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Blood pressure monitoring (NORAH): Exposure to maximum sound levels of nocturnal aircraft noise and self-measured blood pressure

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ABSTRACT

Based on the concept that noise may trigger repeatedly unavoidable autonomous physiological reactions, which each can cause an increase of blood pressure (BP), the blood pressure monitoring of the NORAH study examined the effects of chronic aircraft noise on self-measured blood pressure (SBPM). Study region in the vicinity of Frankfurt Airport includes areas within the 40 dB(A) equivalent continuous sound level contours of aircraft noise for day and night-time, targeting on voluntary adults residing in the defined region. Nocturnal aircraft noise exposure ($L_{pA,eq,22\text{-}06}$, $L_{pAS,max,22\text{-}06}$) was assigned to participants' addresses. Telemedical blood pressure devices were issued for SBPM. Questionnaires with reference to current health, medications, lifestyle, individual factors, and noise sensitivity were completed. After being trained, participants performed 2 daily measurements for 21 days. Whereas multiple regressions reveal a statistically non-significant tendency of association of BP with nocturnal continuous sound levels ($L_{pA,eq,22\text{-}06}$: b=0.10 [mmHg×dB^{-1}]); 95%CI [-0.02;0.21]) the model for systolic BP (n=844) including mean $L_{pAS,max,22\text{-}06}$, adjusted for age, gender, social status, tobacco smoke, and physical activity shows a marginal noise-related increase in systolic BP (b=0.11 [mmHg×dB^{-1}]); 95%CI [0.02;0.20]).

INTRODUCTION

The module "Blood Pressure Monitoring" is part of the research project NORAH (noise-related annoyance, cognition, and health) and investigates the effects of chronic noise exposure on blood pressure in adults [1, 2, 3]. It was conducted in the period from 2012 to 2014 in the Rhine-Main- Area near Frankfurt (FRA) airport. Linked references to the detailed reports of the entire project modules are given below, additional information can be found at http://www.norah-studie.de//de/publikationen.html or http://www.laermstudie.de.

The study design took into consideration previous studies and meta-analyses on effects of noise on health, and in particular on the cardio vascular system [4, 5, 6, 7]. It is based on the concept of the model that noise on a regular basis acts as a stressor on the body and thus triggers repeatedly unavoidable autonomous physiological reactions, which each can cause an increase of the blood pressure [4]. The present study examined the effects of nocturnal aircraft noise as stressor on blood pressure as a measurable physical response. Analyses were calculated for nocturnal maximum levels ($L_{pAS,max,22\text{-}06h}$) as well as equivalent continuous sound levels ($L_{pA,eq,22\text{-}06}$).

METHODS

Recruitment

Study region included areas near Frankfurt airport within the 40 dB(A) equivalent continuous sound level contours of aircraft noise for day and night-time. Voluntary adults of both genders residing at the time of the investigations (2012 -2014) in the defined area were the target group. Recruitment was done among participants of NORAH module 1, excluding those who reported diagnosed hypertension at this state of the project already (n=1824) [1, 2].

Exposure

Nocturnal aircraft noise exposure was assigned for a timeslice from 22:00-06:00h to the respective addresses of the participants of the investigation. To represent chronic exposure the sound parameters (outdoors) were calculated over a period of 12 months ahead of participants' individual start of blood pressure measurements. The equivalent continuous sound pressure level ($L_{pA,eq,22\text{-}06}$) and maximum sound level ($L_{pAS,max,22\text{-}06}$) were set as exposure variables in different analyses. In the NORAH study the $L_{pAS,max,22\text{-}06}$ was estimated which is reached or exceeded by at least 6 flight movements [8]. This definition follows the German Noise Protection Act [9] whereas threshold for the night-time protection zone 6 x L_{Amax} indoors criteria are defined for different types of airports/airfields.

Procedures

Telemedical blood pressure devices handed to study participants were issued for the self-blood-pressure-measurement (SBPM). All participants were trained before they were allowed to perform SBPM each morning and evening during the following period of 21 days. Ahead of the coaching an additional questionnaire with reference to current health, lifestyle, individual factors, as well as noise sensitivity (NoiSeQ-R) was completed. The measurements were done in two sections: observation period 1 (BP1) from July 2012 to June 2013, observation period 2 (BP2) took place from July 2013 to June 2014 [1].

Quality assurance and data processing

All measuring instruments used were approved for operation in accordance with the Medical Device Operator's Ordinance §5 Abs.3 (MPBetreibV §5 para. 3 see [1]). Therefore, the measured values for systole, diastole and heart rate per se are reliable. Following the two-year course, they were periodically subjected to a review (according to § 24 Medical Devices in conjunction with § 11 MPBetreibV) and showed no deviations beyond the permitted limits even after two years of use. The telemedical system used, consisting of an oscillometric blood pressure monitor and a mobile phone connected via Bluetooth®, provided the measurement data per measurement time as follows: For each collected measured value, time and date were stored from the mobile phone together with the measured values.

