Correlations Between Gait Speed, 6-Minute Walk Distance, Physical Activity, and Self-Efficacy in Patients With Severe Chronic Lung Disease

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BACKGROUND: Four-meter gait speed (4MGS) has been associated with functional capacity and overall mortality in elderly patients, and may easily be translated to daily practice. We evaluated the association of 4MGS with meaningful outcomes. METHODS: In 70 subjects we conducted the 4MGS, 6-min walk test (6MWT), objectively measured physical activity, and assessed dyspnea, quality of life, and self-efficacy for walking and routine physical activity. 4MGS was measured in 3 separate time epochs during the 6MWT, to explore 4MGS variability. RESULTS: Diagnoses included COPD (51.4%), interstitial lung disease (38.6%), and other pulmonary conditions (10%). The mean ± SD values were: 4MGS 0.85 ± 0.21 m/s, 6-min walk distance (6MWD) 305 ± 115 m, and physical activity level 1.28 ± 0.17, which is consistent with severe physical inactivity. The gait speeds within the time epochs 1–2, 3–4, and 5–6 min during the 6MWT were not significantly different: 1.01 ± 0.29 m/s, 0.98 ± 0.31 m/s, and 1.00 ± 0.31 m/s, respectively. 4MGS had a significant correlation with 6MWD ($r = 0.70$, $P < .001$). 6MWD was the dominant variable for predicting 4MGS. Other significant predictors of 4MGS included dyspnea, self-efficacy, quality of life, and objectively measured physical activity. CONCLUSIONS: 4MGS is significantly and independently associated with 6MWD, and may serve as a reasonable simple surrogate for 6MWD in subjects with chronic lung disease. Gait speed was remarkably stable throughout the 6MWT, which supports the validity of an abbreviated walk test such as 4MGS. *Key words: gait speed; 6-min walk test; exercise capacity; COPD; interstitial lung disease.* [Respir Care 2013;58(12):2113–2119. © 2013 Daedalus Enterprises]

Introduction

Usual gait speed measured over 4 meters (4MGS) is associated with clinically important outcomes in the elderly, including perceived well-being, disability, cognitive impairment, nursing home admission, falls, exercise capacity, cardiovascular health, and all-cause mortality.[1-8] In chronic lung disease, particularly COPD, 4MGS is associated with pulmonary function, functional capacity, and health-related quality of life.[7,9-11] Measuring gait speed requires little space, time, or training, which makes it an attractive measure of exercise capacity for routine use in the clinic. Gait speed is modifiable through strength training and rehabilitation, which makes it a potential marker

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of functional improvement, or decline indicating approaching end of life.[12-14]

Gait speed has accordingly been promoted as a potential "vital sign" to be recorded at each office visit and trended over time.[15,16] Like other vital signs, gait speed may provide an objective measure of whole organism functioning, and may signal meaningful abnormalities in normal system functions requiring intervention. Alternatively, decreasing gait speed over time may herald short-term mortality, providing an opportunity to address advance care planning and optimizing end-of-life care.[12,14]

Little is known about which factors influence the "construct" of gait speed in patients with chronic lung disease. Psychosocial factors such as perceived self-efficacy and social support affect physical activity level,[17-20] but their effect on gait speed has not been evaluated. Therefore, we studied the relationship between 4MGS and various psychological and physiological measurements, including 6-min walk distance (6MWD), objectively measured physical activity, dyspnea perception, quality of life, and task-specific self-efficacy in a well characterized cohort of patients with chronic lung disease. We also measured gait speed at 3 points within the 6-min walk test (6MWT) to assess the relationship between gait speed and 6MWD.

Methods

This study was approved by the institutional review board of the Mayo Clinic College of Medicine (11-008157). Patients with chronic lung disease of any etiology were recruited from the special pulmonary lab at the time of a previously scheduled 6MWT. Inclusion criteria included age > 18 y, diagnosis of any chronic lung disease, ability to complete the 6MWT and gait speed test, and ability to complete a series of written questionnaires.[7] We excluded patients who had had an acute respiratory illness in the preceding 4 weeks. Baseline demographic information and pulmonary function values from the preceding 12 months were extracted from the electronic medical record. All subjects completed the 6MWT, 4MGS, and questionnaires measuring dyspnea, quality of life, and self-efficacy for physical activity and walking. All subjects were also requested to wear a multi-sensor armband activity monitor (SenseWear Pro, BodyMedia, Pittsburgh, Pennsylvania) for 4 days after returning home.

