RhinoScope
JOURNAL OF POLISH RHINOLOGIC SOCIETY
ISSN 3072-5992
Issue 3 / 2026
Original Article

# Sleep quality in the third trimester of pregnancy – associations with sinonasal symptoms, nasal airflow and Eustachian tube function

A - Research concept and design
B - Collection and/or assembly of data
C - Data analysis and interpretation
D - Writing the article
E - Critical revision of the article
F - Final approval of the article

**Keywords:** pregnancy; sleep quality; PSQI; SNOT-22; Eustachian tube

**Received:** 2026-06-10
**Revised:** 2026-08-18
**Accepted:** 2026-08-25
**Final review:** 2026-07-15

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DOI:10.67832/rhino/242113

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## Abstract

*Background*: Sleep deterioration is common in late pregnancy and may be intensified by pregnancy-related changes in the upper respiratory tract. *Objective*: To present sleep quality as the principal outcome and examine it alongside sinonasal symptoms, nasal airflow and Eustachian tube function. *Methods*: The study group comprised 70 third-trimester pregnant women and the control group 35 healthy non-pregnant women. The mean age was 28.91 ± 4.24 years in the study group and 27.17 ± 2.80 years in controls; mean gestational age was 36.49 ± 2.63 weeks. ENT examination, SNOT-22, rhinomanometry, tympanometry and PSQI-related sleep assessment formed the analytical framework. *Results*: Based on the descriptive subjective sleep-quality categories used in the study questionnaire, 47/70 (67.1%) pregnant participants reported rather low sleep quality, 20/70 (28.6%) rather good and 3/70 (4.3%) very good; among controls, 29/35 (82.9%) reported very good and 6/35 (17.1%) rather good sleep quality. These labels were not treated as validated global PSQI severity categories. Mean global PSQI was 9.09 ± 3.03 in the study group versus 4.31 ± 1.60 in controls, and PSQI >5 was used as the standard threshold for poor sleep quality. Within the study group, PSQI was strongly associated with nasal-obstruction severity (Spearman rho=0.81, p<0.001). Nasal obstruction increased and rhinomanometric airflow decreased with advancing gestation, together with frequent ear fullness and more negative tympanometric peak pressure. *Conclusions*: Poorer sleep quality in late pregnancy coexisted with a greater upper-airway symptom burden, although the cross-sectional design and unmeasured confounding preclude causal inference.

## 1. Introduction

Sleep becomes increasingly vulnerable as pregnancy progresses. In the third trimester, nocturnal rest may be affected by mechanical discomfort, fetal movements, nocturia, gastroesophageal reflux and respiratory symptoms. Upper-airway complaints deserve particular attention because they may interfere directly with comfortable nasal breathing and may also overlap with snoring and sleep-disordered breathing [1, 2].

Pregnancy produces major endocrine and circulatory adaptations. Estrogen and progesterone concentrations rise progressively and reach their highest levels late in gestation. These hormones influence vascular tone, capillary permeability and fluid distribution, while pregnancy itself is accompanied by an increase in interstitial fluid volume. Within the nasal mucosa, these mechanisms can increase vascularity and edema, reduce the functional cross-sectional area of the nasal cavity and produce persistent congestion [3].

Pregnancy-related rhinitis has been described as a distinct clinical condition, typically characterized by obstruction and clear rhinorrhea in the absence of another obvious cause. Published estimates vary because studies differ in diagnostic criteria, trimester examined and method of symptom assessment. The late gestational period is particularly relevant because mucosal and fluid-related changes are often most pronounced at this stage [4-6].

The same physiological environment may affect the Eustachian tube. Edema in the nasopharyngeal region can disturb pressure equalization between the middle ear and the nasopharynx, resulting in fullness, popping or muffled hearing. Most pregnancy-related ENT disturbances are benign and often improve after delivery, but their effect on comfort and quality of life can be substantial.

Sleep quality provides a patient-centered framework in which these ENT findings can be interpreted. The Pittsburgh Sleep Quality Index (PSQI) assesses several dimensions of sleep over the preceding month, including subjective sleep quality, latency, duration, efficiency, disturbances, use of sleep medication and daytime dysfunction. SNOT-22, in turn, captures sinonasal symptoms together with sleep- and quality-of-life-related complaints. Using both approaches makes it possible to consider whether the physiological changes detected by rhinomanometry and tympanometry are accompanied by a broader deterioration in maternal well-being [7, 8].

