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Outdoor reproducibility of a 1-km treadmill-walking test to predict peak oxygen consumption in cardiac outpatients

--Manuscript Draft--

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Abstract:	Introduction The aim of this study was to determine whether the 1-km treadmill-walking test previously developed to predict VO2peak in stable cardiac outpatients could be reproduced outdoors. Methods Fifty male cardiac outpatients performed the 1-km walking test on a treadmill and on a flat track within one week. VO2peak was estimated for both testing conditions considering age, height, weight, walking speed and heart rate. Results Average walking speed was slightly higher during outdoor conditions (5.76 ± 0.77 vs 5.57 ± 0.85 km/h), while mean heart rates were similar for both testing conditions (102 ± 18 vs 103 ± 16 bpm). VO2peak values for treadmill and outdoor tests were not significantly different (26.5 ± 4.1 vs 26.8 ± 4.6 mL/kg/min), and were strongly correlated ($r = 0.93$, $P < 0.0001$). The slope and the intercept of the VO2peak values were not different from the line of identity. Discussion The moderate and perceptually-regulated 1-km walking test administered outdoors gives similar results when performed on a treadmill. VO2peak can be therefore reasonably estimated using both testing conditions. This suggests that the outdoor 1-km test can be applied for indirect estimations of cardiorespiratory fitness in an

	outpatient setting.
Response to Reviewers:	Reviewer Comments and Responses REVIEWER #1: GENERAL COMMENTS A)The purpose of this investigation was to determine if the estimated peak VO2 from an outdoor walking test would be similar to the estimation from an indoor treadmill test that was previously validated. The correlation coefficient was 0.93 and the confidence limits were acceptable with a highly significant p-value. The study results would have been strengthened if the subjects had an actual measurement of peak VO2 as occurred in the previous published validation study using the indoor treadmill protocol. It would also be important to test the between test reproducibility on serial testing. Was the outdoor walking test repeated in the same subjects to determine if similar results were found. Response Reviewer #1 suggests that the results could be strengthned if the subjects had an actual direct measurement of peak VO2, and also that it would have been important to check test reproducibility. We agree that it would have been ideal to have a direct measure of peak VO2, given its greater precision, and we have mentioned this in the Limitations section. In terms of reproducibility, please note that, as indicated in the Methods, the order of the indoor (treadmill) and field tests was randomized, and that the indoor and outdoor tests were carried out by different operators, blinded to the results of the first test. The close similarity of the results obtained during both indoor and outdoor tests is emphasized by the almost identical values of walking speed and heart rate in both conditions (see section Results, lines 43 and 44). B)It was interesting that the subjects were coached to change their walking speed to adjust a RPE rating between 11-13, indicating that the test needs to be performed in a supervised manner and thus differs from the protocol with the 6-minute walking test. It is encouraging that the mean heart rate between the treadmill and outdoor test was also similar and at a level (68% peak HR) that would be below the anaerobic and lactate threshold. Response The reviewer is correct. Several patients followed by our rehab program run the test by themselves, unsupervised. This has been added to the Discussion. C)This test was only evaluated in men and it is unclear whether similar results would be expected in women. Also, these patients were healthy cardiac patients with peak VO2 values > 20 ml/kg/min. The one outlier had a peak VO2 of 10-16 ml/kg/min, depending on the type of test. This suggests that this submaximal test may be less reliable in patients with HFrEF or HFpEF. The mean age of the patients was 68 + 11 yrs, and it appears that this test could be used in moderately elderly patients for whom treadmill exercise may be more difficult. However, the test needs to be validated in patients > 80 yrs. It would be useful to determine the responsiveness of this test to changes in exercise capacity from exercise training or medical interventions. Of course, this would be the topic of another investigation. Response We agree, and we appreciate the thoughts of the reviewer. The subjects examined were stable male cardiac outpatients, and relatively old. Our project is continuing, and all these topics will be considered, including applications of the test in women. REVIEWER #1: SPECIFIC COMMENTS Page 3, lines 44 and 45: It would be useful to include a correlation figure for mean heart rate response during the two tests. Response This is a Brief Report, and only two figures or tables are allowed. However, data from the correlation analysis ($y = 0.78x + 22.6$, $R = 0.88$, $P<0.0001$) have been included in the Results section of the revised manuscript.

