The 6-minute walk: a new measure of exercise capacity in patients with chronic heart failure

Gordon H. Guyatt,* MD
Michael J. Sullivan,† MD
Penelope J. Thompson,‡ MA
Ernest L. Fallen,§ MD
Stewart O. Pugsley,‖ MD
D. Wayne Taylor,¶ MSc
Leslie B. Berman,** MB

Cycle and treadmill exercise tests are unsuitable for elderly, frail and severely limited patients with heart failure and may not reflect capacity to undertake day-to-day activities. Walking tests have proved useful as measures of outcome for patients with chronic lung disease. To investigate the potential value of the 6-minute walk as an objective measure of exercise capacity in patients with chronic heart failure, the test was administered six times over 12 weeks to 18 patients with chronic heart failure and 25 with chronic lung disease. The subjects also underwent cycle ergometer testing, and their functional status was evaluated by means of conventional measures. The walking test proved highly acceptable to the patients, and stable, reproducible results were achieved after the first two walks. The results correlated with the conventional measures of functional status and exercise capacity. The authors conclude that the 6-minute walk is a useful measure of functional exercise capacity and a suitable measure of outcome for clinical trials in patients with chronic heart failure.

La bicyclette ergométrique et le tapis roulant sont mal adaptés à l'examen du malade âgé et affaibli souffrant d'insuffisance cardiaque et ne renseignent peut-être pas sur sa capacité dans les activités de la vie quotidienne. Comme les épreuves à la marche ont su éclairer le pronostic dans l'insuffisance respiratoire chronique, on a voulu voir si la marche de 6 minutes se prêterait à l'étude objective de la tolérance à l'exercice dans l'insuffisance cardiaque chronique. L'épreuve est faite six fois en 12 semaines chez 18 malades atteints d'insuffisance cardiaque chronique et 25 atteints d'insuffisance pulmonaire chronique. On pratique aussi chez tous les sujets une ergométrie à la bicyclette et un bilan fonctionnel par les méthodes classiques. L'épreuve à la marche s'avère hautement satisfaisante du point de vue des malades. À partir de la troisième marche on obtient des résultats fiables et reproductibles qui sont en corrélation avec ceux de l'étude fonctionnelle et de l'ergométrie. On conclut que chez le malade souffrant d'insuffisance cardiaque chronique, la marche de 6 minutes est utile pour la mesure de la tolérance à l'exercice et pourrait servir de barême dans l'analyse des essais cliniques.

Over the last decade the advent of vasodilator therapy and, more recently, the exploration of new inotropic agents have led to a reawakened interest in the treatment of chronic heart failure. Problems have arisen in measuring the benefit of these drugs for patients with heart failure: the three major approaches — measurement of functional status, measurement of hemodynamic variables and measurement of exercise capacity — all have important limitations. The functional classification of the New York Heart Association (NYHA) is imprecise[1] and subjective and provides no information about the mechanism of benefit. While objective and reproducible, the results of hemodynamic studies bear little or no relation to measures of functional status or of exercise capacity.[2-5] Conventional exercise testing can be difficult in patients who are extremely limited by severe cardiac dysfunction. Also, as vasodilators and inotropes may improve resting and exercise hemodynamics without increasing maximum exercise power output,[6-8] a submaximal exercise test may be a better method of assessing the benefit of interventions in patients with heart failure.[9]

Similar problems face investigators examining treatments for patients with chronic lung disease. As a possible solution to these difficulties, McGavin and colleagues[10] introduced the 12-minute walking test, in which patients are asked to walk as far as they can during a 12-minute period. Walking tests have since proved very useful and have been used to test the

From McMaster University, Hamilton, Ont.