The respective means for morning values of the systolic and diastolic blood pressure as well as the heart rate were determined from all measurements out of the 21-day phase. Through the participation in the study itself the blood pressure may change in the first days. Therefore, the values of training measurements and the "resetting" of the blood pressure after the event of the home visit at the same day were excluded from evaluation.

The procedure is based on the guidelines of the European Society of Hypertension for Clinic, Ambulatory and Self-Blood Pressure Measurement (ESH) [10].

Data analyses

Data analyses of the evaluation presented here included participants from BP1 only due to methodological reasons. For analyses of the resulting study group of n=844 small effects of ß=0.10 have a test power of 80% respectively 95% for ß=0.13.

We applied analysis models (multiple linear regressions) for the continuous main (systolic BP, mean of morning readings [mmHg]) and secondary targets (diastolic BP, heart rate, amplitude) including fixed factors (age, gender, socio-economic status) in a base model. Additional predictor variables (smoking, physical activity, waist -to-hip ratio) were included based on their statistical effect size.

RESULTS

Descriptive data

Data analyses included n=844 (58.4% w; 41.6% m) in total. Age varied from 19 to 82 years (mean = 49.0 years; SD = 12.2). According to SWI 10.7% were classified to have low, 46.3% medium and 43.0% high socio demographic status. Blood pressure values (mean of morning readings [mmHg]) were systolic/ diastolic 118.1/72.3 in women and 125.4/78.8 in men. Descriptive analyses show that reliable blood pressure measurements as well as the questionnaire and exposure data is overall completed at a very high level. The evaluated study group was a comparatively healthy sample of the population, thus can be used to answer the scientific issue, including the extensive collected confounder variables into the analysis.

Figures 1 and 2 show boxplots of blood pressure (BP) values for classified (5 dB) sound pressure levels separately for women and men. According to the equivalent continuous sound pressure level (figure 1) during night-time most participants (n=188) were exposed to lowest noise category (≤40dB). Highest class for $L_{pA,eq,22\text{-}06}$ was >55-60dB (n=126) while the highest class of $L_{pA,max,22\text{-}06}$ was >70 dB (n=80). The class with most participants of maximum sound pressure levels was >60-65 dB (n=160) (figure 2). In none of any class of sound levels the 75-percentile of BP values exceeded the limits for hypertension (140mmHg for systolic, 90 mmHg for diastolic BP). Overall these first explorative approaches neither indicated elevation of blood pressure due to higher maximum nor continuous sound pressure levels.

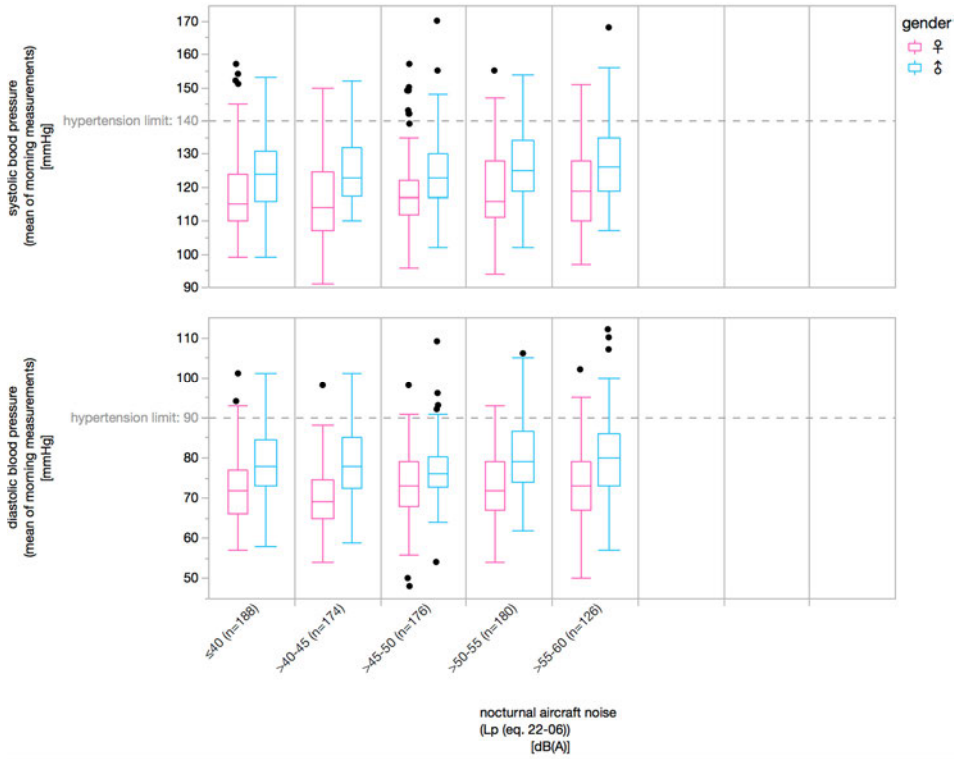

Figure 1: Distribution of 21-day mean values of systolic and diastolic morning blood pressure measurements over classified (5 dB) nocturnal *continuous* sound pressure levels ($L_{pA,eq,22\text{-}06}$) (n=844)

