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The association between depression, anxiety, and cognitive function in the elderly general population—the Hordaland Health Study

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SUMMARY

Objectives To examine the association between depression and/or anxiety and cognitive function in the elderly general population.
Subjects Non-demented participants from the general population ($n = 1{,}930$) aged 72–74 years.
Methods Symptoms and caseness of depression and anxiety disorder were assessed using the Hospital Anxiety and Depression Scale (HADS). Cognitive function was assessed by the Digit Symbol Test (modified version), the Kendrick Object Learning Test, and the 'S'-task from the Controlled Oral Word Association Test.
Results There was a significant association between depression and reduced cognitive function. The inverse association between anxiety and reduced cognitive performance was explained by adjustment for co-morbid depression. The inverse association between depressive symptoms and cognitive function was found to be close to linear, and was also present in the sub-clinical symptom range. Males were more affected cognitively by depressive symptoms than females.
Conclusion The inverse association between depression and cognitive function is not only a finding restricted to severely ill patient samples, but it can also be found in the elderly general population. Copyright © 2005 John Wiley & Sons, Ltd.

KEY WORDS — depression; anxiety; cognitive; elderly; population

INTRODUCTION

An inverse association between depression and cognitive function has previously been reported in clinical studies in both younger and elderly samples (Lyness *et al*., 1994; Tarbuck and Paykel, 1995; Beats *et al*., 1996; Elliott *et al*., 1996; Kindermann and Brown, 1997; Hofman *et al*., 2000; Stordal *et al*., 2004). In most clinical studies that have investigated the relationship between depression and cognitive function, severely ill participants (in-patients) have been compared to healthy controls. This may have lead to overestimation of the effect sizes for the difference between depressed subjects and controls with regard to cognitive performance. The research designs applied in clinical studies are also vulnerable for biases that emerge from the many differences that exist between severely ill patients and healthy controls beyond the degree of depression. In order to estimate the true magnitude of the effect sizes for the

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association between depression and cognitive function, the association should therefore be explored in general population samples.

A small number of population-based studies in which neurocognitive tests have been used have reported higher levels of depressive symptoms to be associated with reduced performance on measures of attention, memory, and concept formation in the non-demented elderly (Paterniti *et al*., 1999; Bryan and Luszcz, 2000; Kizilbash *et al*., 2002). However, one study did not find depression to have significant impact on performance on memory tasks in a population-derived female sample (Clark *et al*., 2004). Thus, in larger population studies, findings have been contradictory with respect to the association between depression and cognitive function.

There is a high degree of co-morbidity between depression and anxiety (Beekman *et al*., 2000; Kessler *et al*., 2003, Smalbrugge *et al*., 2005). Few epidemiological studies have explored the association between anxiety and cognitive function, and again, the results have been conflicting (Paterniti *et al*., 1999; Kizilbash *et al*., 2002).

In the present study, performance on three common neurocognitive tests is explored in relation to depression and/or anxiety in a population of non-demented elderly subjects (72–74 years). The aims of the study were: (1) to explore the relationship between level of depression or anxiety symptoms and cognitive performance; (2) to investigate if caseness of depression and/or anxiety is associated with reduced cognitive function compared to non-caseness; and (3) to examine if there is a dose-response relationship between depressive symptoms and cognitive function, also within the sub-clinical range.

METHODS

Study population

The Hordaland Health Study (HUSK) was conducted from 1997 to 1999 as a collaboration between the National Health Screening Service, the University of Bergen, and the local health services. All inhabitants of Norway have a unique personal identification code, and population registries based on these codes exist in all municipalities, including the city of Bergen (population 230,000). In the HUSK study, all inhabitants born 1925, 1926, and 1927 registered as recidents of Bergen ($n = 4{,}338$) were invited to participate in general somatic and cognitive examinations. Out of the 3,341 from these age cohorts who participated in the general somatic examination, 2,203 also agreed to participate in the cognitive examination.

