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Respiratory Impairment and Dyspnea and Their Associations With Physical Inactivity and Mobility in Sedentary Community-Dwelling Older Persons

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Abstract

OBJECTIVES—To evaluate the prevalence of respiratory impairment and dyspnea, and their associations with objectively-measured physical inactivity and performance-based mobility in sedentary older persons.

DESIGN—Cross-sectional.

SETTING—Lifestyle Interventions and Independence in Elder (LIFE) Study.

PARTICIPANTS—1635 community-dwelling older persons, mean age 78.9, who reported a sedentary status (<20 minutes/week in the past month of regular physical activity and <125 minutes/week of moderate physical activity).

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Author Contributions: Dr. Vaz Fragoso had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. All authors made substantial contributions to study concept and design, to data acquisition, analysis and interpretation, and to drafting the submitted article.

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MEASUREMENTS—Respiratory impairment was defined by a reduced ventilatory capacity (forced expiratory volume in 1-second < lower limit of normal [LLN]) and respiratory muscle weakness (maximal inspiratory pressure <LLN). Dyspnea was defined as moderate-to-severe ratings on the modified Borg index, immediately after a 400-meter walk test (400MWT). Physical inactivity was defined by high sedentary time, as the highest quartile of participants with accelerometry-measured activity <100 counts/min. Performance-based mobility was evaluated by the Short Physical Performance Battery (<7 defined moderate-to-severe mobility impairment) and 400MWT gait speed (<0.8 meter/second was defined as slow).

RESULTS—Prevalence rates of reduced ventilatory capacity, respiratory muscle weakness, and dyspnea were 17.7%, 14.7%, and 31.6%, and of moderate-to-severe mobility impairment and slow gait speed were 44.7% and 43.6%, respectively. Significant associations were found between reduced ventilatory capacity and slow gait speed (adjusted odds ratio [95% confidence interval]: 1.41 [1.03, 1.92]), respiratory muscle weakness and moderate-to-severe mobility impairment (1.42 [1.03, 1.95]), and dyspnea with high sedentary time and slow gait speed (1.98 [1.28, 3.06] and 1.70 [1.22, 2.38], respectively).

CONCLUSION—Among sedentary older persons, respiratory impairment and dyspnea are prevalent and associated with objectively-measured physical inactivity or decreased performance-based mobility. Because they are modifiable, respiratory impairment and dyspnea should be considered in the evaluation of sedentary older persons.

Keywords

FEV1; respiratory muscle weakness; dyspnea; sedentary; mobility

INTRODUCTION

With persons aged ≥70 representing the fastest growing segment of the US population,[1] preventing disability throughout later life is an important public health goal.[2] In particular, having a sedentary status is a strong predictor of physical disability in older persons.[3,4] Hence, identifying modifiable factors that contribute to a sedentary status will inform preventive and therapeutic interventions.

A prevalent mechanism that may underlie a sedentary status could include a respiratory impairment.[5] Older persons are at high risk of having a respiratory impairment, given the cumulative effects of exposures to tobacco smoke, respiratory infections, air pollutants, and occupational dusts.[6] In addition, aging itself reduces the physiologic capacity of the respiratory system, including through an increase in the stiffness of the chest wall and a decrease in the elastic recoil of the lung (among other adverse effects).[6]

The diagnosis of respiratory impairment is most often established by spirometric measures, in particular the forced expiratory volume in 1-second (FEV1).[6-9] Because it is a strong predictor of the maximal attainable ventilation during exercise, a low FEV1 suggests a reduced ventilatory capacity.[9] Alternatively, since aging is associated with sarcopenia (decreased skeletal muscle mass and function), respiratory impairment may be also defined as respiratory muscle weakness, based on a decreased maximal inspiratory pressure

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(MIP).[10-13] When substantial, reductions in FEV1 and MIP can lead to a decreased exercise capacity and an increased risk of physical disability.[5,9,12-14]

A prevalent symptom that may contribute to a sedentary status could include dyspnea.[9,15] Prior work has shown that most older persons experience dyspnea when “hurrying on the level or walking up a slight hill”, while 10% experience more severe dyspnea such as “stop for breath when walking at your own pace on the level”.[8] Adverse outcomes related to dyspnea include a decreased exercise capacity and an increased risk of physical disability.[9,15,16]

