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- and random-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, Multivariate Latent Growth Curve Model, Walking Speed, Grip Strength, Pulmonary Function, Coordinated Analysis, Meta-analysis

* 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.

*To be submitted to special issue of IJE. submissions generally <=3000 words Current word count: 3022*

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 (18). 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 might be expected to correlate more highly with grip strength than would walking speed alone, due to requiring both upper and lower body strength. 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 (19) or mean trends (20), 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(1), 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 because walking most directly requires pulmonary fitness.

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 (21). Data from up to seven waves per person were included to avoid small sex-stratified samples in the later waves.

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(22). Physical capability measures were not available at all data collection waves. Data from waves two, four, and six were available for this study. Respondents with dementia were excluded from the analysis.

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 (23) 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; Schmitt, 2006). Data from the Heidelberg and Leipzig 1930-32 cohorts, which have a longer follow-up, were analyzed here.

The Longitudinal Aging Study Amsterdam (LASA) (24) 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. Bivariate models including grip strength, data from the second wave of data (1995/1996) onward were included, as grip strength was not available at the first wave. For models including pulmonary function, respondents from the fifth wave of data (2005/2006) were excluded given that peak expiratory flow was not available for that wave. Respondents with dementia throughout the study were excluded from the analysis.

The Memory and Aging Project (MAP) began in 1997 with ongoing recruitment (25), 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. Individuals who remained free of dementia throughout the study period were included in the current analysis. Data from up to five waves per person were included to avoid small sex-stratified samples in the later waves.

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 (26, 27). 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 (28)), able to walk without assistance (cane acceptable), to walk 300 meters, and to climb 10 stairs without rest. Exclusionary criteria were 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.

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 (29, 30) selected from older adults participating in the population-based Swedish Twin Registry (31). 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. Up to 7 IPT waves were included in the present analyses, for a total potential follow-up of 19 years (32).

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. As walking was measured as time to walk a distance or course in some studies and as velocity in others, those recorded as time were reversed so that higher scores indicate better performance.

(Table 2 here)

Covariates. Baseline covariates include age (centered at 70 years (75 in HRS; 80 in OCTO-Twin)), education (in years, centered at 7 years, except ELSA and ILSE, dichotomized as no educational qualification (0) versus qualification (1), and SATSA, with elementary school as reference point on four point scale) 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; with the exception of ILSE, for which this information was not available).

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)(33). 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 (34) 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 (35, 36). Syntax and output for all models are available online 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 (37). Unlike a typical meta-analysis of existing literature, however, our “integrative analysis” is less susceptible to publication bias, as results from all studies are reported. 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

*Sex differences.* As models for men and women were separately estimated, differences between the sexes were not tested, however, they are described here to provide context. Men had higher average grip strength and peak expiratory flow than women, and showed greater inter-individual variability, except in ILSE, where grip strength variance was smaller for men. In contrast, walking speeds were very similar for men and women, and men had much smaller walking speed variance, except in ELSA and HRS, where the variances were virtually identical for men and women.

*Age differences.* Almost all of the physical capability variables showed significant differences across baseline age. Exceptions include EAS female grip and male gait and peak flow, ELSA female peak flow, HRS male peak flow, and SATSA male grip. Physical capability variables did not vary significantly by age in ILSE, but this is not relevant because participants only varied in age by two years.

*Age changes.* Walking speed showed few average changes or sex differences over time. Declines were statistically significant in only four of the studies: ELSA, HRS, LASA, and SATSA. Grip strength and peak flow declines were more often statistically significant overall, with men declining more quickly for peak flow in all but two studies (ELSA and OCTO) and fewer consistent sex differences in grip strength change.

Variations in rates of change (i.e., residual slope variances) were uniformly small and, with only a few exceptions, not statistically significant. Based on the Wald test, which is known to be too liberal (Hoffman, 2015), only MAP and NuAge grip strength slope variances, LASA and SATSA peak flow slope variances, and male HRS and female ELSA, MAP, NuAge and SATSA walking speed slope variances were significant.

*Cross-sectional associations.* Correlations among baseline performance (intercepts) on the physical capability measures were often statistically significant (Table 3). They were significant for all variable pairs and both sexes in the ELSA, MAP, and NuAge studies. All intercepts in OCTO-Twin were correlated except male peak flow-grip. About half of the intercept correlations were significant in HRS and LASA. Correlations were not significant for EAS, or ILSE (grip-TUG only), and only male grip-peak flow was significant in SATSA.

