and low risk for OSA was based on responses in three symptom-based categories – snoring, daytime sleepiness, and high blood pressure and/or BMI.

Procedures

After consent was obtained, participants with GH and PE underwent overnight PSG at their earliest convenience. Each control participant underwent PSG within ±4 weeks of gestational age of their matched case. At the time of the PSG, the Berlin Questionnaire was completed and height and weight were recorded. Neck circumference was measured at the most prominent part of the thyroid cartilage while the participant was standing. A sleep technologist with over 10 years of experience (DW) was responsible for all sleep monitoring and anthropometric measurements.

Statistical Analysis

All statistical analyses were performed with SPSS 21.0 (SPSS Inc., Chicago, Illinois). Values are given in means with standard deviations (*M±SD)* or median and interquartile range (*Mdn (IQR)*) for non-normally distributed variables. A two-sided p value of less than 0.05 was considered to indicate statistical significance. SDB as the primary outcome was defined as an RDI of ≥5 events per hour. Secondary outcomes included diagnosis of SDB using stricter cut-offs of RDI ≥10, ≥15 and ≥30, and median RDI.

To test the hypothesis that SDB was more common in women with HDP, the proportion of those with an RDI ≥5, 10, 15 and 30 were compared to the control group using the chi-square test. Within-subjects analysis for SDB and sleep variables was conducted using paired sample t-tests for normally-distributed continuous variables and Wilcoxon signed-rank tests for non-normally distributed continuous variables. Cross tabulations were done to determine sensitivity and specificity values for the Berlin Questionnaire.

Sample size was based on the previously reported prevalence of SDB (RDI ≥5) in gestational hypertensive disorders being 53% (Reid et al., 2011) compared to 19.7% in a clinical obstetric population (Pien et al., 2014). A sample size of 64 (32 cases and 32 controls) would be required to provide a power of 80% (alpha =0.05) to detect this increased prevalence of SDB in HDP. As obesity is a risk factor for both PE and SDB, we suspected that the matched controls would likely be heavier and have a higher prevalence of SDB than previously reported, hence a decision was made to increase the sample size by 25% (40 cases and 40 controls).

Results

A total of 81 pregnant women participated (see Consort Diagram, Fig 1), with one home sleep study failure in the control group due to signal loss. An in-laboratory sleep study was chosen by 22 participants and a home sleep study chosen by 58. The severity of SDB was not different between these two groups (p=0.45); the only difference in overall sleep quality was better sleep efficiency for those who slept at home (81.7% ± 9.8) compared to the laboratory (76.0% ± 10.7, p = .03).

Insert Figure 1

Table 1 confirms the hypertensive and control groups were carefully matched for age, BMI and gestational age at the time of the sleep study. Average age was 32.9 ± 4.6 years and BMI at first antenatal appointment and at the time of the sleep study was 32.6kg/m^2 ± 7.1 and 36.3kg/m^2 ± 6.6 respectively, with no differences between cases and controls. Neck circumference was significantly larger for the HDP women compared to their BMI-matched controls. Sleep studies in both groups were performed at approximately 33 weeks gestation. At the time of the sleep study, 23 (58%) of the hypertensive participants were taking anti-hypertensive medication, most commonly Labetalol, Aldomet, or a combination of the two.

Insert Table 1

Prevalence of SDB

Using our *a priori* definition of RDI ≥5, 36/80 (45%) women in the study met the diagnostic criteria for SDB. SDB was more commonly observed among women with HDP (53%) than the control group (38%) but this difference was not statistically significant (Table 2). An RDI ≥10 was significantly more common among women with HDP (35% compared to 15%, p=0.04). A similar trend was seen for moderate SDB (RDI ≥15) and severe SDB (RDI ≥30) but due to small numbers, these associations failed to achieve statistical significance (Table 2). There were no differences in the prevalence of SDB according to the severity of hypertensive disease (see Figure 2).

Insert Table 2 and Figure 2

The median RDI and AHI did not differ between the HDP and control group overall (Table 3), however, the HDP group had a significantly higher RDI during non-rapid eye movement (NREM) sleep and supine sleep (Fig 3). There were trends toward a higher ODI≥3% and a lower SpO2 nadir in the HDP group but this was not statistically significant.