*Assistant professor, departments of clinical epidemiology and biostatistics and medicine
†Assistant professor, Department of Medicine
‡Research assistant, Department of Medicine
§Professor, Department of Medicine
‖Associate clinical professor, Department of Medicine
¶Assistant professor, Department of Clinical Epidemiology and Biostatistics
**Assistant professor, Department of Medicine

Reprint requests to: Dr. Gordon H. Guyatt, Department of Clinical Epidemiology and Biostatistics, McMaster University, 1200 Main St. W, Hamilton, Ont. L8N 3Z5

← For prescribing information see page 939

efficacy of a variety of physiologic and pharmacologic treatments for patients with chronic lung disease.

Walking tests are simple, inexpensive and safe. They clearly correspond more closely to the demands of everyday activities than does cycle ergometer exercise testing. The same is true, although to a lesser extent, of treadmill exercise testing, which may be intimidating to the frail, elderly or severely disabled and in which the rate of exercise is not under the patient's control. In addition, evidence to date suggests that results of the walking test are highly reproducible[11,12] and show moderate to strong correlations with other measures of exercise capacity and with self-reported measures of functional status.[10,11,13,14] Finally, a positive therapeutic effect was found in 10 of 13 studies in which the walking test was used as a measure of outcome in patients with chronic lung disease;[15-24] in two of the studies statistically significant improvement in exercise capacity was found with the walking test but not with concurrently administered conventional exercise tests.[15,16]

Although most investigators have used a 12-minute walk, Butland and coworkers[12] recently demonstrated that equivalent results can be obtained with a 6-minute walk, which has the advantages of being efficient and less stressful for the patient and corresponding more closely to the usual day-to-day activity of moderately or severely limited patients.

Walking tests may be as useful a measure of exercise capacity in patients with chronic heart failure as they have proven to be in those with chronic lung disease. To investigate the potential value of the 6-minute walk as an objective measure of exercise capacity in patients with chronic heart failure, we administered the walk six times to a group of patients whose primary problem was congestive heart failure and to another group whose disability was primarily due to chronic lung disease. Our objectives were to determine the reproducibility of test results in the cardiac and respiratory groups, the pattern of changes in test scores over time in the two groups, the response in the two groups to encouragement during testing, and the relation between conventional exercise testing and measures of functional status on the one hand and walking-test scores on the other in patients with heart failure. The implications of our findings for respiratory patients have been discussed elsewhere.[25]

Methods

We recruited patients who experienced dyspnea or fatigue while performing activities of daily living. Respiratory patients attended a regional referral centre for patients with pulmonary problems and had a best recorded forced expiratory volume in 1 second (FEV_1) less than 0.7 of the predicted value. Patients with heart failure were referred by local cardiologists and had impaired left ventricular function, as demonstrated by angiography, radionuclide scanning or echocardiography.

Exclusion criteria for both groups were as follows:

- Limitation of activity because of factors other than fatigue or exertional dyspnea, such as arthritis, claudication in the legs or angina.
- Psychiatric disease preventing reliable performance of the walking test.
- Admission to hospital in the 2 months before entry into the study.
- Previous experience with walking tests.

Each patient was tested six times, with 2-week intervals between the tests. Patients were stratified into the cardiac or respiratory group and then randomly assigned to receive or not receive encouragement. All the patients were initially tested without encouragement, and then, according to the randomization schedule, encouragement was consistently either given or not given during the five subsequent walks.

The walking tests were conducted in an enclosed corridor on a course 33 m long. The patients were instructed to walk from end to end, covering as much ground as they could during the allotted time. For the unencouraged group the supervisor sat in a chair at one end of the course, avoiding eye contact with the patient and remaining silent. The supervisor called out "Stop" when 6 minutes had elapsed, and the distance walked was determined. For the encouraged group the supervisor ensured that at 30-second intervals she was facing the subject and then delivered one of a predetermined set of encouraging phrases, such as "You're doing well" or "Keep up the good work". At the end of the test she called out "Stop", and the distance walked was recorded.

Each participant underwent a maximal exercise test using a bicycle ergometer according to the protocol of Jones.[26] The subjects spent 1 minute at each work load, beginning at 100 kpm/min and increasing by increments of 100 kpm/min until they were too exhausted to continue.