Among older persons who specifically report a sedentary status, the prevalence of respiratory impairment and dyspnea, and their associations with physical inactivity and impaired mobility have not been rigorously evaluated. No prior study, to our knowledge, has simultaneously collected data on spirometry, MIP, ratings of exertional dyspnea, and objectively-measured physical inactivity and performance-based mobility in sedentary older persons.[13,14,16-18]

The Lifestyle Interventions and Independence for Elders (LIFE) Study is a randomized controlled trial designed to compare a physical activity program with a health education program in 1635 sedentary community-dwelling older persons.[19] The study included age-appropriate assessments of spirometry and MIP, a validated rating of exertional dyspnea, and objectively-measured physical inactivity and performance-based mobility.[6,11,20-28] Accordingly, using baseline data from the LIFE Study, we set out to evaluate the prevalence of FEV1- and MIP-defined respiratory impairment and exertional dyspnea, and their associations with objectively-measured physical inactivity and performance-based mobility. The results of this work may inform the importance of respiratory impairment and dyspnea as potentially modifiable factors that contribute to a sedentary status in community-dwelling older persons.

METHODS

Study Population

The LIFE Study is a multicenter randomized controlled trial comparing a physical activity program with a health education program in 1635 sedentary community-dwelling persons aged 70-89.[19] The assembly of the cohort has been described in detail elsewhere.[29] In brief, eligibility criteria included having a low physical activity, defined as <20 minutes per week in the past month of regular physical activity and <125 minutes per week of moderate physical activity (based on the modified 18-item Community Healthy Activities Model Program for Seniors questionnaire), and impaired lower extremity function, defined as a Short Physical Performance Battery (SPPB) score <10 (but otherwise able to walk 400 meters in ≤15 minutes without assistance).[19,26,27,29,30] The Institutional Review Boards of participating centers approved all study procedures. The present study reports on the baseline evaluation of LIFE participants.

Demographic and Clinical Characteristics

The baseline characteristics included age, sex, body mass index (BMI), smoking status, chronic conditions, health status, and medication use, including respiratory medications, and oxygen therapy.[19,29] The chronic conditions were self-reported, physician-diagnosed arthritis, chronic lung disease (asthma or chronic obstructive pulmonary disease [COPD]), coronary artery disease, diabetes mellitus, heart failure, hypertension, peripheral arterial disease, and stroke. To assess health status, participants were asked, "Would you say your health is excellent, very good, good, fair, or poor?" Decreased health status was defined as a rating of "fair" or "poor." Respiratory medications included use of bronchodilators and corticosteroids, or "pills" for breathing problems, specifically in the prior 3 days. Oxygen therapy included intermittent use, at night or with exercise (regular use of oxygen therapy was an exclusion criterion in the LIFE Study).

Dyspnea

The modified Borg index is a 10-level severity scale that evaluates dyspnea immediately after an exercise activity.[24] Using this scale, dyspnea was defined as none, mild, and moderate-to-severe based on a Borg index of 0, 0.5-2, and >2, respectively.[24] In the LIFE Study, the Borg index was evaluated immediately after the 400-meter walk test (described below).

Respiratory Impairment

Participants who met safety criteria underwent spirometry, using the EasyOne™ PLUS spirometer (NDD Medical Technologies; Andover, MA) and protocols from the American Thoracic Society (ATS).[7] Participants performed at least three trials of a forceful exhalation maneuver that started from maximal inspiration and concluded with a 6-second end-of-test criterion, with the spirometric measure of interest being the FEV1.[7,31] Of the 1,635 LIFE participants, 1362 (83.3%) achieved a quality grade C or higher for FEV1 (at least two acceptable trials) — these latter participants were included in the final analytical sample.