Assessment of depression and anxiety

Levels of depression and anxiety symptoms were assessed by the Hospital Anxiety and Depression Scale (HADS) (Zigmond and Snaith, 1983). HADS assesses depression (HADS-D) and anxiety (HADS-A) on two separate sub-scales. HADS is reliable as a screening tool in the general population, and it has been shown that the Scales's psychometric properties do not vary between age groups (Bjelland *et al*., 2002; Mykletun *et al*., 2001). Because HADS was developed to avoid false positive cases in somatic hospital settings, no somatic items are included, and the instrument should therefore be particularly suited for detection of depression and anxiety in the elderly (Flint and Rifat, 2002). Only subjects who had completed all the cognitive tests and five or more of the seven sub-scale items on both HADS-D and HADS-A were included ($n = 1{,}955$). However, in order not to reduce the sample size further, 36 subjects with valid HADS-D scores, but with less than five items completed on HADS-A, were included. In line with established procedures for HADS, missing item(s) on HADS-D or HADS-A in those with five or six items completed ($n = 199$) were replaced by the sum of the completed items on the sub-scale divided by the number of items completed (Mykletun *et al*., 2001, Roness *et al*., 2005). HADS-D/HADS-A subscale sumscores ≥ 8 were applied as cut-off for caseness.

Subjects who performed equal to or below a cut-off of nine points on a modified version of the Mini-Mental State Examination that consisted of the 12 items most sensitive to dementia (see Braekhus *et al*., 1992) were excluded due to the probable presence of mild cognitive impairment or dementia ($n = 25$). This cut-off corresponds to 23 points on the Mini-Mental State Examination (MMSE) (Folstein *et al*., 1975). Thus, 1,930 subjects were included in the final analyses.

'Attenders' and 'non-attenders'

For the 2,408 subjects in the original sample ($n = 4{,}338$) who did not participate in the cognitive examination, information about gender and civil status was available from the population registry. In addition, information about highest completed level of education was available for the 1,230 subjects who attended the general somatic examination, but who were excluded in the analyses in the present paper because they did not attend the cognitive examination or because their data was considered invalid. Comparisons between the 1,930 'attenders' and the

2,408 'non-attenders' were made on gender, civil status, and level of education by two-way contingency table analyses. The proportion of females was lower among the 'attenders' compared to among the 'non-attenders' (Pearson χ^2, $p = 0.014$). There was also an overall relationship between education and participation in the cognitive examination (overall Pearson χ^2, $p = 0.000$), pairwise group comparisons showed that those with 8–10 years and those with ≥ 11 years of education were more likely to attend than those with ≤ 7 years of education (both Pearson χ^2, $p = 0.000$).

Cognitive assessment

Cognitive testing was performed by specially trained nurses at the study locality.

A modified version of the *Digit Symbol Test (m-DST)* from WAIS-R was applied. The number of correct digit-symbol matches made in 30 seconds was recorded. The test is regarded as a measure of focused attention, visuo-motor coordination, and psycho-motor speed (Wechsler, 1981).

Kendrick Object Learning Test (KOLT) (Kendrick, 1985) is a simple object learning task that has previously been shown to distinguish both depressed and demented elderly subjects from normal controls (Kendrick, 1985). Cards with pictures of everyday objects were shown to the test person, and the number of objects correctly recalled was recorded (maximum possible score = 70 points).

Controlled Oral Word Association Test (COWAT) (Benton and Hamsher, 1989) is a test of verbal fluency and psycho-motor speed. An abridged version ('S'-task) was used. The subject was required to generate as many words as possible beginning with the letter 'S' within 60 seconds.

Statistical analyses

To investigate the relationship between depression or anxiety symptoms and cognitive function, linear regression analyses with HADS-D or HADS-A as independent variables and the three cognitive measures as dependent variables were conducted. To examine the independent effects of depression or anxiety on cognitive performance, the analysis with HADS-D as an independent variable was adjusted for HADS-A and vice versa.

To examine the effects of caseness of depressive disorder alone, anxiety disorder alone, or co-morbid depression/anxiety disorder compared to non-caseness, categorical variables for pure depression (HADS-D ≥ 8/HADS-A ≤ 7), pure anxiety (HADS-A ≥ 8/HADS-D ≤ 7), and co-morbid depression/anxiety (HADS-A/HADS-D both ≥ 8) were computed. The categorical variables were entered as dummy variables into a linear regression model with the three cognitive tests as dependent variables and the healthy sub-sample with HADS-A/HADS-D both ≤ 7 as reference category.