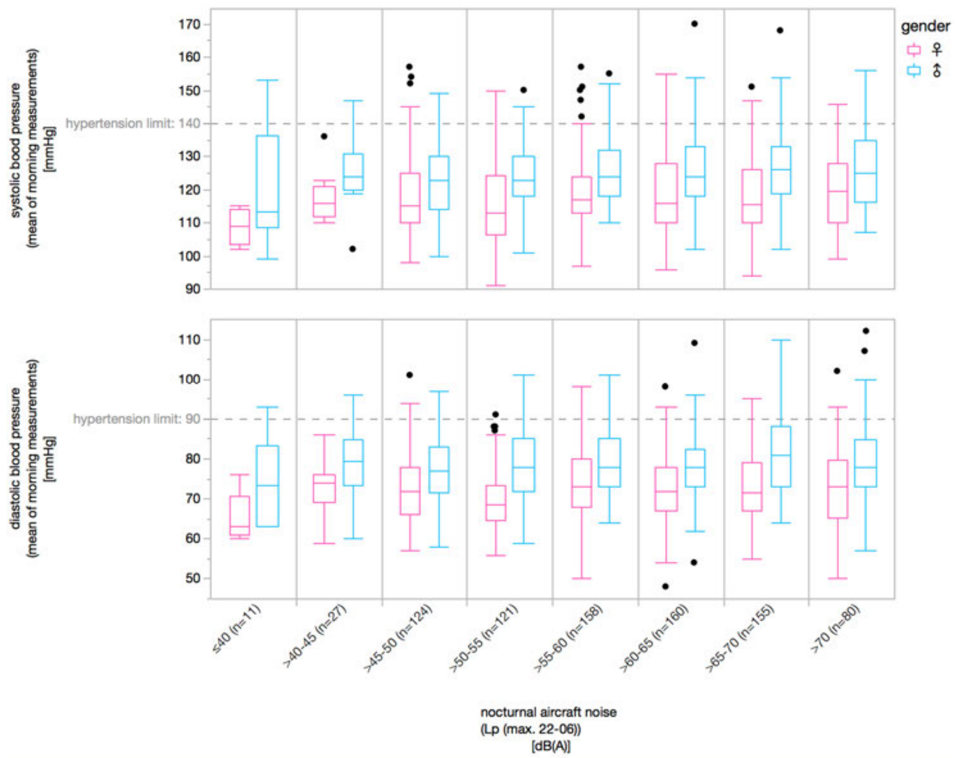

Figure 2: Distribution of 21-day mean values of systolic and diastolic morning blood pressure measurements over classified (5 dB) nocturnal *maximum* sound pressure levels ($L_{pA,max,22\text{-}06}$) (n=844)

Multiple linear regression

Table 1 shows the results of multiple linear regression for maximum ($L_{pA,max,22\text{-}06}$) and continuous ($L_{pA,eq,22\text{-}06}$) nocturnal sound pressure levels. Whereas multiple regressions reveal a statistically non-significant tendency of association of BP with $L_{pA,eq,22\text{-}06}$ the model for systolic BP including mean $L_{pA,max,22\text{-}06}$, adjusted for age, gender, social status, tobacco smoke, and physical activity shows a marginal noise-related increase in systolic BP.

Table 1: Results of multiple linear regressions for exposure to *nocturnal maximum aircraft noise* ($L_{pA,max,22\text{-}06}$) and *nocturnal continuous aircraft noise* ($L_{pA,eq,22\text{-}06}$) adjusted for age, gender, socio-economic status, tobacco smoke & physical activity

		$L_{pA,max,22\text{-}06h}$				$L_{pA,eq,22\text{-}06}$			
	N	**b**	**95%-CI**		**p**	**b**	**95%-CI**		**p**
systolic BP	844	0.11	0.02	0.20	0.017	0.08	-0.03	0.20	0.147
diastolic BP	844	0.06	-0.01	0.13	0.073	0.05	-0.04	0.14	0.265
heart rate	844	0.04	-0.03	0.12	0.260	0.06	-0.04	0.15	0.239
amplitude	844	0.04	-0.02	0.10	0.167	0.03	-0.05	0.11	0.446

SUMMARY

Multiple linear regression models with main outcome systolic blood pressure (n=844) including age, gender, socio-economic status, tobacco smoke, and physical activity as influencing variables result small positive effect estimators for both maximum and equivalent continuous nocturnal aircraft noise exposure. Estimators are very similar to those we calculated earlier to the evening-night time slice ($L_{pA,eq,18\text{-}06}$) [1, 11] and the results of our study are overall comparable to previously conducted scientific research concerning air traffic noise [12, 13]. However, the significant result for the maximum sound level $L_{pA,max,22\text{-}06}$ shows that even if the estimators are weak and do not lead to an obvious result, an association of systolic blood pressure to nocturnal aircraft noise cannot be denied in total.
New scientific questions that have been emerged in the course of the study, suggest a need for further research specifically focused on the evaluation of potential vulnerable groups, as well as analyses, that take into account of the data of other NORAH modules and exposure parameters.

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