(Table 3 here)

*Longitudinal associations*. No bivariate slope correlations were identified for women among the physical capabilities studied (Table 4). For men, pulmonary function was correlated with walking speed only in LASA and OCTO: for these individuals, those who showed decreased peak flow over time also took progressively longer to complete a walking course. Peak flow was correlated positively with grip strength in OCTO-Twin, but negatively in LASA.

(Table 4 here)

*Time-patterned fluctuations.* Virtually no statistically significant correlations were found between occasion-specific residuals (Table 5), and those identified were very weak: walking speed with peak flow for HRS women and grip strength for ELSA women, and, for men, grip timed-up-and-go for ILSE.

(Table 5 here)

Meta-analysis supports the conclusions that 1) level of performance for these three types of physical capability are associated; 2) rate of change in performance is not consistently correlated; and 3) occasion to occasion fluctuations are not correlated. Forest plots in Figure 1 display the intercept, slope and residual correlations for each variable pair by study and sex. Sensitivity to model assumptions was considered by replicating this analysis using random effects estimates, which did not change our conclusions.

(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 capability. Further, we replicated the analysis across nine longitudinal studies of aging and found that results were generally consistent across studies. This goes beyond previous cross-sectional research regarding associations between pulmonary function, walking speed and grip strength in older age.

Four patterns emerge rather clearly from this analysis. First, while age-related differences decline in the three physical capabilities considered here are relatively consistent in all studies, age-related changes reflecting within-person declines, are less consistent, particularly for walking speed. This confirms the existence of cross-sectional differences, but suggests that declines are less universal. Second, the cross-sectional (intercept-intercept) correlations are mainly statistically significant, meaning that individuals performing higher on one of the physical capability measures are likely to also perform well on the others.

Third, the longitudinal (slope-slope) associations – between changes in the three main capabilities – are generally not statistically significant. This implies that although all three types of capabilities 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 one capability, after accounting for age, sex, height (SES) and lifestyle and health characteristics such as smoking history, cardiovascular health and diabetes, does not predict the magnitude of decline in the other capabilities. The only slight exception to this might be for pulmonary function and walking speed in men, where change in time to walk a specified distance was correlated with change in peak expiratory flow in two of the nine studies.

The fourth consistent pattern to note is the lack of association between occasion-to-occasion fluctuations in performance within an individual. This suggests either that these fluctuations are driven by either primarily random or unrelated processes.

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; (38)). Although gait speed was found to be less reliable (for average of two trials, ICC=0.56; (38)), 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.

It is important to note the low slope variances identified for many of the variables and studies, as this could be a factor in the lack of correlations between the slopes. This is not solely an issue of statistical power, as correlations were not seen in ELSA, which had the largest sample, though were in LASA, with the second largest, and OCTO, with the oldest. We also adjusted for some lifestyle and health variables that may, more than age, contribute to declines, and to association among declines.

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 capability measures and study designs, the level of agreement is striking.

We used longitudinal data and models, multi-study coordinated analysis, and meta-analysis to comprehensively address the questions of whether performance across three domains of physical capability are associated, whether associations exist among within-person rates of change in these capabilities, and whether occasion-to-occasion fluctuations in these capabilities rise and fall together. Longitudinal analysis that includes statistical control of baseline age differences permitted focus on the changes that occur during the period of observation, independent of the age-related individual differences that exist at baseline. Coordinated analysis provided results from similarly prepared analyses conditioned as much as possible on the same covariates, without imposing harmonization of measurement across studies. Meta-analysis provided a means to combine the results from the multiple studies. Taking together the results obtained here, we find that although people with greater capabilities in one domain tend to also have stronger capabilities in the others, the changes they show over time – either temporarily or over the long term, do not appear to co-occur in the general healthy population. When these co-occur, it is likely to be related to a disease process.

