Noise sensitivity increases the risk of disability pension

M. Heinonen-Guzejev[1], M. Koskenvuo[1], K. Silventoinen[2], H. Mussalo-Rauhamaa[1], H. S. Vuorinen[1], K. Heikkilä[1], Jaakko Kaprio[1,3,4]

[1] Department of Public Health, Hjelt Institute, University of Helsinki, P.O. Box 41, FI-00014, Helsinki, Finland, marja.heinonen@helsinki.fi

[2] Population Research Unit, Department of Social Research, University of Helsinki, Finland

[3] Department of Mental Health and Substance Abuse Services, National Institute of Health and Welfare, Helsinki, Finland

[4] Institute for Molecular Medicine Finland, University of Helsinki, FIMM, Helsinki, Finland

ABSTRACT

Noise sensitivity is a common trait which increases the harmful health effects of noise. It has been associated with impaired somatic health, anxiety and poor sleep quality. Self-assessed poor health is a strong predictor of early retirement. This study is based on the Finnish Twin Cohort. Questionnaire data of a sample of 706 Finnish twin individuals (age range, 31 to 65 years) with record linkage to information on DP during 16 years of follow-up were analyzed using individual and pairwise Cox proportional hazards models. Noise sensitivity increased the risk of DP (hazard ratio = 1.41, 95% CI 1.03-1.93) among all participants. In within-pair analyses, noise sensitivity increased significantly the risk of DP among all twin pairs (OR 1.80, 95% CI 1.08-3.06) and among female twin pairs (OR 2.63, 95% CI 1.12-6.85). Thus noise sensitivity may be a potential risk factor for disability retirement. It is associated with DP independently of familial background and genetic factors.

INTRODUCTION

Noise sensitivity refers to physiological and psychological internal states, which increase the degree of reactivity to noise in general (Job 1999), and is a predictor of noise annoyance (van Kamp et al. 2004; Stansfeld 1992). It increases the harmful health effects of noise (Miedema & Vos 2003; Marks & Griefahn 2007). Noise sensitivity is a common trait and the percentage of noise-sensitive persons has varied between 20% and 43% in previous studies (Heinonen-Guzejev 2008). It has been associated with both poor somatic and mental health and poor sleep quality (Marks & Griefahn 2007; Nivison & Endresen 1993; Heinonen-Guzejev et al. 2014). Self-assessed poor health is a strong predictor of early retirement due to mental disorders, musculoskeletal disorders, and cardiovascular diseases (Karpansalo et al. 2004). Sleep disturbances have been associated with increased risk for subsequent disabling mental disorders and various physical illnesses and they also predict work disability due to musculoskeletal disorders in Finnish studies (Salo et al. 2010; Ropponen et al. 2011). Noise exposure is common at work. 42% of men and 30% of women in the Finnish working-age population reported in 2000 that they are exposed to disturbing noise at work (Aromaa & Koskinen 2002).

