Validation of the 6-min Walk Test for Predicting Peak $\dot{V}O_2$ in Cancer Survivors

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ABSTRACT

SCHUMACHER, A. N., D. Y. K. SHACKELFORD, J. M. BROWN, and R. HAYWARD. Validation of the 6-min Walk Test for Predicting Peak $\dot{V}O_2$ in Cancer Survivors. *Med. Sci. Sports Exerc.*, Vol. 51, No. 2, pp. 271–277, 2019. **Purpose**: To assess the quality of the relationship between $\dot{V}O_{2peak}$ estimated from patient outcomes on the 6-min walk test (6MWT) and the $\dot{V}O_{2peak}$ calculated from patient outcomes on the University of Northern Colorado Cancer Rehabilitation Institute (UNCCRI) treadmill protocol. **Methods**: Cancer survivors (N = 187) completed the UNCCRI treadmill protocol and a 6MWT 1 wk apart in randomized order to obtain $\dot{V}O_{2peak}$. Values from the UNCCRI treadmill protocol were compared against four common 6MWT $\dot{V}O_{2peak}$ prediction equations. **Results**: All four 6MWT prediction equations significantly ($P < 0.001$) underestimated $\dot{V}O_{2peak}$ with predicted values ranging from 8.0 ± 4.1 mL·kg^{-1}·min^{-1} to 18.6 ± 3.1 mL·kg^{-1}·min^{-1}, whereas the UNCCRI treadmill protocol yielded a significantly higher value of 23.9 ± 7.6 mL·kg^{-1}·min^{-1}. A positive strong correlation occurred between estimated $\dot{V}O_{2peak}$ derived from the UNCCRI treadmill protocol and only one of the $\dot{V}O_{2peak}$ values derived from the 6MWT prediction equations (r = 0.81), and all four equations consistently underpredicted $\dot{V}O_{2peak}$. **Conclusions**: These findings suggest that the 6MWT is not a valid test for predicting $\dot{V}O_{2peak}$ in the cancer population due to its consistent underestimation of $\dot{V}O_{2peak}$ regardless of the prediction equation. Obtaining an accurate and valid $\dot{V}O_{2peak}$ value is necessary to correctly prescribe an individualized exercise rehabilitation regimen for cancer survivors. It is recommended that clinicians avoid the 6MWT and instead implement treadmill testing to volitional fatigue to quantify $\dot{V}O_{2peak}$ in cancer survivors. **Key Words:** SUBMAXIMAL EXERCISE TESTING, TREADMILL, CANCER PATIENTS, CARDIORESPIRATORY FITNESS, AEROBIC CAPACITY

The number of people living beyond a cancer diagnosis in the United States is expected to reach approximately 19 million by 2024 (1). Although cancer accounts for nearly one in four deaths, cancer-related death rates continue to decline (1). Due to the expanding number of survivors, cancer is being viewed as a chronic illness requiring long-term management and rehabilitation (2). Cancer and its treatment can result in significant deleterious side effects that impact the cardiopulmonary system. Cardiotoxicity from chemotherapy leads to decreases in cardiac output and aerobic capacity, resulting in complications, such as cardiomyopathy and left ventricular dysfunction (3–6). Evidence is emerging that now shows cancer itself, in the absence of cancer treatments, can result in cardiac remodeling and cardiac dysfunction (7,8) which may be a contributing factor to decreased cardiorespiratory fitness. Treatment toxicities can be amplified in elderly cancer survivors because gerontological populations are more inclined to have increased rates of heart failure, coronary artery disease, arrhythmias, and left ventricular dysfunction (9). Overall, cardiovascular complications are believed to contribute to weakness, fatigue, and decreased quality of life for cancer survivors, and these cardiovascular complications are a major limiting factor in the rehabilitation of these individuals.