Insert Table 3 and Figure 3

Sleep quality was comparable across the HDP group and their matched controls, apart from a lower percentage of REM sleep in the HDP group (Table 4).

Insert Table 4

Within our cohort, neck circumference was a significant predictor of HDP (OR 1.58, 95% CI 1.20 – 2.08), however the trend towards more commonly observed SDB in the HDP group could not be explained by a relationship between neck circumference and RDI (r_s =.12, p =.33). RDI was weakly related to BMI at the sleep study (r_s =.26, p =.03); those with an RDI ≥5 had a higher BMI than those without SDB in the HDP group (38.4kg/m^2 ± 6.4 vs 33.8 ± 7.0, p=.04) with a similar trend observed in the control group (38.5 ± 6.7 vs 35.1 ± 5.5, p=.09).

Self-Report Data

The majority of women in both the hypertensive and control group were considered at high risk of SDB (Table 5). Significantly more women in the HDP group reported snoring at least three nights per week than their matched controls, and there was a trend towards more frequently witnessed apnoeas.

With the frequency of SDB-related symptoms reported by the participants, the Berlin Risk score overestimated the number of pregnant women with an RDI ≥5 and had poor specificity

(sensitivity =0.81, specificity =0.33, PPV =0.47, NPV =0.70). Using habitual snoring only as a predictor of RDI ≥5 did not improve prediction of SDB (sensitivity =0.60, specificity =0.41, PPV =0.47, NPV =0.54).

Insert Table 5

Discussion

Previous research has suggested a relationship between HDP and SDB, however this study is the first to prospectively address the potential confounding role of obesity using BMI-matching and gold standard PSG to assess SDB. We found SDB to be more common in our control group than in previous studies (O'Brien et al., 2014, Reid et al., 2011), confirming that BMI is an important covariate that requires evaluation in future studies exploring the relationship between SDB and HDP. While SDB occurred in more than half of women with HDP, over a third of BMI-matched controls also had SDB. We found no increase in the overall median RDI and AHI in the HDP group compared to BMI-matched controls. In a planned secondary analysis, we report a significant independent association between HDP and moderate SDB, suggesting that SDB may still play an important role in the development of hypertension in pregnancy.

That the relationship between HDP and SDB is partly confounded by the presence of obesity is unsurprising, since obesity is a known risk factor for both. SDB may be a mechanism by which obesity and adverse perinatal outcomes are linked, but given the important contribution of obesity to both SDB and HDP, failing to adjust for this co-variate will overestimate the strength of association between SDB and HDP. A dose response relationship has been described for both GH and PE among women with Class 1, 2 and 3 obesity (Trojner Bregar et al., 2017), and in a large Danish population cohort of nearly 71,000 women, the risk of PE increased linearly with BMI among nulliparous women (Catov et al., 2007). Obesity drivers of HDP include increased sympathetic activation, inflammation and oxidative stress. These contribute to placental ischemia, which in turn leads to placental production and release of anti-angiogenic factors such as soluble fms-like tyrosine kinase-1 (sFlt-1) and soluble-endoglin (sEng). These circulating factors cause widespread endothelial dysfunction, with the resultant multisystem damage seen in PE (Powe et al., 2011). Obesity is also a strong risk factor for SDB in the non-pregnant (Young et al., 2005) and pregnant population (Facco et al., 2017) and in particular, BMI, neck girth and central fat patterning may independently contribute to SDB (Young et al., 2002). Excess body weight may affect breathing in numerous ways, including changes in upper airway structure or function, reduced chest wall compliance and alterations in the balance between ventilatory drive and load (Strobel and Rosen, 1996). Interestingly, within our sample we had six women with a BMI of around

50kg/m^2, but only two of these women had SDB (one with GH/PE and one control). There are clearly reasons other than obesity- such as changes in hormone levels, respiratory function, and the upper airway and nasal mucosa- which determine whether SDB will be present during pregnancy. Protective factors, such as increased progesterone stimulating ventilatory drive and increasing responsiveness of the upper airway dilator muscle (Popovic and White, 1998), may explain why some women with such a high BMI escape SDB.