To explore if increasing symptom load was associated with quantitative change of performance on cognitive tests, dummy variables for HADS-D intervals 0–1, 2–3, 4–5, 6–7, 8–10, ≥ 11 were computed and entered into a linear regression model with the cognitive measures as dependent variables and the 0–1 category as reference. The R^2/eta^2 fraction was computed in order to examine to what degree the relationship between HADS-D and the cognitive measures was linear. If the R^2/eta^2 ratio is 0, there is no degree of linearity in the association, and if it is 1, the association is completely linear. In order to examine if subclinical depressive symptoms had effect on cognitive function, the linear regression analyses with HADS-D as independent variable and the cognitive tests as dependent variables were repeated in the healthy sub-sample (HADS-D and HADS-A both ≤ 7).

Separate blockwise adjustments were performed for the following variables that could influence cognitive function: (1) demographic variables (gender, education, civil status); (2) health-related variables (somatic disease, medication); and (3) lifestyle variables (level of physical activity, smoking, alcohol use, quality of sleep). Adjustment variables were encoded as categorical, with missing data as separate category. Finally, fully adjusted models were explored.

In the linear regression analyses, all analyses were repeated with log-transformed HADS-A and HADS-D. Significance was reported from the analyses performed on the transformed data. Effect sizes and 95% confidence intervals were reported from analyses performed on the non-transformed variables. The 36 subjects with missing HADS-A were excluded from the linear analyses in Table 2, and entered as separate category in the categorical analyses (Table 3).

All significance tests were two-tailed. Significance level was set at .01 in order to avoid Type I error due to the multiple comparisons conducted. Data analyses were performed by the SPSS 11.5.

Ethics

The study was approved by the Regional Medical Ethics Committee and the Norwegian Data Inspectorate,

and all participants gave written informed consent. The study was funded by the Oxford Project to Investigate Memory and Ageing (OPTIMA) and the Norwegian Institute of Public Health.

RESULTS

Sample characteristics

Mean age was 72.5 (SD = 0.8) years (Table 1). In the valid sample ($n = 1{,}930$), 179 subjects (9.3%) scored above the cut-off for depression on HADS-D, and 249 (12.9%) scored above the cut-off for anxiety disorder on HADS-A. Eighty-three subjects (4.3%) had depression without co-morbid anxiety, 163 (8.5%) had anxiety without co-morbid depression, and 86 (4.5%) had co-morbid depression/anxiety.

The association of depression or anxiety, with cognitive performance

The associations between HADS-D or HADS-A and the cognitive test measures were all inverse (Table 2). Higher HADS-D scores were associated with significantly lower performance on m-DST (crude beta = −0.11, $p = 0.000$), KOLT (beta = −0.12, $p = 0.000$), and 'S'-task (beta = −0.08, $p = 0.001$). Higher HADS-A scores were associated with significantly lower scores on m-DST (crude beta = −0.08, $p = 0.000$). When the model with HADS-D as independent variable and cognitive test scores as

Table 1. Descriptive statistics for the total valid sample (age cohorts 1925–27) that participated in the cognitive examination in the Hordaland Health Study ($n = 1{,}930$)

	Mean (SD)	Range
Age	72.5 (0.8)	71.4–74.3
HADS-D[a]	3.5 (2.8)	0–16
HADS-A[b]	4.1 (3.2)	0–16
m-DST[c]	10.5 (4.2)	1–24
KOLT[d]	35.6 (7.8)	2–65
'S'-task[e]	15.3 (5.5)	1–39
	Number of subjects ($n = 1{,}930$)	Percent
Depression	179	9
Anxiety	249	13
Co-morbid anxiety/depression	86	5
Gender	Males: 871	45
	Females: 1,059	55
Education	≤ 7 years: 678	35
	8–10 years: 765	40
	≥ 11 years: 349	18
	Missing information: 138	7
Civil status	Living alone: 215	11
	Married/co-habiting: 1,299	67
	Widow (-er): 416	22
Somatic disease	Yes: 927	48
	No: 590	31
	Missing information: 413	21
Medication	Yes: 1,000	52
	No: 496	26
	Missing information: 434	23

[a]HADS-Depression sub-scale.
[b]HADS-Anxiety sub-scale.
[c]Modified Digit Symbol Modalities Test.
[d]Kendrick Object Learning Test.

