Associations among age-related rates of change in physical function:

A coordinated analysis

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Abstract

Background: Poor physical function in late life predicts mobility limitations, cognitive decline, dementia, falls and death. Cross-sectional research suggests there are associations across different physical function variables. [may be index vs causal?][Decline in more than one functional domain may…]

Methods: Here, we evaluate whether such associations exist longitudinally across 8-9 studies that are part of the Integrative Analysis of Longitudinal Studies of Aging (IALSA) Network. Bivariate Latent Growth Models…

Results: For men, changes in walking speed were associated with changes in pulmonary function measured by peak expiratory flow. With two exceptions, no associations between grip strength and either walking speed or peak flow were statistically significant in men. No associations between changes over time in any of the variables or studies were significant in women.

Conclusions:

Keywords: Aging, Longitudinal,

no more than 250 words - four sections labelled Background, Methods, Results and Conclusions. T

briefly describe the problem addressed, how the study was performed, the salient results and what conclusions can be made from the results.

Three to ten keywords should be added to the end of the Summary.

KEY MESSAGES

Please include a key messages box with the key messages of the paper in 3-5 succinct bullet points.

Declines in physical function are a well-documented feature of later life with studies showing declines in grip strength, gait, and pulmonary function (Cooper et al., 2011; Jerome, Ko, Kauffman, & Studenski, 2015, Rantanen et al., Ribom, 2010; 1998; Xue et al., 2010; Luigi Ferrucci c, Eleanor M. Simonsick). These declines in physical performance measures can lead to or predict mobility limitations, cognitive decline, dementia, falls and death (Buchman et al., 2008; Brown, Harhay, & Harhay, 2014; Emery, Finkel, & Pedersen, 2012; Laukkanen, Heikkinen, Kauppinen, 1995; Mielke, Roberts, Savica, et al., 2013; Studenski, Perera, Patel, et al. 2011; Waite, Grayson, Piguet, Creasey, Bennett, & Broe, 2005).

Although most studies have examined the effect of only one physical function at a time, associations among the changes in different physical functions may exist and understanding these associations could provide insight into the process by which physical measures impact later life. Based on the cross-sectional evidence, it seems that upper body strength (e.g., grip strength), lower body strength (e.g., walking speed), and pulmonary function are associated (Cook et al., 1995; Buchman et al., 2008, Hirsch et al., 1997; Pegorari, Ruas & Patrizzi, 2013; Rantanen; Guralnik; Izmirlian et al., 1998). Buchman et al., 2008, examined the relationship between extremity muscle strength (e.g. grip strength), respiratory muscle strength, pulmonary function and mortality and found that respiratory muscle strength accounted for the relationship between extremity muscle strength and mortality. Similarly, they also found that the relationship between muscle strength and mortality was mediated by pulmonary function. Furthermore, walking speed and pulmonary function may have a functional association (need to identify and summarize what is out there; [there is a 2013 paper on Nigerian amateur boxers…!]CAN’T FIND THIS PAPER) and grip strength cut-points may help to identify older adults with walking and stair climbing difficulties (Sallinen et al, 2010). Timed-up-and-go, which involves both upper and lower body strength, would be expected to correlate more highly with grip strength than would walking speed alone, due to the construct overlap.

These studies suggest that associations stem from common indexing of general functional decline or from a causal and possibly reciprocal cascade of decline in which one leads to another (Buchman et al., 2008, Jerome, Ko, Kauffman, & Studenski, 2015). For example, loss of physical function may simply reflect general declines associated with biopsychosocial aspects of the aging process. Alternatively, or concurrently, loss in one function may lead to loss in another, such as declining pulmonary function may limit walking speed, which may in turn contribute to loss of pulmonary and cardiac fitness.

Cross-sectional data and analysis, however, represent associations between expected differences among individuals of different ages at a particular point in time, rather than association between changes occurring within individuals over time. Given the risk that these cross-sectional findings may be driven by generational changes (Schaie…) or mean trends (Hofer, Berg & Era, 2003), it is important to validate them, where possible, in longitudinal data. This will address the question of whether it is likely that particular individuals who experience decline in a particular physical function are likely to more or less concurrently experience decline in other physical functions.