Consistent with the observations of others (Champagne et al., 2009, Facco et al., 2017), we confirm a significant association of moderate-severe SDB and HDP. In particular, we found similar frequencies of SDB in HDP across RDI categories to both Reid et al. (2011) and Facco et al. (2013), and like Reid et al. (2011) we found no differences in SDB frequency between GH and PE. We found at the level of RDI ≥10 and RDI ≥30 a doubling of prevalence for the GH/PE compared to the control group, implying that more severe levels of SDB may contribute to the development of HDP. SDB and PE share similar biological pathways. The recurrent episodes of hypoxia in SDB are known to result in sympathetic activation, oxidative stress and activation of inflammatory pathways that can lead to endothelial dysfunction (Somers and Javaheri, 2011); a weak negative trend between SDB severity and endothelial function in PE women has been described by Yinon et al. (2006). These are the proposed mechanisms by which SDB results in hypertension and may plausibly contribute to the development of PE. In the same manner, fetal well-being may also be compromised by SDB contributing to placental ischemia. Habitual snoring in pregnancy has been associated with enhanced fetal erythropoiesis (Tauman et al., 2011), and women with SDB show significantly increased placental markers of chronic hypoxia and uteroplacental underperfusion (Ravishankar et al., 2015).

It is possible that the observed high prevalence of SDB identified after being diagnosed with HDP in our study is partly due to physiological changes accompanying HDP. PE is associated with marked fluid retention that affects the upper airway resulting in pharyngolaryngeal edema (Bourjeily et al., 2011). As a result, upper airway size is smaller in PE (Izci et al., 2003). We also found that our GH/PE group had a significantly larger neck circumference than the controls despite almost identical BMI, suggesting that SDB may be exacerbated by the presence of PE-related upper airway oedema. This is partly supported by our novel finding that RDI was higher among hypertensive women during supine sleep. Within our cohort however, we did not find any relationship between neck size and severity of SDB.

Our study along with others has confirmed that subclinical and undiagnosed mild SDB is extremely common among women with higher BMI, irrespective of whether they have HDP (Louis et al., 2012, Pien et al., 2014). It is not feasible to offer treatment to over a third of all women with an increased BMI, therefore future research needs to determine at what severity threshold SDB should be considered significant enough to intervene. In our study, all women

with SDB were offered clinical review with a sleep physician, yet only three of these women attended and were commenced on CPAP. This has been identified in other studies (Facco et al., 2014b) and suggests that women themselves regard this as relatively low priority and may not commit to what they perceive as onerous treatment. Better engagement may be more likely for women with more severe disease if stronger links with adverse pregnancy outcome are demonstrated.

Strengths of this study were that we used gold standard full PSG to characterise SDB rather than questionnaire data alone, which tends to overestimate the likelihood of SDB (Antony et al., 2014, Wilson et al., 2013). Aligning with many past studies (Izci et al., 2003, O'Brien et al., 2014, Reid et al., 2011), habitual snoring was reported by a substantial proportion of normotensive pregnant women and significantly more GH/PE women. Witnessed apnoeas were also reported by a fifth of GH/PE women. These symptoms along with high BMI and hypertension meant that many women in our cohort were considered as high risk for SDB on the Berlin Questionnaire. Unfortunately, screening tools will significantly overestimate the presence of SDB within hypertensive and obese cohorts of pregnant women, which limits their utility in clinical practice.

Use of full PSG also enabled us to look at differences across sleep stages and body positions and detect subtle changes in airflow as well as more discrete events. In particular, we found that SDB in NREM sleep and supine sleep was significantly more severe in HDP compared to normotensive women despite no difference in overall RDI. This is a strength in comparison to studies that have used abbreviated monitoring techniques (Facco et al., 2013, Facco et al., 2014a, Facco et al., 2017, Louis et al., 2012, Yinon et al., 2006). Abbreviated devices may underestimate SDB prevalence due to estimation of sleep time, and absence of EEG monitoring means hypopneas with arousal will be undetected.

Our study utilised domiciliary PSGs as well as in-laboratory. This may be considered a limitation as unattended studies are prone to signal quality problems, however we had a high success rate with only one failure from 58 home studies. Almost three-quarters of our sample chose to have their sleep study at home. Anecdotally, the pregnant women were not keen on spending an extra night in the hospital in an unfamiliar bed, particularly those who were receiving additional antenatal monitoring for clinical reasons. Our results may be useful for future research in this area, demonstrating that women who have a home study may sleep better in terms of sleep efficiency, but measures of SDB are comparable.