One of us (M.J.S.), who was blinded to the results of all the other tests, interviewed and examined the patients and evaluated their functional status according to the NYHA criteria. At the time of each walking test the Specific Activity Scale, which has been reported to be a more reliable and valid measure of functional status in cardiac patients than the NYHA classification,[1] was administered to each patient by the test supervisor.

Statistical analysis

The results of the study were assessed by means of an analysis of variance, with the distance walked during the first test as a covariate. Three factors were examined: time (test repetition), encouragement and diagnostic group (respiratory or cardiac). Both main effects and interactions were examined. Because Mungall and Hainsworth[11] found improvement in walking-test scores over the first three of six 12-minute walks, we compared the scores on the first two walks with those on the last four.

To assess the variability in walking-test performance over time, the within-person standard deviation for the last four walks was calculated for both groups.

To examine the relation between walking-test scores and the other measures, Spearman rank correlation coefficients between the walking-test scores and the results of cycle ergometer testing were calculated. The

mean score on the last four walks was used for the correlation, and the results were pooled across the encouraged and unencouraged groups.

Results

Of the 57 patients entered in the study 43 (34 men and 9 women) completed the six visits (Fig. 1); their mean age was 64.7 ± 8.3 years. There were 25 respiratory patients and 18 cardiac patients; 23 were in the encouraged group and 20 in the unencouraged group. Of the 14 dropouts 9 were cardiac patients and 5 respiratory patients; 7 had been assigned to the encouraged group and 7 to the unencouraged group. Seven dropped out for reasons unrelated to the study: death, fractured hip, exacerbation of underlying disease, move away from the area, development of concurrent illness or family problems. One patient with heart failure experienced increasing symptoms after his first two walking tests and declined to continue. The remaining six patients expressed dissatisfaction with the study (e.g., "I felt ill after the walking tests"; "The walks didn't seem to be beneficial"; "A doctor wasn't present") and dropped out. Most dropouts occurred after the first walking test (Fig. 1).

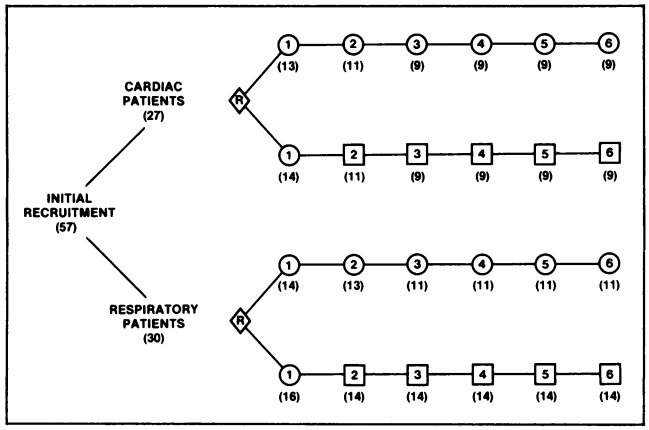

Fig. 1—Study design for 6-minute walk. ○ = without encouragement; □ = with encouragement; numerals within symbols indicate visit number; numerals in parenthesis indicate number of patients; R = randomization.

