[Commentary]

CHEST

Gait Speed

Validity of Measurement in Patients With Severe Chronic Lung Disease, Including Prognostic and Practical Implications

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Gait speed is used increasingly to predict function and future well-being among healthy elderly people as well as for those with long-term medical conditions. When selecting outcome measures such as walking speed, it is important to include the circumstances under which the measurement is made to avoid bias and ensure accurate recommendations. We completed a retrospective chart review of walking test results from patients with chronic lung disease to demonstrate the practical implications of reporting gait speed from either a standing or walking start. In this cohort of 99 patients (55 with COPD), gait speed from a standing start underestimated usual gait speed (difference = 6.1 m/min [5.3-6.9 m/min]) with poor agreement (8 m/min [6.6-9.4 m/min]) between the two methods of reporting speed. The standing start speed incorrectly identified some patients as at higher risk for poor health. In a practical example, gait speed from a standing start produced 11 false-negative evaluations of the ability to complete a road crossing at usual speed. We present walking speeds using both methods, which illustrate the importance of construct validity and measurement protocol.

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Usual gait speed ($\bar{s}_{usual}$) is a simple, accessible, and inexpensive indicator used in a variety of conditions as a marker of a patient's health status as well as a measure of specific capacity and function.[1-4] Gait speed is the key component of the Short Physical Performance Battery (SPPB), which evaluates balance, gait speed, and getting in and out of a chair, all of which represent essential elements of functional capability and independent living.[5] In the SPPB, gait speed is measured from a standing start, and a substantial body of work has evolved regarding its prognostic value. Fast gait speed ($\bar{s}_{fast}$), measured when an individual is asked to walk fast, has also demonstrated prognostic[6] and clinical[7,8] utility.

As with any measure of physical function, the conditions under which a construct is measured influence its measurement properties, such as validity, reliability, and responsiveness. Protocols measuring walking speed have differed by their distance and

ABBREVIATIONS: $\bar{s}_{0-4m}$ = average speed > 4 m from a standing start; $\bar{s}_{fast}$ = fast gait speed; SPPB = Short Physical Performance Battery; $\bar{s}_{usual}$ = usual gait speed

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type of start (if reported at all[9]). Although the test distance used varies considerably, in surveys of walking test methodology,[10,11] the most common distance and start were 10 m and walking (rolling), respectively. When averaged after excluding a brief walking (rolling) start, walking speed measured over short distances[12,13] is valid and remains consistent with speed determined over long distances.[8] However, a standing start adds the physical quantity of acceleration. The average speed will underestimate $\bar{s}_{usual}$ because of this acceleration phase. For example, Asher et al[14] observed that a standing start gait speed over a short distance of 8 feet in an older population was lower than the reported norm measured following a rolling start.[12] In this report, which included the reference values for usual walking speed, the authors cautioned that the comparative speed should not include an acceleration phase. Bohannon et al[15] reported that several meters were provided for acceleration (positive or negative) at each end of the test distance, and the stopwatch was only started as the subjects crossed the starting line and was stopped when they passed the finish line. In a subsequent systematic review of normal walking speed,[12] for an article to meet inclusion criteria, gait speed had to be measured with an allowance for acceleration unless the distance was greater than 25 m. Over short distances, the difference between a standing and a rolling start has been reported as > 7.8 m/min.[10,16] The inaccuracy of estimating $\bar{s}_{usual}$ from walking speed measured from a standing start may have important clinical implications in patients with severe chronic lung disease.

We hypothesized that gait speed, averaged over a short distance (4 m), from a standing start ($\bar{s}_{0-4m}$) would be less than $\bar{s}_{usual}$. We used a confusion matrix to describe the accuracy of $\bar{s}_{0-4m}$ on a classification model used to evaluate the risk of negative health events given that the true value was $\bar{s}_{usual}$. We also applied the results to a practical example of crossing a street at signal-controlled pedestrian crossings to illustrate an important issue of validity with this simple test of walking ability.

We completed a retrospective analysis of all test results in patients with chronic lung disease who were assessed for ambulatory oxygen therapy at our facility. This use of patient data was approved by the Joint West Park Healthcare Centre/Toronto Central LHIN/The Salvation Army Toronto Grace Health Centre Research Ethics Board. Walking times were measured using optical sensors as part of a protocol with demonstrated reliability and validity, which has been described elsewhere.[8,17,18] Patients were requested to walk, using their habitual walking aid, for 18 m at their usual speed, turn around a cone, and return at a fast speed. The timer was triggered from the first movement and by optical sensors placed at 4 and 14 m away. Average walking speed was calculated over the first 4 m ($\bar{s}_{0-4m}$) as well as over the subsequent 10 m between the first and second sensors ($\bar{s}_{usual}$). Speed was also calculated over the 10 m between the second and first sensors ($\bar{s}_{fast}$).

The minimal clinically important difference in speed in reference to clinical prognosis has been reported in different cohorts, including those with respiratory disease.[19-21] Because walking is common and important regardless of health status, we used the most conservative value reported (1.8 m/min), thereby demanding the greatest precision to qualify the agreement[22] between $\bar{s}_{0-4m}$ and $\bar{s}_{usual}$. The speed required to safely cross a city street is functionally important. In most cities, pedestrian crossing light timings are regulated by local guidelines and follow recommendations of the National Association of City Transportation Officials.[23] Timing typically includes three phases: (1) a solid white or green invitation to cross, which is fixed, for example at 7 s, but is dependent on the next phase; (2) a flashing amber light indicating that a pedestrian can complete the crossing but should not start to cross; and (3) a red "don't walk" meaning that automobile traffic has been given the signal to proceed. Together the green and amber phases allow a complete crossing at < 60 m/min.[23] However, a speed of 72 m/min is often reported as the minimum speed required to cross because it assumes crossing occurs at the end of the green phase, that is, at the start of the amber signal. This interpretation, which implies that there are no phases, incorrectly applies the faster speed to the total available crossing time.[24] Therefore, if they stood at the curb on starting to cross four traffic lanes, equaling a total distance of 14 m, one could estimate the proportion of patients that could safely cross depending on whether they started at the beginning or the end of the green signal (when the amber warning signal appears) from the $\bar{s}_{0-4m}$, $\bar{s}_{usual}$, and $\bar{s}_{fast}$.

The data (149 tests) retrieved was from 99 consecutive patients with chronic lung disease (male to female ratio, 48:51; age, 71 years [SD, 12 years]; BMI, 25.6 kg/m^2 [SD, 7.5 kg/m^2]; and Pa_{O_2}, 65 mm Hg [SD, 8 mm Hg]) who were assessed for their exercise oxygen requirements from April 2013 to February 2017. Sixty-eight patients had a primary diagnosis of COPD (FEV_1, 35% of predicted [SD, 17% of predicted]; FEV_1/FVC, 38% [SD, 15%]). All patients walked at their usual and fast speeds

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