Maximal oxygen consumption ($\dot{V}O_{2max}$) reflects the maximal ability of an individual to take in, transport, and use oxygen, and the maximal amount of oxygen that can be consumed has become the preferred means of assessing cardiorespiratory fitness. Oxygen consumption exhibits a plateau near maximal exercise which has traditionally been used as the best indicator of $\dot{V}O_{2max}$. In the clinical setting, a clear plateau in oxygen consumption may not be achieved before symptom-limited termination of the exercise test. Consequently, $\dot{V}O_{2peak}$ is often used as an estimate of VO_{2max} in clinical populations (10). Empirical evidence indicates that the most effective means of prescribing exercise requires an accurate measure of $\dot{V}O_{2peak}$ because exercise intensity is often based on this value (11). Furthermore, it is imperative that reassessments of $\dot{V}O_{2peak}$ are performed regularly during an exercise-based rehabilitation program to adapt the exercise to ensure that the principles of overload and progression are

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being met. As a result, establishing valid assessment protocols that accurately measure $\dot{V}O_{2peak}$ are essential for developing safe, effective, individualized exercise prescriptions for cancer survivors.

Submaximal exercise testing is a means of predicting maximal oxygen consumption without performing maximal exercise (11). Ease of test administration, fewer risks for the participant, minimal cost, and a limited need for trained medical professionals are all benefits of submaximal testing. Whereas maximal exercise testing takes the participant to volitional fatigue, submaximal exercise testing relies on the inherent linear relationship between workload and heart rate (HR). The 6-min walk test (6MWT) is a long-standing submaximal exercise test that is widely used in populations with chronic disease (12–15). Although the 6MWT is often the preferred exercise test in clinical populations, it is not clear whether outcomes from this test can be used to accurately assess $\dot{V}O_{2peak}$ in cancer survivors because it is unknown if the linear relationship between workload and HR for predicting $\dot{V}O_{2peak}$ is accurate within this population (16). The purpose of this study was to evaluate the validity of the 6MWT for predicting $\dot{V}O_{2peak}$ compared to a standardized $\dot{V}O_{2peak}$ treadmill protocol in cancer survivors.

METHODS

Subjects. A total of 187 subjects (72 males, 115 females) participated in the study. All subjects were cancer survivors enrolled in the University of Northern Colorado Cancer Rehabilitation Institute (UNCCRI)'s cancer rehabilitation program. Subjects were referred to UNCCRI and medical records were provided by the referring oncologist or primary care physician. All procedures were approved by the University of Northern Colorado's Institutional Review Board and subjects signed an informed consent before participation. Patients with a wide range of cancer diagnoses were included in the current study including: breast, prostate, lymphoma, leukemia, colorectal, lung, renal, skin, gynecological, sarcoma, myeloma, pancreatic, endocrine, stomach, and esophageal. Subjects were excluded if they had a history of congestive heart failure, myocardial infarction, chronic lung disease, asthma, significant ambulatory issues, history of hemoptysis, fainting, or epilepsy.

Experimental design. Subjects completed one UNCCRI treadmill protocol and one 6MWT 1 wk apart in randomized order. Resting blood pressure (BP), resting HR, blood oxygen saturation (SpO_2), height (cm), and body weight (kg) were measured before each test. BP was measured manually by auscultation, HR was determined using a Polar® Heart Rate Monitor, SpO_2 was measured using a Clinical Guard® pulse oximeter, height was measured by the BSM170 stadiometer, and body weight was measured by the InBody 770®. Participants also performed a pulmonary assessment using a MIR Spirolab III® portable desktop spirometer to determine force vital capacity (FVC) and forced expiratory capacity (FEV_1) of the lungs. Clinical Cancer Exercise Specialists (CCES) conducted all testing procedures and ensured participant safety throughout both protocols. Five different $\dot{V}O_{2peak}$ values were compared using a repeated-measures ANOVA: 1) $\dot{V}O_{2peak}$ obtained from the UNCCRI protocol, and 2) $\dot{V}O_{2peak}$ values derived from four well-documented 6MWT prediction equations.

The 6MWT protocol. The 6MWT took place in a 12.6-m-long hallway at UNCCRI. Two CCES's supervised the test to ensure participant safety. Subjects were asked to walk as far as possible in the 6-min timeframe and every pass of the hallway was recorded. Subjects were asked to walk alone unless gait imbalances required them to have a CCES near to assist them. Subjects were allowed to rest if needed, but were asked to start walking again as soon as able. At the end of the test, subjects were asked to stop where they were, and the total distance covered was measured and recorded. At the end of the test, HR, BP, and SpO_2 values were recorded immediately. Rating of perceived exertion (RPE) on a modified Borg scale (1–10) was also recorded.