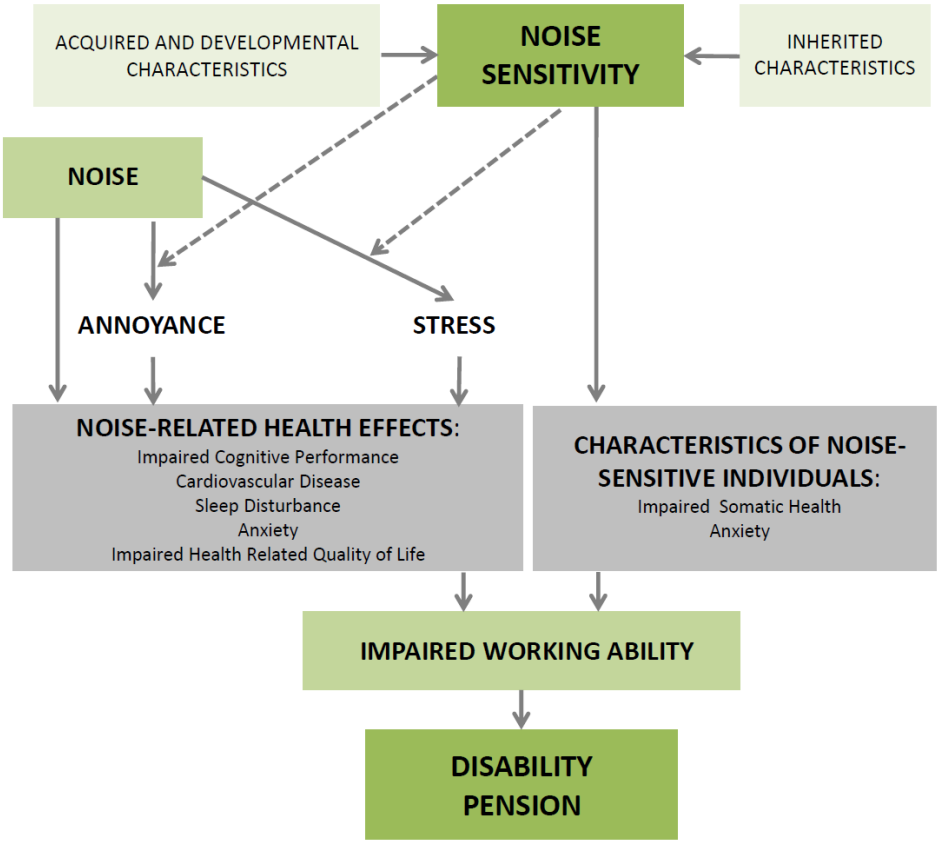

Figure 1: A model of the schematic pathways of the of the possible relationships of noise sensitivity with risk of lowered work ability and subsequent disability retirement

Figure presents a hypothetical model of the schematic pathways of the possible relationships of noise sensitivity with the risk of lowered work ability and subsequent disability retirement. Noise sensitivity increases the harmful health effects of noise. It has been associated with both impaired somatic health and anxiety, which, together with susceptibility to noise-related health effects, like impaired cognitive performance, cardiovascular disease and sleep disturbance, can impair working ability and may lead to disability retirement.

Genetic factors contribute to interindividual differences of both noise sensitivity (Heinonen-Guzejev et al. 2005) and liability to disability retirement (Harkonmäki et al. 2008; Narusyte et al. 2011). A possible association between noise sensitivity and DP can, thus, be due to common underlying familial and genetic factors. Both monozygotic (MZ) and dizygotic (DZ) twins raised together share common environmental factors and MZ twins share 100% and DZ twins 50% of their segregating genes. Thus, the twin study design creates an interesting natural experiment to analyze the genetic and familial background of the association between noise sensitivity and health-related factors. Because of the high prevalence of noise sensitivity and its association with poor somatic and mental health, it can be hypothesized that it is also a predictor of DP, but this has not been studied before. The aim of this study was to investigate whether noise sensitivity predicts DP in a longitudinal cohort of Finnish twins, and if so, if the association independent of familial factors is common to family members.

MATERIALS AND METHODS

This study is based on the Finnish Twin Cohort. In 1988, a questionnaire was sent to 1005 twin pairs discordant for hypertension and 1495 (688 men and 807women) of them replied, giving a response rate of 74.7%. The age range was 31 to 88 years. Of those 1495 individuals, 706 (364 men and 342 women; age range 31 to 65 years;

mean age 48.7 years) had answered the questions on noise sensitivity and confounders and had not retired before 1988 and were of working age and were those who form the final study cohort. This defines the subjects as eligible for future DP. Participants of this study were observed from the date of return of the 1988 questionnaire to the date of any pension, including DP or the date of death or emigration. The follow-up ended at December 31, 2004, or when they turned age 66 years (Harkonmäki et al. 2008).

Noise sensitivity was investigated using the question: “People experience noise in different ways. Do you experience noise generally as very disturbing, quite disturbing, not especially disturbing, not at all disturbing or can’t say?” For most statistical analyses, participants with high and quite high noise sensitivity were classified as noise-sensitive and participants with quite low and low noise sensitivity as nonsensitive. Our previous validation of this noise sensitivity question indicated that it is markedly correlated with Weinstein’s Noise Sensitivity Scale (r = 0.60) and the stability of the question was found adequate (Heinonen-Guzejev et al. 2004).