A further limitation of our study is that we were underpowered for our primary outcome given the higher than expected prevalence of SDB in the control group. In order to have enough power to obtain a significant difference between frequency of SDB in HDP and BMI-matched controls in our study, we would have needed 169 participants per group. Nevertheless, this is

important information to inform the sample size and power of future studies, particularly when matching for the important covariate of BMI.

Conclusion

SDB occurs in half of women diagnosed with a gestational hypertensive disorder however it is also common in normotensive women of similar body habitus, with our results suggesting that the previously reported relationship between SDB and hypertension in pregnancy is due at least in part to the confounding effect of obesity. More severe SDB was at least twice as common in women with HDP, suggesting a multifactorial relationship with directionality still needing to be established. The high prevalence of this condition raises questions of a threshold of clinical significance, with further research required to determine at what severity the value of treatment should be tested.

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Figure Captions

Figure 1 - Consort diagram. GH = gestational hypertension; PE = pre-eclampsia; FGR = fetal growth restriction.

Figure 2. Percentage of participants in each Respiratory Disturbance Index (RDI/hr) category for the GH and PE groups. There was no difference in prevalence at RDI≥5 (p = .34), ≥10, ≥15 or ≥30 (all p = 1.0). GH n = 23, PE n = 17.

Figure 3 - Respiratory Disturbance Index (RDI/hr) across different sleep stages and positions for the GH/PE group compared to the control group (*p value < .05). REM = Rapid Eye Movement sleep; NREM = Non-rapid Eye Movement Sleep.

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Table 1

Demographics for Gestational Hypertension and Pre-Eclampsia Cases with Matched Controls

M ± SD	Cases (n = 40)	Controls (n = 40)	p value
Age (years)	32.5 ± 4.7	33.3 ± 4.4	.47
Nulliparous	26 (65.0%)	19 (47.5%)	.12
First appointment BMI (kg/m^2)	32.4 ± 7.3	32.7 ± 7.0	.83
Sleep study BMI (kg/m^2)	36.2 ± 7.0	36.4 ± 6.1	.90
Neck circumference (cm)	38.1 ± 2.0	35.6 ± 2.0	<.001
Gestation sleep study (weeks)	33.5 ± 3.4	33.1 ± 2.4	.59

Note. BMI = body mass index.

Table 2

RDI categories for Gestational Hypertension and Pre-Eclampsia Cases with Matched Controls

n (%)	Cases (n = 40)	Controls (n = 40)	p value
RDI ≥ 5	21 (52.5%)	15 (37.5%)	.18
RDI ≥ 10	14 (35.0%)	6 (15.0%)	.039
RDI ≥ 15	9 (22.5%)	5 (12.5%)	.24
RDI ≥ 30	6 (15.0%)	3 (7.5%)	.29

Note. RDI = respiratory disturbance index.

Table 3

Indices of SDB for Gestational Hypertension and Pre-Eclampsia Cases with Matched Controls

Mdn (IQR)	Cases (n = 40)	Controls (n = 40)	p value
RDI	5.2 (2.0 – 14.8)	4.1 (2.3 – 7.7)	.20
AHI	4.7 (1.6 – 14.1)	3.9 (2.3 – 7.7)	.38
ODI≥3% overall	2.1 (0.4 – 6.0)	1.5 (0.5 – 4.4)	.06
SpO2 nadir	90.0 (87.3 – 92.8)	91.0 (89.0 – 92.0)	.09
%TST SpO2< 95%**	11.3 (0.6 – 36.7)	13.7 (1.7 – 52.4)	.39

Note. RDI = respiratory disturbance index; AHI = apnea hypopnea index; ODI = oxygen desaturation index, TST = total sleep time.

Table 4

Sleep Quality for Gestational Hypertension and Pre-Eclampsia Cases with Matched Controls

	Cases (n = 40)	Controls (n = 40)	p value
TST (min)	380.3 ± 81.2	391.2 ± 64.7	.54

Sleep efficiency %	79.5 ± 10.9	81.0 ± 9.8	.53
% REM	13.6 ± 7.1	16.2 ± 4.6	.03
% N3	32.9 ± 13.0	31.8 ± 11.2	.66
Sleep latency	7.8 (4.5 – 15.5)	9.8 (4.6 – 18.0)	.30
%TST supine	29.1 (8.3 – 41.8)	17.7 (0.7 – 39.7)	.49
Arousal Index	22.5 (17.6 – 32.6)	22.0 (16.8 – 28.1)	.59

Note. TST = total sleep time; REM = rapid eye movement; N3 = stage N3 sleep.

