



## Original Article

Fixed-Altitude Stair-Climbing Test Replacing the Conventional Symptom-Limited Test. A Pilot Study<sup>☆</sup>

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## ABSTRACT

**Introduction:** The objective of this study was to investigate whether a patient's maximum capacity is comparable in 2 different stair-climbing tests, allowing the simplest to be used in clinical practice.

**Method:** Prospective, observational study of repeated measures on 33 consecutive patients scheduled for lung resection. Stair-climbing tests were: the standard test (climb to 27 m) and the alternative fixed-altitude test (climb to 12 m). In both cases, heart rate and oxygen saturation were monitored before and after the test. The power output of stair-climbing for each test (Watt1 for the standard and Watt2 for the fixed-altitude test) was calculated using the following equation: Power (W)=weight (kg)\*9.8\*height (m)/time (s). Concordance between tests was evaluated using a regression model and the residuals were plotted against Watt1. Finally, power output values were analyzed using a Bland–Altman plot.

**Results:** Twenty-one male and 12 female patients (mean age 63.2±11.2) completed both tests. Only 12 patients finished the standard test, while all finished the fixed-altitude test. Mean power output values were Watt1: 184.1±65 and Watt2: 214.5±75.1. The coefficient of determination ( $R^2$ ) in the linear regression was 0.67. No fixed bias was detected after plotting the residuals. The Bland–Altman plot showed that 32 out of 33 values were within 2 standard deviations of the differences between methods.

**Conclusions:** The results of this study show a reasonable level of concordance between both stair-climbing tests. The standard test can be replaced by the fixed-altitude test up to 12 m.

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## La prueba de escaleras limitada por altura podría sustituir a la prueba estándar en la evaluación funcional previa a la resección pulmonar. Estudio piloto

## RESUMEN

**Introducción:** El objetivo de este estudio es conocer si en una prueba de subir escaleras en la que solo se asciende una altura fija de 12 m se desarrolla una potencia similar a la de la prueba estándar, lo que significaría que ambas son equivalentes.

**Método:** Estudio prospectivo, observacional de medidas repetidas en 33 pacientes consecutivos valorados para resección pulmonar. Prueba estándar: límite de 27 m de altura; prueba altura fija: 12 m. Se monitorizaron saturación de oxígeno y frecuencia cardíaca al inicio y al final del ejercicio y se midió el tiempo de esfuerzo. La potencia desarrollada en cada prueba se calculó (Watt1: estándar y Watt2: altura fija) mediante: Potencia (Watt) = peso (kg)\*9.8\*altura (m)/tiempo(seg). Para evaluar la equivalencia entre potencias, se construyó un modelo de regresión lineal y se contrastaron gráficamente los residuos. Los valores de las potencias se analizaron mediante el método de Bland y Altman.

## Palabras clave:

Evaluación preoperatoria

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**Resultados:** Veintiún varones y 12 mujeres realizaron ambas pruebas. Edad media  $63,2 \pm 11,2$ . Solo 12 pacientes terminaron la prueba estándar. Todos acabaron la prueba de 12 m. Los valores de potencia alcanzados fueron Watt1:  $184,1 \pm 65$  y Watt2:  $214,5 \pm 75,1$ . En la regresión lineal,  $R^2$  fue 0,67. No se encontró ningún sesgo en la distribución gráfica de los residuos. El análisis de Bland y Altman mostró que 32 de los 33 valores de potencia estaban dentro de las 2 desviaciones estándar de las diferencias entre métodos.

**Conclusión:** Los resultados muestran un nivel razonable de concordancia entre ambas pruebas de subir escaleras por lo que la prueba corta podría sustituir a la estándar.

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## Introduction

Predictive models allow patients to be classified according to their surgical risk in lung resection. If the risk is considered excessive, non-surgical treatment of the neoplasm is recommended. According to general consensus, the cardiopulmonary exercise test (CPET) with measurement of oxygen consumption ( $VO_2$ ), performed in the lung function laboratory, is the most sensitive and specific method for predicting this risk.<sup>1</sup> However, this test is not available in all hospitals, and in those where it is used, a considerable number of candidates may have to forego it due to limited availability and other circumstances.<sup>2</sup>

The European Respiratory Society and European Society of Thoracic Surgeons (ERS/ESTS) clinical practice guidelines published in 2009<sup>3</sup> recommend that patients undergo a low technology screening test prior to prescribing a CPET.<sup>1,3</sup> This enables clinicians to identify patients with a high  $VO_2$  level despite abnormal lung function tests. The symptom-limited stair-climbing test is one of 2 recommended.<sup>1,3</sup> This test, however, has its drawbacks, suggesting that a low cost, low technology (compared with CPET) test that is easier to standardize and safer for the patient than the 22 m climb test would be an interesting alternative.

