Associations among age-related changes 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 domains of physical functioning. Such associations may alternatively index multi-domain functional aging, or may represent causal links among functions. This study evaluated whether, and the extent to which, cross-sectional associations are reflective of correlated longitudinal changes across studies.

Methods: Bivariate Latent Growth Models were applied to nine independent studies in the Integrative Analysis of Longitudinal Studies of Aging (IALSA) Network. Results are combined using fixed-effects meta-analysis.

Results: Changes in physical capability variables considered here were significantly correlated. The most consistent correlations across the nine studies were between change in walking speed and change in pulmonary function measured by peak expiratory flow. Significant associations between change in grip strength and change in walking speed were almost as frequent. Change in peak flow and change in grip strength were only associated in half of the studies.

Conclusions: Physical function declines were found to consistently co-occur within individuals. This is suggestive of a common, underlying process indicative of common aging that crosses domains, however, it may also reflect the interdependence of different functional systems.

Keywords: Aging, Longitudinal, Physical Capability

* Physical capability measures are associated across domains in late adulthood.
* Declines in these physical capabilities are associated over time.
* Occasion-related fluctuations are not associated.

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Declines in physical capability are a well-documented feature of later life with studies showing changes in grip strength, walking speed, and pulmonary function (1-5). These declines in physical capability measures are associated with mobility limitations, cognitive decline, dementia, falls and death (6-13).

Although most studies have examined change in only one physical function at a time (ref?), associations among the changes in different physical functions may exist and understanding these associations could provide insight into the process by which measurable changes in physical capabilities may impact each other as well as mobility and mortality in later life. Cross-sectional evidence suggests that grip strength, walking speed, and pulmonary function are associated (6, 14-16). For example, respiratory muscle strength has been found to account for the relationship between extremity muscle (including hand grip) strength and mortality (Buchman et al., (2008)), and grip strength cut-points have been suggested to help identify older adults with walking and stair climbing difficulties (17). However, mixed results have also been reported (16). For instance, forced inspiratory volume (FIV) but not forced expiratory volume (FEV) was related with lower extremities muscle strength and FIV and FEV were not associated with grip strength (Kayode et al., 2013). More research is needed to disentangle the mixed results with regards to the potential strength of the association between various physical capability measures, and to provide insight into the potential process by which physical capabilities are related.

Several interpretations can arise from such associations. Different functional domains may all be indices of general functional decline (Deary, 2012). Associations may reflect the interdependence of different functional systems, or the mobilization of multiple systems to accomplish particular tasks. For example, timed-up-and-go, which involves both upper and lower body strength, might be expected to correlate more highly with grip strength than would walking speed alone, due to requiring both. Associations may also arise from a cascade of multi-morbid declines in which declines in one domain lead to declines in others (3, 6), and these influences may be reciprocal.

Cross-sectional data and analysis, however, represent associations between expected differences among individuals of different birth cohorts, rather than association between changes experienced by individuals over time. Given the risk that cross-sectional findings may be driven by generational changes (Schaie & Strother, 1968) or mean trends (18), it is important to validate these associations in longitudinal data.

This study addresses the question of whether individuals who experience decline in a particular physical function are more likely to experience concurrent declines in other physical functions. It includes simultaneous evaluation of cross-sectional, longitudinal, and patterning of associations between measures of physical capability in the same individuals, and repeats these evaluations in nine longitudinal datasets to determine the consistency of the findings. Given the expected sex differences in physical capability (Cooper et al. 2011), all analyses are conducted separately in men and women within each study.

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 is expected to be strongest.

Methods

Samples.

Samples are briefly described here and in Table 1. Only participants with physical function data were included in the analysis.

(Table 1 here)

The Einstein Aging Study (EAS) systematically recruited community-dwelling, English-speaking, Bronx, New York residents from Health Care Financing Administration/ Centers for Medicaid and Medicare Services rosters for Medicare-eligible persons (1993-2004), then from New York City Board of Elections (2004 onwards). Visual and/or auditory impairments or psychiatric symptomatology that interfere with neuropsychological testing, and nonambulatory status were excluded (Katz, Lipton et al. 2012). We included 7 waves of data in this study.

