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Aircraft noise exposure and saliva cortisol in a pooled-analysis from seven European countries

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ABSTRACT

The HYENA (HYpertension and Exposure to Noise near Airports) study, a well-known study on the health effects of aircraft noise, involved 4,861 participants from six European countries (except France). The DEBATS (Discussion on the health effects of aircraft noise) study, a study with a similar protocol, included 1,244 participants from France. Associations were found between aircraft noise and cortisol levels in each study separately, but they were not consistent between the two studies.

The objective of the present study was to combine both datasets in order to improve statistical power. We investigated the associations between aircraft noise levels and cortisol levels in the morning and in the evening, and the relative variation per hour, adjusted for relevant confounders. Analyses were carried out on the 1,300 participants with complete information for cortisol samplings and for confounders.

We found evidence for an increase in the evening cortisol level in women (exp(β)=1.09, 95%CI: 1.01;1.18), and for flattening of the relative variation per hour also in women (exp(β)= 0.90, 95%CI: 0.840.97), with a L_{den} 10-dB(A) increase. There were no significant associations in men.

These findings provide some support for a psychological stress induced by aircraft noise exposure, resulting in disruption of hormonal rhythms.

Keywords: aircraft noise exposure, cortisol levels, Europe

1. INTRODUCTION

Many studies have evidenced adverse effects of aircraft noise exposure on health, such as annoyance, cardiovascular diseases, sleep disorders or altered cognitive performance (1–6). The precise mechanisms underlying noise-induced health physiological effects would imply release of stress hormones with noise exposure (7). Although they were widely discussed, the effects of noise exposure including occupational, road, railway and air traffic noise on cortisol secretion are still unclear. The conclusions of the largest epidemiological studies to date about the associations between aircraft noise exposure and cortisol levels are inconsistent (8,9). On one hand, the HYENA (HYpertension and Exposure to Noise near Airports) study, including 439 participants, suggests that exposure to aircraft noise increases morning saliva cortisol levels in women, but no similar association was found in men (8). On the other hand, the DEBATS study (Discussion on the health effects of aircraft noise), including 1,244 participants, observed an increase in evening cortisol levels and a flattening of the usual variation per hour when aircraft noise exposure increased, but in that study no difference were shown between gender subgroups (9).

The objective of the present study was to combine data collected in both HYENA and DEBATS studies in order to improve statistical power, and provide a pooled-analysis of these two largest studies to date.

2. METHODS

2.1 Study population

The HYENA study included randomly-selected 4,861 participants between 45-70 years of age at the time of the interview and living near one of the seven major European airports [London Heathrow (United Kingdom), Berlin Tegel (Germany), Amsterdam Schiphol (the Netherlands), Stockholm Arlanda and Bromma (Sweden), Milan Malpensa (Italy), and Athens Eleftherios Venizelos (Greece) Airports]. Then, nearly 500 participants with the highest and lowest levels of exposure to aircraft noise in each country were selected for saliva sampling. Among them, 439 participants had complete information on their cortisol levels.

The DEBATS study included randomly-selected 1,244 participants over 18 years of age at the time of the interview and living near one of the three French airports (Paris-Charles de Gaulle, Lyon-Saint-Exupéry and Toulouse-Blagnac). Among them, 1,199 participants had complete information on their cortisol levels.

Participants from both studies responded to a similar questionnaire administered by an interviewer at their place of residence. The questionnaire collected in particular demographic and socio-economic information, lifestyle factors such as smoking and alcohol consumption, and personal medical history.

The final pooled analyses were carried out on N = 1,300 participants (359 from HYENA and 941 from DEBATS, including 555 men and 745 women) who had completed information for all the covariates included in the final model.

2.2 Cortisol measurements

All the participants received a kit with test tubes and instructions. Participants were requested to collect a saliva sample 30 min (in HYENA) (corresponding usually to the peak in cortisol concentration) or immediately (in DEBATS) after awakening, and another one just before going to bed in the evening (which usually coincides with the nadir in cortisol concentration).

Cortisols levels were then determined by the Spectria cortisol coated tube radioimmunoassay kit (Orion Diagnostica, Espoo, Finland) in HYENA, and by cortisol saliva ELISA kit in DEBATS (IBL international, Hamburg, Germany).

2.3 Aircraft noise exposure assessments

Exposure to aircraft noise was estimated with a 1-dB(A) resolution at the place of residence of the participants, in front of their buildings, and were provided by the INM (Integrated Noise Model) (10) for almost all the countries of the study. Only the UK used another model, the national Aircraft Noise Contour Model (ANCON v 2) (11), similar to the INM model.

Four noise indicators were derived and used in the statistical analyses: L_{den}, L_{Aeq24h}, $L_{Aeq6h-22h}$, and L_{night}.