	REVIEWER #2 The present brief/case report reports clinically useful, well-controlled, and evidence-based research. The purpose of the study was to validate reproducibility of an outdoor 1-km walking test against the previously established 1-km treadmill walking test in stable cardiac patients. The purpose is focused, methodology appropriate and well-described, and results support the conclusions. This research, as the authors identify in the discussion, has important clinical application. The only minor concern is that the regression figure detailing the agreement between VO2peak for the treadmill and outdoor tests is of low quality. It is quite possible that this will be corrected at the time of publication but in present form text, points, and confidence interval lines are blurry and in some cases (CI lines) barely visible. The quality of the Figure has been improved as suggested. It would also be useful to include the limitation in the Discussion section that peak VO2 was not measured in this trial. The direct VO2 peak assessment was not performed in this trial. This limitation has been mentioned in the revised manuscript.

Ferrara, October 12, 2015

Larry F. Hamm, PhD
Washington, DC

Editor-in-Chief
Journal of Cardiopulmonary Rehabilitation and Prevention

Dear Prof.Hamm,

on behalf of my co-authors, I submit for publication on the Journal of Cardiopulmonary Rehabilitation and Prevention a manuscript entitled:

"Outdoor reproducibility of a 1-km treadmill-walking test to predict peak oxygen consumption in cardiac outpatients"

by Giovanni Grazzi, Giorgio Chiaranda, Jonathan Myers, Giovanni Pasanisi, Rosario Lordi, Francesco Conconi, and Gianni Mazzoni.

I hereby declare that this paper is original and not under consideration or published elsewhere. Each author has contributed substantially to the submitted work, reviewed and approved this final version of the manuscript. Funding received for this work: none.

Looking forward to hearing from you at your convenience,

Best regards.

Sincerely yours,

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TITLE PAGE

Outdoor reproducibility of a 1-km treadmill-walking test to predict peak oxygen consumption in cardiac outpatients

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Brief title: Outdoor 1-km walking test

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Word count: 1610

STRUCTURED ABSTRACT

Introduction

The aim of this study was to determine whether the 1-km treadmill-walking test previously developed to predict VO_2peak in stable cardiac outpatients could be reproduced outdoors.

Methods

Fifty male cardiac outpatients performed the 1-km walking test on a treadmill and on a flat track within one week. VO_2peak was estimated for both testing conditions considering age, height, weight, walking speed and heart rate.

Results

Average walking speed was slightly higher during outdoor conditions (5.76 ± 0.77 vs 5.57 ± 0.85 km/h), while mean heart rates were similar for both testing conditions (102 ± 18 vs 103 ± 16 bpm). VO_2peak values for treadmill and outdoor tests were not significantly different (26.5 ± 4.1 vs 26.8 ± 4.6 mL/kg/min), and were strongly correlated ($r = 0.93$, $P < 0.0001$). The slope and the intercept of the VO_2peak values were not different from the line of identity.

Discussion

The moderate and perceptually-regulated 1-km walking test administered outdoors gives similar results when performed on a treadmill. VO_2peak can be therefore reasonably estimated using both testing conditions. This suggests that the outdoor 1-km test can be applied for indirect estimations of cardiorespiratory fitness in an outpatient setting.

Key words: 1-km walk test, cardiorespiratory fitness, secondary prevention

CONDENSED ABSTRACT

In 50 cardiac outpatients, outdoor and treadmill 1-km walking tests provided similar results. Data derived from the outdoor 1-km test can be used to provide a reasonable estimate of VO2 peak when evaluating cardiac outpatients.