Table 2. Linear regression model for the relationship between HADS-D or HADS-A and cognitive variables in the the age cohorts 1925–27 in the Hordaland Health Study ($n = 1{,}930$)

		HADS-D			HADS-A[a]		
		m-DST	KOLT	'S'-task	m-DST	KOLT	'S'-task
Crude	B	−0.17*	−0.33*	−0.16*	−0.11*	−0.12	−0.02
	95% CI	−0.24, −0.10	−0.45, −0.21	−0.25, −0.08	−0.17, −0.05	−0.23, −0.01	−0.10–0.06
	Beta	−0.11	−0.12	−0.08	−0.08	−0.05	−0.01
	P	0.000	0.000	0.001	0.000	0.031	0.543
Adj. for demographic variables (gender, education, civil status)	B	−0.13*	−0.29*	−0.11*	−0.08*	−0.21*	0.02
	Beta	−0.08	−0.11	−0.06	−0.06	−0.09	0.01
Adj. for health-related factors (somatic disease, medication)	B	−0.17*	−0.32*	−0.16*	−0.11*	−0.12	−0.02
	Beta	−0.11	−0.12	−0.08	−0.08	−0.05	−0.01
Adj. for lifestyle-related factors (physical activity, alcohol, smoking, sleep)	B	−0.17*	−0.33*	−0.16*	−0.11*	−0.16	−0.02
	Beta	−0.11	−0.12	−0.08	−0.08	−0.07	−0.01
Adj. for all of the above	B	−0.12*	−0.28*	−0.11*	−0.08*	−0.21*	0.02
	95% CI	−0.18, −0.06	−0.40, −0.16	−0.20, −0.03	−0.13, −0.20	−0.32, −0.10	−0.06, 0.10
	Beta	−0.08	−0.10	−0.06	−0.06	−0.09	0.01
	P	0.000	0.000	0.010	0.005	0.000	0.785

*Significant at the 0.01 level.
[a]$n = 1{,}894$.

dependent variables was adjusted for HADS-A, only a slight change of the betas for the associations occurred (from −0.11 to −0.09 for m-DST, from −0.12 to −0.13 for KOLT, and from −0.08 to −0.11 for 'S'-task), and the associations were still significant ($p = 0.003$ for m-DST, $p = 0.000$ for KOLT, and $p = 0.000$ for 'S'-task). In the analyses with HADS-A as independent variable, adjustment for HADS-D reduced the effect estimates markedly (from −0.08 to −0.04 for m-DST, from −0.05 to +0.02 for KOLT, and from −0.01 to +0.05 for 'S'-task), and none of the associations between HADS-A and the three cognitive measures were significant after adjustment for HADS-D ($p = 0.166$, $p = 0.593$, and $p = 0.161$, for m-DST, KOLT, and 'S'-task, respectively).

The effects of depression alone, anxiety alone, and co-morbid depression/anxiety on cognitive performance

There was a significant difference between the sub-sample of depressed subjects without co-morbid anxiety and the healthy sub-sample on all three tests (crude beta = −0.08, $p = 0.000$ for m-DST, beta = −0.09, $p = 0.000$ for KOLT, and beta = −0.09, $p = 0.000$ for 'S'-task) (Table 3). A significant difference between the sub-sample of subjects with co-morbid depression/anxiety and the healthy sub-sample was found for KOLT (crude beta = −0.07, $p = 0.003$). In contrast, no significant difference was found between the sample with anxiety without co-morbid depression and the healthy sub-sample on the cognitive test measures.

Is there a dose-response association between depressive symptoms and cognitive performance, and is this eventually present also in the sub-clinical range?

Depressive symptoms exhibited a detectable effect on test performance even in the sub-clinical symptom range (Figure 1). However, betas were more than doubled in the HADS-D interval 8–10 (i.e. above cut-off for depression) compared to in the 2–3 interval, and statistical significance for the associations was reached at the HADS-D interval 8–10 for m-DST ($p = 0.010$) and KOLT ($p = 0.000$). The mean R^2/eta^2 fraction in the total sample was 0.72 for the three cognitive measures, indicating that there was a fairly linear relationship between depression symptom load and cognitive reduction. In the analyses performed in the healthy sub-sample in order to assess if depressive symptoms had a negative effect on cognitive function also in the sub-clinical symptom range, the crude associations of HADS-D with m-DST or KOLT were significant also in this range (crude beta = −0.08, $p = 0.008$ for m-DST, beta = −0.08, $p = 0.004$ for KOLT, and beta = −0.06, $p = 0.025$ for 'S'-task). However, significance was lost after adjustment ($p = 0.029$, $p = 0.028$, and $p = 0.070$ for m-DST, KOLT, and 'S'-task, respectively).