Dyspnea Measurement

Dyspnea was measured with the modified Medical Research Council (MMRC) dyspnea scale (range 0–4), as previously described.[21]

QUICK LOOK

Current knowledge

Usual gait speed measured over 4 meters (4MGS) is associated with clinically important outcomes in the elderly. In chronic lung disease, particularly COPD, 4MGS is associated with pulmonary function, functional capacity, and health-related quality of life. Measuring gait speed requires little space, time, or training, making it an attractive routine measure of exercise capacity.

What this paper contributes to our knowledge

4MGS was significantly and independently associated with 6-min walk distance, and may serve as a simple surrogate for 6-min walk distance in patients with chronic lung disease. Gait speed was remarkably stable throughout the 6-min walk test, which provides a rationale for an abbreviated walk test such as 4MGS.

Self-Efficacy for Walking

To assess self-efficacy for walking during the 6MWT, we generated a non-validated Likert-style questionnaire specifically for use in this study (see the supplementary materials at http://www.rcjournal.com). The questionnaire comprises 7 items (numbered 1–7) that ask the subject to rate his or her confidence, from 1 (not at all confident) to 5 (highly confident) about completing the following 7 distances during the 6MWT: 55, 110, 165, 220, 330, 402, and 805 m. For each distance the questionnaire provides a rough equivalency in American football fields and average city blocks, to provide a more tangible, real-world feeling for the distance. For example, one football field or city block equals roughly 110 m. Prior to completing the questionnaire, subjects were also asked to visualize the length of the 6MWT pathway and were informed that it is 105 feet (32 m) in length. Each subject completed the questionnaire twice: before and after the 6MWT. The scores ranged from 0–7, and were assigned according to the greatest distance (item number) for which the subject rated at least moderate confidence for success (≥ 4). For example, if a subject rated his or her confidence for walking up to 165 m (comprising items 1–3) as 5/5, 220 m (item 4) as 4/5, 330 m (item 5) as 3/5, and the remaining distances (items 6–7) as 1/5, the self-efficacy for walking score was 4, corresponding to the greatest distance (220 m) for which the subject reported a confidence score of at least 4/5.

Self-Efficacy for Physical Activity

Self-efficacy for minimal daily physical activity was assessed with a non-validated Likert-style questionnaire also generated specifically for this study (see the supplementary materials at http://www.rcjournal.com). The questionnaire comprises 5 items that ask the subject to rate his or her confidence from 1 (not at all confident) to 5 (highly confident) that he or she is physically active daily and in the face of various barriers:

- How confident are you that you are physically active every day?
- How confident are you that you are physically active even when:
  - Your day doesn't go the way you wanted or expected?
  - You feel tired or fatigued?
  - You are in mild pain or have mild respiratory discomfort?
  - You feel depressed, worried, or stressed out?

The scores ranged from 1–5, and were determined by adding the results of each item and dividing by 5 to determine an average of the 5 items.

Linear Analog Self-Assessment

The linear analog self-assessment (see the supplementary materials at http://www.rcjournal.com) is composed of multiple Likert scales that target specific domains of quality of life, ranging from 0 (as bad as it can be) to 10 (as good as it can be). It has been utilized and validated in various formats.[22-25] For this study we utilized 6 individual items that assess well-being in 4 domains (physical, mental, emotional, and spiritual) in addition to levels of social activity and overall quality of life.

Pulmonary Function Testing

The most recent pulmonary function results completed within the preceding 12 months were extracted from the electronic medical record for each subject for whom they were available. All pulmonary function tests were performed according to the current guidelines and established reference values.[26] Pre-bronchodilator values were used for all statistical analyses.

Four-Meter Gait Speed

4MGS was measured using a technique similar to that described by Kon et al.[11] The subject placed his or her toes at the starting line of a 4-meter course clearly demarcated with red tape. The subject was instructed to walk at his or her normal comfortable walking speed, specifically: "Walk as though you are walking out to your mailbox or walking to your car in a parking lot." The instruction to begin walking was given with the countdown "3, 2, 1, go." A handheld timer was started on the word "go" and stopped when one of the subject's feet struck the ground completely beyond the finish line. This process was performed twice consecutively, without rest, and the faster of the 2 times was used for data analysis. The subject was allowed to use his or her usual walking aids and oxygen supplementation. Gait speed was calculated by dividing 4 meters by the time in seconds required to complete the course.