2.4 Confounders

The major potential confounders were obtained from the questionnaire. They were a priori included in the models: country (seven categories), gender (dichotomous), age (continuous), BMI (continuous), smoking habits (five categories: non-smoker; ex-smoker; 1-10 units/day; 11-20 units/day; >20 units/day), alcohol consumption (4 categories: teetotaller; 1-7 units a week; 8-14 units/week; >14 units/week), physical activity (2 categories: no or a little; regular), and education level (coded as quartiles of number of years in education previously standardized by country means).

2.5 Statistical analysis

Morning and evening cortisol levels were analysed separately.

As cortisol is a biological measure following a circadian rhythm, the relative variation in cortisol per hour between both samplings was also investigated. The variation in cortisol per hour has been divided by the morning level as reference level.

Each of these outcomes were firstly log-transformed to compensate for a non-normal distribution.

Then, each outcome was analysed in relation to aircraft noise exposure using linear regression, adjusted for the confounders.

Statistical analyses were carried out for men and women separately.

3. RESULTS

Means (sd) for cortisol outcomes were 24.1 (12.6), 5.5 (6.0), 0.08 (0.11) $nmol.L^{-1}$ in men, and 23.9 (13.4), 6.0 (6.5), 0.08 (0.07) $nmol.L^{-1}$ in women, for the morning level, the evening level, and the relative variation respectively.

In women, significant associations were found between noise indicators (except $LA_{eq,\ 24h}$ where the association was border significant) and the evening cortisol level, suggesting an increase of cortisol concentration with aircraft noise exposure level; and between every noise indicators and the relative variation per hour, towards a flattening of the cortisol variation. Any association was found between aircraft noise exposure and the morning cortisol level.

No association was found in men.

Table 1 – Linear regression results for the relation between aircraft noise exposure and cortisol outcomes

	MALE						FEMALE					
	Morning level ($nmol.L^{-1}$)		**Evening level ($nmol.L^{-1}$)**		**Relative variation per hour**		**Morning level ($nmol.L^{-1}$)**		**Evening level ($nmol.L^{-1}$)**		**Relative variation per hour**	
	exp(β)	CI95%	exp(β)	CI95%	exp(β)	CI95%	exp(β)	CI95%	exp(β)	CI95%	exp(β)	CI95%
$L_{Aeq,16h}$	0.99	(0.92;1.06)	1.04	(0.95;1.12)	0.97	(0.90;1.04)	1.04	(0.98;1.10)	**1.08**	**(1.00;1.16)**	**0.92**	**(0.86;0.98)**
$L_{Aeq,24h}$	0.98	(0.91;1.05)	1.03	(0.94;1.12)	0.96	(0.89;1.04)	1.05	(0.98;1.12)	1.08	(1.00;1.17)	**0.92**	**(0.85;0.98)**
L_{den}	0.99	(0.92;1.06)	1.04	(0.95;1.14)	0.96	(0.89;1.04)	1.03	(0.97;1.10)	**1.09**	**(1.01;1.18)**	**0.90**	**(0.84;0.97)**
L_{night}	1.00	(0.93;1.08)	1.05	(0.97;1.15)	0.95	(0.88;1.02)	1.00	(0.94;1.07)	**1.11**	**(1.02;1.20)**	**0.89**	**(0.83;0.96)**

4. DISCUSSION

The results of the present study are partly in line with those found based on the DEBATS participants only (8), where similar conclusions were drawn, but where no difference was shown between gender subgroups. Considering the HYENA participants only, significant associations were found only in women, but for an increase in the morning cortisol levels (9). The pooled-analyses, providing a greater statistical power, found significant associations between aircraft noise exposure and modification of the cortisol stress-hormone secretion for women only.

The use of relative-variation per hour contributes to a new approach to analyze cortisol in relation to noise exposure. This allows for potential measurement differences between HYENA and DEBATS related to sampling and cortisol determinations.

Associations were stronger for women with an exposure during the night. The hypothesis that women have a higher susceptibility to noise during sleep could be relevant (12). However, when sleep duration was added to the model, results were similar.

Noise exposure was calculated at participants' home address. It does not take into account exposure outside their home. However it is more likely that participants were in their home at night, so the L_{night} should be the indicator closest to the real exposure: it may be the reason why the strongest associations were observed for L_{night}.

5. CONCLUSIONS

The present results support the hypothesis that exposure to aircraft noise could be related to higher average values for the evening cortisol concentration, and therefore a flattening of the relative variation between morning and evening levels, especially in women. However, the cause/effect relations and the biological process between noise exposure and hormone dysregulation are still of major importance and need to be elucidated.

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