The current research simultaneously evaluates cross-sectional, longitudinal, and patterning of associations in the same individuals, and repeats these evaluations in eight-nine longitudinal datasets.

On the assumption that cross-sectional data may overestimate associations among functional performance indices, we expect smaller longitudinal associations. Of these, however, the association between changes in walking speed and changes in pulmonary function to be strongest.

Methods

Samples.

Longitudinal Aging Study Amsterdam (LASA) (Huisman, Poppelaars, Van der Horst, & et al., 2011). The objective of this interdisciplinary cross-sequential study was to examine predictors and consequences of increasing age on autonomy and well-being. Data were collected in 1992/1993, 1995/1996, 1998/1999, 2001/2002, 2005/2006, 2008/2009, 2011/2012. Respondents were recruited from the 3805 respondents of the Living Arrangements and Social Network of Older Adults (LSN) study. At the first data collection time of LASA, 3107 respondents participated in LASA.

English Longitudinal Study of Ageing (ELSA). This sample is mostly composed of respondents aged 50 years and over, living in England, who participated in the Health Survey for England (HSE). The HSE data was collected in 1998, 1999, and 2001. The first wave of ELSA data collection occurred in 2002/03. Six waves of data were collected at approximately two year intervals (2002/03, 2004/05, 2006/07, 2008/09, 2010/11, 2012/13)(I still have to add ref.), however, physical measures were not available at all data collection waves. Data from waves two, four, and six were available for this study.

Origins of Variance in the Oldest-Old (OCTO-Twin). The OCTO-Twin study includes dizygotic (DZ) and monozygotic (MZ) twin pairs aged 80 years of age and older (Johansson et al., 2004; McClearn et al., 1997) selected from older adults participating in the population-based Swedish Twin Registry (Cederlof & Lorich, 1978). The initial sample consisted of 702 individuals (351 same-sex pairs). Five cycles of longitudinal data were then collected at two year intervals.

(couple of sentences and a reference for each study, then point to table for characteristics to compare – less detail than above)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Baseline age range | Number of occasions | Inter-occasion intervals (year) | Sampling | ? |
| Einstein Aging Study |  | 7 | 1 |  |  |
| English Longitudinal Study of Aging |  | 3 |  |  |  |
| Health and Retirement Study |  | 3 (2004,06,10) | 2,4 |  |  |
| ILSE |  | 3 |  |  |  |
| Longitudinal Aging Study Amsterdam |  | 4-5 | 3 |  |  |
| Memory and Aging Project |  | 5 | 1 |  |  |
| Nutrition and Aging |  |  |  |  |  |
| Octogenarian Twins | 80-9x | 5 | 2 |  |  |
| Swedish Adoption Twin Study of Aging |  | 4-5 |  |  |  |

Measures.

Physical Measures. Three physical measures were examined including grip strength, pulmonary function, and lower body strength. The measure varied somewhat from one study to the next. See Table 1 for a description of the measures used from each study.

Covariates. Baseline covariates include age (centered at 80 years), education (in years, centered at 7 years, except ELSA and ILSE, dichotomized as no educational qualification (0) versus qualification (1)) height (centered at 1.72m for men and 1.60m for women), smoking history (non-smoker reference), cardiovascular disease (no symptoms as reference) and diabetes (not diabetic as reference).