Gender differences

Because a gender difference in test performance appeared in the descriptive analyses (Table 1), we repeated the linear analyses with HADS-D as independent variable and the cognitive tests as dependent variables with samples stratified by gender (Figure 2). The inverse associations between depression and lower test performance were significant for all measures (crude and adjusted analyses) in the male sub-sample (crude $p = 0.000$ for all), but only for KOLT in the female sub-sample (crude $p = 0.001$). This apparent gender difference was tested by interactions terms gender by depression in General Linear Models (GLM). The interaction terms were marginally significant for 'S'-task ($p = 0.021$), and noteworthy, yet not statistically significant, for m-DST ($p = 0.102$).

DISCUSSION

In this population sample, depression was associated with significant reduction of performance on objective measures of cognitive function. The dose-response relationship between depressive symptoms and performance on the cognitive tests was close to linear. Even in the sub-clinical range, depressive symptoms had a detectable effect on cognitive performance. The effect of anxiety on cognitive performance could be explained by co-morbid depression.

Our finding of an inverse association between depression and cognitive performance is in accordance with Bryan and Luszcz (2000), who found that depressive symptoms correlated inversely with performance on the Digit Symbol Test, a phonetic fluency task, and several measures of recall in a larger population-derived sample of elderly (Bryan and Luszcz, 2000). In our study, males were more affected cognitively by depressive symptoms than females. This is consistent with Paterniti *et al.* (1999), who reported a significant inverse correlation

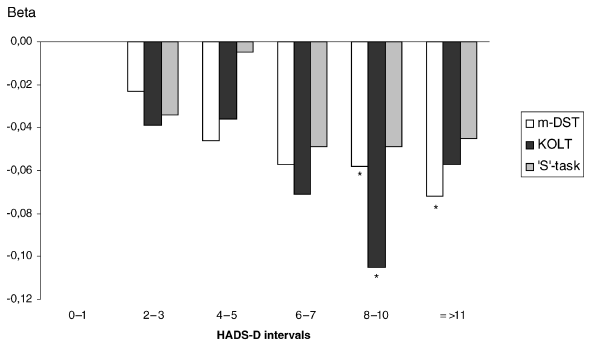
Table 3. Linear regression model showing the association of categorical pure depression, pure anxiety, and co-morbid depression/anxiety with cognitive variables in the age cohorts 1925–27 in the Hordaland Health Study