Distance and variables such as age, height, weight, FVC, and FEV_1 were used to calculate predicted $\dot{V}O_{2peak}$ from four well-established prediction equations:

$$\dot{V}O_{2peak} = 0.03 \times \text{distance (m)} + 3.98 \text{ (13)}, \quad [1]$$

$$\dot{V}O_{2peak} = 0.02 \times \text{distance (m)} - 0.191 \times \text{age (yr)} - 0.07 \times \text{weight (kg)} + 0.09 \times \text{height (cm)} + 0.26 \times \left(\text{RPP} \times 10^{-3}\right) + 2.45 \text{ (13)}, \quad [2]$$

$$\dot{V}O_{2peak} = 0.02 + \text{distance (m)} - 0.14 \times \text{age (yr)} - 0.07 \times \text{weight (kg)} + 0.03 \times \text{height (cm)} + 0.23 \times \left(\text{RPP} \times 10^{-3}\right) + 0.10 \times \text{FEV}_1\text{(L)} - 1.19 \times \text{FVC (L)} + 7.77 \text{ (13), and} \quad [3]$$

$$\dot{V}O_{2peak} = 4.948 + 0.023 \times \text{distance (m) (14)}. \quad [4]$$

UNCCRI treadmill protocol. The UNCCRI Treadmill Protocol consists of twenty-one 1-min stages in which speed and/or grade increases with each stage. A summary of the protocol appears in Table 1, and it has been described elsewhere in detail (16). Subjects were informed that they could terminate the test at any time, but were encouraged to continue to their maximum effort. BP was taken every 3 min by a CCES. Another CCES recorded HR and SpO_2 while changing speed and/or grade every minute. A third CCES spotted subjects during the test for safety and to ensure proper placement on the treadmill belt. It was recommended that subjects avoid use of the handrails, but if necessary, they were asked to hold the handrails for the duration of the protocol. Testing concluded when the subject verbally expressed that they had reached maximum effort, or when they physically grabbed onto the handrails to signal the end of the test. Once the participant indicated they had reached maximum effort, a cool down phase was initiated. The duration of the test from initiation until maximum exertion along with the final completed stage were recorded.

TABLE 1. The UNCCRI Treadmill Protocol.

Stage	Speed, mph	Grade	Time
0	1.0	0%	1 min
1	1.5	0%	1 min
2	2.0	0%	1 min
3	2.5	0%	1 min
4	2.5	2%	1 min
5	3.0	2%	1 min
6	3.3	3%	1 min
7	3.4	4%	1 min
8	3.5	5%	1 min
9	3.6	6%	1 min
10	3.7	7%	1 min
11	3.8	8%	1 min
12	3.9	9%	1 min
13	4.0	10%	1 min
14	4.1	11%	1 min
15	4.2	12%	1 min
16	4.3	13%	1 min
17	4.4	14%	1 min
18	4.5	15%	1 min
19	4.6	16%	1 min
20	4.7	17%	1 min
Cool Down	[a]	0%	[a]

[a]Cool down period was individualized for each subject.

The American College of Sports Medicine running and walking equations were used to calculate $\dot{V}O_{2peak}$ from the last completed stage of the protocol (11,16). If the subject was walking at maximum exertion the following equation was used:

$$\dot{V}O_{2peak}\left(mL{\cdot}kg^{-1}{\cdot}min^{-1}\right) = 0.1S + 1.8SG + 3.5$$

where S is the speed in meters per minute and G is the percent grade in decimal form. If the subject was running at maximum exertion the following equation was used:

$$\dot{V}O_{2peak} = 0.2S + 0.9SG + 3.5.$$

If the subject was using handrails during the protocol the following equation was used:

$$\dot{V}O_{2peak} = 0.694 \times [\text{ACSM walking/running value from above}] + 3.33.$$

Gas analysis was not used during the treadmill test to directly measure $\dot{V}O_{2peak}$, but the UNCCRI treadmill protocol has been validated with gas analysis in a previous study ($r = 0.93$) (16).