For comparisons between measured and predicted FEV1 values, we used reference equations from the Global Lung Function Initiative (GLI).[21] The use of GLI equations is ideal for aging populations, because they rigorously account for age-related changes in lung function, including the three elements of distribution (mean, coefficient-of-variation, and skewness), and because they are applicable for ages up to 95.[20,21] Using the GLI equations, Z-scores for FEV1 were calculated for each participant, with a Z-score of -1.64 defining the lower limit of normal (LLN) as the 5^{th} percentile of the distribution.[20,21] Participants were classified as having a reduced ventilatory capacity if FEV1<LLN.[9,17,20,21,23]

Next, to assess respiratory muscle weakness as a basis for respiratory impairment, we obtained MIP readings (cm H2O), using a Magnehelic 2000-200 pressure gauge (Dwyer Instruments, Michigan City, IN). Of the 1,635 LIFE participants, 1401 (88.9%) had at least 2 MIP readings recorded (1260 participants had five MIP readings). Of these 1401 participants, 1373 (84.0%) achieved a variability ≤10 cm H2O for the two highest MIP readings (including when only two MIP readings were recorded) — these 1373 participants were included in the final analytical sample.

For comparisons between measured and predicted MIP values, we used reference equations from the Multi-Ethnic Study of Atherosclerosis Lung Study (MESA), which included participants aged 45-84.[11] Using the MESA equations, participants were classified as having respiratory muscle weakness if the highest MIP reading was <LLN (<5th percentile of the distribution of reference values).[11]

Physical Activity and Performance-Based Mobility

Physical activity was measured by accelerometry, using the ActiGraph GT3X (ActiGraphTM LLC, Pensacola, FL) over a period of 7-days. Sedentary time was defined by percent of wear-time with activity <100 counts/minute, averaged across days.[25] Participants who were in the highest quartile were classified as having high sedentary time.

Mobility-related measures included the Short Physical Performance Battery (SPPB) and 400-meter walk test (400MWT). The SPPB is a summary performance measure consisting of time to walk 4 meters at usual pace, time to complete five chair stands, and three increasingly difficult standing balance maneuvers.[26,27] An SPPB score ≤7 was selected to identify participants as having moderate-to-severe mobility impairment (relative to scores of 8 and 9, which were considered mild mobility impairment). The 400MWT was completed at the participant's usual walking pace over a 40-meter course. A gait speed of <0.8 meter/second was operationalized as slow.[28]

Statistical Analysis

The baseline characteristics of the study population, including continuous measures of dyspnea, FEV1, MIP, accelerometry, SPPB, and 400MWT, were summarized as means and standard deviations or as counts and percentages. In addition, using the earlier described diagnostic thresholds, the frequency distributions of dyspnea severity, respiratory impairment, moderate-to-severe mobility impairment, and slow gait speed were also summarized.

Next, using a logistic regression model that was adjusted for age, height, sex, race, smoking, BMI, number of chronic conditions, health status, and LIFE field site, odds ratios with 95% Wald confidence intervals were calculated as measures of the association of respiratory impairment and dyspnea severity, respectively, with high sedentary time, moderate-to-severe mobility impairment, and slow gait speed. Respiratory impairment included reduced ventilatory capacity and respiratory muscle weakness. Dyspnea severity included mild and moderate-to-severe levels, as defined by the Borg index.

All statistical analyses were performed using SAS v9.2 (SAS Institute; Cary, NC).

RESULTS

Table 1 summarizes baseline demographic and clinical characteristics. The mean age was 78.9 years; 67.2% were female, 78.9% were white, and the mean BMI was 30.2 kg/m^2, with 46% of participants having a BMI ≥30 kg/m^2. A smoking history, including former and current smoking, was reported by 48.1% of participants. The mean number of chronic conditions was 2.0, with chronic lung disease reported in 15.6% of participants.

Cardiovascular conditions (including risk factors) were also prevalent, with hypertension, diabetes, peripheral arterial disease, coronary artery disease, stroke, and heart failure reported by 71.0%, 25.4%, 9.1%, 7.9%, 6.7%, and 5.9% of participants, respectively. Respiratory medications were used by 10.9%, while oxygen was used by 2.0%. Fair-to-poor health status was reported by 34.8% of participants. Any dyspnea, as defined by the Borg Index, was reported by 82.1%, being moderate-to-severe in 31.6%.

Table 2 summarizes the results for baseline spirometry, MIP, sedentary time, and mobility. Using the previously described diagnostic thresholds for FEV1 and MIP, the prevalence rates of respiratory impairment as defined by reduced ventilatory capacity and respiratory muscle weakness were 17.7% and 14.7%, respectively. Similarly, using the previously described diagnostic thresholds for mobility, the prevalence rates of moderate-to-severe mobility impairment and slow gait speed were 44.7% and 43.6%, respectively.

