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I forgot when I lost my grip—strong associations between cognition and grip strength in level of performance and change across time in relation to impending death

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An association between level of cognitive function and grip strength is well established, whereas evidence for longitudinal associations of change in the 2 functions is still unclear. We examined associations between cognition and grip strength in levels of performance and in longitudinal change in late life in a population-based sample, aged ≥80 years at baseline, followed until death. The sample consisted of 449 nondemented individuals drawn from the OCTO-Twin Study. A test battery assessing 6 cognitive domains and grip strength was administered at 5 occasions with measurements intervals of 2 years. We fitted time to death bivariate growth curve models, adjusted for age, education, and sex which resulted in associations between grip strength and cognition in both levels of performance (across all cognitive domains) and rates of change (in 4 of 6 domains). These results show that cognition and grip strength change conjointly in later life and that the association between cognition and grip strength is stronger before death than earlier in life.

1. Introduction

In the present study, we further investigate the nature of the association between cognition and grip strength. More specifically, we examine whether these 2 bio-behavioral functions change conjointly before death.

Baltes and Lindenberger (1997) suggested that the associations between cognitive performance and sensory function in later life share a common cause (i.e., a third factor) that drives the relationship where the third factor reflects general brain aging. In a similar vein, Christensen et al. (2001) explored the common cause hypothesis of cognitive aging were they found support for a common factor involved in performance in a range of physical and cognitive functions, among others grip strength. More recent studies have examined the relationship between cognition and grip strength in later life (Clouston et al., 2013; Deary et al., 2011; Sternäng et al., 2015). Both functions decline in later life (Singh-Manoux et al., 2012; Sternäng et al., 2014) and have been shown to be related to health and subsequent mortality (Cooper et al., 2010, 2011; Leong et al., 2015; Small et al., 2011). However, the nature of the observed association is not yet fully understood. Although there is clear evidence of associations between cognition and grip strength in the level of performance, the evidence for longitudinal associations is still unclear (Clouston et al., 2013).

In a systematic review and meta-analysis on the relationship between global cognitive function and physical function, Clouston et al. (2013) found small ($\beta = 0.14$; 95% CI: $\beta = 0.06$ to $\beta = 0.27$) but consistent associations between level of cognitive performance and level of grip strength. One conclusion of the review, related to methodological concerns, was that despite a large number of longitudinal studies on the association between cognition and grip strength, few studies investigated if cognition and grip strength change conjointly. Only 2 longitudinal studies have examined the associations of simultaneous change in cognition and grip strength in a multiwave design (i.e., ≥3 waves; see Deary et al., 2011; Sternäng et al., 2015). Deary et al. (2011) investigated trajectories of change in associations between fluid ability and grip strength. They confirmed a relationship between the level of fluid ability and the level of grip strength ($r = 0.20$) but found no evidence that fluid ability and grip strength share similar trajectories of change, a conclusion that does not lend support to the common cause hypothesis. On the other hand, Sternäng et al. (2015) examined change in cognition as a function of chronological age and a function of change in grip strength using time-variant covariant models (Sternäng et al., 2015). Their findings even suggest that change in grip strength preceded change in several cognitive domains (verbal

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ability, spatial ability, processing speed, and memory), an association that became more evident after age of 65 years, with effects ranging from $\beta = 0.006$ to $\beta = 0.012$.

The finding of more substantial association among older adults may relate to the terminal cognitive decline hypothesis (Kleemeier, 1962; Riegel and Riegel, 1972) which assumes that decline in cognitive functioning accelerates before death and that individual differences in cognitive change in later life are more strongly related to distance to death than to chronological age (Siegler, 1975). Several studies have confirmed that trajectories of cognition (Muniz-Terrera et al., 2013; Piccinin et al., 2011; Wilson et al., 2012) and grip strength (Wilson et al., 2012) are related to impending death (i.e., terminal decline). But no previous study has, to our knowledge, investigated potential associations between change in cognition and change in grip strength in relation to impending death. Thus, given that impending death reflects underlying global biological aging, it is of significance to examine if change in cognition is related to change in grip strength before death.

In the present study, we examine if cognition and grip strength changes conjointly before death, by conducting bivariate growth curve models (e.g., Deary et al., 2011). This is tested in very old individuals, without severe cognitive impairment (i.e., dementia), by using information from up to 5 assessments of both grip strength and multiple tests tapping several cognitive domains (i.e., semantic memory, episodic memory, spatial ability, motor and perceptual speed, short-term memory and working memory). Given that both cognition and grip strength are related to mortality and decline in old age, we expect significant associations of shared common variability of change between cognition and grip strength and that these associations will be profound in this terminal phase of life.