6-Minute Walk Test

The 6MWT was completed according to the American Thoracic Society guidelines.[27]

Gate Speeds During the 6MWT

Gate speed was also measured during the 6MWT, within 3 time epochs (1–2 min, 3–4 min, and 5–6 min into the test), as they passed through a 4-meter course that was clearly demarcated with 2 pieces of red tape in the center of the 32-meter 6MWT course. In each case a handheld timer was started once one foot struck the ground completely beyond the starting line, and then stopped once one foot struck the ground completely beyond the finish line. If a subject did not pass through the 4-meter course during a given time epoch, no 4MGS measurement was acquired. Gait speed was calculated by dividing 4 meters by the time in seconds required to complete the 4-meter course.

Objective Measurement of Physical Activity

The physical activity level has been proposed by the World Health Organization as an objective measure of physical activity: a physical activity level $\geq$ 1.70 defines an active person, 1.40–1.69 defines a sedentary person, and $<$ 1.40 defines severe physical inactivity. We measured physical activity with the validated multi-sensor SenseWear Pro armband.[28,29] Subjects were instructed in the use of the activity monitor, and were asked to wear it for 23 hours per day (except when bathing) for 4 days. The device was mailed to the subject's home and was returned via a pre-paid return envelope. The data from the device was downloaded to a dedicated software package (InnerView Research Software v.2.2, BodyMedia, Pittsburgh, Pennsylvania). Resting metabolic expenditure was calculated by multiplying a consistent value of energy expenditure during one minute of sleep by 1,440, to estimate daily resting energy expenditure. The physical activity level was subsequently calculated by dividing total daily energy expenditure by daily resting energy expenditure.[30] Time spent engaged in sedentary ($<$ 2 metabolic equivalents), light (2–4 metabolic equivalents), moderate (4–6 metabolic equivalents), and vigorous ($>$ 6 metabolic equivalents) activity was also recorded.[31]

Table 1. Subjects and Test Results (n = 70)

Male/female, no. (%)	33 (47)/37 (53)
Age, y	61.4 ± 9.6
Body mass index, kg/m^2	28.6 ± 7.6
Modified Medical Research Council dyspnea score (scale 0–4)	2.6 ± 0.73
Self-efficacy for walking score	3.11 ± 2.15
Self-efficacy for physical activity score	3.18 ± 1.04
FEV_1, % of predicted (subjects with COPD)	31.5 ± 13.9
Total lung capacity, % of predicted (subjects with interstitial lung disease)	60.4 ± 12.2
Diffusing capacity of the lung for carbon monoxide, mL/min/mm Hg	42 ± 18.6
Physical activity level score	1.28 ± 0.17
6-min walk distance, m	305 ± 115
4-m gait speed, m/s	0.85 ± 0.21
Gait speed during 6-min walk test, m/s	
1–2 min	1.01 ± 0.29
3–4 min	0.98 ± 0.31
5–6 min	1.00 ± 0.31

± Values are mean ± SD.

Table 2. Spearman Correlation Coefficients Between 4-Meter Gait Speed and Significant Variables

	r	P
6-min-walk test	0.70	< .001
Modified Medical Research Council dyspnea score	−0.44	< .001
LASA social activity domain score	0.42	< .001
Time in moderate activity (4–6 metabolic equivalents)	0.41	.003
Self-efficacy for walking	0.38	.001
LASA quality of life domain score	0.36	.002
Self-efficacy for physical activity	0.35	.003
Mean physical activity level	0.35	.007
LASA emotional well-being domain score	0.32	.006
Time in vigorous activity (> 6 metabolic equivalents)	0.32	.03
LASA mental well-being domain score	0.30	.01
LASA physical well-being domain score	0.27	.03

LASA = Linear Analog Self Assessment

Statistical Analysis

Based on prior literature, the expected correlation (r) between 6MWD and gait speed was assumed to be 0.7. Determined with the probability of type 1 (alpha) error of .05, power (1 − beta) of .9, and correlation of 0.7, the number of subjects needed for the study was calculated as 57. Descriptive summary statistics are reported for all included subjects. We assessed the associations between variables with Spearman correlations and Bland-Altman analysis. Comparisons of subgroups were carried out with the Wilcoxon test for continuous variables, and the chi-square test for categorical variables. We used stepwise multivariate linear regression to explore the associations between gait speed and other measurements. All analyses were done with statistics software (SAS 9, SAS Institute, Cary, North Carolina).