Statistical analysis. For both protocols a repeated-measures ANOVA was used to examine the differences in $\dot{V}O_{2peak}$ obtained by the UNCCRI treadmill protocol and the $\dot{V}O_{2peak}$ values determined by the four 6MWT prediction equations. Paired t tests were used to test differences in HR and SBP between the UNCCRI protocol and the 6MWT protocol. Pearson r correlations between $\dot{V}O_{2peak}$ values obtained using the UNCCRI treadmill protocol and 6MWT equations 1–4 were run to determine the strength of relationship in $\dot{V}O_{2peak}$. Significance was set to $P < 0.05$. All statistical analyses were conducted using the Statistical Package for the Social Sciences software package (SPSS) (17).

RESULTS

Participants were comprised of 72 males and 115 females with a mean age of 61 ± 13 yr, a mean height of 169 ± 10 cm, and a mean weight of 81 ± 24 kg. Mean FVC was 3.48 ± 0.94 L and mean FEV_1 was 2.65 ± 0.72 L. Mean resting HR (RHR), systolic blood pressure (RSBP), and diastolic blood pressure (RDBP) before the UNCCRI treadmill test were 84 ± 16 bpm, 125 ± 14 mm Hg and 75 ± 9 mm Hg, respectively. The mean RHR, RSBP, and RDBP before the 6MWT was 80 ± 15 bpm, 123 ± 12 mm Hg and 74 ± 8 mm Hg, respectively. There was a significant difference observed between RHR before the treadmill test and before the 6MWT ($P < 0.001$). There was a significant difference observed in RSBP ($P = 0.016$) but not in RDPB ($P = 0.094$) before each test. Thirty-one percent of the cancer survivors were undergoing chemotherapy and/or radiation treatments during testing. All participants completed each of the testing protocols without complications.

Validity of predicted $\dot{V}O_{2peak}$ for the 6MWT. Table 2 summarizes predicted peak oxygen consumption values derived from the outcomes of the UNCCRI treadmill test and the 6MWT. Average time spent on the treadmill was 10.4 ± 3.1 min and the average distance walked during the 6MWT was 485 ± 108 m. 6MWT peak HR (109 ± 21 bpm), SBP (139 ± 19 mm Hg), DPB (76 ± 10 mm Hg), and RPE (5 ± 2) were significantly lower ($P < 0.05$) compared to the UNCCRI treadmill protocol peak HR (150 ± 22 bpm), SBP (150 ± 18 mm Hg), DPB (78 ± 9 mm Hg), and RPE (9 ± 2). Oxygen saturation during the 6MWT was significantly higher (95 ± 3%) than the UNCCRI protocol (94 ± 3%) ($P = 0.008$). The UNCCRI protocol yielded a significantly higher $\dot{V}O_{2peak}$ of 23.9 ± 7.6 $mL{\cdot}kg^{-1}{\cdot}min^{-1}$ compared to all four 6MWT prediction equations ($P < 0.001$). Figure 1 displays mean $\dot{V}O_{2peak}$ values based on the outcomes of the UNCCRI treadmill protocol and all four 6MWT prediction equations. Equations 1, 2, 3, and 4 yielded $\dot{V}O_{2peak}$ values of 18.6 ± 3.1 $mL{\cdot}kg^{-1}{\cdot}min^{-1}$, 13.7 ± 4.5 $mL{\cdot}kg^{-1}{\cdot}min^{-1}$, 8.0 ± 4.1 $mL{\cdot}kg^{-1}{\cdot}min^{-1}$, and 16.0 ± 2.7 $mL{\cdot}kg^{-1}{\cdot}min^{-1}$, respectively.