The present article therefore places PSQI-related sleep quality at the center of the analysis. Sinonasal symptoms, nasal airflow and Eustachian tube function are treated as potential accompanying factors rather than as the primary endpoint. The main objective was to characterize sleep quality in women in the third trimester and to integrate it with subjective and objective ENT findings. A secondary objective was to identify which pregnancy-related ENT changes show the strongest progression with gestational age and therefore may be particularly relevant to nocturnal symptoms.

## 2. Materials and methods

### 2.1. Study design and population

this observational cross-sectional study included 70 women aged 20-40 years (mean 28.91 ± 4.24 years) in the third trimester, between gestational weeks 31 and 41 (mean 36.49 ± 2.63 weeks). The control group comprised 35 healthy non-pregnant women aged 22-32 years (mean 27.17 ± 2.80 years).

### 2.2. ENT examination and instrumentation

All participants underwent an otorhinolaryngological examination including anterior and posterior rhinoscopy, upper-airway fiberoscopy and otoscopy. Nasal airflow and middle-ear pressure were measured using the COMBI 4000 diagnostic system (Homoth Medizinelektronik). The available source description indicates exclusion of major structural, inflammatory and neoplastic conditions capable of materially affecting nasal patency. However, the full screening checklist, diagnostic definitions, and detailed inclusion/exclusion criteria are not recoverable

from the available documentation; these should be verified against the original study protocol before submission. In particular, any handling of pre-existing chronic rhinosinusitis, allergic rhinitis, previous nasal surgery, or other nasal disease should be reported only after source verification.

### 2.3. Rhinomanometry

Rhinomanometry was performed separately for the left and right nasal cavities during inspiration and expiration using the COMBI 4000 system. Airflow values (ml/s) were recorded at the nominal pressure levels reported in the study dataset: 75, 150 and 300 Pa. The same pressure levels were used for pregnant participants and controls, and the four measurement series (left/right; inspiration/expiration) were analyzed separately. The available study documentation did not contain sufficient technical detail to reconstruct additional acquisition parameters such as the exact order and timing of pressure steps, stabilization interval, or whether repeated traces were averaged. These protocol details should therefore not be inferred beyond what is reported here. Because the pregnant group showed lower recorded flow at higher nominal pressures, an atypical pattern for a conventional steady-state pressure-flow relationship, the values were analyzed as device-recorded measurements at the specified pressure levels rather than interpreted as a normal physiological pressure-flow response.

### 2.4. Tympanometry

Tympanometric testing quantified middle-ear peak pressure in daPa for each ear. The device measures middle-ear pressure over a broad positive-to-negative range while generating a compliance curve. Tympanogram type and quantitative peak-pressure values were recorded. Quantitative pressure was retained in the analysis even when the overall tympanogram remained type A.

### 2.5. Questionnaires and sleep assessment

Sinonasal symptoms were assessed using the Sino-Nasal Outcome Test-22 (SNOT-22), a 22-item patient-reported outcome measure. Each item is scored from 0 (no problem) to 5 (problem as bad as it can be), giving a total score from 0 to 110; higher scores indicate greater symptom burden and impact on quality of life. Selected items, including nasal obstruction, need to blow the nose, sneezing, runny nose and ear fullness, were also considered individually. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI), which comprises seven components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medication, and daytime dysfunction. Component scores range from 0 to 3, yielding a global PSQI score from 0 to 21, with higher scores indicating poorer sleep quality; a global score >5 is a commonly used threshold for poor sleep quality.

### 2.6. Statistical analysis

Statistical analyses were performed in R version 4.1.2. Continuous variables were summarized as mean ± standard deviation (SD), and categorical variables as counts and percentages. Distributional characteristics were assessed using the Shapiro-Wilk test together with skewness and kurtosis. Between-group differences in categorical sleep-quality distributions were assessed with Pearson's chi-square test. Global PSQI was compared between the study and control groups using a two-sample Welch t-test; the mean difference was accompanied by a 95% confidence interval. Between-group comparisons of continuous ENT outcomes were summarized using mean differences with 95% confidence intervals and the corresponding two-group tests used in the original analysis. Spearman rank correlation was used for ordinal or non-normally distributed associations, including relationships between gestational week and symptom scores, gestational week and rhinomanometric/tympanometric variables, and nasal-obstruction severity and PSQI. Repeated-measures ANOVA was used to assess within-participant differences in rhinomanometric airflow across the three nominal pressure levels separately for each side and respiratory phase; post-hoc paired comparisons were Bonferroni-adjusted. All tests were two-sided, and $p<0.05$ was considered statistically significant. Exact p-values are reported where available; values below 0.001 are presented as $p<0.001$. No multivariable adjustment for potential sleep-related confounders was performed.

## 2.7. Ethical considerations

The study received approval from the Bioethics Committee of the Regional Medical Chamber in Warsaw (KB/1440/23). Informed consent was obtained from all participants.