		Depression alone[a] ($n = 83$)	Anxiety alone[b] ($n = 163$)	Co-morbid[c] depression/anxiety ($n = 86$)
Dependent variable: m-DST				
Crude	B	−1.72*	−0.42	−0.92
	95% CI	−2.64, −0.79	−1.09, 0.26	−1.83, −0.01
	Beta	−0.08	−0.03	−0.05
	P	0.000	0.228	0.047
Adjusted for demographic variables	B	−1.28*	−0.22	−0.57
	Beta	−0.06	−0.02	−0.03
Adjusted for health-related factors	B	−1.72*	−0.42	−0.93
	Beta	−0.08	−0.03	−0.05
Adjusted for lifestyle-related factors	B	−1.70*	−0.35	−0.90
	Beta	−0.08	−0.02	−0.04
Adjusted for all of the above	B	−1.29*	−0.18	−0.56
	95% CI	−2.15, −0.42	−0.82, 0.46	−1.41, 0.29
	Beta	−0.06	−0.01	−0.03
	P	0.004	0.579	0.193
Dependent variable: KOLT				
Crude	B	−3.42*	−0.89	−2.59*
	95% CI	−5.14, −1.70	−2.15, 0.36	−4.28, −0.90
	Beta	−0.09	−0.03	−0.07
	P	0.000	0.163	0.003
Adjusted for demographic variables	B	−2.68*	−1.47	−2.71*
	Beta	−0.07	−0.05	−0.07
Adjusted for health-related factors	B	−3.40*	−0.89	−2.56*
	Beta	−0.09	−0.03	−0.07
Adjusted for lifestyle-related factors	B	−3.41*	−0.88	−2.61*
	Beta	−0.09	−0.03	−0.07
Adjusted for all of the above	B	−2.61*	−1.51	−2.70*
	95% CI	−4.30, −0.92	−2.75, −0.28	−4.3, −1.08
	Beta	−0.07	−0.05	−0.07
	P	0.002	0.017	0.001
Dependent variable: 'S'-task				
Crude	B	−2.47*	−0.36	−0.25
	95% CI	−3.67, −1.27	−1.23, 0.52	−1.43, 0.93
	Beta	−0.09	−0.02	−0.01
	P	0.000	0.425	0.681
Adjusted for demographic variables	B	−1.97*	−0.16	+0.16
	Beta	−0.07	−0.01	+0.01
Adjusted for health-related factors	B	−2.46*	−0.35	−0.22
	Beta	−0.09	−0.02	−0.01
Adjusted for lifestyle-related factors	B	−2.48*	−0.32	−0.24
	Beta	−0.09	−0.02	−0.01
Adjusted for all of the above	B	−2.02*	−0.16	+0.19
	95% CI	−3.17, −0.86	−1.00, 0.69	−0.95, 1.30
	Beta	−0.08	−0.01	+0.01
	P	0.001	0.719	0.760

*Significant at the 0.01 level.
[a]HADS-D $\geq$ 8/HADS-A $\leq$ 7.
[b]HADS-A $\geq$ 8/HADS-D $\leq$ 7.
[c]HADS-D and HADS-A both $\geq$ 7.

between depressive symptoms and scores on an attention-demanding task in males, but not in females (Paterniti *et al*., 1999). Such a quantitative gender-difference in the effect of depressive symptoms on cognitive function could also explain why Clark *et al*. (2004) did not find a significant correlation between level of depression and verbal memory performance in their female sample (Clark *et al*., 2004).

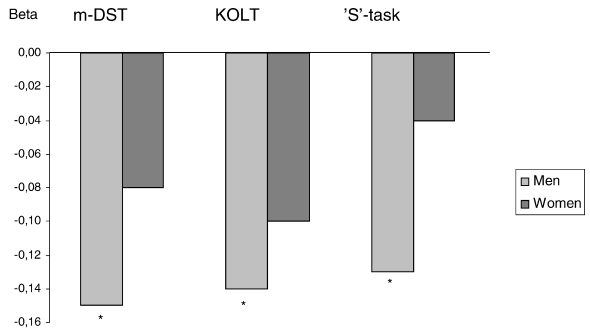
In smaller controlled clinical studies, the difference between depressed patients and controls on cognitive



* Significant at the 0.01 level

Figure 1. Effect sizes (betas) for the associations between HADS-D intervals and cognitive variables for the age cohorts 1925–27 in the Hordaland Health Study. Adjusted for gender and education

test scores has been found to be approximately half a standard deviation of the sample mean in favour of the controls (Lyness *et al*., 1994; Kindermann and Brown, 1997; Stordal *et al*., 2004). In our study, the corresponding group differences were 0.20 SD for 'S'-task, 0.26 SD for m-DST, and 0.30 SD for KOLT in favour of the healthy subjects (data not shown). Several reasons could account for the lower effect sizes in population studies as compared with clinical trials: Firstly, the group difference in clinical studies might be artificially high due to high levels of depressive symptoms in depressed subjects and low levels of depressive symptoms in control subjects. Secondly, depressed subjects who are cognitively impaired possibly tend to be included more frequently in clinical trials than non-impaired depressed subjects (selection bias). Thirdly, diagnoses of depression or anxiety are most often made by specialised clinicians using



* Significant at the 0.01 level

Figure 2. Crude effect sizes (betas) for the associations between HADS-D and cognitive variables stratified by gender for the age cohorts 1925–27 in the Hordaland Health Study

standardised diagnostic tools, and therefore diagnostic reliability is higher in clinical trials than in population studies with lay interviewers or self-ratings of symptoms (correlations and effect sizes tend to be higher when diagnostic reliability increases). Finally, in population studies, the variance in symptomatology might be restricted because more severely ill subjects are less likely to participate (Hansen *et al*., 2001).