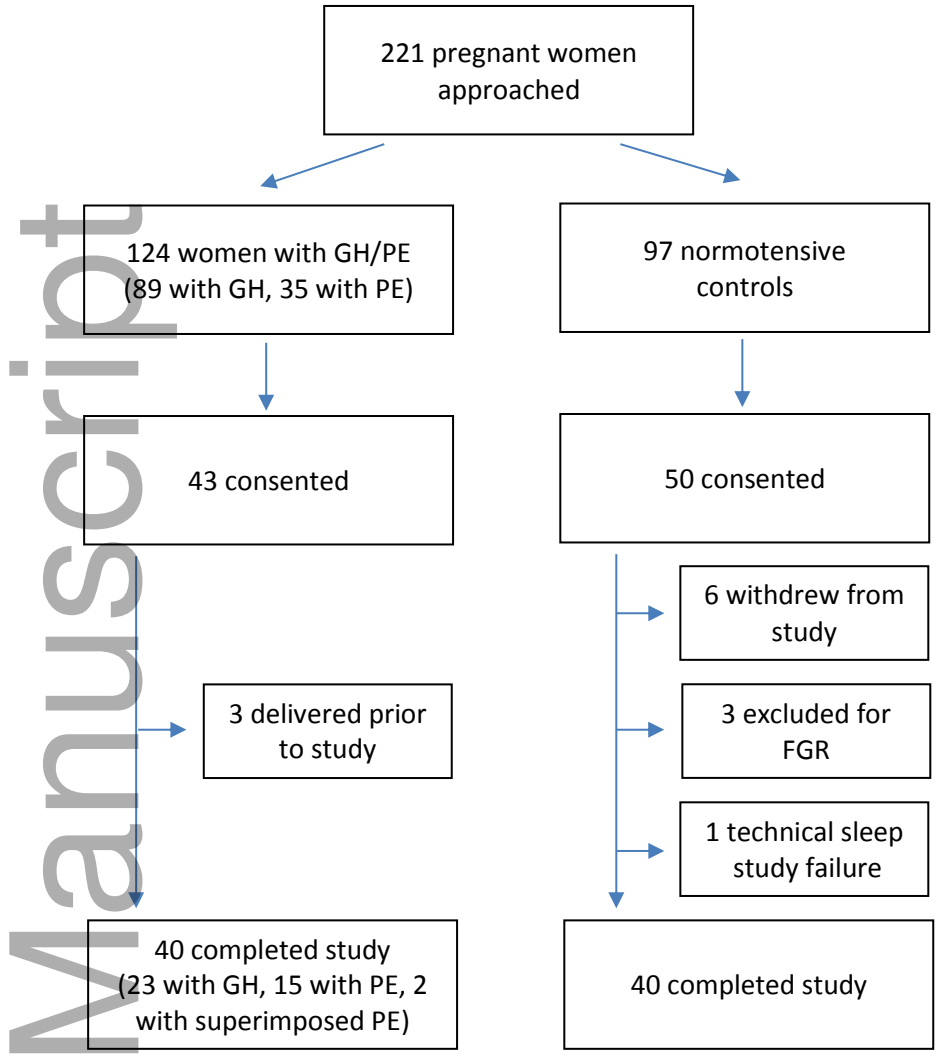
Values given as M ± SD for normally distributed and Mdn (IQR) for non-normally distributed data.