## 3. Results

### 3.1. Sleep quality as the primary outcome

The distribution of the descriptive subjective sleep-quality categories differed markedly between groups (Pearson chi-square=72.00, df=2, p<0.001). In the study group, 47/70 (67.1%) reported rather low sleep quality, 20/70 (28.6%) rather good and 3/70 (4.3%) very good. In the control group, 29/35 (82.9%) reported very good and 6/35 (17.1%) rather good sleep quality; none were in the rather-low category. These categories describe the subjective sleep-quality item used in the study and are not global PSQI severity classes. Global PSQI results are reported separately in Section 3.7.

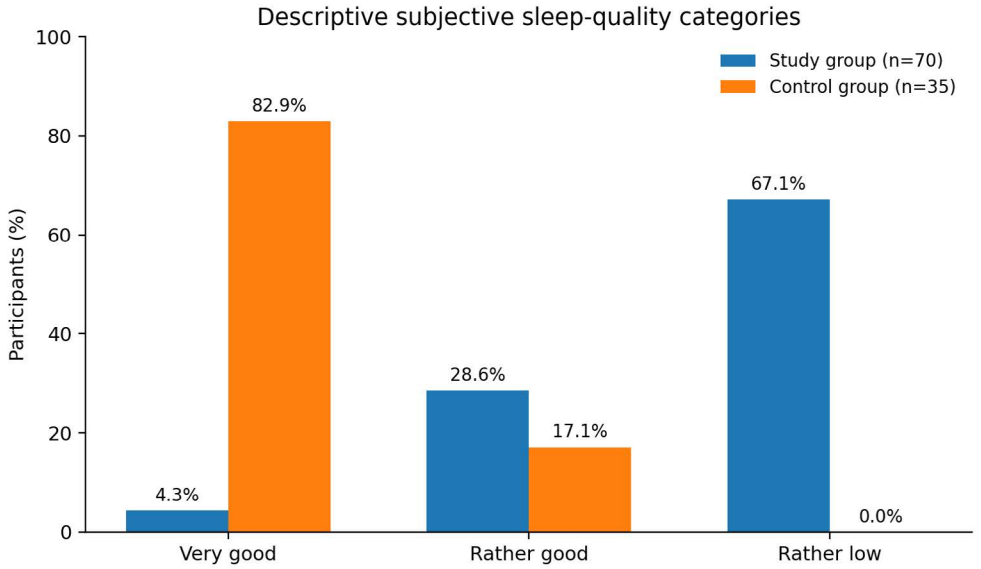



**Figure 1.** Distribution of descriptive subjective sleep-quality categories in pregnant participants and controls. These categories are not validated global PSQI severity strata.

**Table 1.** Descriptive subjective sleep-quality categories in the study and control groups.

| Descriptive subjective sleep-quality category | **Pregnant group, n (%)** | **Control group, n (%)** | Interpretation |
|---|---|---|---|
| Very good | 3 (4.3%) | 29 (82.9%) | Descriptive response category; not a global PSQI severity class |
| Rather good | 20 (28.6%) | 6 (17.1%) | Descriptive response category; not a global PSQI severity class |
| Rather low | 47 (67.1%) | 0 (0.0%) | Descriptive response category; not a global PSQI severity class |

### 3.2. Sinonasal symptom burden

The sleep-quality difference occurred in a group with a high prevalence of upper-airway symptoms. Sixty-six of 70 pregnant participants (94.3%) reported impaired nasal patency. Nasal obstruction was the most prominent complaint: its mean severity was 2.48 ± 1.16, and 30/70 (42.9%) rated it as strong, very strong or unbearable. Other symptoms were also frequent, although generally less intense: 46/70 (65.7%) reported a need to blow the nose, 45/70 (64.3%) sneezing and 42/70 (60.0%) runny nose.