History of hypertension and self-reported noise exposure was obtained from the 1988 questionnaire, education from the questionnaire in 1981 and smoking status from the questionnaire in 1990 or from the questionnaire in 1981 if information in 1990 was missing. These items were chosen as confounders because in previous studies they have been associated both with noise sensitivity (Heinonen-Guzejev et al. 2004) and with early retirement (Hagen et al. 2000; Husemoen et al. 2004; Kaprio et al. 1996; Kiiskinen et al. 1998; Koskenvuo et al. 2011; Krokstad et al. 2002). Other risk factors of early retirement, such as obesity and alcohol use, were not taken into account, because they have not been associated with noise sensitivity in previous studies. Hypertension was elicited by asking, “Has a doctor ever told you that you have elevated blood pressure?” The response alternatives were “no” or “yes” (Heinonen-Guzejev et al. 2004). The participants were divided into the categories of current, former, and never-smokers as described earlier in detail (Heinonen-Guzejev et al. 2004; Kaprio & Koskenvuo 1988). Education was assessed by asking what schooling the respondent had completed; this information was then converted into years of education (Romanov et al. 1996). Self-reported history of noise exposure at work was investigated using the question: “For how many years during your lifetime have you been in such work where noise has disturbed hearing normal speech?” In the analyses, those who had answered “not at all” were classified as having no noise exposure at work and other answers as having noise exposure at work (Heinonen-Guzejev et al. 2011). Self-reported history of lifetime noise exposure was measured using three questions about noise exposure at home, at work, and noisy leisure time hobbies. A lifetime noise exposure scale was formed by summing these three items as described earlier in detail (Heinonen-Guzejev 2008; Heinonen-Guzejev et al. 2004).

Information on retirement events during the follow-up period from the date of return of the 1988 questionnaire to December 31, 2004, including DP with diagnoses based on the 8th, 9th, and 10th revisions of the International Classification of Diseases (ICD), was obtained from the Finnish official pension registers (Social Insurance Institution and the Finnish Centre for Pensions), which cover the whole Finnish population. Diagnoses were encoded using ICD-8, ICD-9, and ICD-10, which were registered as part of pension decisions made by the Finnish insurance institutions, for depressive disorders, for all other mental disorders (in this study, depressive disorders and all other mental disorders were combined and analyzed together as

mental disorders), for cardiovascular diseases, for musculoskeletal disorders, and for other reasons; the exact classification criteria being described in detail elsewhere (Harkonmäki et al. 2008). Information on mortality and emigration was derived from the Central Population Register of Finland. The record linkage was done by using the unique personal identity numbers given to all residents of Finland.

Statistical Methods

The Cox proportional hazards regression model was used to evaluate the risk of disability retirement in relation to noise sensitivity (Cox & Oakes 1984).To take into account the sampling of twin pairs, the possible lack of statistical independence of cotwins, robust estimators of variance were computed with the cluster option in the Stata statistical software to derive correct confidence intervals (Williams 2000). In the analyses pooling men and women together, sex was included into the model. We also made paired analyses of twin pairs discordant for both noise sensitivity and DP. Thus, twins were analyzed in a matched case-control design (Fig. 2). Among these pairs, four types of distribution of noise sensitivity are possible. First, both can be noise sensitive (A) or neither is noise-sensitive (D). Such pairs (A and D) do not contribute to assessing the relationship between noise sensitivity and DP. The third category of pairs includes those in which the twin with future DP was noise sensitive and the healthy cotwin was not noise-sensitive (C), whereas in the fourth case, the opposite was true; that is, the twin with future DP was not noise-sensitive and the healthy cotwin was noise-sensitive (B).

		DISABILITY PENSION +	
		NOISE SENSITIVITY +	NOISE SENSITIVITY -
DISABILITY PENSION -	NOISE SENSITIVITY +	A	B
	NOISE SENSITIVITY -	C	D

Figure 2: Study design of paired analyses of twin pairs discordant for both noise sensitivity and DP

The ratio of C to B is a measure of the within-pair association of noise sensitivity with DP and is tested using the McNemar test:

McNemar OR = C/B

$\chi^2 = (C-B)^2/C+B$

The possible association between noise sensitivity and DP could be due to underlying familial and genetic factors in common as genetic factors contribute to both noise sensitivity (Heinonen-Guzejev et al. 2005) and liability of disability retirement (Harkonmäki et al. 2008; Narusyte et al. 2011). If the retired twin was more often noise sensitive than the not-retired cotwin, the association would be related to noise sensitivity and would not be explained by underlying familial and genetic factors in common.