The English Longitudinal Study of Ageing (ELSA) is composed primarily of respondents aged 50 and over, living in England, who participated in the Health Survey for England (HSE) in 1998, 1999, and 2001. The first wave of ELSA data collection occurred in 2002/03. Physical capability measures were not available at all data collection waves. Data from waves two, four, and six were available for this study.

Health and Retirement Study (HRS). Physical capability measurements were made in a random subsample of ~3,300 randomly selected respondents in 2004. In 2006, measurement was expanded to half of all participants (randomly selected), who also had follow-up physical measurements in 2010. Only participants assessed in both 2006 and 2004 (19) were included here.

The Interdisciplinary Longitudinal Study of Adult Development (ILSE) includes persons from East (Leipzig and Rostock) and West Germany (Heidelberg, Bonn and Erlangen-Nuremberg), stratified by sex and cohort membership (born 1930-32 and 1950-52). Data from the 1930-32 cohort were analyzed here.

The Longitudinal Aging Study Amsterdam (LASA) (20) objective was to examine predictors and consequences of increasing age on autonomy and well-being. Respondents were recruited in 1992 from the 3805 respondents of the Living Arrangements and Social Network of Older Adults (LSN) study.

The Memory and Aging Project (MAP) began in 1997 with ongoing recruitment (Bennett et al., 2005), primarily through continuous care retirement communities in northeastern Illinois as well as through subsidized retirement homes, local churches, and social service agencies. Individuals were required to be free from dementia at study enrollment, participate in annual clinical evaluations, and agree to donation of their spinal cord and brain at the time of death. There were no other exclusion criteria and all clinical evaluations were conducted as home visits.

The Nutrition as a determinant of successful Aging study (NuAge), is a five-year observational study of 1,793 community-dwelling individuals in good gen­eral health at recruitment in 2003, drawn from a random sample stratified by age and sex obtained from the Québec Medicare database (RAMQ) for the regions of Montreal, Laval, and Sherbrooke in Québec, Canada (Payette et al. 2011, Bouchard et al. 2009). Participants had to be either French or English speaking, willing to commit for the 5 years of the study, free of disabilities in activities of daily living, without cognitive impairment (modified mini mental state examination, 3MS, >79 (Teng and Chui, 1987)), able to walk without assistance (cane acceptable), to walk 300 meters, and to climb 10 stairs without rest. Class II heart failure, chronic obstructive pulmonary disease requiring oxygen therapy or oral steroids, inflammatory digestive diseases, or cancer treated either by radiation therapy, chemotherapy or surgery in the 5 years prior to enrolment were excluded.

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 (21, 22) selected from older adults participating in the population-based Swedish Twin Registry (23). The initial sample consisted of 702 individuals (351 same-sex pairs). Five cycles of longitudinal data were then collected at two year intervals. Only participants not diagnosed with dementia were included in the current analysis.

The Swedish Adoption Twin Study of Aging (SATSA) is a subset of twins from the population-based Swedish Twin Registry. In 1984, twins were mailed the baseline questionnaires (Q1) and a sample of those pairs age 50 years or older in which both twins responded was invited to participate in an additional in-person examination of health and cognitive abilities. In-person testing (IPT1) took place in a location convenient to the twins during a single 4-hour visit. Up to IPT5, new participants were added at each wave as they reached age 50. A total of 7 IPT waves were included in the present analyses, for a total potential follow-up of 19 years (Finkel & Pedersen, 2004).

Measures.

Three physical capability domains were examined: grip strength, pulmonary function, and walking speed. Table 2 provides brief descriptions of the measures used in each study.

(Table 2 here)

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).

Statistical analysis.

Bivariate Latent Growth models were used to examine the relationship between growth trends for the multiple physical outcomes. This model extends the basic univariate growth model, allowing examination of the association between individual differences at baseline (intercept-intercept association) between rates of change (slope-slope association), and between within-person, time-specific fluctuations around people's long-term developmental trends (occasion-specific residuals)(24). Each growth model was 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. Models were run separately for men and women. Mplus (version 7) was used for fitting the models (25) 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 (26, 27). Syntax and output for all models are available at GitHub/IALSA/IALSA-2015-Portland.