Table 3 shows the adjusted odds ratios (95% confidence intervals) for high sedentary time, moderate-to-severe mobility impairment, and slow gait speed, according to respiratory impairment and dyspnea severity. Reduced ventilatory capacity was significantly associated with slow gait speed — adjusted odds ratio (aOR) 1.41 (1.03, 1.92), with borderline associations observed for high sedentary time and moderate-to-severe mobility impairment — aORs 1.42 (0.97, 2.07) and 1.32 (0.98, 1.78), respectively. Respiratory muscle weakness was significantly associated with moderate-to-severe mobility impairment — aOR 1.42 (1.03, 1.95), with a borderline association observed for slow gait speed — aOR 1.36 (0.97, 1.90). Dyspnea, when rated as moderate-to-severe on the Borg scale, was significantly associated with high sedentary time and slow gait speed — aORs 1.98 (1.28, 3.06) and 1.70 (1.22, 2.38), respectively. Otherwise, mild dyspnea was not significantly associated with any outcome, with the only exception being a borderline association with high sedentary time — aOR 1.47 (0.98, 2.20).

DISCUSSION

In a large sample of sedentary community-dwelling older persons, we found that respiratory impairment, when defined as reduced ventilatory capacity, occurred in 17.7% of participants and was significantly associated with a 41% increased odds of having slow gait speed. Similarly, respiratory impairment, when defined as respiratory muscle weakness, was also prevalent, occurring in 14.7% of participants, and was significantly associated with a 42% increased odds of having moderate-to-severe mobility impairment. We also found that dyspnea, when rated as moderate-to-severe immediately after the 400MWT, was especially prevalent, occurring in 31.6% of participants and was significantly associated with a 98% and 70% increased odds of having high sedentary time and slow gait speed, respectively.

Our results suggest that a reduced ventilatory capacity should be considered when evaluating older persons who report a sedentary status. The prevalence of a reduced ventilatory capacity was substantial and was significantly associated with slow gait speed, an important indicator of physical frailty that increases the risk of injurious falls, cognitive impairment, disability, institutionalization, and mortality.[28,32-34] In contrast, the associations of a reduced ventilatory capacity with high sedentary time and moderate-to-severe mobility impairment were not statistically significant. These differences in associations further suggest that a reduced ventilatory capacity has a greater effect on endurance (slow gait speed was determined during the 400MWT), than on measures that establish physical inactivity (high sedentary time) or require a short walking distance (moderate-to-severe mobility impairment was based on the SPPB, which included only 4 meters of walking).

As discussed earlier, we established a reduced ventilatory capacity based on a low FEV1 (<LLN).[9] Because a low FEV1 is often due to cardiopulmonary disease,[6-9,35] it is likely that cardiopulmonary mechanisms contributed to the high prevalence of reduced ventilatory capacity among LIFE participants, including its association with slow gait speed. Life participants had a frequent smoking history (48.1%) and high rates of chronic lung disease, including asthma or COPD (15.6%), and of cardiovascular conditions and related risk factors, including hypertension (71.0%), obesity (46.0%), diabetes (25.4%), coronary artery disease (7.9%), stroke (6.7%), and heart failure (5.9%).

Our results also suggest that respiratory muscle weakness should be considered when evaluating older persons who report a sedentary status. The prevalence of respiratory muscle weakness was substantial and was associated with moderate-to-severe mobility impairment. The latter is highly predictive of disability in activities of daily living and mobility-related disability.[36]

Because the SPPB included tasks that require lower extremity proximal muscle strength (chair stands and difficult standing balance maneuvers), we postulate that the association between respiratory muscle weakness and moderate-to-severe mobility impairment was due to a sarcopenic state which adversely affected the muscles of breathing (decreased MIP) and the muscles of ambulation (decreased SPPB).[9-13,15] Risk factors for having a sarcopenic state were common among LIFE participants, including advanced age, sedentary lifestyle (deconditioning), obesity, and cardiopulmonary disease.[10]