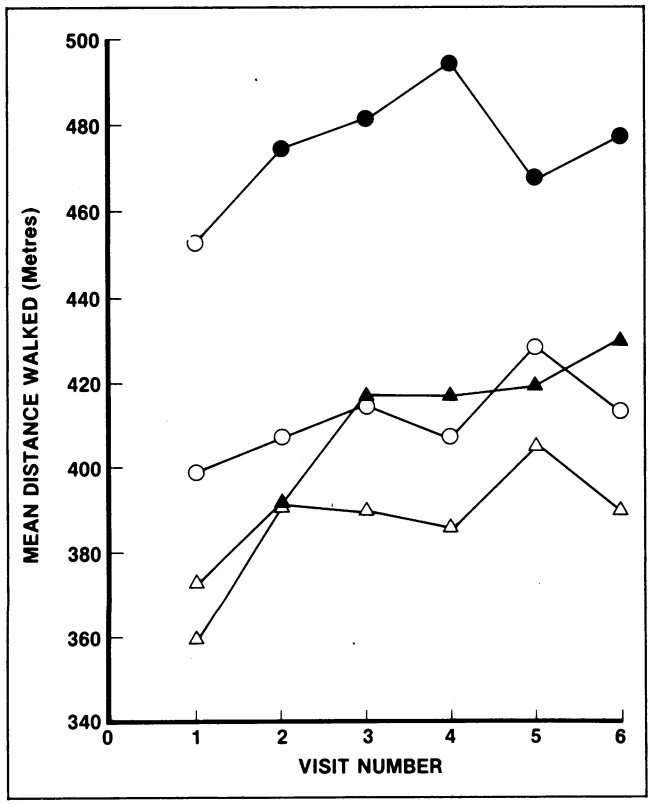

Fig. 2—Mean distance walked by 18 cardiac and 25 respiratory patients during six walking tests. ● = encouraged cardiac group; ○ = unencouraged cardiac group; ▲ = encouraged respiratory group; △ = unencouraged respiratory group.

The 25 respiratory patients had a mean FEV_1 of 0.97 ± 0.25 L and a mean vital capacity of 2.4 ± 0.87 L. Of the 18 cardiac patients 5 were in NYHA class II, 12 were in class III and 1 was in class IV. All but two had a cardiothoracic ratio greater than 0.5, as determined by posteroanterior chest roentgenography. All were taking both digoxin and one or more diuretics, and 12 were taking vasodilators (prazosin, hydralazine, captopril or nitrates). Eight of the participants met the inclusion criteria for both diagnostic groups.

Encouragement improved walking-test performance ($p < 0.02$), and the respiratory patients improved more over time than did the cardiac group, irrespective of encouragement ($p < 0.05$) (Fig. 2). There was no interaction between diagnostic group and encouragement, which suggests that encouragement had a similar effect on the two groups.

Although the cardiac patients walked farther than did the respiratory patients, this difference did not reach statistical significance ($p = 0.178$) because of the small sample size and the large between-person variability. The large difference in baseline scores between encouraged and unencouraged cardiac patients was a chance phenomenon.

Comparison of the results of the first two walks with those of the last four showed that the subjects walked farther during the last four walks ($p < 0.001$) (Fig. 2). The scores plateaued during the last four walks.

The variability of test results was comparable for both the cardiac and the respiratory patients irrespective of encouragement, and the within-person standard deviation was in each case less than 6% of the mean score. That is, the subjects' walking-test scores were within 6% of their mean score 65% of the time and within 12% of their mean score 95% of the time. This compares favourably with the results of most clinical and laboratory tests; for example, the variability of results of spirometry in patients with chronic airflow limitation[11] was approximately twice the variability we found in the walking test.

The correlations between the mean walking-test score and the results of cycle ergometer testing and functional classification were similar in the cardiac and respiratory groups, and the magnitude of the correlations was low to moderate (Table I). Sicker patients received higher scores on the NYHA classification and the Specific Activity Scale and walked shorter distances; thus, the correlations between walking-test scores and results of functional classification were negative.

Discussion

In accordance with the results of previous work,[11,12] we found that both the cardiac and the respiratory group showed improvement in walking-test scores up to the third walk, and consistent results were obtained thereafter. The high precision seen in both groups following the first two walks (Table I) suggests that in clinical trials in patients with heart failure in which the 6-minute walk is used as a measure of outcome, it will be possible to detect small treatment effects with feasible sample sizes. For example, with conventional specifications for both power and statistical significance and an independent groups design, one would need only 13 subjects per group to detect an improvement in score of 25 m (which is about 6% of the mean baseline score and less than the effect of encouragement in our study).