|  |  |  |  |
| --- | --- | --- | --- |
|  | Upper body strength (Grip) | Pulmonary function (FEV, PEF) | Lower body strength (Walking)\* |
| Einstein Aging Study | Maximum force; 3 dominant hand trials, grip dynamometer(?) | Maximum of three trials? | Walk 12 ft at usual pace on GAITRite walkway; two trials; average cm/s |
| English Longitudinal Study of Aging | Average force; 6 trials (3 trials per hand); ADD TYPE OF GRIP TOOL (kg) | Maximum of three trials, Vitalograph Micro Spirometer (l in first s (FEV1); waves 2,4,6 | Walk 8 ft at usual pace; Average of two trials;  Walking aids permitted; Waves 1-6; (m/s) |
| Health and Retirement Study | AVERAGE OR MAX force; 2 trials for per hand, Smedley spring-type hand dynamometer (kg) | Average Maximum expiration speed of three trials of Mini-Wright peak flow meter, taken 30s apart. | Walk 98.5in (~2.5m), turn and return; Average of up to two trials (s) |
| ILSE | AVERAGE OR MAX force; 3 trials per hand (+2 practice); Vigorimeter (largest bulb) (kg??? ) | -- | *Timed Up-and-Go*: Stand from chair, walk 3m, return and sit down (s) |
| Longitudinal Aging Study Amsterdam | Average of maximum force from each hand; 2 trials per hand; Takei strain-gauged dynamometer adjusted to each hand (?) | Maximum expiration speed of three trials of Mini-Wright peak flow meter. | Walk 3m, turn and return as quickly as possible (s) |
| Memory and Aging Project | Average force; 2 trials per hand; WHAT TYPE OF TOOL (lbs) | Average of two spirometer trials (l/s) | Time to walk 8m (m/s) |
| Nutrition and Aging | Average of maximum force for each hand; 3 trials per hand; Martin Vigorimeter (KPa) | --- | *Timed Up-and-Go*: Stand from chair, walk 3m, return and sit down (s)  *Gait speed*: faster of two usual pace trials, 4m (s) |
| Octogenarian Twins | Maximum force; 3 trials per hand; Martin Vigorimeter (lbs/in2) | Maximum of three spirometer trials repeated twice (15 mins apart) (l/s) | Normal gait 3m, turn and return (s) |
| Swedish Adoption Twin Study of Aging | Maximum force; 3 trials per hand; dynamometer (kg) | \_\_\_\_trial of portable 10-1 dry bellows Vicatest spirometers (Mijnhardt, Bunnik, The Netherlands) with subjects in seated position and nasal passages blocked with nose clips. Forced expiratory volume during the first second (FEV1) was collected. At IPT3, pulmonary function for 30% of the subjects was measured using the Vicatest, with the remaining assessed using portable ML 330 spirometer (Micor Medical, Kent, United Kingdom). FEV1 values for both spirometers were expressed in BTPS (body temperature and pressure saturated with water vapor). | Normal gait 3m, turn and return (s) |

Note. \*Values for walking speed measured in seconds are reversed so that for all measures in all studies higher scores indicate better performance.

Statistical analysis.

We fit Bivariate Latent Growth models to examine the relationship between growth trends for the multiple physical outcome. This model extends the basic univariate growth model allowing for the examination of the association between individual differences at baseline (intercept-intercept association) and in the rate of change (slope-slope association), and of the association between within-person, time-specific fluctuations around people's long-term developmental trends (occasion-specific residuals, Hofer et al., 2009). In the interest of space, here we focus on correlations among the slopes, though summarize other relevant aspects of the models to provide context. Linear growth models were specified using time since first measurement as the chronological metric. Individually-varying times of observation were used in order to account for variation in time of measurement across individuals. The models were run separately for men and women. Mplus (version 7) was used for fitting the models (Muthén & Muthén, 1998-2011) using full information maximum likelihood (FIML) estimation to address missing data on the dependent variables under the missing at random (MAR) assumption. Parameter estimates were estimated using MLR (Muthén & Muthén, 1998-2010; Yuan & Bentler, 2000). Syntax and output for all models are available at GitHub/IALSA/IALSA-2015-Portland.

Results

*Sex differences.* On average, men had higher scores than women on all physical functions. (compare variability – in EAS men more variable except for gait)

*Age differences.* On average, all of the physical functions showed significant differences across baseline age (LASA; check the rest!!).