Similarly, exertional dyspnea should be considered when evaluating older persons who report a sedentary status. LIFE participants frequently described moderate-to-severe dyspnea immediately after the 400MWT, and this was associated with slow gait speed and high sedentary time. These results may again reflect underlying cardiopulmonary disease and sarcopenia, including the effect of dyspnea as a symptom limitation on endurance (slow gait speed) and with physical inactivity (high sedentary time) as a potential compensatory response.[8-10,12-18]

The present study has two major strengths. First, it evaluated a highly vulnerable population of older persons, whose sedentary status increases the risk of future disability.[3,4] Second, it evaluated objective measures of respiratory impairment, physical inactivity, and performance-based mobility, as well as a rating of exertional dyspnea based on the 400MWT. The respiratory impairment additionally included an age-appropriate method for reporting the FEV1,[6,20,21] not previously evaluated regarding its association with physical inactivity and performance-based mobility.

Nonetheless, we acknowledge that the baseline (cross-sectional) evaluation of LIFE participants cannot establish cause-effect relationships. The longitudinal component of the

LIFE Study may, however, provide important insights. Because exercise can improve cardiovascular conditions and related risk factors, as well as sarcopenia,[9,10,37-40] we hypothesize that the exercise program in the LIFE Study may improve respiratory impairment and dyspnea, and, in turn, physical activity and mobility. We plan to test this hypothesis when the LIFE longitudinal data become available.

We acknowledge three other limitations. First, we excluded from analysis participants who had not achieved an acceptable FEV1 and MIP (16.7% and 16.0%, respectively). Older persons who cannot adequately perform spirometry or MIP are likely to be more physically frail and, as a result, have a sedentary status and decreased mobility.[2,32-34,41] Second, because the LIFE Study only included sedentary individuals who had functional limitations but were otherwise non-disabled (able to complete the 400MWT without assistance), the range of scores on measures of physical activity and mobility was constrained and likely attenuated the associations of interest. Third, several other factors may have also impacted the associations of interest. In particular, prior work suggests that sarcopenia of the muscles of ambulation and psychosocial factors may contribute independently to decreased mobility and physical inactivity, including among individuals who have COPD (i.e., have a respiratory impairment).[10,35,42,43] These same factors potentially increase the risk of other adverse outcomes, such as worsening of symptom-limiting dyspnea and hospitalization.[9,10,15,43] Consequently, when the longitudinal data of the LIFE Study become available, we plan to evaluate whether measures of peripheral muscle strength (i.e., grip strength) and psychosocial factors mediate the effects of respiratory impairment (i.e., reduced ventilatory capacity or respiratory muscle weakness) and dyspnea on a broad array of adverse outcomes, including the development of slow gait speed, moderate-to-severe mobility impairment, mobility disability (unable to complete the 400MWT), physical inactivity, and hospitalization.

In conclusion, among sedentary community-dwelling older persons, we found that respiratory impairment and dyspnea were prevalent and associated with objectively-measured physical inactivity or decreased performance-based mobility. Because they are modifiable, respiratory impairment and dyspnea should be considered in the evaluation of sedentary older persons.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Research investigators for the LIFE Study group are listed in the On-Line Appendix.