**Funding:** This work was supported by the National Institute on Aging at the National Institutes of Health (grant numbers R01 AG026453, P01 AG043362) for the Integrative Analysis of Longitudinal Studies of Aging (IALSA) research network. Please add funding statements in alphabetical order. The HRS is a cooperative agreement between the National Institute on Aging and the University of Michigan (U01 AG009740). The Interdisciplinary Longitudinal Study of Adult Development (ILSE) was supported by the German Federal Ministry of Family, Senior Citizens, Women and Youth (BMFSFJ) and the Baden-Württemberg Ministry of Science, Research and Art (MWK) grant Ref. 314-1722-102/16. The Memory and Aging Project was supported by the National Institute on Aging at the National Institutes of Health (grant number R01 AG17917). The Swedish Adoption/Twin Study of Aging (SATSA) is supported by R01 AG04563, R01 AG10175, the Swedish Council For Working Life and Social Research (FAS) (97:0147:1B, 2009-0795, 2013-2292) and Swedish Research Council (825-2007-7460, 825-2009-6141, 521-2013-8689). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.

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

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 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) | 164 (10) | 161 (9) | 161.68 | 165.93 (9.78) |
| 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\*: | 96.1 (22.3) | 0.83 (0.3) | 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) |
|  |  |  |  |  |  |  |  |  |  |
| Table 1. (cont’d) Descriptive Baseline Statistics and Characteristics for the Participating Studies | | | | | | | | | |
| Smoking history(%) | 53 | 64 | 52 | 78 | 26 | 46 | 48 | 39 | 46 |
| Cardiovascular disease (%) | 17 | 12 | 30 | 29 | 29 | 10 | 78 | 45 | 13 |
| Diabetes (%) | 17 | 7 | 20 | . | 8 | 14 | 11 | 10 | 3 |
| Study Characteristics |  |  |  |  |  |  |  |  |  |
| N Occasions Modeled | 7 | 3 | 3 | 3 | 4-5 | 5 | 4 | 5 | 6 |
| Inter-occasion Intervals (yrs) | 1 | 4 | 2,4 | 4,8 | 3 | 1 | 1 | 2 | 3 |
| Total follow-up (yrs) | 6 | 8 | 6 | 12 | 12 | 4 | 3 | 8 | 19 |
| Retention to final wave (%) | NA |  | 83 |  |  | 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

For each study and variable: Please clarify whether values modeled were maximum trial or average of maximum force applied in multiple trials.

The variation in means across studies suggests that different units are being used. Please add the units (e.g., (l/s) )

|  |  |  |  |
| --- | --- | --- | --- |
|  | 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) (lbs ) | -- | *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 in first second; portable 10-1 dry bellows Vicatest spirometer until IPT3, when 30% used Vicatest and rest used portable ML 330. (l/s). | 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 | 0.19 | 0.29 | 0.15 | 0.18 | 0.17 |  |  |
| ELSA | 3511 | 0.22\* | 0.04 | 0.25\* | 0.05 | 0.36\* | 0.03 |  |  |
| HRS | 285 | 0.29\* | 0.11 | 0.29\* | 0.09 | 0.21 | 0.13 |  |  |
| ILSE | 224 |  |  |  |  |  |  | -0.06 | 0.23 |
| LASA | 782 | 0.23 | 0.13 | 0.28\* | 0.10 | 0.34 | 0.21 |  |  |
| MAP | 931 | 0.24\* | 0.05 | 0.13\* | 0.04 | 0.30\* | 0.05 |  |  |
| NuAge | 934 |  |  |  |  | 0.18\* | 0.04 | 0.27\* | 0.04 |
| OCTO | 270 | 0.35\* | 0.08 | 0.39\* | 0.07 | 0.33\* | 0.07 |  |  |
| SATSA | 367 | 0.38 | 0.23 | 0.22 | 0.15 | 0.17 | 0.42 |  |  |

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 | 0.53 | 0.11 | 0.38 | 0.32 | 0.45 |  |  |
| ELSA | 3210 | 0.19\* | 0.04 | 0.19\* | 0.04 | 0.28\* | 0.05 |  |  |
| HRS | 236 | 0.30\* | 0.10 | 0.11 | 0.08 | 0.16 | 0.11 |  |  |
| ILSE | 252 |  |  |  |  |  |  | -0.29 | 0.44 |
| LASA | 800 | 0.36\* | 0.06 | -0.22\* | 0.05 | 0.32\* | 1.25 |  |  |
| MAP | 309 | 0.25\* | 0.09 | 0.25\* | 0.07 | 0.31\* | 0.08 |  |  |
| NuAge | 847 |  |  |  |  | 0.20\* | 0.06 | 0.25\* | 0.05 |
| OCTO | 132 | 0.36\* | 0.06 | 0.15 | 0.14 | 0.35\* | 0.14 |  |  |
| SATSA | 266 | 0.10 | 0.34 | -0.21\* | -0.10 | 0.51 | 0.49 |  |  |