2. Methods

2.1. Participants

Data were drawn from the OCTO-Twin Study (McClearn et al., 1997) including a Swedish population-based twin sample, aged ≥80 years, born in 1893–1913, where both twins were alive at inclusion ($N = 702$ individuals/351 pairs). All participants were informed about the study in accordance with the ethics committee of the Karolinska Institute, the Swedish Data Inspection Board, and the institutional board at the University of Southern California or the Pennsylvania State University. Participants were examined 5 times at 2-year intervals in between 1991–2002. All examinations were conducted by registered nurses in the participant's place of residency with a broad-based behavioral test battery. Test sessions took 3.5–4 hours, including rest periods. Individuals with dementia ($n = 233$) and individuals still alive at the time of the present study ($n = 20$) were excluded in the present analyses. After exclusions, 449 participants remained.

2.2. Measures

Ten tests were used to measure cognitive performance; the tests represent the domains of semantic memory, episodic memory, spatial ability, motor- and perceptual speed, short-term memory, and working memory. The domains of semantic memory, episodic memory, and spatial ability included more than 1 test. For these domains, we constructed factor scores using regression scores of each factor at each measurement.

2.2.1. Semantic memory

The Information test measures general knowledge and is a modified version (Jonson and Molander, 1964) of the Wechsler Adult Intelligence Scale, WAIS (Wechsler, 1981). Maximum score is 44 points. The Synonyms test requires the participant to find a synonym to match a target word; the task taps knowledge of verbal ability and is a part of the Dureman–Sälde battery (Dureman and Sälde, 1959).

2.2.2. Episodic memory

The Memory-in-Reality test first requires the naming of 10 common real-life objects shown to the subject. The subjects are then instructed to place these objects in the different rooms of a three-dimensional model of an apartment, according to their own preferences. Thirty minutes later they are asked to recall the objects followed by a recognition task for the objects not recalled. Subjects are then asked to place the objects in the same locations as they did previously—the relocation test. The maximum score in each subtest is 10 (Johansson, 1988/1989). The present study only uses the recall subtest. Prose Recall is a Swedish prose recall task similar to the prose passages in the Wechsler Memory Test (Wechsler, 1945). To maintain attention during presentation of the story, it was designed to be brief (100 words) and to have a humorous point. Subjects are asked to recall the story after presentation. Responses are coded for the amount of information recalled in a manner similar to the Wechsler Memory Test. The maximum score is 16. Thurstone's Picture Memory is a nonverbal, long-term memory test (Thurstone and Thurstone, 1949). Subjects are shown 28 pictures and then asked for recognition of these among other distractors. The pictures were enlarged from the original version to minimize any possible visual problems. The maximum score is 28.

2.2.3. Spatial ability

Block Design requires reproduction of a pattern shown on a set of cards using red and white blocks and has a maximum score of 42. The Figure Logic task requires the person to identify 1 figure of 5 in a row that is different in concept from the rest. Maximum score is 30. Both are part of the Dureman and Sälde battery (Dureman and Sälde, 1959).

2.2.4. Motor and perceptual speed

A modified version of the speeded Digit–Symbol Substitution Test (Wechsler, 1981) was used which measures motor speed and accuracy. The participant is given a list of symbols associated with digits from 1 to 9 and is asked to fill in the blanks with the symbols that correspond to each number. The test score is the total number of correct sequential matching of digits to symbols in a 90-second interval.

2.2.5. Short-term memory

The Digit Span forward Test measures short-term memory for orally presented digits (Wechsler, 1981). The subjects are asked to recall the digits in the same order as they were presented. The maximum score is 9.

2.2.6. Working memory

The Digit Span backward Test measures working memory for orally presented digits (Wechsler, 1981). The subjects are asked to recall the digits in reverse order. The maximum score is 8 for the backward part of the test.

2.2.7. Grip strength

Grip strength was measured by having participants squeeze a Martin vigorimeter (Elmed Inc., Addison, IL, USA; medium size bulb) 3 times for each hand, with the final score being the maximum force (in pounds per square inch) exerted in the 6 trials.

2.2.8. Age and education

Chronological age at first measurement occasion, gender, and education were included in the analyses. Education was defined as