Combining estimates.—Results from the studies analyzed here have also been robustly combined to obtain a variance-weighted average effect using meta-analytic techniques (DerSimonian & Laird 1986). Unlike a typical meta-analysis of existing literature, however, our “integrative analysis” is less susceptible to publication bias. We used fixed-effects meta-analysis in STATA 11 to combine our independently obtained estimates and I2 to test for heterogeneity among them. Since the samples differ substantially in size, we use standardized estimates.

Results

*Cross-sectional associations.* In men and women, correlations among baseline performance (intercepts; Table 3) on the physical measures were statistically significant for almost all variable pairs. The only exceptions were PEF-Walking in EAS and in SATSA men, PEF-Grip in SATSA women and EAS, HRS and OCTO men, and TUG-Grip for ILSE women.

(Table 3 here)

*Longitudinal associations*. Most bivariate slope correlations were statistically significant (Table 4). Changes in peak expiratory flow and changes in walking were correlated in all groups except MAP men and women. Individuals who showed decreased pulmonary function over time also took progressively longer to complete a walking course. However, the association for EAS participants, while significant, was in the opposite direction. Changes in walking speed were also quite consistently correlated with changes in grip strength, although this association was not significant for male HRS, female OCTO, and SATSA participants. Correlations between changes in peak flow and changes in grip strength were the least consistent, with only half of them significant in either the male or female subsamples.

*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, peak flow and grip strength for SATSA women, and, for men, grip strength and peak flow in SATSA and grip strength with timed-up-and-go for ILSE (Table 4).

(Table 4 here)

Meta-analysis supports the conclusions that level and change in performance for these three types of physical function are associated and that occasion to occasion fluctuations are not. Forest plots in Figure 1 display the slope-slope correlations for each variable pair by study and sex.

(Figure 1 here)

Discussion

To date, analyses have largely examined domains of physical functioning separately from one another and, when looking at associations between domains, have largely relied on cross-sectional data. Our goal was to study the interdependence of aging-related change in three domains of physical functioning. Further, we replicated the analysis across nine studies of aging and found that results were consistent across studies. This extends previous cross-sectional research suggesting that associations exist between pulmonary function, walking speed and grip strength in older age.

Three patterns emerge very clearly from this analysis. First, in almost all of the studies, cross-sectional (intercept-intercept) correlations between the three types of physical capabilities were statistically significant. Second, the longitudinal (slope-slope) associations between the three types of physical capabilities were statistically significant for virtually all variables and studies. These longitudinal correlations are almost as consistent as, and often larger than, the cross-sectional associations. This suggests that declines in physical capability do not occur in isolation, but tend to co-occur. The magnitude of age-related declines in gait speed, grip strength, and pulmonary function are interrelated among older adults. A third consistent pattern to note is the lack of association between occasion-to-occasion fluctuations in performance within an individual. This suggests that these fluctuations are primarily driven by either random or unrelated processes.

In terms of inconsistencies, three of the studies produced two correlations each that stood in stark contrast to the rest: EAS peak flow and gait, HRS peak flow and grip, ILSE grip and gait, and MAP gait and peak flow for men, gait and grip for women. Except for HRS, gait is the common variable. All of the slope variances were very small and often not statistically significant, so while this was surprising, it would not account for these difference either. A third possibility is that these particular variables in these studies were among those for which the average rate of change was not statistically significant. Combined with the small slope variances this could perhaps have resulted in the anomalous results.

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, for example, 50% of ILSE participants were not assessed on TUG at Wave 3, and HRS measured only a small, though randomly selected, subsample of individuals. Given the variety of physical functioning measures and study designs across studies, the level of agreement is striking.

Our analyses do not provide evidence to assess whether correlations between changes in these functional capability measures reflect a general index of decline, or specific functional links. While the pulmonary-walking changes, for which the functional conclusion would be most plausible, were the most consistently associated, correlations among all the changes were observed suggesting they may represent the joint consequences of fitness loss. While not explored here, it may also be that concurrent simultaneous decline in more than one functional domain may either forebode or reflect other major health events. The designs of long-term longitudinal observational studies do not lend themselves to causal inference, however, we controlled for two common chronic diseases of aging, as well as for smoking history, and either conclusion supports advocating 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.