*Age changes.* On average, all of the physical functions showed significant declines over time (check, and describe magnitude relative to the cross-sectional differences – and comment). For most of the studies, sexes and variable combinations

*Cross-sectional associations.* Correlations among baseline performance (intercepts) on the physical measures were statistically significant for all variable pairs and both sexes in the ELSA, MAP, and NuAge studies. None of the correlations were significant for EAS or ILSE (Grip Strength and Timed-up-and-go only). HRS and LASA had significant correlations between PEF and walking for both sexes and between PEF and Grip (women only in HRS). Similarly, PEF and Grip were correlated only for women in OCTO-Twin. (SATSA?)

*Longitudinal associations*. No bivariate slope correlations were identified for women among the physical functions studied. For men, pulmonary function and walking speed were correlated for half of the studies (HRS, LASA, OCTO), such that individuals who showed decreased pulmonary function over time also took progressively longer to complete a walking course. In particular, all studies where this correlation was significant, the task was 3m walk, turn and return. Changes in Grip and Timed-up-and-go were significantly associated over time in NuAge. A longitudinal association between pulmonary function and grip was found for LASA alone.

*Time-patterned fluctuations.* Virtually no statistically significant correlations were found between occasion-specific residuals, and those identified were weak: maximum expiration and walking speed for HRS women, and, for men, grip strength and walking in NuAge and grip with timed-up-and-go for ILSE.

Table …. Bivariate Slope Correlations among Physical Functioning Measures for Women

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | FEV-GAIT | | FEV-GRIP | | GAIT-GRIP | | TUG-Grip | |
|  | n | r | se | r | se | r | se | r | se |
| EAS | 150 | -0.444 | 0.76 | -0.152 | 0.875 | 0.412 | 0.484 |  |  |
| ELSA | 3905 | 0.358 | 0.609 | 0.335 | 0.547 | 0.742 | 0.431 |  |  |
| HRS | 286 | 0.578 | 1.189 | -0.523 | 1.109 | 0.12 | 0.987 |  |  |
| ILSE | 224 |  |  |  |  |  |  | 0.488 | 1.13 |
| LASA | 850+ | -0.316 | 0.197 | 0.096 | 1.283 | -0.532 | 3.202 |  |  |
| MAP | 950 | -0.028 | 0.386 | 0.016 | 0.362 | -0.471 | 0.306 |  |  |
| NuAge | 934 |  |  |  |  | -0.104 | 0.116 | -0.26 | 0.17 |
| OCTO | 270 | -0.583 | 0.909 | 0.344 | 0.374 | -0.043 | 0.24 |  |  |
| SATSA |  |  |  |  |  |  |  |  |  |

Table …. Bivariate Slope Correlations among Physical Functioning Measures for Men

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | FEV-GAIT | | FEV-GRIP | | GAIT-GRIP | | TUG-Grip | |
|  | n | r | se | r | se | r | se | r | se |
| EAS | 72 | -0.487 | 1.779 | 0.032 | 2.346 | 0.42 | 2.312 |  |  |
| ELSA | 3210 | 0.261 | 0.303 | 0.336 | 0.29 | 0.426 | 0.299 |  |  |
| HRS | 238 | 0.816 | 0.311 | -0.262 | 0.913 | 0.07 | 0.667 |  |  |
| ILSE | 252 |  |  |  |  |  |  | 0.828 | 6.663 |
| LASA | 800+ | -0.513 | 0.099 | 0.565 | 0.097 | -0.321 | 0.319 |  |  |
| MAP | 325 | -0.475 | 0.59 | -0.027 | 0.393 | 0.345 | 0.327 |  |  |
| NuAge | 847 |  |  |  |  | -0.245 | 0.283 | -0.238 | 0.119 |
| OCTO | 138 | -0.792 | 0.169 | 0.101 | 0.604 | -0.7 | 0.51 |  |  |
| SATSA |  |  |  |  |  |  |  |  |  |

Discussion

Our goal was to study the interdependence of aging-related change in three physical functions. This extends previous cross-sectional research suggesting that associations exist between pulmonary function, walking speed and grip strength in older age. We repeated the analysis in nine studies of aging to provide information regarding the replicability of the findings.