Note: \* p < 0.05

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 | 0.52 | 0.03 | 0.80 | 0.38 | 0.50 |  |  |
| ELSA | 3511 | 0.40 | 0.25 | 0.63 | 0.95 | 0.50 | 0.10 |  |  |
| HRS | 285 | 0.58 | 1.21 | -0.52 | 1.12 | 0.13 | 1.00 |  |  |
| ILSE | 224 |  |  |  |  |  |  | 0.40 | 1.63 |
| LASA | 782 | 0.25 | 0.20 | 0.03 | 1.57 | -0.69 | 1.64 |  |  |
| MAP | 931 | -0.03 | 0.39 | 0.16 | 0.37 | -0.46 | 0.31 |  |  |
| NuAge | 934 |  |  |  |  | 0.10 | 0.12 | 0.26 | 0.17 |
| OCTO | 270 | 0.58 | 0.91 | 0.34 | 0.37 | 0.04 | 0.24 |  |  |
| SATSA | 367 | 0.38 | 0.36 | 0.89 | 0.67 | 0.03 | 0.59 |  |  |

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 | 2.63 | 0.20 | 1.84 | 0.24 | 2.86 |  |  |
| ELSA | 3210 | 0.42 | 0.34 | 0.42 | 0.34 | 0.55 | 0.41 |  |  |
| HRS | 236 | 0.85 | 0.48 | -0.16 | 1.17 | 0.10 | 0.76 |  |  |
| ILSE | 252 |  |  |  |  |  |  | -0.84 | 1.24 |
| LASA | 800 | 0.40\* | 0.09 | -0.57\* | 0.09 | 0.76 | 0.60 |  |  |
| MAP | 309 | -0.46 | 0.62 | -0.04 | 0.40 | 0.40 | 0.34 |  |  |
| NuAge | 847 |  |  |  |  | 0.25 | 0.28 | 0.24 | 0.12 |
| OCTO | 132 | 0.40\* | 0.09 | 0.40\* | 0.13 | 0.70 | 0.51 |  |  |
| SATSA | 266 | 0.55 | 0.62 | -0.75 | 0.45 | 0.42 | 0.46 |  |  |

Note: \* p < 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 | 0.12 | 0.11 | 0.10 | 0.03 | 0.10 |  |  |
| ELSA | 3511 | 0.02 | 0.03 | 0.01 | 0.02 | 0.06\* | 0.02 |  |  |
| HRS | 286 | 0.14\* | 0.06 | 0.08 | 0.07 | 0.02 | 0.05 |  |  |
| ILSE | 224 |  |  |  |  |  |  | 0.10 | 0.14 |
| LASA | 782 | 0.02 | 0.03 | 0.03 | 0.04 | 0.01 | 0.03 |  |  |
| MAP | 931 | 0.02 | 0.03 | 0.02 | 0.03 | -0.01 | 0.03 |  |  |
| NuAge | 934 |  |  |  |  | 0.04 | 0.03 | 0.01 | 0.03 |
| OCTO | 270 | 0.02 | 0.07 | 0.03 | 0.06 | 0.05 | 0.05 |  |  |
| SATSA | 367 | 0.04 | 0.06 | -0.05 | -0.08 | 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 | 0.20 | 0.23 | 0.14 | 0.22 | 0.25 |  |  |
| ELSA | 3210 | 0.01 | 0.03 | 0.01 | 0.03 | 0.02 | 0.03 |  |  |
| HRS | 238 | 0.05 | 0.08 | 0.12 | 0.07 | 0.06 | 0.07 |  |  |
| ILSE | 252 |  |  |  |  |  |  | 0.28\* | 0.10 |
| LASA | 800 | 0.03 | 0.03 | 0.05 | 0.03 | 0.04 | 0.05 |  |  |
| MAP | 309 | -0.01 | 0.05 | -0.01 | 0.05 | 0.01 | 0.06 |  |  |
| NuAge | 847 |  |  |  |  | -0.05 | 0.03 | 0.04 | 0.02 |
| OCTO | 132 | 0.03 | 0.03 | 0.14 | 0.09 | 0.13 | 0.09 |  |  |
| SATSA | 266 | -0.05 | 0.07 | -0.16 | -0.04 | 0.02 | 0.07 |  |  |

Note: \* p < 0.05