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Reliability and validity of 6MWT for outpatients with schizophrenia: A preliminary study

Eluana Gomes [a,*], Tânia Bastos [b,d], Michel Probst [c], José Carlos Ribeiro [a], Gustavo Silva [a], Rui Corredeira [a]

[a] Research Centre in Physical Activity, Health and Leisure (CIAFEL), Faculty of Sport, University of Porto, Porto, Portugal
[b] Centre of Research, Education, Innovation and Intervention in Sport (CIFI2D), Faculty of Sport, University of Porto, Porto, Portugal
[c] Faculty of Kinesiology and Rehabilitation Sciences, Research Group for Adapted Physical Activity and Psychomotor Rehabilitation, Catholic University of Leuven, Belgium
[d] Research Center in Sports Sciences, Health Sciences and Human Development, CIDESD, University Institute of Maia, ISMAI, Portugal

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ABSTRACT

Although the 6-minute walk test (6MWT) has been widely used in patients with schizophrenia, there is a lack of scientific evidence about its reliability and validity in this population. The first goal of this study was to explore the test–retest reliability of the 6MWT and to identify the associated parameters that contribute to the variability of the distance walked during the 6MWT in outpatients with schizophrenia. The second goal was to assess the criterion validity of the 6MWT in men with schizophrenia. Fifty one outpatients with schizophrenia participated in the study. To test–retest reliability (men=39; women=12), participants performed the 6MWT twice within 3 days interval. To test criterion validity (men=13), peak oxygen uptake (VO_{2peak}) was measured on a treadmill. For the associated parameters with the distance walked (n=51), medications use, smoking behavior, body and bone composition, and physical activity levels were analyzed. No significant differences between the means of the two 6MWTs were found. The intraclass correlation coefficient was 0.94 indicating good reliability. 6MWT correlated significantly with VO_{2peak} (r=0.67) indicating criterion validity. Height, body fat mass, smoking behavior and minutes of PA/week were significantly associated with the 6MWT. Results suggest that 6MWT shows good reliability for individuals with schizophrenia and good validity for the small sample of male participants in this study.

1. Introduction

Schizophrenia is a leading cause of disability worldwide (World Health Organization, 2008), which affects about 21 million people (World Health Organization, 2012). For most of these people, the antipsychotic medication is important to control the symptoms of the disease (Tandon et al., 2010). However, the use of this medication has been associated with metabolic disturbances (Newcomer, 2004; Blouin et al., 2009). Individuals with schizophrenia have a higher prevalence of diabetes mellitus (Wani et al., 2015), overweight and metabolic diseases, as well as disease of the cardiovascular and respiratory systems (Leucht et al., 2007; De Hert et al., 2009).

Additionally, many individuals with schizophrenia have an unhealthy lifestyle with an inadequate diet (Stokes and Peet, 2004); substance abuse (Kalman et al., 2005; Winklbaur et al., 2006) and insufficient levels of daily physical activity (PA) for the general health maintenance (Faulkner et al., 2006; Beebe and Harris, 2013). It has also been documented that individuals with schizophrenia have suboptimal levels of cardiovascular fitness (Saha et al., 2007; Vancampfort et al., 2011a). Previous studies (Vancampfort et al., 2011a, 2011c) reported association between low functional exercise capacity and low level of perceived sports competence, perceived physical fitness, and PA participation in individuals with schizophrenia.

Despite the importance of PA in the prevention and reduction of disorders often associated with schizophrenia (e.g., metabolic syndrome, cardiovascular disease, obesity) (Faulkner and Biddle, 1999; Fogarty et al., 2004; Beebe et al., 2005; Richardson et al., 2005; Marzolini et al., 2009; Vittaca et al., 2013) and in the reduction of the specific symptoms (negative and positive) of the disease (Bernard and Ninot, 2012; Vancampfort et al., 2012a) few studies have analyzed the validity and reliability of the instruments that assess the effects of regular PA in individuals with schizophrenia (Vancampfort et al., 2011b, 2014).

* Correspondence to: Faculty of Sport, University of Porto, Rua Dr. Plácido Costa, no. 91, 4200-450 Porto, Portugal.
E-mail address: aeluana@yahoo.com.br (E. Gomes).

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In this context, the best measure used to assess the benefits of regular PA is the maximal oxygen consumption (VO_{2max}) determined by ergospirometry. This method measures cardiovascular fitness (VO_2 max/peak) and is conducted in a laboratory using respired gas analysis (American Thoracic Society and American College of Chest Physicians, 2003; Mezzani et al., 2009). Nonetheless, ergospirometry is expensive and not always available in clinical practice (Elmahgoub et al., 2012). Moreover, adults with schizophrenia generally exhibit lower cardiopulmonary fitness (i.e., higher respiratory quotient on submaximal workloads and lower calculated VO_{2max}) than the general population (Nilsson et al., 2012). Therefore, it is difficult to motivate individuals with severe schizophrenia to consistently undertake exhausting exercise (Dodd et al., 2011).

The 6-minute walking test (6MWT) is considered an adequate submaximal test for individuals with schizophrenia (Beebe et al., 2005; Marzolini et al., 2009; Martín-Sierra et al., 2011; Vancampfort et al., 2011a, 2011b, 2012b, 2013; Bernard et al., 2014). It is a self-paced test, it is better tolerated and more reflective of daily activities than other maximal exercise tests (Solway et al., 2001). From a clinical perspective, it has the advantages of practicality and safety; it requires no special equipment or advanced training, and unlike maximal cardiopulmonary exercise testing, it can be performed by patients with severe impairments (American Thoracic Society, 2002; Enright, 2003). This is why the 6MWT is commonly used to measure the functional exercise capacity in individuals with different diseases (i.e., cardiovascular diseases, chronic obstructive pulmonary disease, traumatic brain injury) (Langenfeld et al., 1990; Campo et al., 2006; Roberts et al., 2006; Mossberg and Fortini, 2012).