Correlation analyses. Figure 2 summarizes the correlations between the values obtained from the UNCCRI treadmill protocol and each of the 6MWT $\dot{V}O_{2peak}$ prediction equations. A positive strong correlation occurred between the $\dot{V}O_{2peak}$ values obtained from the UNCCRI treadmill protocol and 6MWT equation 1 ($r = 0.81$). Moderately strong correlations were observed between the UNCCRI treadmill protocol values and 6MWT equations 2 ($r = 0.70$) and 4 ($r = 0.76$), and 6MWT equation 3 had the weakest correlation ($r = 0.59$). Each of the 6MWT prediction equations underpredicted

TABLE 2. Exercise values.

	UNCCRI Treadmill Protocol	6MWT	P
Maximal HR (bpm)	150 ± 22	109 ± 21	<0.001*
Maximal SBP (mm Hg)	150 ± 18	139 ± 19	<0.001*
Maximal DBP (mm Hg)	78 ± 9	76 ± 10	0.001*
Maximal RPE	9 ± 2	5 ± 2	<0.001*
SO_2 at peak (%)	94 ± 3	95 ± 3	0.008*
TM time (min)	10.4 ± 3.1	—	—
Walk distance (m)	—	485 ± 108	—

DBP, diastolic blood pressure.
*Significant differences between groups.

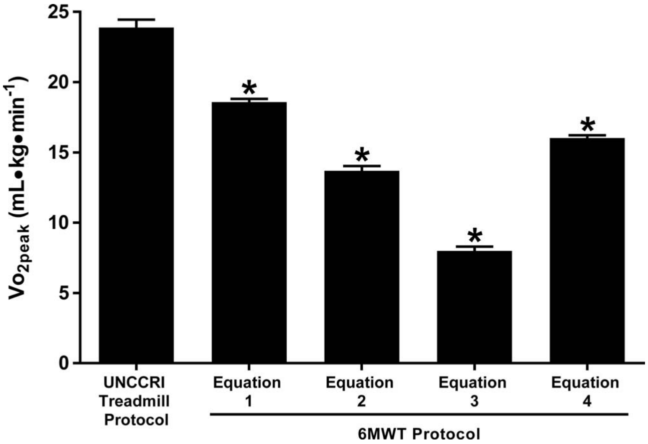

FIGURE 1—Mean $\dot{V}O_{2peak}$ values derived from outcomes of the UNCCRI TM Protocol and each of the 6MWT Prediction Equations described in the methods section. *Significantly different (P < 0.001) from the UNCCRI treadmill $\dot{V}O_{2peak}$ value.

$\dot{V}O_{2peak}$ at a high rate, with equations 1, 2, 3, and 4 resulting in underprediction in 82%, 98%, 100%, and 92% of the tests, respectively. The average magnitude of underprediction ranged from a low of 9.2 mL·kg^{-1}·min^{-1} for equation 1 to a high of 17.7 mL·kg^{-1}·min^{-1} for equation 3.

DISCUSSION

The importance of obtaining a valid, reliable, and accurate measure of peak oxygen consumption before and during an exercise-based rehabilitation program for cancer survivors cannot be overstated. It is the basis for determining aerobic exercise intensity and provides the means of adjusting exercise intensity to safeguard the implementation of overload and progression during rehabilitation. Furthermore, it is a key tool for managing exercise intensity in such a way as to limit the likelihood of causing an infection in a population that may be immunocompromised. Considering that the 6MWT is one of the most widely used submaximal exercise tests with cancer survivors, we sought to determine the validity of the 6MWT as a means to predict $\dot{V}O_{2peak}$ in a cancer specific population.

All participants in this study were able to safely complete both testing protocols with no adverse events. Even for those cancer survivors severely compromised by disease and treatment-related side effects, the UNCCRI treadmill protocol was able to safely quantify $\dot{V}O_{2peak}$. Furthermore, using handrails with the treadmill protocol still produced higher $\dot{V}O_{2peak}$ values even in the most physically compromised cancer survivors. Results showed that the UNCCRI treadmill protocol yielded significantly higher $\dot{V}O_{2peak}$