Three patterns emerge very clearly from this analysis. First, both age-related differences and age-related changes reflect decline in (almost) all of the three physical functions considered here, in (almost) all of the studies. This provides both cross-sectional and longitudinal evidence for age-related decline in physical function.

Second, the cross-sectional (intercept-intercept) correlations were statistically significant for all variables and studies except EAS, ILSE, male grip-peak flow in OCTO-Twin and HRS, and grip-walk (male and female) in HRS.

Third, and the focus of the current paper, the longitudinal associations – between changes in the three main functions are (almost always?) smaller than the cross-sectional associations among the functions at baseline. This implies that although all three types of functions are strongly correlated with age (controlling for smoking history, cardiovascular disease and diabetes), meaning that individuals who are older are more likely to perform less well, declines in the different functions do not tend to be associated within an individual. The magnitude of someone’s decline in any once function, after accounting for age, sex, height (SES) and some health characteristics such as smoking history, cardiovascular health and diabetes, does not predict the magnitude of decline in the other functions. The only somewhat consistent exception to this is for pulmonary function and walking speed for men, where change in time to walk a specified distance was negatively correlated with change in peak expiratory flow in half of the studies.

These findings apply across the time scale considered here (i.e., long term, over 6-8 years), and do not necessarily refer to much shorter (e.g., moment to moment) or much longer (e.g., decades) periods. A fourth consistent pattern to note, however, is the lack of association between occasion-to-occasion fluctuations in performance within an individual.

One possible limitation of this research is low reliability of physical functioning measures. However, grip strength in particular has been shown to have high test-retest stability (for average of three trials, ICC=0.81; Wolinsky et al., 2005). Although gait speed was found to be less reliable (for average of two trials, ICC=0.56; Wolinsky et al., 2005), this may be an underestimate due to variations in the course length for half of the participants. In the data considered here, X of XX studies used average performance over 2-3 trials, which may have reduced measurement error.

Ideally, more occasions of measurement would have been available in some of the studies. For example, while the overall ELSA study has six data waves, physical function measures were available for only three each. Several of the other studies had also not collected physical function data at all waves, and HRS measured only a subsample of individuals.

We conclude that correlations between changes in peak flow and walking speed likely reflect a functional link. Although they may represent the joint consequences of fitness loss, the corresponding lack of correlations between changes in upper body strength and pulmonary or lower body strength underscore the greater plausibility of the functional hypothesis. This likely also holds for the association between declines in upper body and timed-up-and-go test. While the designs of long-term longitudinal observational studies do not lend themselves to causal inference, given that we controlled for two common chronic diseases of aging, as well as for smoking history, and that it is generally more sensible to intervene in walking than in pulmonary function, this is yet another reason to advocate for increased physical activity in individuals of all ages.

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**Conflict of Interest:** The authors declare that they have no conflict of interest.

**Ethical approval:** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Acknowledgements:**

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(possibly see also Buchman et al, 2008, Physical frailty in older persons is associated with Alzheimer disease pathology)

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To incorporate in discussion from intro

On average, estimates from longitudinal studies suggest grip strength loss of from 0.71 kg/year over 9 years (in women initially aged 70-79; Xue et al., 2010) to 1.49 kg/year over 27 years (men initially 65-68; Rantanen et al., 1998). In a sample with similar average initial age, but including a wider cross-section of ages, yearly estimated declines reached 2.2 kg/year (over 6 years; MacDonald et al., 2011). Peak expiratory flow loss of 7.4 l/minute were reported in the latter. Cross-sectional evidence, while confounded with generational differences, suggests differences of 0.5 to 0.8 kg/year in men aged 70-80 (Cooper et al., 2011; Ribom, 2010).

Annie – Could you possibly combine the following tables so that this first one contains, rather than each of the years for EAS, the baseline year for each study (in alphabetical order)? I’ve put EAS in col 1 and LASA in col 4 already.