TEXT

Introduction

Exercise capacity is mainly related to the ability to perform activities requiring activation of aerobic mechanisms. Peak oxygen uptake (VO_2 peak), reflecting the upper limits of the body's aerobic function, is the most widely used parameter to assess cardiorespiratory fitness.[1] VO_2 peak is also recommended for the evaluation of cardiovascular disease severity, to estimate prognosis, and to examine the effectiveness of training in cardiac rehabilitation and secondary prevention programs.[2]

However, because of physical, financial and time limitations, direct determination of VO_2 peak is often not routinely assessed in rehabilitation, other clinical settings, or in health-fitness facilities. In addition, maximal testing with expired gas analysis may not be the most applicable approach to follow patients who rarely engage in activities that approach this level of intensity.[3] In such cases, the assessment of cardiorespiratory function by submaximal exercise testing provides a reasonable approach to health-related fitness assessment.[4]

Recently, a simple, submaximal 1-km treadmill-walking test for estimating VO_2peak in clinically stable cardiac outpatients was developed and cross-validated.[5] The walking speed during the test is perceptually regulated in an individualized fashion to a moderate exercise intensity. This treadmill protocol has been demonstrated to predict long-term survival,[6,7] in cardiac outpatients.

While several existing treadmill protocols can be used to predict VO_2 peak and prognosis, we felt a submaximal test valid for both treadmill and field applications would be valuable. Therefore, the aim of this study was to investigate whether the 1-km treadmill-walking test would give similar results when administered outdoors to those validated in the laboratory.

Methods

Fifty male cardiac outpatients, aged 31 to 85 years, were referred by their personal physician for our secondary prevention program. Each subject completed a clinical evaluation including personal and family history and a medical examination. All subjects performed both an indoor and outdoor 1-km walking test while receiving their usual medications without need to modify overall therapy for at least three months before testing. Subjects were instructed not to change dietary habits, not to consume any food or beverages except water for ≥2 hours before testing, and not to engage in any type of vigorous physical activity during the two days before testing. The study was approved by the Human Studies Committee at the University of Ferrara, and all subjects gave written informed consent.

The order of the indoor (treadmill) and field tests was randomized, the tests were performed on separate days, and both tests were performed within 1 week. Temperature, humidity, and time of day for the two tests were similar. Subjects were asked not to change their usual therapy, diet or training habits during the days between tests. The tests were supervised by trained exercise specialists, and supported by a physician skilled in exercise testing or emergency medicine who was in close proximity. An independent exercise specialist, blinded to the results of the first test, carried out the second tests.

Participants were asked to describe their typical leisure-time physical activity during a typical week during the two months preceding the tests. The "dose" was calculated as the product of the duration (hours per week) of the various activities weighted by an estimate of metabolic equivalent (MET) of each activity.[8]

Prior to both tests, subjects were instructed on how to use the Borg 15 point Rating of Perceived Exertion (RPE) scale,[9] and asked to select a pace that they could maintain for 10–20 min at a moderate perceived exercise intensity (11–13 on the Borg scale).

Treadmill testing. The 1-km test was carried out as previously described.[5] The initial walking speed was set at 2.0 km/h with no incline, with subsequent increases of 0.3 km/h every 30 s up to a walking speed corresponding to the target RPE. The test was then started and the RPE checked every 200 m: the walking speed was adjusted to maintain the selected intensity. Tight gripping of the handrails was not permitted; placement of a finger or palm on the handrails was allowed for balance only. Heart rate was monitored continuously during the test using a Polar RS 100 heart rate monitor (Polar Electro, Kempele, Finland). Blood pressure was monitored before and immediately after the test. The time to complete 1-km was recorded and average walking speed calculated accordingly.

Outdoor testing. Each patient performed the 1-km field walk on a 200m flat dirt track. Participants began the test after a 200 m warm-up at a perceived exertion of 9-11 on the Borg scale. On the second lap the walking speed was increased progressively until an intensity of 11-13 on the Borg Scale was achieved. At the end of the second lap the 1-km portion was begun. The rate of perceived exertion was checked every lap and walking speed was adjusted to maintain the selected intensity. Heart rate and blood pressure were monitored and recorded as described for the treadmill testing.

Data analysis. Time to walk 1 km, heart rate, age, height and weight were entered into the original equations to estimate peak VO_2.[5] Predicted VO_2 peak values by treadmill and field tests were compared using paired *t*-tests. Passing and Bablok regression analysis was used to determine the relationship between values obtained during the two experimental conditions. Pearson correlation coefficients between treadmill and field values were computed, along with standard errors of estimate (SEE). Appropriateness of the model was assessed using Bland-Altman analysis and normal probability plots of the residuals. To evaluate test repeatability, concordance correlation coefficient for predicted VO_2 peak was calculated. The level of statistical significance was set at $P < 0.05$. Statistical analyses were performed using the package Medcalc 15.8 software (Mariakerke, Belgium).