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REFERENCES

1. Manton KG, Vaupel JW. Survival after the age of 80 in the United States, Sweden, France, England, and Japan. N Engl J Med. 1995; 333(18):1232–1235. [PubMed: 7565998]
2. Branch LG, Guralnik JM, Foley DJ, et al. Active life expectancy for 10,000 Caucasian men and women in three communities. J Gerontol. 1991; 46(4):M145–150. [PubMed: 2071836]
3. Buchner DM, Beresford SA, Larson EB, et al. Effects of physical activity on health status in older adults. II. Intervention studies. Annu Rev Public Health. 1992; 13:469–488. [PubMed: 1599599]
4. Stuck AE, Walthert JM, Nikolaus T, et al. Risk factors for functional status decline in community-living elderly people: a systematic literature review. Soc Sci Med. 1999; 48(4):445–469. [PubMed: 10075171]
5. Vaz Fragoso CA, Enright PL, McAvay G, et al. Frailty and respiratory impairment in older persons. Am J Med. 2012; 125:79–86. [PubMed: 22195532]
6. Vaz Fragoso CA, Gill T. Respiratory Impairment and the aging lung: a novel paradigm for assessing pulmonary function. J Gerontol Med Sci. 2012; 67:264–275.
7. Pellegrino R, Viegi G, Brusasco V, et al. Interpretative strategies for lung function tests. Eur Respir J. 2005; 26:948–968. [PubMed: 16264058]
8. Enright P, Kronmal RA, Higgins MW, et al. Prevalence and correlates of respiratory symptoms and disease in the elderly. Chest. 1994; 106:827–834. [PubMed: 8082366]
9. American Thoracic Society/American College of Chest Physicians (ATS/ACCP) Statement on Cardiopulmonary Exercise Testing. Am J Respir Crit Care Med. 2003; 167:211–277. [PubMed: 12524257]
10. Cruz-Jentoft AJ, Baeyens JP, Bauer JM, et al. Sarcopenia: European consensus on definition and diagnosis. Report of the European Working Group on Sarcopenia in Older People. Age Ageing. 2010; 39:412–423. [PubMed: 20392703]
11. Sachs MC, Enright PL, Stukovsky KDH, et al. Performance of maximum inspiratory pressure tests and maximum inspiratory pressure reference equations for 4 race/ethnic groups. Respir Care. 2009; 54(10):1321–1328. [PubMed: 19796411]
12. van der Palen J, Rea TD, Manolio TA, et al. Respiratory muscle strength and the risk of incident cardiovascular events. Thorax. 2004; 59(12):1063–1067. [PubMed: 15563706]
13. Enright PL, Kronmal RA, Manolio TA, et al. Respiratory muscle strength in the elderly; correlates and reference values. Am J Respir Crit Care Med. 1994; 149:430–438. [PubMed: 8306041]
14. Vaz Fragoso CA, Gill TM, McAvay G, et al. Respiratory impairment in older persons: when less means more. Am J Med. 2013; 126:49–57. [PubMed: 23177541]
15. American Thoracic Society Statement: update on the mechanisms, assessment, and management of Dyspnea. Am J Respir Crit Care Med. 2012; 185:435–452. [PubMed: 22336677]
16. Huijnen B, van der Horst F, van Amelsvoort L, et al. Dyspnea in elderly family practice patients. Occurrence, severity, quality of life and mortality over an 8-year period. Family Practice. 2006; 23:34–39. [PubMed: 16115834]
17. Vaz Fragoso CA, Concato J, McAvay G, et al. Staging the severity of chronic obstructive pulmonary disease in older persons based on spirometric Z-scores. J Am Geriatr Soc. 2011; 59:1847–1854. [PubMed: 22091498]
18. Sin DD, Jones RL, Mannino DM, Man SFP. Forced expiratory volume in 1 second and physical activity in the general population. Am J Med. 2004; 117:270–273. [PubMed: 15308437]
19. Fielding RA, Rejeski WJ, Blair S, et al. The lifestyle interventions and independence for elders study: design and methods. J Gerontol Med Sci. 2011; 66A(11):1226–1237.
20. Stanojevic S, Wade A, Stocks J, et al. Reference ranges for spirometry across all ages. Am J Respir Crit Care Med. 2008; 177:253–260. [PubMed: 18006882]
21. Quanjer PH, Stanojevic S, Cole TJ, et al. Multi-ethnic reference values for spirometry for the 3-95 year age range: the global lung function 2012 equations. Eur Respir J. 2012; 40(6):1324–1343. [PubMed: 22743675]
22. Vaz Fragoso CA, Gill TM, McAvay G, et al. Respiratory impairment and mortality in older persons: a novel spirometric method. J Invest Med. 2011; 59(7):1089–1095.

