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Relation Between Health Status and Cognitive Functioning: A 6-Year Follow-Up of the Maastricht Aging Study

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The aim of this study was to determine whether physical and psychological functioning can predict 6-year cognitive decline in older adults. A group of 669 participants aged 60 to 81 years was recruited from a longitudinal study (the Maastricht Aging Study). Physical functioning was measured in terms of perceived health and instrumental activities of daily living. Psychological functioning or mood was evaluated by the Depression and Anxiety subscales of the Symptom Check List-90. Although physical functioning and psychological functioning were related to several measures of cognitive functioning at baseline, psychological functioning was specifically related to memory functioning 6 years later. Poor psychological functioning (i.e., depressive and anxiety symptomatology), rather than poor physical health, may have the strongest implications for long-term cognitive functioning in older men and women.

FROM a gerontological viewpoint, knowledge of factors that are associated with optimal functioning may help to improve autonomy and well-being in old age. Such knowledge may also make it possible to develop dedicated intervention programs to specifically modify these factors. In this respect, much can be learned from individuals who function on a high level according to psychological and physical criteria (World Health Organization, 1948). A high level of general functioning is suggested to be positively associated with high cognitive functioning (Berkman et al., 1993; Rowe & Kahn, 1997). Cognitive functioning is often a major concern for older adults, because many cognitive functions decline in old age. However, few studies have examined in depth the relationship between general high functioning and cognitive performance in old age.

Previous studies have identified associations between the components of health status and cognitive functioning (e.g. Jorm, 2000; McNeal et al., 2001). For example, complaints about depressed mood have been associated with a decline in speed of information processing over a 3-year period in healthy older adults (Comijs, Jonker, Beekman, & Deeg, 2001). This may be because depression or anxiety initiates or accelerates neurodegenerative processes; alternatively, depression or anxiety may be a reaction to a perceived deterioration in cognitive function (Paterniti, Verdier-Taillefer, Dufouil, & Alperovitch, 2002; Stewart, 2004). In both explanations, psychological functioning is assumed to have a general effect on various cognitive domains rather than a specific effect on certain cognitive domains. Likewise, poor physical function, as indexed by self-rated health (Hultsch, Hammer, & Small, 1993; Tabbarah, Crimmins, & Seeman, 2002), was found to be related to poor performance on neuropsychological tests in a healthy population. It was suggested that physical functioning may influence basic biological mechanisms, such as limb strength and aerobic capacity, and as a consequence may affect

basic cognitive processes, such as speeded task performance, in particular (Hultsch et al., 1993).

A limitation of these studies is that they highlighted either physical or psychological functioning, but not both. In addition, many studies addressing the relationship between aspects of health status and cognitive aging used a cross-sectional design, and thus inferences about cause and effect could not be made. Longitudinal studies that have specifically addressed this still are scarce (Baltes & Baltes, 1990; Schaie & Hofer, 2001). Therefore, we investigated whether physical functioning and psychological functioning, in particular depressive and anxiety symptomatology, are related to cognitive functioning and cognitive change over a 6-year period in a large population sample aged 60 years and older derived from the Maastricht Aging Study.

METHODS

Participants

The data we used in the present study were derived from the Maastricht Aging Study, a longitudinal study examining determinants of normal cognitive aging. Participants were recruited from the Registration Network Family Practices (RNH; Metsemakers, Höppener, Knottnerus, Kocken, & Limonard, 1992), a sample frame for research in primary care. Participants, aged 24 to 81 at the moment of inclusion, were without medical conditions known to interfere with normal cognitive function (e.g., dementia, mental retardation, or cerebrovascular pathology). The study population was stratified for age group, gender, and general ability. In the baseline period between 1993 and 1995, 1,823 people underwent a cognitive and physical examination (Jolles, Houx, van Boxtel, & Ponds, 1995). Six years after the baseline measurements, all participants

were invited for a reassessment of neuropsychological function. As a result of refusal ($n = 275$), death ($n = 116$), loss to follow-up ($n = 37$), and other reasons ($n = 19$), in total 1,376 participants were actually tested (74 %). For the present study, we used only data for participants aged 60 years or older, because problems in both health and cognitive function are particularly prevalent in this age category. Among those 60 years and older, 64% of the participants tested at baseline were available to participate at follow-up. This resulted in a total of 669 participants (37% of the total study population tested at baseline); 335 were men and 334 were women. We excluded participants with clinically verified major depression or dementia at 6-year follow-up from further analyses ($n = 12$; 1.8%). The local medical ethics committee approved the study and all participants gave their informed consent.