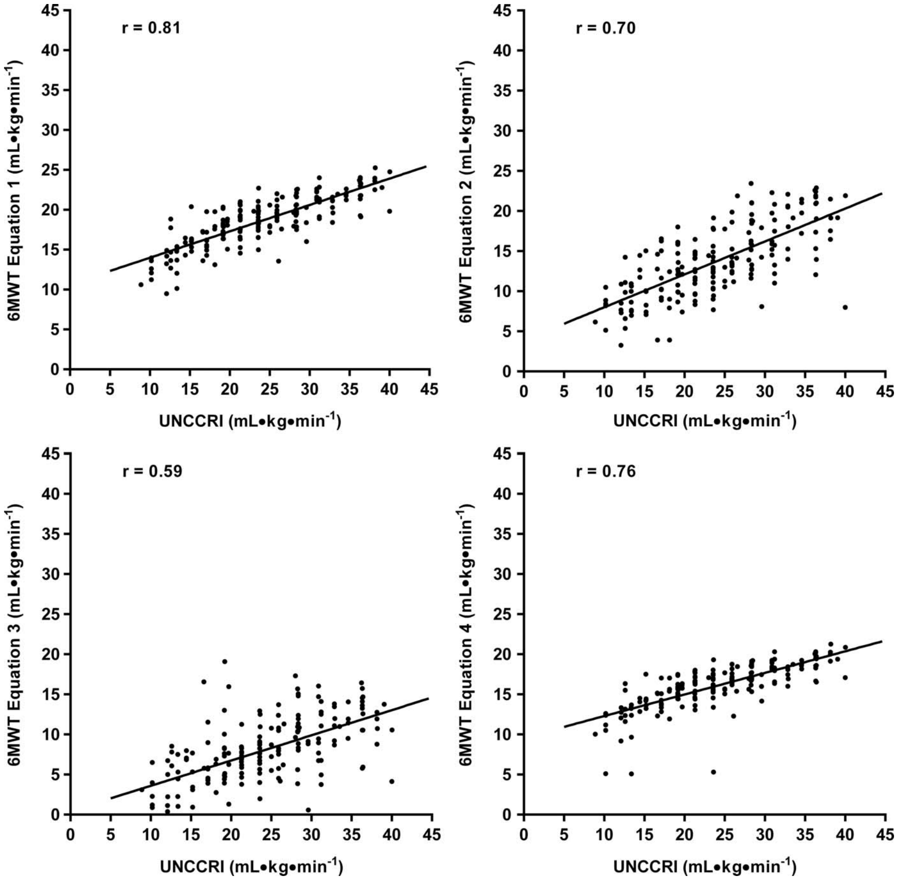

FIGURE 2—Correlations between $\dot{V}O_{2peak}$ values derived from the outcomes of the UNCCRI treadmill protocol and each of the 6MWT prediction equations described in the methods section.

values ($P < 0.001$) when compared to all four 6MWT prediction values. Equation 1 was found to have the strongest correlation with $\dot{V}O_{2peak}$ values obtained from the UNCCRI protocol ($r = 0.81$), yet it still underpredicted $\dot{V}O_{2peak}$ in 82% of tests with an average magnitude of underprediction in excess of 9 $mL \cdot kg^{-1} \cdot min^{-1}$. Although each of the prediction equations showed a positive correlation with $\dot{V}O_{2peak}$ values obtained from the UNCCRI treadmill protocol, all prediction equations consistently underestimated $\dot{V}O_{2peak}$. Equation 3 underpredicted $\dot{V}O_{2peak}$ in 100% of the 187 subjects, and 25% of the predicted $\dot{V}O_{2peak}$ values obtained with this equation were more than 20 $mL \cdot kg^{-1} \cdot min^{-1}$ lower that the actual $\dot{V}O_{2peak}$ measured with the UNCCRI treadmill protocol. Collectively, the 6MWT prediction equations underpredicted $\dot{V}O_{2peak}$ in 700 of 748 possible tests and underpredicted $\dot{V}O_{2peak}$ by an average of over 10 $mL \cdot kg^{-1} \cdot min^{-1}$.