Results

Characteristics of the 50 participants are presented in the Table. All subjects completed both treadmill and outdoor tests without complications.

Average walking speed was slightly higher for the outdoor test (5.73 ± 0.77 vs 5.55 ± 0.84 km/h, p = 0.04), whereas mean heart rate was not different (102 ± 18 vs 103 ± 16 bpm, p = 0.25). The correlation between mean heart rate during treadmill and outdoor testing yielded the following values: y = 0.78x + 22.6, R = 0.88, P<0.0001. The average heart rate during both tests was 68% of the age-predicted maximal heart rate (based on 220-age).

Peak oxygen consumption values predicted from treadmill and outdoor tests were 26.4 ± 4.1 and 26.8 ± 4.5 mL/kg/min, respectively. The slope and the intercept of the relationship between treadmill and outdoor test values were not significantly different from the line of identity (Passing and Bablock analysis, P = 0.88, Figure).

The correlation coefficient for predicted VO_2 peak between the two tests was 0.93 (95% CI 0.89 to 0.96, P < 0.0001), and the SEE = 1.1 mL/kg/min. Residuals were normally distributed with a mean residual value of 1.1 mL/kg/min. Examination of the Bland-Altman analysis demonstrated that 96% of the data points were within the limits of agreement. Concordance correlation coefficients for predicted VO_2peak across trials was 0.93 (95% CI from 0.88 to 0.96) indicating good precision, accuracy and repeatability.

Discussion

The main finding of this study was that the 1-km walking test when performed in the field setting gives results comparable to those obtained when the 1-km walk is performed in the laboratory. Heart rate values were identical during indoor and outdoor tests, while walking speed was slightly higher during field testing. It is doubtful whether this small difference (0.18 km/h) is of any practical importance.

VO_2 peak values predicted by the 1-km outdoor walking test using equations developed and cross-validated for a 1-km treadmill-walking test[5] were superimposable, highly correlated and in good agreement. The high correlation (r = 0.93) and concordance (0.93) coefficients, the small SEE (1.1 mL/kg/min), and the modest residuals indicate that the equations validated for treadmill testing are appropriate for predicting VO_2 peak during outdoor testing in stable cardiac outpatients.

The results obtained in the present study are similar to those reported in studies of other outdoor walking tests (see references 10 and 11). However, few data exist regarding the relationship between moderate walking and cardiorespiratory fitness assessment in stable cardiac outpatients. Correlation coefficients observed in our original study and the present results provide further support for the strong association between walking performance to peak VO_2,[11] even though direct VO_2 peak determination was not carried out in this trial.

The present protocol relies on the familiar task of outdoor moderate walking that is the most common physical activity engaged in by adults. This reduces the possibility that lack of familiarity with the task may reduce the predictive accuracy of the test. Walking has been proposed as an exercise testing modality for cardiac patients in both laboratory and field settings;[10] thus we felt a submaximal test valid for both treadmill and the field would be valuable. An advantage of this 1-Km outdoor walking test is the fact that the test is carried out at an individualized and patient-determined moderate intensity (11 to 13 RPE scale). This is confirmed by the average 68% of the age-predicted maximal heart rate value, which falls within the current recommended limits for moderate intensity (64% to 77%).[12] As such, the test may also serve as a learning trial for proper intensity of exercise. In fact, the exercise intensity at an RPE value of 11 to 13 has been associated with the lactate threshold, independent of training state (see reference 13). Aerobic conditioning at such an intensity has been demonstrated to be safe and optimal to enhance cardio-respiratory function in patients with chronic disease.[13]

In conclusion, the 1-km treadmill-walking test is a reliable method for predicting VO_2 peak in cardiac outpatients when administered outdoors. The results of the present study may have practical implications in the context of transitioning from clinically based and supervised programs to fitness facilities or self-guided exercise programs. The ability to use this test in the field allows testing by health professionals in more “real world” situations, requiring only a measured kilometer and a heart rate monitor. Interestingly, several patients followed by our rehab program are able to run the test by themselves, unsupervised.