Independent Variables

We measured physical functioning in terms of perceived health and problems with instrumental activities of daily living (IADLs). We determined perceived health by asking respondents, "How would you describe your health?" Answers ranged from *extremely good* (1) to *extremely poor* (5). We measured problems with IADLs by asking the respondents whether they needed help with shopping, housekeeping, personal hygiene, dressing, or preparing meals, with scores ranging from 0 (*no help*) to 10 (*maximum help*). Cronbach's alpha for this instrument was .66, based on data from the baseline measurement and 3-year follow-up.

We determined psychological functioning or mood by using the Depression and Anxiety subscales of the Symptom Check List-90 (SCL-90). The SCL-90 is a widely used multidimensional checklist for psychopathological complaints (Arrindell & Ettema, 1986; Derogatis, 1977); scores range from 0 (good) to 80 (poor) for depression and from 0 (good) to 50 (poor) for anxiety. To obtain a single score for physical functioning and mood, we first standardized the two variables for each domain of functioning (z scores) and then averaged them for each domain separately.

Cognitive Variables

We administered a broad range of cognitive tests to assess perceptual speed, speed of information processing, cognitive flexibility, memory, and verbal fluency. These tests have been shown to be sensitive to age-related changes and subtle changes in health (Salthouse, 1992; van Boxtel et al., 1998).

The Stroop Colour-Word Test (SCWT) involves three cards displaying 100 stimuli each (Houx & Jolles, 1993). The first card (reading color words aloud) and the second card (naming colored patches) reflect cognitive speed. The last card displays color names printed in incongruously colored ink. Participants were instructed to name the ink color of words. By subtracting the time needed for the last part from the mean score of the first and second parts, we can calculate an interference score. This interference score is a measure of inhibition of a habitual response, which can be considered an aspect of executive function.

The Concept Shifting Task (CST) is a modified version of the Trial Making Test (Vink & Jolles, 1985) and consists of three parts. Part I (crossing out numbers) and Part II (crossing out letters) are used to measure simple cognitive speed. The last

part (alternating between numbers and letters) is used to measure cognitive flexibility. The scores correspond to the time needed to complete each trial. The difference between the last part and the mean score of the first and second parts is considered to reflect the additional time needed to shift between both sets of stimuli.

We measured verbal memory functioning by using the Visual Verbal Learning Test (VVL; Brand & Jolles, 1985). Fifteen monosyllabic words are presented one after another and subjects are asked to recall as many words as possible. This procedure is repeated five times. After 20 min, delayed recall is tested.

Cognitive Compound Scores

In order to reduce the number of tests while improving the robustness of the underlying cognitive construct (Lezak, 1995), we calculated cognitive compound scores. To this end, we transformed raw scores of both baseline assessment and follow-up assessment to z scores in the total group of participants that was selected in this study. We pooled both observations for each individual for z -score computation, in order to obtain both interindividual differences and intraindividual change over time. We based the memory compound score on the immediate and delayed recall of the VVL. We derived the speed compound from the first and second subtask of the SCWT and CST. The executive functioning compound score was calculated by averaging the interference scores of the SCWT and CST. We inverted the sign of the speed and executive compound scores to make them reflect above average performance when positive and below average performance when negative (van Boxtel et al., 1998).

Other Measures

We considered age, gender, and level of education to be potential confounders. We indexed level of education on an 8-point ordinal scale: 1 = primary education, 2 = lower vocational education, 3 = intermediate general secondary education, 4 = intermediate vocational education, 5 = higher general secondary education-university preparatory education, 6 = higher vocational preparatory education, 7 = higher professional education, 8 = university education (De Bie, 1987).

RESULTS

The mean age of this study population was 69.74 years ($SD = 5.98$), and the mean educational level was 2.65 ($SD = 1.72$). Perceived health was rated as good by 48% of the participants (7% very good, 43% reasonable, and 2% poor). The majority (78%) of the participants did not report problems with IADLs (15% experienced problems in one domain, 5% in two domains, 1% in three domains, and 1% in four or five domains). The mean score on the Depression subscale of the SCL-90 was 20.57 ($SD = 5.35$), and the mean score on the Anxiety subscale was 12.41 ($SD = 3.38$).