Since encouragement had a substantial impact on walking-test scores ($p < 0.02$) that was similar in both the cardiac and the respiratory patients, administration of the test should be rigorously standardized in both patients with chronic heart failure and those with chronic lung disease.

The correlations between walking-test scores and conventional measures were low to moderate in magnitude, statistically significant and similar in the cardiac and respiratory patients (Table I). The low correlation with the results of cycle ergometer testing suggests that the walking test measures something different: since walking is a regular daily activity, the walking test may measure a patient's ability to undertake the physically demanding activities of day-to-day life, as opposed to laboratory exercise capacity. If this were so, one might have expected higher correlations with the measures of functional status. However, the limitations of the functional classifications (including limited reliability and the fact that both classifications have only four categories) may have attenuated the correlations. In other studies in respiratory patients walking-test scores correlated well with other measures of functional status.[13,14] This issue needs further exploration in patients with heart failure.

In summary, in the patients with chronic heart failure the 6-minute walk was both safe and highly acceptable to the patients and produced stable results after the first two walks. The results were reproducible and correlated with conventional measures of functional status and exercise capacity. The walking test appears promising as a simple measure of functional exercise capacity for clinical trials in patients with chronic heart failure.

Table I—Correlations between walking-test scores and results of functional classification and cycle ergometer testing in cardiac and respiratory patients

Test	Diagnostic group: Cardiac (n = 18)	Respiratory (n = 25)	Total (n = 43)	p value (n = 18)*
New York Heart Association functional classification	−0.45			0.058
Specific Activity Scale[1]	−0.37	−0.52	−0.47	0.001
Cycle ergometer	0.42	0.57	0.58	< 0.001

*Pairwise analysis.

We thank Drs. John L.C. Morse, Frederick E. Hargreave and Michael T. Newhouse, for their help in recruiting patients for the study, and Ms. Marie Townsend, for her technical assistance in the data analysis.

References

1. Goldman L, Hashimoto B, Cook EF et al: Comparative reproducibility and validity of systems for assessing cardiovascular functional class: advantages of a new specific activity scale. *Circulation* 1981; 64: 1227–1234
2. Franciosa JA, Ziesch ES, Wylan M: Functional capacity of patients with chronic left ventricular failure. *Am J Med* 1979; 67: 460–465
3. Franciosa JA, Park M, Levine TB: Lack of correlation between exercise capacity and indexes of resting left ventricular performance in heart failure. *Am J Cardiol* 1981; 47: 33–39
4. Frances GS, Goldsmith SR, Cohn JN: Relationship of exercise capacity to resting left ventricular performance and basal plasma norepinephrine levels in patients with congestive heart failure. *Am Heart J* 1982; 104: 725–731
5. Benge W, Litchfield RL, Marcus ML: Exercise capacity in patients with severe left ventricular dysfunction. *Circulation* 1980; 61: 955–959
6. Franciosa JA, Cohn JN: Effect of isosorbide dinitrate on response to submaximal and maximal exercise in patients with congestive heart failure. *Am J Cardiol* 1979; 43: 1009–1014
7. Rubin SA, Chatterjee K, Ports TA et al: Influence of short-term oral hydralazine therapy on exercise hemodynamics in patients with severe chronic heart failure. *Am J Cardiol* 1979; 44: 1183–1189
8. Maskin CS, Forman R, Klein NA et al: Long-term amrinone therapy in patients with severe heart failure. *Am J Med* 1982; 72: 113–118
9. Conradson T, Ryden L: Sustained effect of hydralazine in long-term treatment of CHF. *Acta Med Scand* 1981; suppl 652: 173–176
10. McGavin CR, Gupta SP, McHardy GJR: Twelve-minute walking test for assessing disability in chronic bronchitis. *Br Med J* 1976; 1: 822–823
11. Mungall IPF, Hainsworth R: Assessment of respiratory function in patients with chronic obstructive airways disease. *Thorax* 1979; 34: 254–258
12. Butland RJA, Pang J, Gross ER et al: Two-, six-, and twelve-minute walking tests in respiratory disease. *Br Med J* 1982; 284: 1607–1608
13. McGavin CR, Artvinli M, Naoe H et al: Dyspnoea, disability, and estimates of exercise performance in respiratory disease. *Br Med J* 1978; 2: 241–243
14. Morgan AD, Peck DF, Buchanan DR et al: Effect of attitudes and beliefs on exercise tolerance in chronic bronchitis. *Br Med J* 1983; 286: 171–173
15. Pardy RL, Rivington RN, Despas PJ et al: Inspiratory muscle training compared with physiotherapy in chronic airflow limitation. *Am Rev Respir Dis* 1981; 123: 421–425
16. Leitch AG, Morgan A, Ellis DA et al: Effect of oral salbutamol and slow-release aminophylline on exercise tolerance in chronic bronchitis. *Thorax* 1981; 36: 787–789
17. Leggett RJE, Flenley DC: Portable oxygen and exercise tolerance in patients with chronic hypoxic cor pulmonale. *Br Med J* 1977; 2: 84–86
18. McGavin CR, Gupta SP, Lloyd EL et al: Physical rehabilitation for the chronic bronchitic: results of a controlled trial of exercises in the home. *Thorax* 1977; 32: 307–311
19. Belman MJ, Mittman C: Ventilatory muscle training improves exercise capacity in chronic obstructive pulmonary disease patients. *Am Rev Respir Dis* 1980; 121: 273–280