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Annie: When you get a chance, could you please add -

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Teng and Chui, 1987

Finkel & Pedersen, 2004

DerSimonian & Laird 1986).

Wolinsky et al., 2005

Table 1. Descriptive Baseline Statistics and Characteristics for the Participating Studies

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | Study | | |  | | |  | | |  | |
| Variable | EAS  (n = 222) | ELSA  (n =6602) | | HRS  (n =524) | ILSE (n=476) | | LASA  (n = 1582) | MAP  (n =1240) | | NuAge  (n =1781) | OCTO-Twin (n=402) | | SATSA (n=633) |
|  | M (SD) | M (SD) | | M (SD) | M (SD) | | M (SD) | M (SD) | | M (SD) | M (SD) | | M (SD) |
| Age, years | 78.3 (5.4) | 64.98 (10.0) | | 5.32 (6.49) | 62.96 (.92) | | 70.8 | 78.79 (7.73) | | 74.42 (4.20) | 83.58 (3.2) | | 65.60 (8.47) |
| Education, years | 13.0 (3.7) |  | | 5.56 (3.21) |  | | 8.76 (3.32) | 14.57 (3.21) | | 11.62 (4.51) | 7.14 (2.29) | | 1.60 (0.88) |
| Height, cm | 163.9 (9.9) | 165.27 (9.6) | | 0.08 (0.11) | 168.36 (8.87) | | 171.10 (8.7) | 1.64 (0.10) | | 1.61 (0.09) | 161.68 | | 165.93 (9.78) |
| Smoking history(%) | 53.4 | 63.5 | | 51.9 | 78 | | 25.5% | 46 | | 47.6 | 39 | | 46 |
| Cardiovascular disease (%) | 16.8 | 12.6 | | 30.2 | 29 | | 29% | 10 | | 77.9 | 45 | | 13 |
| Diabetes (%) | 16.8 | 7.4 | | 19.5 | . | | 7.9% | 14 | | 11 | 10.3 | | 3 |
| Peak Expiratory Flow: | 319.3 (120.7) | 2.30 (.9) | | 322.95 (114.12) | --- | | 403.07 (130.1) | 1.69 (0.58) | | --- | 319.69 (108.4) | | 2.24 (0.72) |
| Grip Strength: | 20.6 (8.0) | 27.8 (11.1) | | 0.85 (0.25) | 77.76 (27.84) | | -- | 48.37 (18.95) | | 64.82 (18.15) | 8.96 (9.0) | | 28.99 (12.08) |
| Walking Speed\*: |  | 0.83(.3) | | 29.13 (9.83) | 5.80 (1.28) | | 8.62 (5.93) | 0.65(0.21) | | 4.24 (0.92) | 11.33 (3.75) | | 10.11 (3.17) |
| Study Characteristics |  |  | |  |  | |  |  | |  |  | |  |
| Retention to final wave (%) | NA |  | |  |  | |  | NA | |  | 32% | | 52 |
| Representative sample | Yes | Yes | | Yes |  | | Yes |  | | Yes | Yes | |  |
| Start year | 1993 | 2002 | | 2004 | 1993 | | 1992 | 1997 | | 2003 | 1991 | | 1984 |

Note: \*Timed-up-and-go for ILSE; Final wave not defined for studies with rolling enrolment (EAS and MAP).