Maldonado-Martin et al. (18) and Du et al. (19) cautioned against the use of the 6MWT in heart failure patients where an accurate determination of functional capacity is essential. Ross et al. (14) reviewed several studies and used a linear mixed model analysis to derive an equation to predict $\dot{V}O_{2peak}$ using data points from 1083 patients with diverse cardiopulmonary disease diagnoses. A weak correlation (r = 0.59) was found between distance covered and predicted $\dot{V}O_{2peak}$, but the standard estimation of error (SEE) was unacceptably large (3.82 $mL \cdot kg^{-1} \cdot min^{-1}$) for clinical usefulness in individual patients (14). Similar to the results of the present study, several studies have shown positive correlations between $\dot{V}O_{2peak}$ measured during a cardiopulmonary exercise test (CPET) when compared to $\dot{V}O_{2peak}$ estimated from the 6MWT (13,15,20–22). In 37 patients with varying classifications of heart failure, a positive correlation ($r = 0.72$) was observed between the 6MWT predicted $\dot{V}O_{2peak}$ and CPET $\dot{V}O_{2peak}$ (22). However, when these patients were grouped according to their $\dot{V}O_{2peak}$, the correlation was highly dependent on the functional impairments demonstrated by each subject. In subjects with a $\dot{V}O_{2peak}$ greater than 25.2 $mL \cdot kg^{-1} \cdot min^{-1}$, the 6MWT derived $\dot{V}O_{2peak}$ was significantly lower than the CPET test (23.4 ± 2.6 $mL \cdot kg^{-1} \cdot min^{-1}$ vs 27.6 ± 3.3 $mL \cdot kg^{-1} \cdot min^{-1}$). Conversely, in those with a $\dot{V}O_{2peak}$ equal to or lower than 17.5 $mL \cdot kg^{-1} \cdot min^{-1}$, the 6MWT derived $\dot{V}O_{2peak}$ was significantly higher than the CPET test (15.5 ± 3.6 vs 13.6 ± 2.5) (22).

Other studies have reported similar results that at higher levels of functional capacity the 6MWT does not provide an accurate estimation of $\dot{V}O_{2peak}$ (23–25). Lipkin et al. (23) found that maximal CPET tests may be more appropriate for patients who have mild heart failure, or a $\dot{V}O_2$ greater than 20 $mL \cdot kg^{-1} \cdot min^{-1}$. Deboeck et al. (24) reported that a distance greater than 500 m covered during the 6MWT results in the test becoming less sensitive to increases in $\dot{V}O_{2peak}$. Fujino et al. (25) found a weak correlation between $\dot{V}O_{2peak}$ and 6MWT distances below 450 m ($r = 0.55$, $P < 0.01$) and no correlation with distances greater than 450 m (r = 0.304, P = 0.193). Several other studies report no significant correlation between the 6MWT-derived $\dot{V}O_{2peak}$ and a CPET measured $\dot{V}O_{2peak}$ in healthy and elderly populations who have higher degrees of functional capacity compared to chronic disease populations (24,26,27). In healthy individuals and those who may have early stage clinical disease, the 6MWT may not be suitable for evaluating exercise capacity (28,29). The value of the 6MWT has been questioned by other investigators due to the fact that the test can elicit a maximal exercise response in participants with a low $\dot{V}O_{2peak}$, whereas other individuals may not give the appropriate effort. Faggiano et al. (20) found the walk test to be questionable as a submaximal test in heart failure populations because 73% of subjects had exceeded their anaerobic threshold at termination. Conversely, in the present study it was uncommon to find cancer survivors putting in maximum effort during the 6MWT, even when the stated goal of the test is to walk as far as possible in the given time frame. This reduced effort was reflected by an average RPE of 5 ± 2 on the 6MWT compared to an average RPE of 9 ± 2 on the treadmill test.