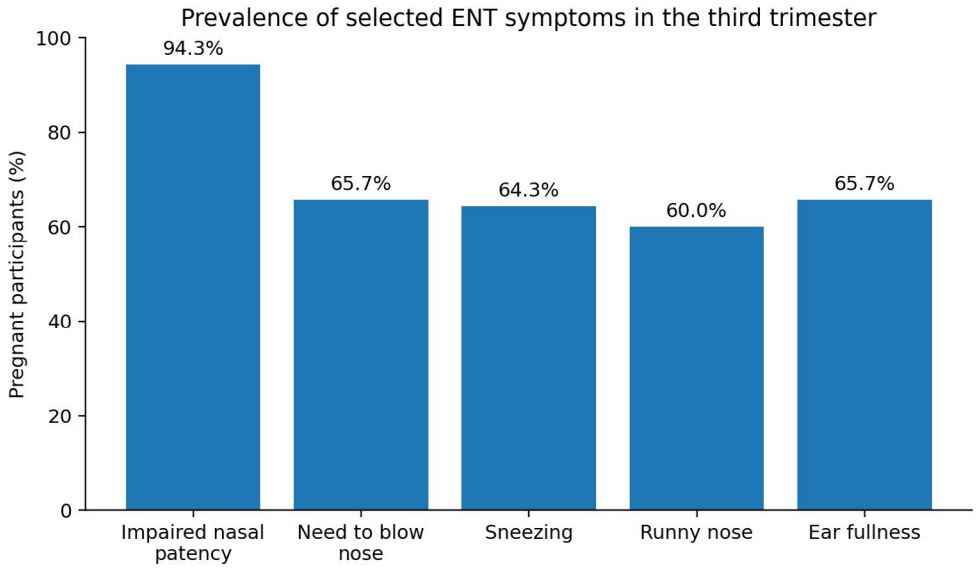



**Figure 2.** Prevalence of selected sinonasal and otological complaints among pregnant participants.

**Table 2.** Prevalence, severity and gestational-age associations of selected ENT symptoms.

| Symptom | Observed frequency | Mean severity (0-5) | Relation with gestational week |
|---|---|---|---|
| Impaired nasal patency | 66/70 (94.3%) | Nasal obstruction: 2.48 ± 1.16 | rho=0.77, p<0.001 |
| Need to blow nose | 46/70 (65.7%) | 1.36 ± 1.27 | rho=0.43, p=0.002 |
| Sneezing | 45/70 (64.3%) | 1.34 ± 1.27 | rho=0.19, p=0.175 |
| Runny nose | 42/70 (60.0%) | 1.06 ± 1.00 | rho=0.34, p=0.014 |
| Ear fullness | 46/70 (65.7%) | Not reported as mean in source table | rho=0.59, p<0.001 |

### 3.3. Progression of symptoms with gestational age

The symptom most strongly related to gestational advancement was nasal obstruction (rho=0.77, p<0.001). Ear fullness also showed a clear positive relationship with gestational week (rho=0.59, p<0.001). The need to blow the nose and runny nose showed weaker but statistically significant positive associations. Sneezing was the exception: its correlation with gestational week was small and non-significant (rho=0.19, p=0.175). This heterogeneity suggests that progressive congestion, rather than every form of nasal symptomatology, is the characteristic late-pregnancy pattern.

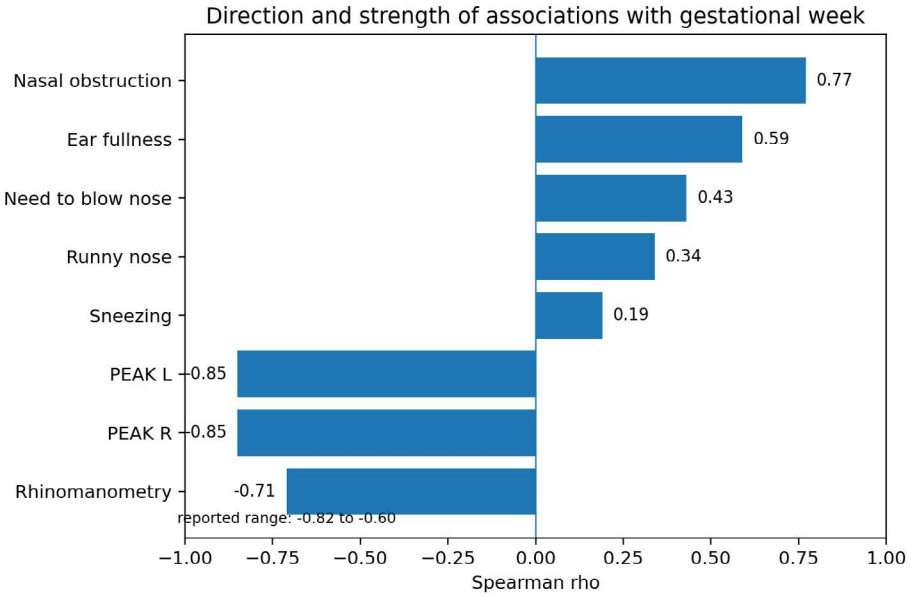



**Figure 3.** Associations of selected ENT outcomes with gestational week. For rhinomanometry, the label indicates the reported range across airflow parameters (rho=-0.82 to -0.60).