Table 2. Physical Capability Variables

|  |  |  |  |
| --- | --- | --- | --- |
|  | Upper body strength (Grip strength) | Pulmonary function (FEV, PEF) | Lower body strength (Walking, TUG)\* |
| Einstein Aging Study | Maximum force; 3 dominant hand trials, grip dynamometer(kg) | Maximum expiration of three trials, peak flow meter, taken 30s apart. | Walk 12 ft at usual pace on GAITRite walkway; Average of two trials; (cm/s) |
| English Longitudinal Study of Aging | Average force; 6 trials (3 trials per hand) (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 of maximum force in 2 trials with dominant hand, Smedley spring-type hand dynamometer (kg) | Average maximum expiration speed of three trials of Mini-Wright peak flow meter, 30s apart. | Walk 98.5in (~2.5m), turn and return; Average of up to two trials (m/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; Jamar hydraulic hand dynamometer (Lafayette Instrument, Lafayette, Ind., USA) (lbs) | Average of two spirometer trials (MicroPlus Spirometer MS03, MicroMedical Ltd.) (l/s) | Time to walk 2.48m (m/s) |
| Nutrition and Aging | Average of maximum force, 3 trials per hand; Martin Vigorimeter (KPa) | --- | *Timed Up-and-Go*: Stand from chair, walk 3m, return and sit down (s)  *Walk*: 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) | FEV1: Forced expiratory volume during the first second; portable 10-1 dry bellows Vicatest spirometer (Mijnhardt, Bunnik, The Netherlands) with subjects in seated position and nasal passages blocked with nose clips. At IPT3, 30% of subjects used Vicatest, the rest used a portable ML 330 spirometer (Micor Medical, Kent, United Kingdom). (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.

Table 3a. Bivariate Intercept 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 | 0.05 | 0.08 | 0.29\* | 0.08 | 0.18\* | 0.08 |  |  |
| ELSA | 3511 | 0.22\* | 0.02 | 0.25\* | 0.02 | 0.36\* | 0.01 |  |  |
| HRS | 286 | 0.29\* | 0.05 | 0.29\* | 0.05 | 0.21\* | 0.06 |  |  |
| ILSE | 224 |  |  |  |  |  |  | -0.06 | 0.07 |
| LASA | 782 | 0.23\* | 0.03 | 0.28\* | 0.03 | 0.34\* | 0.03 |  |  |
| MAP | 950 | 0.24\* | 0.03 | 0.12\* | 0.03 | 0.30\* | 0.03 |  |  |
| NuAge | 934 |  |  |  |  | 0.18\* | 0.03 | 0.27\* | 0.03 |
| OCTO | 270 | 0.35\* | 0.05 | 0.39\* | 0.05 | 0.33\* | 0.05 |  |  |
| SATSA | 367 | 0.38\* | 0.04 | 0.06 | 0.05 | 0.18\* | 0.05 |  |  |

Note: \* p < 0.05

>>> exact p values will be added to these tables as well

[Colours are just to make these easier to look at for now, all peach (salmon?) will be replaced by \*.]

Table 3b. Bivariate Intercept 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 | -0.01 | 0.12 | 0.11 | 0.12 | 0.32\* | 0.11 |  |  |
| ELSA | 3210 | 0.24\* | 0.02 | 0.19\* | 0.02 | 0.28\* | 0.02 |  |  |
| HRS | 238 | 0.30\* | 0.06 | 0.11 | 0.06 | 0.16\* | 0.06 |  |  |
| ILSE | 252 |  |  |  |  |  |  | -0.29\* | 0.06 |
| LASA | 800 | 0.36\* | 0.03 | 0.22\* | 0.03 | 0.32\* | 0.03 |  |  |
| MAP | 325 | 0.22\* | 0.05 | 0.29\* | 0.05 | 0.27\* | 0.05 |  |  |
| NuAge | 847 |  |  |  |  | 0.20\* | 0.03 | 0.25\* | 0.03 |
| OCTO | 132 | 0.38\* | 0.08 | 0.15 | 0.09 | 0.35\* | 0.08 |  |  |
| SATSA | 266 | 0.1 | 0.06 | 0.19\* | 0.06 | 0.76\* | 0.03 |  |  |