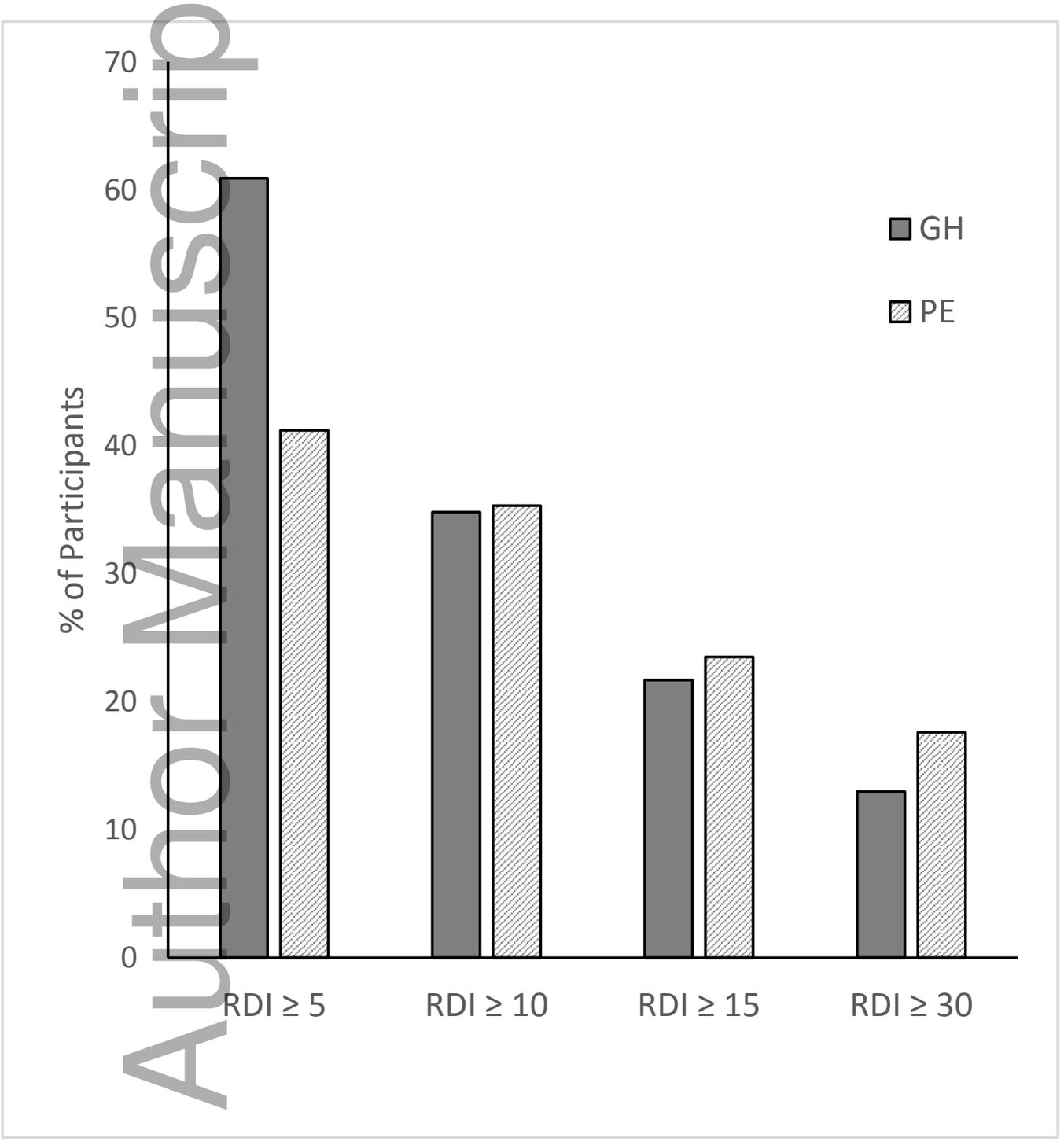
Table 5

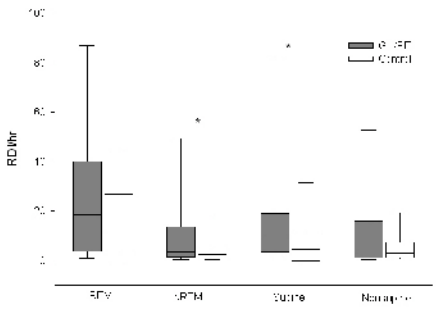
Berlin Questionnaire Results

	Cases	Controls	p value
Berlin High Risk	30/37 (81.1%)	25/38 (65.8%)	.19
Habitual Snoring	22/30 (73.3%)	16/34 (47.1%)	.04
Witnessed Apneas	7/36 (19.4%)	2/37 (5.4%)	.09

Note. Missing data due to response of “I don’t know”.







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