Patients who cannot reach 22 m in the standard stair-climbing test<sup>4</sup> have been shown to have a higher probability of post-operative cardiopulmonary complications (CPC), as these are patients with deconditioned cardiopulmonary, vascular and muscular systems.<sup>5</sup>

In recent years, 2 groups of investigators have published a variation of the symptom-limited stair-climbing test.<sup>6–8</sup> Ambrozin et al.<sup>8</sup> named their variation the *fixed altitude stair-climbing test*. Both groups encouraged the patient to climb to a fixed altitude (12.6 m or 20 m), less than in the symptom-limited test, as fast as they could. The variation lies in that it is the time taken<sup>6,8</sup> or speed.<sup>7,9</sup> at which the patient climbs to this altitude that is measured. Both groups found a significant association between the parameters measured and CPC,<sup>8</sup> and also with the patient's  $VO_2$ .<sup>7,9</sup> However, none of these studies analyzed the possible relationship between these variations of the stair-climbing test and the test described by Brunelli et al.<sup>4</sup> and recommended in the latest 2 clinical guidelines published.<sup>1,3</sup>

The aim of this study was to determine whether a variant of the symptom-limited stair-climbing test, in which the patient is invited to climb to a fixed altitude of 12 m as quickly as possible, generates a power output similar to that of the symptom-limited stair-climbing test (to at least 22 m). This would suggest that both tests are equivalent. If this is the case, the short test could replace the standard test accepted in clinical practice guidelines.

## Methods

This was a prospective, repeated-measures observational study conducted in March 2014.

## Study Population

We included 33 consecutive patients with any diagnosis who were referred to the thoracic surgery clinic for lung resection assessment. All patients met the minimum operability criteria published previously,<sup>10</sup> agreed to undergo the proposed lung surgery, and had no limitations for climbing stairs due to joint problems or unstable comorbidities. The inclusion of patients with ischemic heart disease in the study was conditional upon previous coronary revascularization or evidence of good functional capacity evidenced by ergometry or an equivalent examination.

All patients signed an informed consent form and the study was authorized by the local ethics committee.

## Exercise Tests

All patients performed the 2 stair-climbing tests in the hospital, on the same stairs and accompanied by the same team of doctors. The 2 doctors who accompanied the patient monitored their vital signs and took the appropriate measurements. They were prepared to halt the test if the patient's condition so advised, and to provide medical assistance if required.

The height of the stairs was measured at various levels to determine the real altitude of each flight of stairs, and to accurately determine the altitude reached by the patient in the long test and the point at which the patient had climbed 12 m from a fixed starting point.

Both tests were carried out within 3 weeks of each other. As a rule, the symptom-limited stair-climbing test was done on the day of the assessment in outpatients, while the fixed-altitude test was done on the day of admission prior to the procedure. All patients were weighed before performing the second test to confirm that there had been no changes in their weight between both tests.

Before climbing the stairs, the patient did a 3–5 min leg warm-up on an unloaded cycle ergometer.

Both types of tests ended when the patient stopped at any point on the flight of stairs, the doctor accompanying the patient suspended the test due to the onset of warning signs, or when the stipulated altitude of 12 m or 27 m was reached.

The standard test<sup>4</sup> consisted of climbing up to 27 m (8 floors), at a steady pace as far as possible, without holding on to the banister except in the case of instability. In the fixed-altitude test, the patient was asked to climb 12 m as quickly as possible. In both tests, the patients were encouraged by the staff accompanying them to keep going.

## Variables Collected

Patient demographic variables were recorded: age, sex, weight, height and lung function studies (FVC%, FEV1%, FEV1%/FVC and DLCO%).

The following parameters were recorded during the exercise tests: heart rate and oxygen saturation immediately before

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