### 3.4. Objective nasal airflow

Objective testing showed statistically significant differences across the three nominal pressure levels in pregnant women for each inspiratory and expiratory series (repeated-measures ANOVA, $p<0.001$). The recorded mean flow values decreased from 75 to 300 Pa in all four measurement series. This direction is atypical for a conventional steady-state pressure-flow relationship and should therefore not be interpreted as an expected physiological response to increasing transnasal pressure. Rather, it describes the empirical values recorded by the study protocol at the specified nominal pressure levels. The corresponding pressure-related pattern was not statistically significant in controls. In addition, every analyzed rhinomanometric parameter was inversely associated with gestational week, with Spearman coefficients ranging from -0.82 to -0.60 (all $p<0.001$).

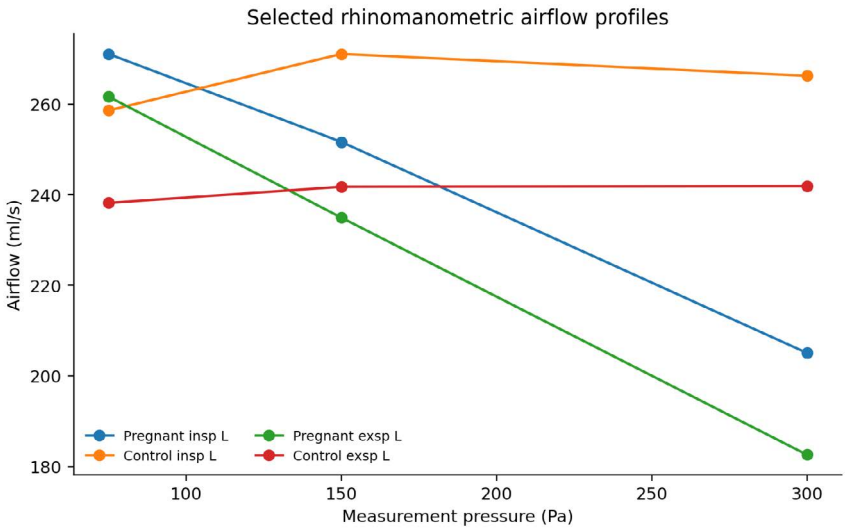



**Figure 4.** Selected left-sided rhinomanometric airflow profiles in pregnant and control participants.

**Table 3.** Rhinomanometric airflow values at 75, 150 and 300 Pa.

| Measurement | Pregnant 75 Pa | Pregnant 150 Pa | Pregnant 300 Pa | Control 75 Pa | Control 150 Pa | Control 300 Pa |
|---|---|---|---|---|---|---|
| Inspiration L | 271.02 ± 76.26 | 251.62 ± 75.31 | 205.04 ± 92.71 | 258.56 ± 70.59 | 271.04 ± 71.15 | 266.20 ± 85.65 |
| Expiration L | 261.60 ± 91.68 | 234.90 ± 92.99 | 182.58 ± 98.64 | 238.16 ± 48.23 | 241.72 ± 47.81 | 241.84 ± 66.92 |
| Inspiration R | 234.02 ± 92.66 | 217.62 ± 86.17 | 180.30 ± 98.97 | 260.44 ± 49.36 | 262.32 ± 54.73 | 271.84 ± 67.29 |
| Expiration R | 234.80 ± 88.28 | 216.24 ± 82.25 | 164.40 ± 97.66 | 255.96 ± 52.33 | 246.08 ± 63.51 | 238.48 ± 68.21 |

### 3.5. Subjective obstruction and measured airflow

Patient perception and physiological measurement were concordant. Across all rhinomanometric parameters, higher SNOT-22 nasal-obstruction scores were associated with lower airflow. The correlations ranged from rho=-0.69 to -0.62, with $p<0.001$ throughout. This finding is important for a sleep-centered interpretation because it indicates that the respiratory discomfort experienced by pregnant participants was not merely subjective; women reporting greater obstruction generally also had poorer objective nasal patency.

The pregnant group also had substantially more severe nasal obstruction than controls (mean difference 2.04 points, 95% CI 1.64-2.44; $p<0.001$). Significant between-group airflow differences were particularly evident for selected higher-pressure measurements, including left inspiratory flow at 300 Pa and right inspiratory flow at 150 and 300 Pa.

### 3.6. Ear fullness and Eustachian tube function

Otological symptoms were frequent: 46 of 70 pregnant women (65.7%) reported ear fullness or congestion, compared with 36% of controls, whose symptoms were mild. Ear-fullness severity was significantly greater in the pregnant group (mean difference 2.00, 95% CI 1.00-2.00; $p<0.001$) and increased with gestational week (rho=0.59, $p<0.001$).