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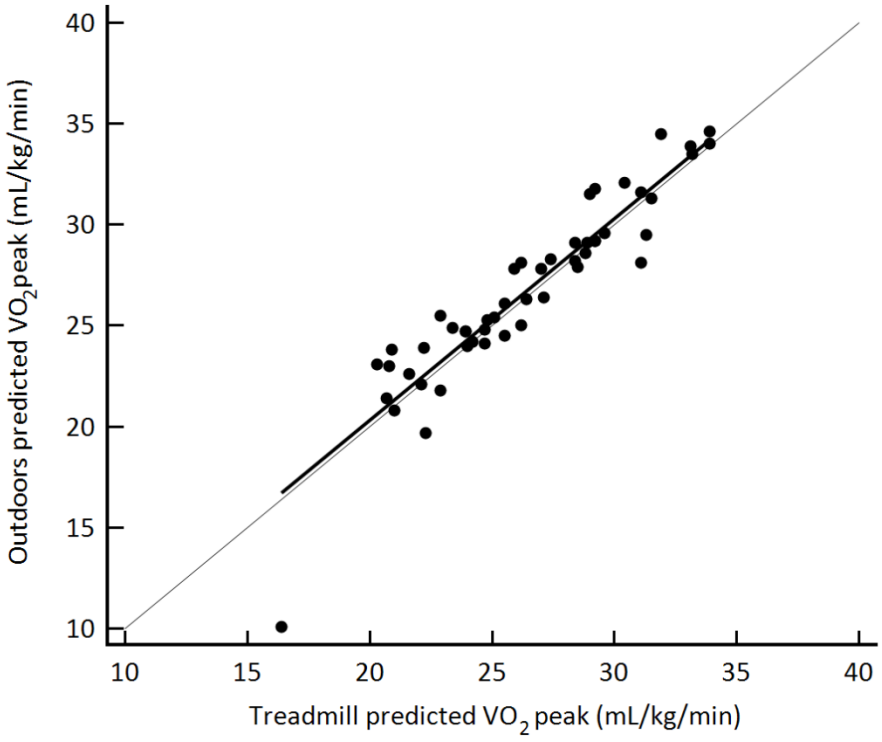
Figure Legend. Regression between peak oxygen uptake estimated outdoors and in the lab setting on the treadmill (r = 0,93, SEE = 1.1 mL/kg/min)


Outdoors predicted VO2peak (mL/kg/min)
Treadmill predicted VO2 peak (mL/kg/min)
10
15
20
25
30
35
40

Table

Table. Characteristics of the study population

General	
Age (yr)	68 (11)
BMI	26,7 (3,6)
LV ejection fraction (%)	57,3 (10,2)
LTPA (MET/h/week)	24,3 (11,8)
Risk factor	
Family history (%)	34
Current smoking (%)	0
Hypertension (%)	46
SBP (mm/Hg)	125 (11)
DBP (mm/Hg)	75 (8)
Fasting glucose (mg/dl)	100 (16)
Total cholesterol (mg/dl)	166 (47)
HDL-cholesterol (mg/dl)	51 (13)
LDL-cholesterol (mg/dl)	91 (21)
Serum triglycerides (mg/dl)	121 (65)
Medical history	
Myocardial infarction (%)	30
PTCA (%)	42
CABG (%)	26
Valvular replacement (%)	12
Medications	
ACE inhibitor or ARB (%)	55
Aspirin (%)	71
β-blocker (%)	71
Calcium antagonist (%)	15
Diuretic (%)	17
Statin (%)	81
Number of medications (n)	3 (2)

Data are presented as mean (standard deviation) or %.

Abbreviations: ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; BMI, body mass index; CABG, coronary artery bypass graft; DBP, resting diastolic blood pressure; HDL, high-density lipoproteins; LTPA, leisure time physical activity; LV, left ventricular; PTCA, percutaneous transluminal coronary angioplasty, stenting or both; SBP, resting systolic blood pressure

Figure

Click here to download Figure Figure revised.tif