The validity of the 6MWT has been investigated in healthy subjects as well as in numerous chronic disease populations, but to our knowledge only one study investigated its validity in cancer survivors. Schmidt et al. (29) reported that the 6MWT is valid and recommended its use with cancer patients. However, there are several key differences between the Schmidt et al. study and the present study. Schmidt et al. (29) used a cycle ergometer test as opposed to a treadmill test to measure actual $\dot{V}O_{2peak}$. Cycle ergometry is a less familiar activity for many cancer survivors than walking/running, which may explain why cycle ergometer tests often result in lower $\dot{V}O_2$ values when compared to treadmill tests (30–32). In addition, the 6MWT was performed less than 1 h after completing the cycle ergometer CPET, and the order of the two tests was not randomized. In the current study, the tests were performed 1 wk apart and the order of the tests was randomized. Furthermore, Schmidt et al. (29) did not calculate a predicted $\dot{V}O_{2peak}$ value but instead correlated distance covered during the 6MWT with actual $\dot{V}O_{2peak}$ values obtained during the cycle ergometer CPET. Although many studies have attempted to use 6MWT distance covered as the primary outcome measure when assessing functional capacity or fitness level, such a measure is not of value when prescribing exercise based on a percentage of $\dot{V}O_{2peak}$.

The 6MWT was originally developed to assess exercise capacity in the cardiopulmonary patient population (33,34). Our results highlight the fact that assuming universal application of prediction equations across different patient populations to estimate oxygen uptake may well be inappropriate and could lead to incorrect conclusions and inappropriate treatment interventions. Here, we focused on the rehabilitation management of cancer survivors, a subpopulation that the exercise and rehabilitation communities have taken an increasing interest in. With this increased attention has come the need to accurately assess individuals with a history of cancer to prescribe the most effective exercise dose, and by extension this requires an evaluation of the clinical utility of assessment tools such as the 6MWT and clinical exercise testing. It should be noted that the article first identifying the 6MWT as a useful measure of functional exercise capacity in heart failure patients also stated that walking tests, such as the 6MWT assessed a patient's ability to perform activities of day-to-day life rather than laboratory-based exercise capacity (33). Others have recognized this and have routinely viewed results from the 6MWT as functional rather than physiologic (14,34,35). It has also been reported that psychological and functional factors that affect 6MWT performance may have no impact on clinical exercise testing results suggesting that these are not equivalent tests (14). Although the endpoints of the 6MWT and clinical exercise testing are overlapping, they are not equivalent. Thus, the 6MWT is a test that assesses physical functional capacity which has been coopted to serve as a surrogate physiologic test in several patient populations including cancer (36,37). Carter et al. (38) proposed the use of 6-min work (6 MW), calculated as 6-min distance $\times$ body weight product, as an improved outcome measure with a more physiologic foundation but this has yet to be investigated in the cancer population. With this backdrop, it is imperative that clinicians recognize the clinical utility of each test and use the test most appropriate for the desired outcomes. In the context of exercise-based rehabilitation, accurate exercise prescription, particularly exercise intensity, requires assessment of exercise capacity as opposed to the ability to perform activities of daily living (i.e., functional capacity).

The 6MWT has been used for over 50 yr and has been shown to be a useful screening, prognostic, and predictive tool if used in the proper context. Utilization of the 6MWT may be valuable for remote monitoring of patients with limited access to health care facilities, as a home-based self-assessment for patients interested in tracking their progress, or possibly as a component of a mobile application. Although there are many studies in support of the 6MWT as a predictor of $\dot{V}O_{2peak}$, there are also many studies pointing to the lack of validity and usefulness in both healthy and diseased populations. Collectively, the data suggest that peak oxygen consumption estimated by using the results from a 6MWT does not accurately reflect peak oxygen consumption. The American Thoracic Society states that although investigators have used the 6MWT in clinical settings, this does not prove that the test is clinically useful or that it is the best test for determining functional capacity (12). Thus, the information provided by the 6MWT should not be considered a replacement for peak cardiopulmonary exercise testing. It is strongly recommended that health care professionals working in a clinical/professional exercise setting use a treadmill exercise test to volitional fatigue to obtain a $\dot{V}O_{2peak}$ value for prescribing exercise in cancer survivors. Exercise testing to volitional fatigue is safe for these individuals and should be the test of choice when quantifying $\dot{V}O_{2peak}$ in this population.

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The results of the study are presented clearly, honestly, and without fabrication, falsification, or inappropriate data manipulation. The results of the study do not constitute endorsement by the American College of Sports Medicine. The authors declare no conflicts of interest.

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