All participants in both groups displayed type A tympanograms, but quantitative peak pressure differed markedly. In pregnant women, mean PEAK was -60.22 ± 33.79 daPa in the left ear and -61.68 ± 32.07 daPa in the right ear, compared with 9.48 ± 22.45 and 8.72 ± 23.99 daPa in controls. The between-group difference was significant for both ears ($p<0.001$). Within pregnancy, advancing gestational age was strongly associated with more negative peak pressure (rho=-0.85 for each ear, $p<0.001$).

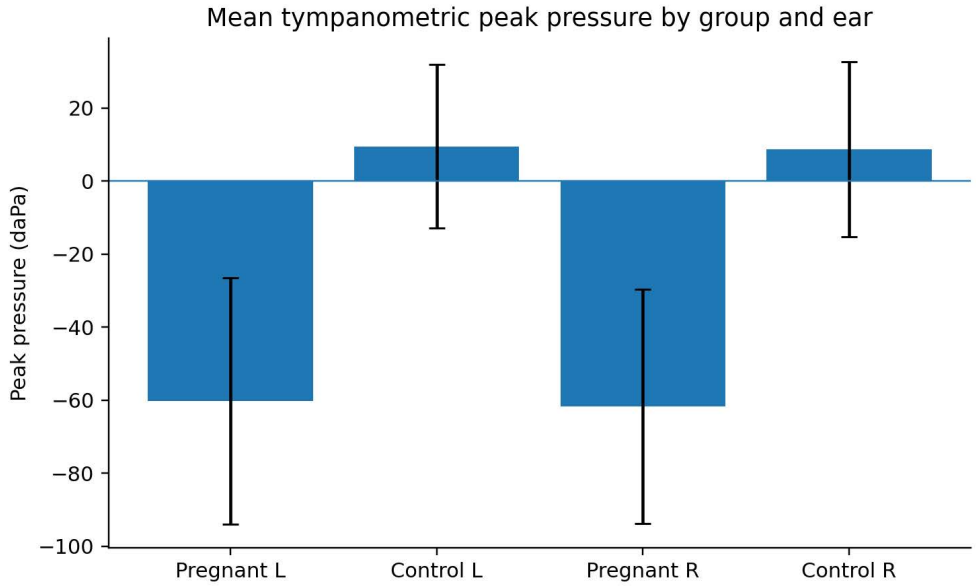



**Figure 5.** Mean tympanometric peak pressure (±SD) in pregnant and control groups.

### 3.7. PSQI analysis

The study group contained 70 participant-level PSQI records and the control group 35. Mean global PSQI was 9.09 ± 3.03 in the study group and 4.31 ± 1.60 in controls. The between-group mean difference was 4.78 points (95% CI 3.88-5.68; Welch t=10.58, df=102.64, p<0.001). Using the conventional global PSQI threshold >5, poor sleep quality was identified in 61/70 (87.1%) study participants and 8/35 (22.9%) controls. Within the study group, global PSQI was strongly associated with SNOT-22 nasal-obstruction severity (Spearman rho=0.81, p<0.001). The >5 threshold is the validated global-score criterion used in this analysis; the descriptive categories presented in Section 3.1 represent a separate subjective sleep-quality assessment.