Results

Subject characteristics are listed in Table 1. The subjects were older and slightly overweight in general. The most common diagnosis was COPD (51.4%), followed by interstitial lung disease (38.6%), pulmonary arterial hypertension (7.1%), and other miscellaneous conditions (2.9%). In the interstitial lung disease group, 20 subjects (74%) had usual interstitial pneumonia, and 3 (11%) had non-specific interstitial pneumonia. Disease burden was severe overall: the mean percent-of-predicted FEV_1 was 31.5% in the subjects with COPD, and the mean percent-of-predicted total lung capacity was 60.4% in the subjects with interstitial lung disease. 6MWD was fair overall, with a mean of 305 m, but ranged from extremely poor (minimum 40 m) to excellent (maximum 568 m).[31] The mean self-efficacy score for physical activity was moderate (3.2/5), and the mean self-efficacy score for walking was generally low (3.1/7). Objectively measured daily physical activity was very low, with a mean physical activity level of 1.28 in the 58 subjects who wore the monitor for the 4 days required for data extraction.[32] When subjects were divided into those with COPD and those with all other diagnoses, there were no differences in age, sex, MMRC dyspnea score, 4MGS, 6MWD, time spent in various levels of activity (sedentary, light, moderate, and vigorous), or physical activity level (all $P > .15$).

Gait Speeds

The mean ± SD 4MGS was 0.85 ± 0.21 m/s. The mean ± SD gait speeds during the 6MWT were 1.01 ± 0.29 (min 1–2), 0.98 ± 0.31 (min 3–4), and 1.00 ± 0.31 m/s (min 5–6). Pair-wise Bland-Altman analyses showed no significant differences per subject between the 3 gait speeds measured during the 6MWT.

4MGS Correlations

Statistically significant Spearman correlation coefficients between 4MGS and the other measurements are shown in Table 2. The strongest correlation was between 4MGS and 6MWD (r = 0.70, $P < .001$), followed by MMRC dyspnea score (r = −0.44 ($P < .001$). Five of the 6 items in the linear analog self-assessment had significant correlations with 4MGS, the highest of which was social activity level (r = 0.42, $P < .001$) . Both self-efficacy measures correlated modestly with 4MGS: self-efficacy for walking r = 0.38, $P = .001$; self-efficacy for physical activity r = 0.35, $P = .003$. A significant but modest correlation was present between 4MGS and physical activity level (r = 0.35, $P = 007$). Time spent in moderate and vigorous physical activity also both modestly correlated with 4MGS: moderate physical activity r = 0.41, $P = .003$; vigorous physical activity r = 0.32, $P = .03$. The correlation between 4MGS and time spent in light activity was weak: r = 0.25, $P = .08$.

Multivariate Modeling for Predicting 4MGS

The construct of gate speed was explored by fitting multivariate linear regression models to predict 4MGS, including the following variables: age, sex, MMRC dyspnea score, diagnosis (COPD vs other), body mass index, diffusing capacity of the lung for carbon monoxide, 6 linear analog self-assessment domains (overall health, physical, spiritual, emotional, intellectual, and mental), self-efficacy for walking score, self-efficacy for physical activity score, and 6MWD. The first model showed that only 6MWD significantly correlated: adjusted R^2 0.49, $P < .001$. A second model that excluded 6MWD to determine which other variables affected 4MGS showed that self-efficacy for walking score ($P = .02$), self-efficacy for physical activity score ($P = .044$), diagnosis of COPD ($P = .03$), and social activity level ($P = .02$) were associated with 4MGS, with a combined R^2 value of 0.30 ($P < .001$).