Population attributable fractions (PAF) were used to evaluate the contribution of noise sensitivity in disability retirement. The PAF is describing the expected change in an outcome if its risk factors are modified. It assesses the proportion of outcome that could be avoided if the current exposure distribution was replaced by a hypothetical, presumably preferable exposure distribution (Rothman et al. 1998; Laaksonen et al. 2010).

RESULTS

During the follow-up from 1988 until 2004, 173 of the 706 participants (24.5%) retired because of disability (89 men and 84 women). Of these participants who retired because of disability, 114 had one diagnostic reason, 52 had two diagnostic reasons, and 7 had three diagnostic reasons for DP.

Table 1 gives age- and sex-adjusted (for all) or age-adjusted (for men and women) hazard ratios (HR) and multivariate model that was used to investigate the relationship of noise sensitivity with disability retirement (all reasons) for all participants and separately for men and women. Model included age, sex, hypertension, smoking status, and education. Table 1 also shows PAF values, describing the expected change in an outcome if its risk factors are modified. The age- and sex-adjusted HR for disability retirement among noise-sensitive participants was statistically significantly elevated with a point estimate of 1.41 (95% confidence interval [CI]: 1.03 to 1.93). When hypertension, smoking status, and education were adjusted for, the HR decreased to 1.34 (95% CI: 0.97 to 1.83) and was marginally nonsignificant. We next proceeded to look at subgroups and whether there were significant stratification effects. The age adjusted HR for men (1.49; 95% CI: 0.96 to 2.31) was slightly higher than that for women (1.33; 95% CI: 0.85 to 2.07) (Table 1).

Table 1. Adjusted Hazard Ratios (HR) and Population Attributable Fractions (PAF) for disability retirement of noise sensitive participants

All disability retirements	All	Men	Women
Reference category with no noise sensitivity	1.00	1.00	1.00
HR* for noise sensitivity (95 % CI) PAF	**1.41 (1.03–1.93)** 15 %	1.49 (0.96–2.31) 18 %	1.33 (0.85–2.07) 12 %
Adjusted (Full model)** HR(95% CI) PAF	1.34 (0.97–1.83) 13 %	1.27 (0.81–2.00) 11 %	1.35 (0.85–2.15) 13 %
n/N***	173/706	89/364	84/342

*Among all participants: age and sex adjusted, among men and women: age adjusted
**Among all participants full model includes age, sex, hypertension, smoking status, education; In the analyses separately in men and in women full model includes age, hypertension, smoking status, education
***n = number of cases, N is total number of participants at baseline

We then made additional analyses of those reporting noise exposure at work and those not reporting it. Among those reporting noise exposure at work, the age- and sex-adjusted HR for disability retirement for all noise-sensitive participants was 1.42 (95% CI: 1.04 to 1.93) whereas among those not reporting noise exposure at work, the HR was somewhat lower and not significant (1.22; 95% CI: 0.91 to 1.62). Among those reporting lifetime noise exposure (noise exposure at home, at work, and noisy leisure time hobbies), the age- and sex-adjusted HR for disability retirement among all noise sensitive participants was significant (1.31; 95% CI: 1.004 to 1.72). Among those not reporting lifetime noise exposure, noise exposure HR was somewhat lower and not significant (1.22; 95% CI: 0.89 to 1.66). Nevertheless, the interaction of noise sensitivity and noise at work or lifetime noise exposure with disability retirement for noise sensitive individuals was not significant (P for interaction, 0.83).

To see whether the observed associations were independent of familial factors, we also made within-pair analyses of twin pairs discordant for both noise sensitivity and

DP. Table 2 shows the results of the McNemar test on the disability retirement of noise-sensitive discordant twin pairs for all, male and female twin pairs and Table 3 for MZ and DZ twin pairs. Noise sensitivity increased significantly the risk of DP due to any cause among all twin pairs (odds ratio [OR] = 1.80; 95% CI: 1.08 to 3.06; n of twin pairs 70) and among female twin pairs (OR = 2.63; 95% CI: 1.12 to 6.85; n of twin pairs 29) but not significantly among male twin pairs (OR = 1.41; 95% CI: 0.73 to 2.89; n of twin pairs 41) (Table 2). Nevertheless, the point estimate for male pair was similar to that found among individuals overall. The difference between male and female twin pairs was not statistically significant (P = 0.23). The number of MZ pairs was low (n = 8) and the risk of disability among noise sensitive was increased (OR = 7.00; 95% CI: 0.90 to 315). Among DZ pairs, OR was 1.58 (95% CI: 0.93 to 2.76; n of twin pairs 62) (Table 3). The difference between MZ and DZ twin pairs was not statistically significant (P = 0.15).