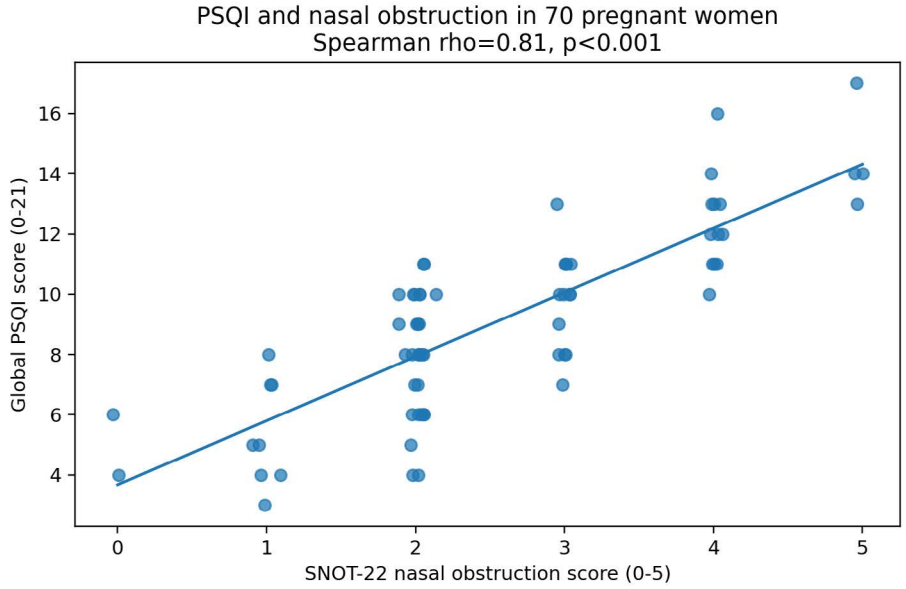



**Figure 6.** Relationship between SNOT-22 nasal obstruction and PSQI in 70 pregnant women. Spearmanrho=0.81, p<0.001.

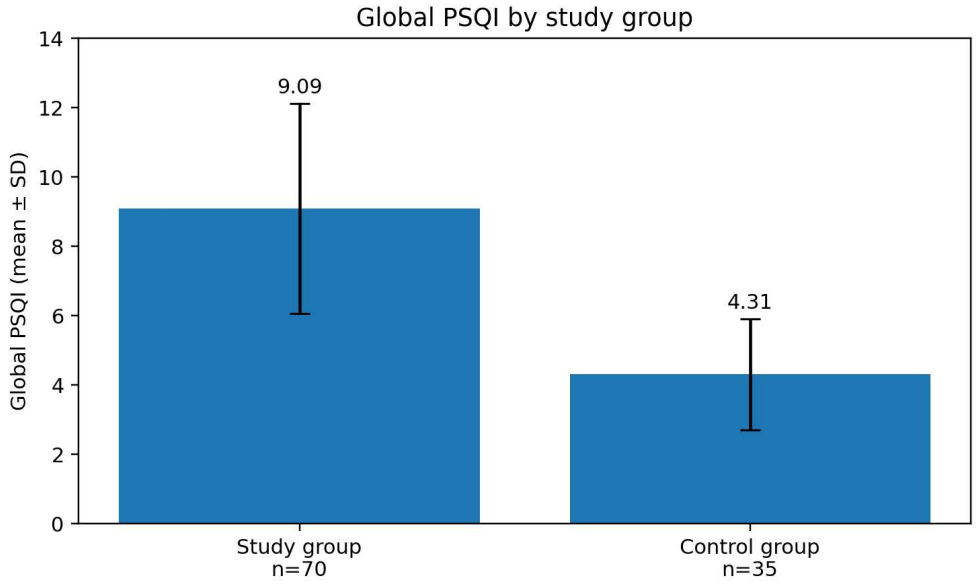



**Figure 7.** Comparison of global PSQI in the study group (n=70) and control group (n=35).

## 4. Discussion

The principal finding of this sleep-centered manuscript is the marked difference in subjective sleep quality between women in the third trimester and non-pregnant controls. More than two thirds of pregnant participants fell into the rather-low sleep-quality category, whereas almost nine in ten controls reported very good sleep. This contrast places sleep disturbance among the clinically meaningful manifestations accompanying late pregnancy in this cohort.

The ENT findings offer a plausible physiological context for this deterioration. Nasal obstruction was reported by almost the entire pregnant group and showed the strongest positive relationship with gestational age among the analyzed SNOT-22 symptoms. Previous work has linked pregnancy to increased nasal mucosal vascularity, edema and changes in nasal physiology. The present study extends that context by demonstrating concordance between symptom severity and rhinomanometric airflow.

The predominance of obstruction over other nasal symptoms is noteworthy. Need to blow the nose and rhinorrhea increased with gestational age, but their correlations were weaker, while sneezing did not show a statistically significant gestational relationship. This pattern is compatible with a mechanism dominated by progressive mucosal congestion and fluid-related narrowing rather than a uniform increase in all rhinitis-like symptoms. Published studies have reported pregnancy-induced rhinitis with variable prevalence and symptom profiles, reflecting differences in diagnostic definitions and gestational timing.

The rhinomanometric pressure-related pattern requires particular consideration. In the pregnant group, recorded airflow decreased significantly across the nominal measurement pressures from 75 to 300 Pa, whereas no significant pressure-related change was observed in the control group. This finding was consistently present across inspiratory and expiratory measurements on both sides. Moreover, lower rhinomanometric airflow was associated both with advancing gestational age (Spearman rho from −0.82 to −0.60; all $p<0.001$) and with greater subjective nasal obstruction (rho from −0.69 to −0.62; all $p<0.001$). Thus, although the direction of the pressure–flow relationship is atypical for a conventional steady-state rhinomanometric response, the associations of lower recorded nasal airflow with more advanced pregnancy and greater subjective obstruction were internally consistent. The available study documentation does not provide sufficient technical detail to determine whether the

unusual pressure-related pattern reflects measurement conditions, acquisition sequence, nasal-cycle variability, or another protocol-related factor. Therefore, the decrease in airflow across increasing nominal pressure levels should not be interpreted as evidence that increasing transnasal pressure itself physiologically reduces airflow. The results should primarily be interpreted in relation to gestational age and subjective nasal obstruction, with replication under a fully documented standardized protocol.