Table 1. Descriptive Statistics for the Participating Studies

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | |  | | Study | |  | |  | |
| Variable |  | | EAS  (n = 2254) | ELSA  (n =) | HRS  (n =) | ILSE | LASA  (n = 3107) | MAP  (n =) | NuAge  (n =) | OCTO-Twin |
|  |  | | M (SD) | M (SD) | M (SD) |  | M (SD) | M (SD) | M (SD) |  |
| Demographic | | |  |  |  |  |  |  |  |  |
| Age, years | | | 78.3 (5.4) |  |  |  | 70.8 |  |  |  |
| Education, years | | | 13.0 (3.7) |  |  |  | 8.76(3.32) |  |  |  |
| Height, cm | | | 163.9 (9.9) |  |  |  | 171.10(8.7) |  |  |  |
| Smoking history(%) | | | 1125 (53.4) |  |  |  | 25.5% |  |  |  |
| Cardiovascular disease (%) | | | 364 (16.8) |  |  |  | 29% |  |  |  |
| Diabetes (%) | | | 365 (16.8) |  |  |  | 7.9% |  |  |  |
| Physical | |  |  |  |  |  |  |  |  |  |
| Peak Expiratory Flow: | |  | 319.3 (120.7) |  |  |  | 403.07 (130.1) |  |  |  |
| Grip Strength: | |  | 20.6 (8.0) |  |  |  | -- |  |  |  |
| Walking Speed: | |  |  |  |  |  | 8.62 (5.93) |  |  |  |
| Study Characteristics | | |  |  |  |  |  |  |  |  |
| Retention to final wave (%) | | | NA |  |  |  |  |  |  |  |
| Representative sample | | | Yes |  |  |  | Yes |  |  |  |
| Oldest Birth Cohort (year) | | | 1898 |  |  |  | 1908 |  |  |  |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  | Year of Assessment | | | | |
| Variable | |  | Baseline  (n = 2254) | Year 2  (n = 1355) | Year 4  (n = 729) | Year 6  (n = 441) | Year 8  (n = 242) |
|  | |  | M (SD) | M (SD) | M (SD) | M (SD) | M (SD) |
| Demographic | | |  |  |  |  |  |
| Age, years | | | 78.3 (5.4) | 79.5 (5.5) | 81.4 (5.2) | 82.8 (5.1) | 84.0 (4.5) |
| Education, years | | | 13.0 (3.7) | 13.5 (3.6) | 13.8 (3.5) | 14.1 (3.5) | 14.1 (3.6) |
| Height, cm | | | 163.9 (9.9) | 163.1 (10.2) | 163.4 (9.9) | 163.8 (10.3) | 162.4 (9.8) |
| Smoking historya (%) | | | 1125 (53.4) | 684 (53.3) | 371 (54.1) | 216 (50.9) | 98 (46.7) |
| Cardiovascular diseasea,b (%) | | | 364 (16.8) | 229 (17.2) | 130 (17.9) | 95 (22.1) | 51 (24.1) |
| Diabetesa (%) | | | 365 (16.8) | 218 (16.4) | 132 (18.2) | 87 (20.3) | 41 (19.3) |
| Physical |  | |  |  |  |  |  |
| Pulmonary: | Peak flow, L/min | | 319.3 (120.7) | 306.3 (112.3) | 301.2 (122.2) | 285.1 (114.6) | 270.3 (121.5) |
| Muscle: | Grip strength, kg | | 20.6 (8.0) | 19.9 (7.9) | 18.8 (8.9) | 18.2 (8.3) | 16.7 (9.1) |
| Cognitive |  | |  |  |  |  |  |
| Global: | MMSE | | 25.7 (2.4) | 25.9 (2.3) | 26.2 (2.3) | 26.4 (1.9) | 26.5 (1.6) |
| Memory: | Logical Memory | | 18.7 (7.2) | 19.8 (7.6) | 20.7 (7.7) | 21.1 (7.5) | 20.8 (8.2) |
| Working M: | Digit Span (total) | | 13.3 (3.7) | 13.6 (3.7) | 14.5 (3.6) | 14.9 (3.6) | 15.1 (3.3) |
| Knowledge: | Vocabulary | | 44.7 (14.1) | 45.7 (13.1) | 45.2 (13.1) | 44.3 (12.9) | 44.0 (12.8) |
| Reasoning: | Block Design | | 19.6 (9.5) | 20.5 (9.6) | 23.4 (9.9) | 24.5 (9.1) | 25.2 (8.7) |
| Speed: | Digit Symbol Coding | | 37.2 (14.8) | 39.2 (14.6) | 42.7 (14.4) | 43.9 (14.7) | 44.1 (12.9) |
| Visuospatial: | Figure Copy Recall | | 10.5 (3.8) | 10.8 (4.1) | 11.4 (4.1) | 11.1 (4.4) | 10.5 (4.6) |
| Executive: | Trail Making Test B | | 157.0 (77.3) | 148.6 (74.7) | 145.3 (72.7) | 149.1 (76.1) | 148.2 (74.) |
| Fluency: | Category | | 35.0 (9.7) | 35.6 (10.1) | 36.2 (10.3) | 35.8 (10.3) | 36.0 (10.9) |
|  | FAS | | 32.7 (13.3) | 34.1 (13.3) | 36.1 (13.6) | 38.0 (13.6) | 38.2 (13.3) |
|  | Boston Naming Task | | 11.2 (2.9) | 11.3 (2.8) | 11.5 (2.9) | 11.6 (2.8) | 11.9 (2.7) |
| Study Characteristics | | |  |  |  |  |  |
| Retention from previous wave (%) | | | NA | 60.2 | 53.8 | 60.5 | 54.9 |
| Representative sample | | | Yes | Yes | Yes | Yes | Yes |
| Oldest Birth Cohort (year) | | | 1898 | 1899 | 1903 | 1908 | 1911 |