20. Sinclair DJM, Ingram CG: Controlled trial of supervised exercise training in chronic bronchitis. *Br Med J* 1980; 280: 519-521

21. Pardy RL, Rivington RN, Despas PJ et al: The effects of inspiratory muscle training on exercise performance in chronic airflow limitation. *Am Rev Respir Dis* 1981; 123: 426-433

22. Woodcock AA, Gross ER, Geddes DM: Oxygen relieves breathlessness in "pink puffers". *Lancet* 1981; 1: 907-909

23. Cockcroft AE, Saunders MJ, Berry G: Randomised controlled trial of rehabilitation in chronic respiratory disability. *Thorax* 1981; 36: 200-203

24. Woodcock AA, Gross ER, Geddes DM: Drug treatment of breathlessness: contrasting effects of diazepam and promethazine in pink puffers. *Br Med J* 1981; 283: 343-346

25. Guyatt GH, Pugsley SO, Sullivan MJ et al: The effect of encouragement on walking test performance. *Thorax* 1984; 39: 818-822

26. Jones NL, Campbell EJM: *Clinical Exercise Testing*, Saunders, Philadelphia, 1982

ANNOUNCEMENT OF MEETINGS

CMAJ *will print notices of forthcoming meetings of interest to Canadian physicians as space allows. Because of the large number of meetings, we will list only those of national interest taking place in Canada or those outside Canada that are sponsored by a Canadian organization. Notices should be received at least 3 months before the meeting, and should include the following information:*

Date
Title
Place and city
Contact person and telephone number

Alternatively, publication of these and other notices of meetings can be guaranteed by placing an advertisement in our Classified Advertising section, where the appropriate charges and deadline dates can be found.

June

June 6–13, 1985

Canadian Anaesthetists' Society annual meeting
Hilton Harbour Castle Hotel, Toronto
Mr. Frank A. Teepell, Executive director, Canadian Anaesthetists' Society, 94 Cumberland St., Ste. 901, Toronto, Ont. M5R 1A3; (416) 923-1449

August

Aug. 24–27, 1985

International Meeting on Immunogenetics of Endocrine Disorders
St. John's, Nfld.
Dr. Nadir R. Farid, Program chairman, International Meeting on Immunogenetics, Health Sciences Centre, Memorial University of Newfoundland, St. John's, Nfld. A1B 3V6; (709) 737-6300