Discussion

This study shows that 4MGS, a reproducible and easily performed measurement, is significantly associated with 6MWD. Our results suggest that 4MGS may be a reasonable surrogate for the underutilized 6MWD, which is an unquestionable measure of morbidity in chronic lung disease.[33-40] Given that a gait speed reduction of 0.15m/s/y during the 6MWT is associated with significantly worse mortality over the ensuing year in patients with severe COPD, our finding of an association between 4MGS and 6MWD has relevance and may prompt further investigation.[12,14]

Kon et al found that 4MGS correlated well with the incremental shuttle walk test in patients with COPD.[11] Our results are corroborative; however, we have extended upon their findings by demonstrating an association with a much more widely utilized measure of exercise capacity and wellness: the 6MWD. Furthermore, our demonstration of the remarkable stability of gait speed during the 6MWT provides further rationale for the value and predictive abilities of a shorter walk test utilizing gait speed analysis. Leung et al found that a 2-min walk test had a very high correlation (r = 0.94) with 6MWD in patients with COPD,[41] and that the 2-min walk test was equally responsive to improvement after a pulmonary rehabilitation program, which indicates that an abbreviated walk test can still be sensitive to change. Their findings, in conjunction with ours, suggest that a short walk test such as 4MGS may be acceptable for routine use in the clinic.

The construct of gait speed and the possible influence of psychosocial factors, such as self-efficacy, emotional well-being, social activity, and spiritual well-being, have not been extensively evaluated previously. After testing an extensive number of important psychological and physiological factors, we found that 6MWD was the strongest predictor of 4MGS (r = 0.70), indicating that 4MGS is more related to a self-paced exercise test than objectively measured physical activity or perception measures, including dyspnea, self-efficacy, and quality of life. This was evidenced by a fairly informative multivariate regression model that included only the 6MWD ($R^2 = 0.49$). We speculate that the dominance of the 6MWD in our multivariate model indicates that the 6MWT (in which the patient self-regulates walking velocity) intrinsically accounts for volitional and perceptive factors such as self-efficacy, subjective dyspnea, and overall well-being. We also found that self-efficacy for walking and physical activity, level of social activity, and a diagnosis of COPD contributed to the construct of gait speed in an alternative but less informative model that excluded the 6MWD ($R^2 = 0.30$).

To our knowledge this is the first study of the correlation between usual gait speed and objectively measured physical activity. Interestingly, we found that the correlation between gait speed and overall physical activity was relatively weak (r = 0.35). More specifically, 4MGS was associated with vigorous (> 6 metabolic equivalents, r = 0.41) and moderate (4–6 metabolic equivalents, r = 0.32) activity, but not light activity (2–4 metabolic equivalents). The inherent limitation of using any measure of exercise capacity as a surrogate for physical activity is that patient preferences and priorities toward physical activity are left unaccounted for. Patients may choose to live sedentary lifestyles despite relatively high exercise capacities and, conversely, patients with exercise limitations may still make daily physical activity a priority. This is a limitation that is unlikely to be overcome by any simple measure of exercise capacity, making the prediction of physical activity a challenging goal that will most likely require both physical and psychosocial assessments.

There are limitations to our study. First, the sample size prevented generation of more robust prediction models. However, the comprehensiveness of our measurements begins to fill the knowledge gap regarding the construct of gait speed and helps in the design of future longitudinal studies with gait speed. Second, we measured 4MGS using the most commonly employed normal velocity "static start" methodology. We are, therefore, unable to comment on methodologic advantages of "usual" versus "fast" gait speed. Given that a decline in maximum sustainable gait speed derived from 6MWD is related to end of life in COPD, additional work in this area is needed. Finally, our self-efficacy questionnaires were created specifically for this study and are therefore not validated tools; nonetheless, we believe they performed the desired goal of assessing patient confidence for the tasks in question (walking during the 6MWT and minimal physical activity).

Conclusions

4MGS is strongly associated with 6MWD and may be a reasonable surrogate for 6MWD in patients with chronic lung disease. We believe that demonstrating an association between 4MGS and 6MWD is an advantage of this study, since 6MWD is an unquestionable measure of wellness in all lung diseases. To our knowledge, this is the first report regarding the association of usual gate speed, maximum sustainable walking velocity, and physical activity level. Also, our demonstration of the stability of gait speed during the 6MWT further suggests that an abbreviated walk test may provide much of the same information as the full 6MWT. We believe the value of our study is that it sheds light on the construct of 4MGS: a novel, objective, and longitudinal measurement of functional status and exercise capacity, allowing for optimization in the care of patients with chronic lung disease.

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