ESC European Society of Cardiology
European Heart Journal - Digital Health (2021) **2**, 75–76
doi:10.1093/ehjdh/ztab021

EDITORIAL

Appraisal of digital home-based 6-Minute Walk Test for use in remote healthcare delivery

Marlien Varnfield[1]* and Alison Mahoney[2]

[1]Australian e-Health Research Centre, CSIRO, Royal Brisbane and Women's Hospital, Herston 4029, Australia; and [2]Physiotherapy Department, The Prince Charles Hospital, Metro North Health, Chermside 4032, Australia

Online publish-ahead-of-print 11 February 2021

This editorial refers to 'Reliability and repeatability of a smartphone-based 6-minute walk test as a patient-centred outcome measure', by J. Mak *et al.* on page 77.

Introduction

Patients with chronic conditions, such as cardiovascular disease and chronic obstructive pulmonary disease, have varying levels of functional capacity, which can be objectively measured via several different modalities. One of the assessments of functional capacity is the 6-min walk test (6MWT), a submaximal test in widespread use. The 6MWT is commonly used to evaluate extent of cardiopulmonary disease, response to therapy, assessment of oxygen therapy, prediction of mortality and morbidity, and to guide exercise prescription.[1] Distance walked is the primary measurement outcome of the 6MWT, but the test can also include blood oxygen saturation, subjective effort, dyspnoea, and heart rate/blood pressure response. The appeal of the 6MWT arises from its simplicity, ease of performance, low cost, ease of standardization, and acceptance by test subjects.[2]

In-clinic, 6MWTs are performed under clearly defined conditions[2,3] using a flat, straight, and hard surfaced enclosed corridor at least 30 m long, marked in increments. For out-of-clinic testing, a walking track can be either continuous or a point-to-point with an emphasis on consistent conditions and layouts for all patients to ensure the test is as reproducible, accurate, and comparable as possible. For 6MWT, the minimal important difference (MID) in distance is estimated at 30 m for chronic lung disease,[4] 25 m for coronary artery disease,[5] 36 m in heart failure,[6] and 25–38 m in pulmonary arterial hypertension.[7]

One of the limitations of the 6MWT is that patients must attend the hospital, outpatient facility, or community care facility where the test is performed by qualified personnel, depending on the patient's clinical needs. The COVID-19 pandemic has significantly disrupted traditional delivery of care and many in-clinic based cardiac and pulmonary programmes have had to transition rapidly to remote delivery models. This has increased the impetus to develop alternative methods for home and community-based exercise testing (including the 6MWT).[8]

Indeed, Salvi *et al.*[9] developed a mobile phone app using GPS technology and algorithms to enable patients to compute their 6MWT distance both indoors and outdoors. They reported acceptable performance with maximal mean difference of 2 m for the indoor algorithm and 0.8 m for the outdoor algorithm over a total of 79 tests.

Most recently and prompted from their previous study of an in-clinic smartphone-administered 6MWT, Mak *et al.*[10] evaluated the accuracy of iPhone steps as a measure for the 6MWT. In this study, the authors evaluated a substantial number of tests—444 supervised in-clinic and 2030 home 6MWTs and found an error of 2–8% between ground truth and phone-calculated steps for in-clinic 6MWT. For patients performing 6MWTs at home and in-clinic within a 14-day period, a mean of 35 additional steps was measured in clinic as compared to home measurements. This difference is clinically relevant, as depending on an individual's step length, it could represent up to an additional 26.5 m, which is the MID for certain pathologies. This discrepancy will be greater in patients who are outliers. Awareness of this variability is important to ensure correct clinical judgments are made, and it is of merit that a mean estimate is known. If comparative 6MWTs are performed in a population under similar conditions to this study, the measured variability in step measurements should be factored into clinical decision-making.

To our knowledge, there are only few published digitally-supported 6MWT trials[11,12]; however, others are currently underway (e.g. https://clinicaltrials.gov/NCT04633538; NCT03893500). For the purposes of this Editorial, collectively, 'electronic' 6MWT (e6MWT) will be discussed more broadly.

Discussion

The option of an accurate e6MWT as a surrogate for in-clinic testing of functional capacity is appealing to clinicians. Health service providers are actively encouraging virtual consultations as an alternative

The opinions expressed in this article are not necessarily those of the Editors of the *European Heart Journal – Digital Health* or of the European Society of Cardiology.

* Corresponding author. Tel: +61 732533603, Email: Marlien.Varnfield@csiro.au

to face-to-face reviews, both in response to the pandemic as well as another option in a plan to provide a broader menu-based approach to healthcare. Essential to this effort is addressing safety in the administration of the e6MWT out of clinic and developing accurate and user-friendly methods. Performing unsupervised e6MWTs is a potential safety risk in patient populations and despite being a submaximal test, would not be recommended for conditions where cardiovascular or cardiorespiratory compromise could occur or to determine drug efficacy in conditions, such as pulmonary arterial hypertension. However, once the safety of the particular e6MWT is determined in-clinic, it could find utility in monitoring functional status in select patient populations, for example, peripheral vascular disease. It could be used for patients who are medically stable and at low risk, as a self-regulated monitoring tool. It might encourage patients to participate more in the monitoring of their own health, and improve their health engagement, especially in those unable to attend the clinic regularly.

Steps taken may be a good alternative to GPS monitoring in conditions where GPS signal is not accurate and is a measure that patients understand well. However, there are limitations when using steps as a measure. Step length is variable between individuals and may vary from test to test if conditions of the test are inconsistent, such as using a different route. Step length may also alter if the patient is unwell, has a musculoskeletal complaint, or wears different footwear. Total distance achieved in the e6MWT may also be altered by the space a patient has available in their home. Frail or elderly patients are often slower at turning which may decrease their capacity to walk as far in the e6MWT when they have a smaller distance to navigate in their home. Prior efforts have evaluated mobile phone step count accuracy, with historical improvements continuing today as new technologies and algorithms are introduced.

The process of adopting remote data collection and assessments has been accelerated during the COVID-19 pandemic. In modern Health Services, there is a well-defined place for e6MWT's either via GPS or step counts. This place exists as long as safety concerns and limitations of this form of testing are well understood, and that it is recognized that currently there is no real replacement for an in-clinic standardized 6MWT performed with experienced personnel. Despite limitations, the studies by Salvi *et al.*[9] and Mak *et al.*[10] provide compelling, initial evidence that e6MWT could be reliable compared to an in-clinic ground truth measurement in patients with cardiopulmonary disease. The potential of e6MWT's within future health care is great, particularly in low-resource settings, and rural and remote areas lacking infrastructure. However, no feasibility studies in these contexts exist to date. Prior to widespread e6MWT implementation, further consideration must be given to subject usability, meeting the minimum standards of testing, and determination of the important parameters to support implementation.

Conflict of interest: none declared.

References

1. Solway S, Brooks D, Lacasse Y, Thomas S. A qualitative systematic overview of the measurement properties of functional walk tests used in the cardiorespiratory domain. *Chest* 2001;**119**:256–270.
2. American Thoracic Society. ATS statement: guidelines for the six-minute walk test. *Am J Respir Crit Care Med* 2002;**166**:111–117.
3. Queensland Cardiorespiratory Physiotherapy Network. *Technical Standard for Functional Exercise Testing – 6 Minute Walk Test, Version 2*. Physiotherapy Guidelines; 2015, Queensland. https://www.health.qld.gov.au/__data/assets/pdf_file/0018/426204/qcpn_6mwt.pdf
4. Holland AE, Hill CJ, Rasekaba T, Lee A, Naughton MT, McDonald CF. Updating the minimal important difference for six-minute walk distance in patients with chronic obstructive pulmonary disease. *Arch Phys Med Rehabil* 2010;**91**:221–225.
5. Gremeaux, V, Troisgros O, Benaïm S, Hannequin A, Laurent Y, Casillas JM, Benaïm C. Determining the minimal clinically important difference for the six-minute walk test and the 200-meter fast-walk test during cardiac rehabilitation program in coronary artery disease patients after acute coronary syndrome. *Arch Phys Med Rehabil* 2011;**92**:611–619.
6. Tager T, Troisgros O, Benaïm S, Hannequin A, Laurent Y, Casillas J-M, Benaïm C. Minimum important difference for 6 minute walk distances among patients with chronic heart failure. *Int J Cardiol* 2014;**176**:94–98.
7. Mathai SC, Puhan MA, Lam D, Wise RA. The minimum important difference for 6 minute walk test for patients with pulmonary arterial hypertension. *Am J Respir Crit Care Med* 2012;**186**:428–433.
8. Holland AE, Malaguti C, Hoffman M, Lahham A, Burge AT, Dowman L, May AK, Bondarenko J, Graco M, Tikellis G, Lee JYT, Cox NS. Home-based or remote exercise testing in chronic respiratory disease, during the COVID-19 pandemic and beyond: a rapid review. *Chron Respir Dis* 2020;**17**:1–18.
9. Salvi D, Poffley E, Orchard E, Tarassenko L. The mobile-based 6-minute walk test: usability study and algorithm development and validation. *JMIR Mhealth Uhealth* 2020;**8**:e13756.
10. Mak J, Rens N, Savage D, Aalami O.. Reliability and repeatability of a smartphone-based 6-minute walk test as a patient-centred outcome measure. *Eur Heart J Dig Health* 2021;**2**:77–87.
11. Brooks GC, Vittinghoff E, Iyer S, Tandon D, Kuhar P, Madsen K, Marcus G, Pletcher M, Olgin J. Accuracy and usability of a self-administered 6-minute walk test smartphone application. *Circ Heart Fail* 2015;**8**:905–913.
12. Ata R, Gandhi N, Rasmussen H, El-Gabalawy O, Gutierrez S, Ahmad A, Suresh, S, Ravi R, Rothenberg K, Aalami O. Clinical validation of smartphone-based activity tracking in peripheral artery disease patients. *NPJ Dig Med* 2018;**1**:66.