From a sleep perspective, reduced nasal patency may matter through several pathways. Persistent obstruction can make nasal breathing less comfortable in the supine position, encourage mouth breathing and contribute to snoring or sleep fragmentation. Pregnancy-related upper-airway narrowing has also attracted attention because sleep-disordered breathing and obstructive sleep apnea may emerge or worsen during gestation. The present dataset does not contain polysomnography or apnea-hypopnea measurements, so it cannot determine whether the poorer sleep-quality categories reflect obstructive sleep apnea. It does, however, support the relevance of respiratory symptoms when assessing sleep complaints in late pregnancy. [8-10].

The Eustachian tube findings add another potential source of nocturnal discomfort. Ear fullness affected 65.7% of pregnant participants and became more severe later in gestation. Although tympanograms remained type A, peak pressures were substantially more negative than in controls and were strongly related to gestational week. Earlier studies have described Eustachian tube dysfunction and pregnancy-related auditory changes. Fluid retention and mucosal edema have been proposed as contributing mechanisms.

An important clinical message is that a type A tympanogram does not necessarily exclude subjective ear symptoms. More negative peak middle-ear pressure in pregnant women may be compatible with altered middle-ear ventilation or transient pressure equalization changes, potentially related to pregnancy-associated nasopharyngeal mucosal changes. Nevertheless, type A morphology indicates that the measured tracing remained within that classification, and the observed pressure shift alone is insufficient to establish clinically significant Eustachian tube dysfunction. Ear fullness, peak pressure and tympanogram classification should therefore be interpreted together, without inferring a definitive diagnosis from any single measurement.

The source article also emphasizes that most pregnancy-related ENT disturbances are benign and often resolve after childbirth. This is reassuring, but spontaneous resolution does not make the symptoms irrelevant. Sleep loss and persistent nasal discomfort can reduce daily functioning and quality of life during a period in which maternal well-being is especially important. Management should therefore balance symptom burden with treatment safety [4, 5].

PSQI component-level analysis would also help determine whether respiratory symptoms are most closely related to sleep latency, nocturnal disturbances, reduced duration or daytime dysfunction.

A longitudinal design would further strengthen causal interpretation. Repeated assessment across all three trimesters and again postpartum could establish whether worsening nasal patency precedes deterioration in PSQI and whether both improve after delivery. Such a design would also help distinguish pregnancy-induced rhinitis from pre-existing allergic or non-allergic rhinitis and clarify the temporal relationship between middle-ear pressure changes and ear symptoms.

### 4.1. Strengths and limitations

the study combines patient-reported symptoms with objective measurements of two anatomically related systems: the nasal airway and the middle ear. The consistency between SNOT-22 nasal obstruction and rhinomanometry is a particular strength because it links symptom burden to measurable physiology. A non-pregnant comparison group provides additional context, and the restriction to the third trimester captures a period in which hormonal and fluid-related changes are expected to be pronounced.

Limitations include the cross-sectional design, the smaller control group, possible menstrual-cycle effects in controls, and the absence of multivariable adjustment for important determinants of sleep quality. Potential confounders include pre-pregnancy BMI and BMI at assessment, gestational weight gain, gastroesophageal reflux, pre-existing allergic or non-allergic rhinitis, smoking or nicotine exposure, snoring, risk of sleep-disordered breathing or obstructive sleep apnea, parity, relevant medical comorbidities, medication use, nocturia, restless-legs symptoms, anxiety, depression and other psychological factors. These variables may influence both sleep quality and upper-airway symptoms; therefore, the observed association between nasal obstruction and PSQI should be interpreted as an association rather than evidence of an independent or causal effect.

## 5. Conclusions

Women in the third trimester showed substantially poorer subjective sleep quality than non-pregnant controls. This deterioration coexisted with a high burden of nasal obstruction, progressive reduction in objective nasal airflow, frequent ear fullness and increasingly negative middle-ear peak pressure. The close relationship between perceived nasal obstruction and rhinomanometry suggests that the respiratory symptoms experienced by pregnant women reflect measurable physiological changes.

Supplementary Materials: None.

Author Contributions: To be completed by the authors before submission according to the journal requirements.

Acknowledgments: To be completed by the authors, if applicable.

Funding: The source manuscript reports funding from the Centre of Postgraduate Medical Education (grant 501-1-019-56-23).

Conflicts of Interest: The authors declare no conflict of interest.

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