In this study, we conclude that the effect of anxiety upon cognitive function was due to co-morbid depression, because in the analyses with categorical variables for depression alone, anxiety alone, or co-morbid depression/anxiety, anxiety alone showed weak, non-consistent and non-significant crude associations with the cognitive outcome measures. In addition, when the analyses with the linear HADS-A were adjusted for the moderating effect of HADS-D, betas decreased, and the associations were non-significant. In contrast, significance was preserved after the analysis with HADS-D as independent variable was adjusted for HADS-A. These findings are consistent with Kizilbash *et al*. (2002), who found performance on a word learning task to be significantly lower in a sub-sample with depression with co-morbid anxiety compared to a sub-sample with low levels of symptomatology, whereas a sub-sample with higher level of anxiety did not show significantly lower performance compared to a low-anxiety sub-sample (Kizilbash *et al*., 2002). But it contrasts with Sinoff and Werner (2003), who claimed that anxiety exerts a negative effect on cognitive function on its own, in addition to a negative effect mediated by depression (Sinoff and Werner, 2003). However, their study was not comparable to ours with respect to design and outcome measures.

A trend in which depressive symptoms had impact on cognitive function also in the sub-clinical symptom-range was found. Although effect sizes were small for the association between depression and cognitive function in this range, the effect may represent a change in functioning that likely will be of importance for the depressed subject who experiences it. Although our sample was restricted to subjects aged 72–74, and we therefore do not know the magnitude of the inverse relationship between depression and cognitive function in other age samples, it is reasonable to infer that a burden may exist in the population as a whole as a result of the effect of lower-scale depressive symptoms on cognitive function, since such symptoms are present in a large proportion of the population (Kessler *et al*., 1997).

The cognitive tests used in our study are validated and have been used extensively (Wechsler, 1981;

Kendrick, 1985; Benton and Hamsher, 1989). They have been shown to be sensitive to depression in previous studies in the non-demented elderly (Tarbuck and Paykel, 1995; Beats *et al*., 1996; Bryan and Luszcz, 2000). The study's strengths also include that the total age cohorts within the city boundaries were invited to participate, and that the analyses were adjusted for the presence of somatic conditions and medication use, which are both frequently co-existent with depression and anxiety in the elderly (van Balkom *et al*., 2000; Stordal *et al*., 2003).

A weakness of our study is the participation rate, and the fact that females and subjects with the lowest level of education were more likely not to attend may also have influenced the results.

Depression might be seen as prodrome of or as an early clinical manifestation of dementia, and there is a high degree of co-morbidity of these disorders (Jorm, 2001). Although the MMSE has shown high sensitivity as a screening instrument for dementia (Folstein *et al*., 1975; Braekhus *et al*., 1992), there may still be non-detected cases in our sample, which may lead to an over-estimation of the association between depression and cognitive function. However, when KOLT, which is very sensitive to dementia (Kendrick, 1985), was applied for exclusion of subjects (cut-off = 1.5 SD below the sample mean) in addition to m-MMSE, crude betas from the linear analyses were only reduced by 10% or less, and the associations were still significant (all $p < 0.01$).

CONCLUSION

By employing epidemiological large-scale analyses and data from the general population, this study represents a new approach to the examination of associations between anxiety and depression and cognitive function. The population basis avoids selection biases that are commonly found in clinical studies, and the large sample-size gives sufficient statistical power to detect also fairly weak associations. The main findings of the study were that the apparent inverse association between anxiety and cognitive function reported in several studies is confounded by depression, and there is no independent effect of anxiety upon cognitive function beyond that of depression. Males were more affected cognitively by depressive symptoms than females. The inverse association between depressive symptoms and cognitive reduction is not a finding restricted to severely ill population samples, but rather a normal phenomenon present (however weakly) in a sub-clinical range of depressive symptoms in the general population.

KEY POINTS

- A significant inverse association was found between depressive symptom load and cognitive function
- Males were more severely affected cognitively by depression than females
- The inverse association between depressive symptoms and cognitive function was found to be almost linear, and also present, however weakly, in the sub-clinical symptom range

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