Table 4a. 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 | -0.55\* | 0.06 | 0.03 | 0.08 | 0.38\* | 0.07 |  |  |
| ELSA | 3511 | 0.40\* | 0.01 | 0.63\* | 0.01 | 0.50\* | 0.01 |  |  |
| HRS | 286 | 0.58\* | 0.04 | -0.52\* | 0.04 | 0.13\* | 0.06 |  |  |
| ILSE | 224 |  |  |  |  |  |  | -0.49\* | 0.05 |
| LASA | 782 | 0.25\* | 0.03 | 0.03 | 0.04 | 0.69\* | 0.02 |  |  |
| MAP | 950 | -0.028 | 0.03 | 0.016 | 0.03 | -0.47\* | 0.03 |  |  |
| NuAge | 934 |  |  |  |  | 0.10\* | 0.03 | 0.26\* | 0.03 |
| OCTO | 270 | 0.58\* | 0.04 | 0.34\* | 0.05 | 0.043 | 0.06 |  |  |
| SATSA | 367 | 0.35\* | 0.05 | 0.03 | 0.05 | -0.012 | 0.05 |  |  |

Table 4b. 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 | -0.53\* | 0.09 | 0.20 | 0.11 | 0.24 | 0.11 |  |  |
| ELSA | 3210 | 0.34\* | 0.02 | 0.42\* | 0.01 | 0.55\* | 0.01 |  |  |
| HRS | 238 | 0.85\* | 0.02 | -0.16\* | 0.06 | 0.10 | 0.06 |  |  |
| ILSE | 252 |  |  |  |  |  |  | -0.83\* | 0.02 |
| LASA | 800 | 0.40\* | 0.03 | 0.57\* | 0.02 | 0.76\* | 0.01 |  |  |
| MAP | 325 | -0.46\* | 0.04 | -0.03 | 0.06 | 0.35\* | 0.05 |  |  |
| NuAge | 847 |  |  |  |  | 0.25\* | 0.03 | 0.24\* | 0.03 |
| OCTO | 132 | 0.79\* | 0.03 | 0.10 | 0.09 | 0.70\* | 0.04 |  |  |
| SATSA | 266 | 0.55\* | 0.04 | 0.67\* | 0.03 | 0.35\* | 0.05 |  |  |

Table 5a. Bivariate Residual 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 | 0.10 | 0.08 | 0.11 | 0.08 | 0.03 | 0.08 |  |  |
| ELSA | 3511 | 0.02 | 0.02 | 0.01 | 0.02 | 0.06 | 0.02 |  |  |
| HRS | 286 | 0.14\* | 0.06 | 0.08 | 0.06 | 0.02 | 0.06 |  |  |
| ILSE | 224 |  |  |  |  |  |  | -0.10 | 0.07 |
| LASA | 782 | 0.02 | 0.04 | 0.03 | 0.04 | 0.01 | 0.04 |  |  |
| MAP | 950 | 0.02 | 0.03 | 0.03 | 0.03 | -0.01 | 0.03 |  |  |
| NuAge | 934 |  |  |  |  | 0.04 | 0.03 | 0.01 | 0.03 |
| OCTO | 270 | 0.02 | 0.06 | 0.03 | 0.06 | 0.05 | 0.06 |  |  |
| SATSA | 367 | 0.04 | 0.05 | 0.15\* | 0.05 | 0.01 | 0.05 |  |  |

Table 5b. Bivariate Residual 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 | 0.14 | 0.12 | 0.23 | 0.11 | 0.22 | 0.11 |  |  |
| ELSA | 3210 | 0.01 | 0.02 | 0.01 | 0.02 | 0.02 | 0.02 |  |  |
| HRS | 238 | 0.05 | 0.06 | 0.12 | 0.06 | 0.06 | 0.06 |  |  |
| ILSE | 252 |  |  |  |  |  |  | 0.28\* | 0.06 |
| LASA | 800 | 0.03 | 0.04 | -0.05 | 0.04 | 0.05 | 0.04 |  |  |
| MAP | 325 | -0.01 | 0.06 | -0.01 | 0.06 | 0.00 | 0.06 |  |  |
| NuAge | 847 |  |  |  |  | 0.05 | 0.03 | 0.04 | 0.03 |
| OCTO | 132 | 0.05 | 0.09 | 0.14 | 0.09 | 0.13 | 0.09 |  |  |
| SATSA | 266 | -0.05 | 0.06 | 0.14\* | 0.06 | 0.00 | 0.06 |  |  |