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23. Vaz Fragoso CA, Concato J, McAvay G, Van Ness PH, Gill TM. Respiratory impairment and COPD hospitalization: a competing risk analysis. Eur Respir J. 2012; 40:37–44. [PubMed: 22267770]
24. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982; 14:377–381. [PubMed: 7154893]
25. Clark BK, Healy GN, Winkler EAH, et al. Relationship of television time with accelerometer-derived sedentary time: NHANES. Med Sci Sports Exerc. 2011; 43(5):822–828. [PubMed: 20980928]
26. Guralnik JM, Ferrucci L, Pieper CF, et al. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. J Gerontol Med Sci. 2000; 55(4):M221–231.
27. Guralnik JM, Simonsick EM, Ferucci L, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality in nursing home admission. J. Gerontol. 1994; 49:M85–94. [PubMed: 8126356]
28. Studenski S, Perera S, Patel K, et al. Gait speed and survival in older adults. JAMA. 2011; 305(1): 50–58. [PubMed: 21205966]
29. Marsh AP, Kennedy K, Lovato LC, et al. Lifestyle Interventions and Independence for Elders Study: Recruitment and Baseline Characteristics. J Gerontol Med Sci. 2013; 68(12):1549–1558.
30. Stewart AL, Verboncoeur CJ, McLellan BY, et al. Physical activity outcomes of CHAMPS II. J Gerontol Med Sci. 2001; 56(8):M465–470.
31. Allen SC, Yeung P. Inability to draw intersecting pentagons as a predictor of unsatisfactory spirometry technique in elderly hospital inpatients. Age and Ageing. 2006; 35:304–316. [PubMed: 16638772]
32. Fried L, Tangen M, Walston J, et al. Frailty in older adults: Evidence for a phenotype. J Gerontol Med Sci. 2001; 56A:M146–156.
33. Rothman MD, Summers LL, Gill TM. Prognostic significance of potential frailty criteria. J Am Geriatr Soc. 2008; 56:2211–2216. [PubMed: 19093920]
34. Abellan van Kan G, Rolland Y, Andrieu S, et al. Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people. J Nutr Health Aging. 2009; 13(10):881–9. [PubMed: 19924348]
35. Chan ED, Welsh CH. Geriatric Respiratory Medicine. Chest. 1998; 114:1704–1733. [PubMed: 9872208]
36. Guralnik JM, Ferrucci L, Simonsick EM, et al. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. New Engl J Med. 1995; 332:556–561. [PubMed: 7838189]
37. Babb TG, Wyrick BL, Chase PJ, et al. Weight loss via diet and exercise improves exercise breathing mechanics in obese men. Chest. 2011; 140(2):454–460. [PubMed: 21273293]
38. Ries AL, Bauldoff GS, Carlin BW, et al. Pulmonary rehabilitation: Joint ACCP/AACVPR evidence-based clinical practice guidelines. Chest. 2007; 131:S4–42.
39. ACC/AHA 2005 Guideline Update for the Diagnosis and Management of Chronic Heart Failure in the Adult. Circulation. 2005; 112:e154–e235. [PubMed: 16160202]
40. Roubenoff R, Hughes VA. Sarcopenia: current concepts. J Gerontol Med Sci. 2000; 55A:M716–724.
41. Griffith KA, Sherrill DL, Siegel EM, et al. Predictors of loss of lung function in the elderly: the Cardiovascular Health Study. Am J Respir Crit Care Med. 2001; 163:61–68. [PubMed: 11208627]
42. Serres I, Gautier V, Préfault C, Varray A. Impaired skeletal muscle endurance related to physical inactivity and altered lung function in COPD patients. Chest. 1998; 113:900–905. [PubMed: 9554623]
43. Garcia-Aymerich J, Farrero E, Félez MA, et al. Risk factors of readmission to hospital for a COPD exacerbation: a prospective study. Thorax. 2003; 58:100–105. [PubMed: 12554887]

Table 1

Baseline demographic and clinical characteristics

Characteristic	N[a]	Mean ± SD or No. (%)
Age (years)	1,635	78.9 ± 5.2
Females		1098 (67.2)
White		1290 (78.9)
BMI (kg/m^2)		30.2 ± 6.1
BMI ≥30, No. (%)		752 (46.0)
Smoking status		
Never	1,606	834 (51.9)
Former		722 (45.0)
Current		50 (3.1)
Number of chronic conditions[b]	1,631	2.0 ± 1.2
Hypertension	1,621	1151 (71.0)
Diabetes mellitus	1,628	414 (25.4)
Arthritis	1,625	318 (19.6)
Chronic lung disease[c]	1,627	253 (15.6)
Peripheral arterial disease[d]	1,631	149 (9.1)
Coronary artery disease	1,627	129 (7.9)
Stroke	1628	109 (6.7)
Heart failure	1622	96 (5.9)
Respiratory medication use	1,634	178 (10.9)
Oxygen therapy		32 (2.0)
Fair-to-poor health status	1,629	567 (34.8)
Dyspnea severity		
Borg index (400MWT)[e]	1,632	1.1 ± 0.7
0 (none)		292 (17.9)
0.5-2 (mild)		824 (50.5)
>2 (moderate-to-severe)		516 (31.6)

Abbreviations: BMI, body mass index; SD, standard deviation; SPPB, short physical performance battery; 400MWT, 400-meter walk test.