Table 2. The McNemar-test on the disability retirement of noise sensitive discordant twin pairs (all, male and female twin pairs)

	All Twin Pairs		**Male Twin Pairs**		**Female Twin Pairs**	
	n*	OR (95% CI)	n*	OR (95% CI)	n*	OR (95% CI)
Noise Sensitive	70	**1.80 (1.08-3.06)**	41	1.41 (0.73-2.80)	29	**2.63 (1.12-6.85)**
Exact McNemar Significance Probability	p = 0.02		p = 0.35		p = 0.02	

Table 3. The McNemar-test on the disability retirement of noise sensitive discordant twin pairs (MZ and DZ twin pairs)

	MZ Twin Pairs		**DZ Twin Pairs**	
	n*	OR (95% CI)	n*	OR (95% CI)
Noise Sensitive	8	7.00 (0.90-315)	62	1.58 (0.92-2.76)
Exact McNemar Significance Probability	p = 0.07		p = 0.10	

DISCUSSION

According to the available literature, this is the first study investigating how noise sensitivity is associated with disability retirement. Based on the HR estimates, the total disability retirement among all noise-sensitive participants was 41% (among men 49% and among women 33%) higher than among nonsensitive participants. The disability retirement was partly explained by smoking status, education, and hypertension, and when they were included in the model, the total disability retirement remained 34% higher in all noise-sensitive participants than in nonsensitive participants.

In paired analyses, noise sensitivity increased 80% the risk of DP due to any cause. In pairs discordant for noise sensitivity and for DP, noise sensitivity was associated with DP independently of familial factors including family environment and genetic factors. As genetic factors contribute both to noise sensitivity (Heinonen-Guzejev et al. 2005) and to liability of disability retirement (Harkonmäki et al. 2008; Narusyte et al. 2011), the association between noise sensitivity and DP could be due to common

underlying familial and genetic factors. Nevertheless, the analysis of discordant pairs suggests that the association is independent of familial factors when all pairs are considered. Furthermore, the association was seen in both MZ and DZ pairs. Of the eight MZ pairs in which they were discordant for noise sensitivity and for DP, seven pairs were such that the noise sensitive twin became work disabled while the nonsensitive cotwin remained able to work during the time frame of the study. This exceptionally strong association within discordant twin pairs suggests that noise sensitivity is a causal risk factor for DP, independent of genetic factors and shared family background. In this study, in paired analyses with twins discordant for DP status and for noise sensitivity, noise sensitivity increased significantly the risk of DP due to any cause among female twins, but not among male twins. Nevertheless, the difference between male and female twins was not statistically significant.

This epidemiological study shows that noise sensitivity may be a potential risk factor for disability retirement. Nevertheless, our data did not allow us to investigate deeper mechanisms behind this association. Although in this study the interaction of noise sensitivity and self-reported noise exposure at work with disability retirement was not significant, this aspect of the association should be studied further. In their review, Belojević et al. concluded that noise might prevent individuals with high noise sensitivity from achieving the same work results compared with less-sensitive individuals leading to psychosomatic, neurotic, and other difficulties whereas individuals with lower noise sensitivity might be expected to better adapt to noise during mental performance (Belojević et al. 1992). The methodological strength of this study consists of long follow-up and use of national registers covering the whole Finnish population. Nevertheless, as a limitation it needs to be mentioned that there were relatively few discordant pairs. Thus, larger studies are needed to discover the effects of genes and environment in the association of noise sensitivity and DP.

CONCLUSIONS

Results of this study indicate that noise sensitivity may be a potential risk factor for disability retirement. It is associated with DP independently of familial background and genetic factors. Noise sensitivity should be taken into account in occupational health and in planning working conditions.

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