a.Dichotomous variable (0=no; 1=yes). b = Cardiovascular disease = History of myocardial infarction or angina or ever had heart failure.

**SLOPE-SLOPE Correlations**

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  | FEMALE | |  |  |  |  |  |  | MALE |  |  |  |  |
|  | FEV-GAIT | | FEV-GRIP | | GAIT-GRIP | | TUG-Grip | | FEV-GAIT | | FEV-GRIP | | GAIT-GRIP | | GRIP-TUG | |
|  | r | se | r | se | r | se |  |  | r | se | r | se | r | se |  |  |
| EAS | -0.444 | 0.76 | -0.152 | 0.875 | 0.412 | 0.484 |  |  | -0.487 | 1.779 | 0.032 | 2.346 | 0.42 | 2.312 |  |  |
| ELSA | 0.358 | 0.609 | 0.335 | 0.547 | 0.742 | 0.431 |  |  | 0.261 | 0.303 | 0.336 | 0.29 | 0.426 | 0.299 |  |  |
| HRS | 0.578 | 1.189 | -0.523 | 1.109 | 0.12 | 0.987 |  |  | 0.816 | 0.311 | -0.262 | 0.913 | 0.07 | 0.667 |  |  |
| ILSE |  |  |  |  |  |  | 0.488 | 1.13 |  |  |  |  |  |  | 0.828 | 6.663 |
| LASA | -0.316 | 0.197 | 0.096 | 1.283 | -0.532 | 3.202 |  |  | -0.513 | 0.099 | 0.565 | 0.097 | -0.321 | 0.319 |  |  |
| MAP | -0.028 | 0.386 | 0.016 | 0.362 | -0.471 | 0.306 |  |  | -0.475 | 0.59 | -0.027 | 0.393 | 0.345 | 0.327 |  |  |
| NuAge |  |  |  |  | -0.104 | 0.116 | -0.26 | 0.17 |  |  |  |  | -0.245 | 0.283 | -0.238 | 0.119 |
| OCTO | -0.583 | 0.909 | 0.344 | 0.374 | -0.043 | 0.24 |  |  | -0.792 | 0.169 | 0.101 | 0.604 | -0.7 | 0.51 |  |  |
| SATSA |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |