

# Assessing Exercise Capacity Using Telehealth: A Feasibility Study in Adults With Cystic Fibrosis

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**BACKGROUND:** Provision of healthcare from a remote site may assist patients to access important services. We aimed to establish the feasibility of monitoring an assessment of exercise capacity using telehealth technology. **METHODS:** Adults with CF completed two 3-min step tests, monitored in-person or remotely via videoconferencing, in randomized order. Measurements were physiological responses to exercise, system usability, ease of clinician interaction, metronome acoustics, and participant comfort. **RESULTS:** Ten adults (5 male), mean  $\pm$  SD age  $32 \pm 7$  years, and FEV<sub>1</sub> 55.4% of predicted (range 38–90% of predicted), completed both tests. Participants reported good system usability, with a mean (95% CI) System Usability Scale score of 85.63 out of 100 (79.8–91.5). Metronome acoustics were rated as significantly poorer remotely ( $P = .006$ ). There were no differences in measurements of oxyhemoglobin saturation or heart rate between assessment settings. **CONCLUSION:** Exercise capacity assessment using the 3-min step test is feasible and accurate via remote videoconferencing in adults with CF. *Key words:* cystic fibrosis; telehealth; telemedicine; physical activity; exercise test. [Respir Care 2013;58(2):286–290. © 2013 Daedalus Enterprises]

## Introduction

Globally, household computer access ranges from 12% to 92% of dwellings.<sup>1</sup> In Australia, nearly 80% of all homes have a computer, representing an almost 100% increase in

the 10 years to 2008/2009, while Internet access quadrupled in the same period.<sup>1</sup> With upwards of 80% of all individuals in the age groups 15–44 years having and accessing the Internet,<sup>1</sup> it would seem plausible that children and young adults affected with cystic fibrosis (CF) would make a prime audience for the use of Internet health technology.

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Despite improving survival for individuals with CF, the burden of therapy remains sizeable. Daily healthcare tasks can include administration of medication (intravenous, oral and/or nebulized), performing physiotherapy, and managing supplemental feeding.<sup>2</sup> Added to this daily therapy regimen are the need to participate in regular physical activity and exercise, and frequent visits to specialist centers for reassessment and intensive treatment. Increasingly, strategies to alleviate some of the burden of therapy in this group are being sought.

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Healthcare technology advances have the potential to provide specialist health services to geographically removed patients.<sup>3</sup> The use of video-conferencing,<sup>2</sup> data enabled transfer of physiological measures,<sup>4–6</sup> and assessment of adherence using electronically enabled devices<sup>7–9</sup> are all examples of technology that have been trialed to varying extents within the CF population. Despite this, literature regarding the use of health technologies in this

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population is limited, and, to the best of our knowledge, has not previously investigated the use of remote monitoring for the assessment of exercise capacity in this patient group.

Aerobic fitness is an independent predictor of survival in CF,<sup>10,11</sup> and a relationship has been demonstrated between improvements in aerobic capacity and quality of life.<sup>12,13</sup> Thus, maintaining physical fitness is a cornerstone of CF care. Moreover, rate of decline in respiratory function is related to level of physical activity in girls with CF, with those who had the lowest levels of physical activity participation demonstrating significantly greater rate of FEV<sub>1</sub> decline.<sup>14</sup> The 3-min step test is a simple, readily available assessment of exercise tolerance commonly used in individuals with CF.<sup>15</sup> In children with CF the 3-min step test is responsive to change during hospitalization for intravenous antibiotics,<sup>16</sup> and induces significantly greater increases in heart rate and breathlessness score, as compared to the 6-min walk test.<sup>15</sup> While the test does not elicit a maximal exercise response, particularly in those with mild disease,<sup>17</sup> performance in adults has found that those who desaturate to < 90% have more hospital days and a greater decline in FEV<sub>1</sub> over the following 12 months.<sup>18</sup> The test requires minimal equipment and space in order to be performed. Regular assessment of the 3-min step test may prove useful to monitor changes in exercise performance over time.

We hypothesized that a simple, submaximal exercise test (the 3-min step test) could be performed and monitored equally as well via remote video-conferencing as it would with the clinician in attendance. As such, we aimed to assess the feasibility of conducting and supervising a submaximal exercise test via remote video-monitoring, and to also assess the repeatability of a submaximal exercise test (the 3-min step test) when performed in a supervised clinical environment versus remotely.

### Methods

Participants for this study were adults with a confirmed diagnosis of CF, recruited prospectively upon admission to the Alfred Hospital, Melbourne, Australia, for intravenous antibiotics. All participants were > 18 years old and were cardiovascularly stable and afebrile for over 24 hours. Adults with CF who were pregnant, had comorbidities preventing exercise, or who had previously had a lung transplant were excluded from participation. All participants provided written, informed consent for participation. Ethics approval for this study was obtained from both the Alfred Hospital and La Trobe University human research ethics committees.

Participants performed the 3-min step test on 2 occasions within a 24-hour period. One step test was undertaken with a clinician physically present supervising the testing session. On the other occasion the clinician super-

### QUICK LOOK

#### Current knowledge

Aerobic fitness is an independent predictor of survival in cystic fibrosis (CF), and a relationship has been demonstrated between improvements in aerobic capacity and quality of life. Thus, maintaining physical fitness is a cornerstone of CF care. The 3-min step test is a simple, readily available assessment of exercise tolerance commonly used in individuals with CF. Regular assessment of the 3-min step test may prove useful to monitor changes in exercise performance over time.

#### What this paper contributes to our knowledge

In adults with CF, the 3-min step test could be performed and supervised equally as well via remote video-conferencing as it was in person. Physiological performance measures and participant comfort were not different. Remote assessment of exercise tolerance may be appropriate in the CF population.

vised the step test via video-conferencing. For safety reasons, when conducting video-conferencing step test assessments the supervising clinician was geographically located within the same building as the participant, but in a separate room. The order in which the directly supervised or remotely supervised step tests were performed was determined by an individual unrelated to the study team, using a computer generated list of random allocation. Demographic data, including age, height, weight, sex, as well as recent spirometry measures, were recorded prior to initial testing.

The 3-min step test was performed according to standard protocol.<sup>15</sup> The protocol utilized a commercially available 15 cm high step, and participants stepped at a pace of 30 steps/min for 3 min. The rate of stepping was externally paced using a metronome (120 beats/min). The metronome utilized on all testing occasions was obtained freely on-line (<http://simple.bestmetronome.com>) and was operated by the clinician via video-conferencing during remote supervision of step test performance. Heart rate and S<sub>pO<sub>2</sub></sub> were monitored throughout the test (Palmsat 2500, Nonin, Plymouth, Minnesota), and at 1 min and 3 min of recovery. Participants were asked to rate their breathlessness and leg fatigue according to the modified category ratio 0–10 scale for dyspnea and rate of perceived exertion<sup>19</sup> prior to, at completion of the test, and during recovery. Participants were instructed to cease the test if their oxygen saturation fell below 80%, in which case the total number of steps taken was calculated.<sup>17,18</sup> Participants were given the opportunity to practice stepping prior to commencing the assessment, and were instructed on changing

their lead leg while stepping in order to avoid localized muscle fatigue. During step-test performance the total number of steps completed was recorded, along with peak heart rate and lowest  $S_{pO_2}$ .

Video-conferencing equipment comprised a desktop computer with attached Web camera. Video-collaboration software (VSee, Sunnyvale, California) was used. This VSee software is secure, high-resolution video-conferencing software that allows up to 10-way group video calls. Important features of video-conferencing software to consider for telehealth applications are data security, video quality, and management of network traffic. The VSee video-collaboration software met these requirements by providing extremely low bandwidth video-calling, control of bandwidth utilization, and strong data security features. VSee software is available on the Internet free for commercial, government, and corporate use ([www.vsee.com](http://www.vsee.com)).

Subjects received written and pictorial instructions detailing the process for them to follow to access the computer network and log into the VSee video-conferencing program, prior to entering the testing room. Included within these instructions were telephone contact details for the remotely located clinician in the event participants needed additional assistance or encountered technical difficulties. Once logged into the video-conferencing program and able to communicate with the clinician, participants were asked to confirm their ability to hear the clinician clearly, and to turn on and position the pulse oximeter on a provided height adjustable stand, in-line with the webcam, such that it could be viewed by the clinician remotely.

On both testing occasions, following the recovery period and prior to leaving the testing location, participants completed a survey of their experience. The survey utilized a 5-point Likert scale ("very difficult" to "very easy" or "very uncomfortable" to "very comfortable") to answer questions pertaining to participant perception of ease of ability to interact with the clinician, ease of hearing of the metronome pacing, and participant comfort in performing the test.

On completion of the remote video-conferencing step test, participants were asked to complete the 10 question System Usability Scale,<sup>20</sup> which is a validated measurement tool, freely available, that rates a user's experience of technology.<sup>20</sup> The questionnaire utilizes a 5-point Likert scale ("strongly agree" to "strongly disagree") and covers various aspects of a system's use, such as the need for support, training, and complexity. It has been found superior to other similar tools in assessing Web site usability,<sup>21</sup> and has a maximum high score of 100 points.

After completion of both step test sessions participants were asked to identify, via a tick-box form, which session they preferred: the directly supervised or the remotely supervised via video-conferencing. Participants were also

Table. Participant Experience of In-Person and Remote Supervision

	In-Person Supervision*	Remote Supervision*	<i>P</i>
Ease of clinician interaction	5 ± 0	4.8 ± 0.4	.34
Ease of hearing the metronome	4.8 ± 0.1	3.3 ± 0.4	.006
Participant comfort	4.8 ± 0.4	4.7 ± 0.9	.68

\* Scored on a 5-point Likert scale in which 1 was either "very difficult" or "very comfortable," and 5 was either "very easy" or "very uncomfortable". Values are mean ± SD

able to indicate no preference for one session over the other.

Analyses were performed using statistics software (PASW Statistics 18, SPSS, Chicago, Illinois). Paired values were compared using the paired *t* test, and *P* values < .05 were considered significant. Agreement between testing occasions was assessed using the method of Bland and Altman.<sup>22</sup> Results are expressed as mean ± SD or 95% CI unless otherwise noted.

## Results

Ten adults (5 male) with CF undertook the 3-min step-test on 2 occasions. The mean ± SD age of participants was 32 ± 7 years and mean FEV<sub>1</sub> was 55.4% of predicted (range 38–90% of predicted). All participants completed the entire 3-min step test on each occasion. In 2 participants oxygen desaturation below 90% occurred in both step test sessions.

When participants' ratings of the 2 step test occasions were reviewed, only metronome acoustics were rated significantly poorer with remote supervision, compared to direct supervision (*P* = .006). There were no significant differences in participant rating of in-person and remote supervision in terms of ability to interact with the clinician and participant comfort (Table). Responses on the usability of the video-conferencing system were positive: the mean System Usability Scale score was 85.6 (95% CI 79.8–91.5). Nine participants (90%) indicated no preference for in-person versus remote supervision, with one participant preferring in-person supervision.

There were no significant differences in physiological responses measured on the 2 step tests. There was good agreement for lowest  $S_{pO_2}$  measured between directly supervised and remotely supervised step tests (Figure). The mean difference in lowest  $S_{pO_2}$  between tests was 0.2% (limits of agreement –3.4 to 3.6%), in rate of perceived exertion was 0.5 points (limits of agreement –1.1 to 2.1 points), and for heart rate –0.6 beats/min (limits of agreement –11.3 to 10.1 beats/min).

## Discussion

In this small study assessing the feasibility of supervising a test of exercise capacity using video-conferencing

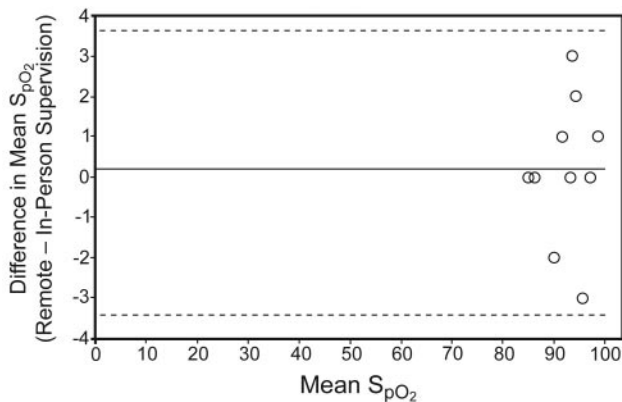


Figure. Bland-Altman plot for agreement between lowest  $S_{pO_2}$  measured during 3-min step-test supervised in-person and remotely. The solid line represents the mean difference between testing occasions. The dashed lines represent the limits of agreement.

technology there were no significant differences in terms of monitored physiological parameters between the 2 testing occasions. Participants indicated no preference for in-person over remote supervision, and video-conferencing as the format for telehealth delivery in this context was well received.

Three-minute step test performance in adults with CF has been shown to be an indicator of prognosis over the following 12 months, with those who desaturate to  $< 90\%$  having more hospital days and a greater decline in  $FEV_1$  than those who maintain oxyhemoglobin saturation above  $90\%$ .<sup>18</sup> In the present study, desaturation below  $90\%$  during step test performance could be detected in both remote and in-person supervision settings. Two participants desaturated below  $90\%$  on both testing occasions, while a third participant recorded a lowest  $S_{pO_2}$  of  $89\%$  only during remote supervision. This indicates that important clinical outcomes can be identified during remote supervision of the 3-min step test, as they are during direct supervision. The limits of agreement for lowest  $S_{pO_2}$  between directly supervised and remotely supervised step-test performance was found to be  $\pm 3\%$ . This variation is in keeping with the generally accepted margin of error for pulse oximeter readings,<sup>23</sup> and as such suggests that the differences in lowest pulse oximetry measurement recorded between direct and remote supervision of the 3-min step test are not clinically important.

Participants' ratings of their experience were not different between the 2 supervision settings, with the exception of metronome-pacing acoustics being less audible during remote supervision. Metronome pacing was delivered from an online application via the Internet and was accessed by the clinician in both testing circumstances. This meant that during remote supervision of the step test, metronome pacing acoustics were generated from the computer located with the clinician in the remote location. As such, issues

relating to sound quality and volume may have been generated by the proximity of the Webcam microphone to the computer sound outlet, by sound acoustics, including other noise sources in the room where remote supervision took place, or by echo within the room where step-test performance took place. In future use of this testing method, possible solutions for this issue may include having the participant access the metronome from the computer in the testing location, rather than remotely via the clinician, access to higher quality sound speakers or microphone equipment, or the use of a standard commercially available metronome rather than an electronic version.

Like most studies of telehealth in CF identified in a recent systematic review, the current feasibility trial is both small and of short duration.<sup>24</sup> In the CF population adherence to data reporting via telehealth has been reported between  $52\%$ <sup>6</sup> and  $80\%$ .<sup>25</sup> All participants completed all data provision requirements for the video-conferencing component of this trial, likely due to the short time required for the testing procedure and the visual and auditory cues provided instantaneously by the supervising clinician. Like other studies of telehealth utility for patients with CF,<sup>24</sup> we found this patient group willing to adopt the use of health technology and comfortable with the use of equipment involved in telehealth applications. Additionally, the high scores achieved on the System Usability Scale in this trial indicate that the technology interface was appropriate in this context.

While the 3-min step test is not a maximal test of exercise capacity, especially in those with mild disease,<sup>17</sup> its requirements for minimal equipment and space allow it to be performed in any setting where people with CF receive care, including home, hospital, specialist clinic, and local healthcare services. These attributes made the 3-min step test a practical choice for an assessment of exercise capacity via video-conferencing, where formal cardiopulmonary exercise testing equipment was unavailable. Having only a finite field of view is a limitation of video-conferencing assessment. While laboratory based treadmill or bike tests of exercise capacity may not pose issues for remote viewing, due to their stationary nature, field exercise tolerance assessments commonly used in people with respiratory disease, such as the 6-min walk test or modified shuttle test,<sup>26</sup> would pose challenges for remote supervision with regard to being able to ensure good quality, 2-way visual images, and auditory acoustics over the entire length of the testing track. To achieve this would likely require access to a complex, and more expensive, system of Web-camera placement and audio equipment, and would preclude remote assessment of exercise tolerance in the home setting.

Telehealth technology may also be useful to enable the CF population access to pulmonary rehabilitation programs while conforming with infection control requirements that

dictate that individuals with CF should be isolated from their peers to prevent cross-infection,<sup>27</sup> a requirement that presently prevents participation in group exercise programs. Health technology applications have been successfully implemented in providing remote rehabilitation programs via video-conferencing in people with COPD,<sup>28</sup> and Web-enabled smart phones in people with cardiac conditions.<sup>29,30</sup> Strickland et al<sup>28</sup> delivered pulmonary rehabilitation to subjects with COPD using videoconferencing between remotely located healthcare sites, and achieved significant improvements in quality of life and exercise capacity at the conclusion of the 8 week program. The results of the remote rehabilitation group were not different to those who received standard, center-based pulmonary rehabilitation.<sup>28</sup> Establishing the ability to assess physical performance in adults with CF via remote videoconferencing provides a platform for the potential use of this technology in delivering exercise-based interventions.

### Conclusions

In summary, in adults with CF, the 3-min step test, a submaximal test of exercise capacity, was performed and supervised equally as well via remote video-conferencing as it was when a clinician was in attendance, in participants with a range of disease severity. Physiological performance measures and participant comfort were not different during remote supervision conditions, compared to in-person supervision. Remote assessment of exercise tolerance may be appropriate in the CF population.

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