The correlation between physical functioning and mood was significant ($r = .37, p < .001$). Table 1 summarizes standardized regression coefficients of physical functioning and mood for each cognitive measure separately. There we present both bivariate and multivariate prediction models. We adjusted the cross-sectional analyses for age, gender, and educational level. We found that physical functioning was significantly correlated with the speed compound score: Higher physical functioning

Table 1. Cross-Sectional Standardized Regression Coefficients of Standardized Health Status Components for Each Cognitive Measure

Prediction Model	B		
	Speed	Executive Functioning	Memory
Bivariate			
Mood	-0.09*	-0.13**	-0.03
Physical functioning	-0.12**	-0.02	-0.06
Multivariate			
Mood	-0.06	-0.13**	0.01
Physical functioning	-0.12**	-0.02	-0.08

Notes: Cross-sectional analyses were adjusted for age, gender, and educational level. Multivariate models had components simultaneously controlled.

* $p < .05$; ** $p < .01$.

was associated with better performance on speed tasks ($B = -0.12$, $p < .01$, change in $R^2 = .01$). The association between mood and speed disappeared when we added physical functioning to the regression model. The mood component was related to the executive compound score: Elevated mood was associated with better performance ($B = -0.13$, $p < .01$, change in $R^2 = .02$).

We adjusted longitudinal analyses (Table 2) for age, gender, educational level, and duration of follow-up interval ($M = 2,259$ days, $SD = 63$). Physical functioning did not predict cognitive functioning 6 years later. Mood was related to the memory compound score 6 years later, even when we adjusted it for physical functioning ($B = -0.11$, $p < .01$, change in $R^2 = .01$). We found similar results when we analyzed cognitive tests variables, instead of compound scores.

DISCUSSION

Our aim in this study was to examine the relationship between components of health status and cognitive functioning. Results indicated that older individuals with a higher level of physical functioning or elevated mood perform better on cognitive tasks. Mood was related to cognitive functioning and predicted memory performance 6 years later, even after taking physical functioning into account. These results suggest that there may be a time lag in the effect of mood on memory processes. One possible mechanism underlying this delayed effect may be related to cortisol dysregulation. Depressive symptoms have been associated with elevated levels of cortisol and may in the long run have a negative effect on the hippocampus, which is especially involved in explicit memory functioning (McAllister-Williams, Ferrier, & Young, 1998). As expected, a high level of physical functioning was associated with a better speed compound score. This finding is in line with the notion that physical functioning may affect basic biological mechanisms and as a result may slow down more basic cognitive processes (Hultsch et al., 1993). Physical functioning was not a predictor of cognitive functions 6 years later. We hypothesize, however, that 6 years may be too short a time to detect longitudinal effects. We suggest that the relation between physical functioning and cognition will change over time as a result of emerging diseases and disabilities.

Several methodological issues have to be considered. First, despite having a large sample of participants followed over a

Table 2. Longitudinal Standardized Regression Coefficients of Standardized Health Status Components for Each Cognitive measure

	B		
	Speed	Executive Functioning	Memory
Bivariate			
Mood	-0.01	-0.05	-0.11**
Physical functioning	-0.02	-0.07	-0.05
Multivariate			
Mood	<0.01	0.03	-0.10**
Physical functioning	-0.02	-0.05	-0.03

Notes: In longitudinal analyses, age, gender, educational level, period to follow-up, and baseline cognitive performance were included as covariates. Multivariate models had components simultaneously controlled.

* $p < .05$; ** $p < .01$.

6-year interval, we found that measures of health status did not substantially account for the variance in cognitive functioning. The population investigated in this study consisted of community-dwelling older adults, who functioned at a normal level with respect to physical functioning and mood as well as cognitive functioning. A longer time lag and therefore a larger decrease in health status and cognitive functions may be needed to demonstrate a more robust association between cognitive functioning and health status. Second, we measured aspects of health status by means of self-report. A disadvantage of self-report data is that informants may forget information, which will decrease reliability, particularly in older individuals. However, the ecological validity of self-reported information is generally considered to be good.

In conclusion, physical functioning and mood predicts cognitive functioning in older adults. A comparison of the relative contribution of these components revealed that poor psychological functioning (i.e., more depressive and anxiety symptoms) is the best predictor of cognitive decline. The important role of symptoms related to mood, energetic functions, mild dysthymia, or anxiety complaints should be investigated more rigorously in future research.

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