[a]N varies as a consequence of missing values.

[b]Self-reported, physician-diagnosed.

[c]Asthma or chronic obstructive pulmonary disease (chronic bronchitis or emphysema).

[d]Included a self-reported, physician-diagnosis or prior hospitalization for an operation or procedure to improve the blood flow to the legs (i.e., angioplasty or stent).

[e]Includes the following scale: 0, 0.5, 1, and continuing as integers up to 10.

Table 2

Baseline spirometry, maximal inspiratory pressure, sedentary time, and mobility

Characteristic	**N[a]**	**Mean ± SD or No. (%)**
Spirometry		
FEV1, Liters	1,362	1.86 ± 0.57
Reduced ventilatory capacity[b]		241 (17.7)
Maximal inspiratory pressure (MIP), cm H2O	1,373	59.2 ± 22.6
Respiratory muscle weakness[c]		202 (14.7)
Sedentary time [d]	1,306	77.4 ± 7.7
Mobility		
SPPB score	1,635	7.4 ± 1.6
Moderate-to-severe mobility impairment[e]		731 (44.7)
400-meter walk time (seconds)		508.9 ± 114.1
Slow gait speed[f]		712 (43.6)

Abbreviations: FEV1, forced expiratory volume in 1-second; LLN, lower limit of normal; SD, standard deviation; SPPB, short physical performance battery; 400MWT, 400-meter walk test.

[a]N varies as a consequence of missing values.

[b]FEV1<LLN.

[c]MIP<LLN.

[d]Percent of wear-time with activity <100 counts/min, averaged across days.

[e]SPPB≤7.

[f]<0.8 meter/second (400MWT).

Table 3

Adjusted odds ratios (OR) for high sedentary time, moderate-to-severe mobility impairment, and slow gait speed, according to respiratory impairment[a] and dyspnea severity[b]

Characteristic	High Sedentary Time[c]	Moderate-to-Severe Mobility Impairment[d]	Slow Gait Speed[e]
	Adjusted OR (95% Confidence Interval)[f]		
Respiratory impairment [g]			
Reduced ventilatory capacity	1.42 (0.97, 2.07)	1.32 (0.98, 1.78)	1.41 (1.03, 1.92)
Respiratory muscle weakness	1.04 (0.68, 1.60)	1.42 (1.03, 1.95)	1.36 (0.97, 1.90)
Dyspnea severity			
Borg 0.5-2 (mild)	1.47 (0.98, 2.20)	1.10 (0.82, 1.47)	1.12 (0.83, 1.53)
Borg >2 (moderate-to-severe)	1.98 (1.28, 3.06)	1.31 (0.95, 1.80)	1.70 (1.22, 2.38)

Abbreviations: BMI, body mass index; FEV1, forced expiratory volume in 1-second; LLN, lower limit of normal; MIP, maximal inspiratory pressure; OR, odds ratio; SPPB, short physical performance battery; 400MWT, 400-meter walk test.

[a] Logistic regression model, with ≥LLN as the reference group.

[b] Logistic regression model, with no dyspnea (Borg index of 0) as the reference group.

[c] Highest quartile of sedentary time vs. the lower three quartiles of sedentary time (accelerometry). Sedentary time is defined as percent of wear-time with activity <100 counts/min, averaged across days.

[d] SPPB score ≤7 vs. scores of 8 and 9.

[e] 400MWT gait speed < vs. ≥0.8 meter/second.

[f] Adjusted for age, height, sex, race, smoking, BMI, # of chronic conditions, health status, and LIFE field site.

[g] Included reduced ventilatory capacity (FEV1<LLN) and respiratory muscle weakness (MIP<LLN).