Although 6MWT has been widely used in individuals with schizophrenia (Beebe et al., 2005; Marzolini et al., 2009; Vittaca et al., 2013; Gomes et al., 2014), to our knowledge only one study had evaluated the test–retest reliability of the 6MWT in this population (Vancampfort et al., 2011b). The authors found high values of test–retest reliability with Intraclass Correlation Coefficient (ICC) between the two 6MWT distances of 0.96 (CI 95% of 0.94–0.98). However, the generalization of this result is limited due to some methodological issues namely: i) focus only in inpatients; ii) focus only in one mental health center; and, iii) lack of information about the amount of the participants' daily exercise (Vancampfort et al., 2011b; Bernard et al., 2014). Lastly, to our knowledge, the association between the 6MWT and maximal exercise tests was never explored in individuals with schizophrenia.

Therefore, the first goal of this study was to explore the test–retest reliability of the 6MWT and to identify the associated parameters that contribute to the variability of the distance walked during the 6MWT in outpatients with schizophrenia. The second goal was to assess the criterion validity of the 6MWT in men with schizophrenia.

2. Methods

2.1. Participants

Over a five-month period, outpatients with a DSM-IV diagnosis of schizophrenia and stable on antipsychotic medication (i.e., using the same dosage for at least four weeks prior to inclusion) were included. Patients were excluded if they had co-morbid substance abuse and evidence of uncontrolled cardiovascular, neuromuscular and endocrine disorders.

The participants were recruited from three psychiatric rehabilitation units from Porto, Portugal and invited to participate by the psychiatrists. Afterwards, the research team had a meeting with the participants to explain the study in detail and to answer the participants' questions. This study was carried out following the Declaration of Helsinki guidelines for human research. The Faculty Ethics Committee approved this study. All participants gave their written informed consent.

2.2. Sample size analysis

With a minimal expected ICC of 0.80 and the hypothesis that present findings would be consistent with a minimum ICC of 0.90, a minimum sample size of 46 patients was required to achieve a level of significance (α) of 0.05 and power of 0.8 (β=0.2) (Walter et al., 1998). Consequently, a sample size of 51 participants was pre-specified.

2.3. Medication use

Antipsychotic medication was recorded for each patient and converted into a daily equivalent dosage of chlorpromazine according to Gardner et al. (2010).

2.4. Body and bone composition

Height and weight were measured before testing, with participants wearing shorts and t-shirts only. Height was measured using a Holtain stadiometer (Holtain Ltd., Crymmych, UK) and recorded in centimeters to the nearest millimeter. Weight was measured to the nearest 0.1 kg with a Seca weight scale. Body mass index (BMI) was calculated by the ratio between weight and squared height ($kg\,m^{-2}$). Waist circumference was measured at the level of the navel and hip circumference was measured at the largest circumference of the hips.

Bone mineral density, lean mass and fat mass were assessed through dual energy X-ray scan (Explorer QDR 4500, Hologic, Bedford, MA) with whole body protocol. Participants were placed in a supine position with their arms in extension near the trunk and lower limbs in extension, with a slight abduction of the feet. Participants removed clothes and all metallic objects (earrings, watches, etc.) and wore a gown.

2.5. Level of physical activity

Level of PA was measured using the short form of International Physical Activity Questionnaire (IPAQ-SF) (Craig et al., 2003). This questionnaire asked participants to recall the amount of minutes spent in vigorous and moderate intense activity and walking during the last 7 days. For all categories patients have to define on how many days and how many minutes they spent at a specific activity category. The minutes spent every week on each type of activity are computed separately by multiplying the duration and frequency of activity. A continuous activity score is calculated by multiplying the selected metabolic equivalent (MET) value and weekly minutes of activity, therefore expressing PA as MET-min per week. MET is a measured of energy output equal to the basal metabolic rate of resting subject; assumed to be equal to an oxygen uptake of 3.5 mm for kilograms of body weight per minute, or approximately 1 kcal per kilogram of body weight per hour (Nieman, 1950). Previous research indicated that the IPAQ may be considered a reliable surveillance tool to assess levels of PA in patients with schizophrenia (Faulkner et al., 2006).

2.6. 6MWT

The 6-minute walk test (6MWT) was performed in an indoor corridor with a minimum of external stimuli. Two cones, 25 m apart, indicated the length of the walkway. Participants were instructed to walk back and forth around the cones during six

minutes, without running or jogging. The protocol stated that the testing was to be interrupted if threatening symptoms appeared. Walks were timed with a stopwatch for six minutes and measured to the nearest foot. Standardized encouragements were provided at recommended intervals (American Thoracic Society, 2002). Heart Rate (HR) was registered with a Polar watch (Polar Electro Oy, Kempele, Finland), blood pressure was registered with Omron M6 (HEM-7001-E) and the participants were asked to rate perceived exertion on the Borg Scale (Borg, 1982). For reliability, the 6MWT was repeated within three-day interval (test–retest).

2.7. Estimation of $VO_{2máx}$

The participants were invited to perform a treadmill test to estimate VO_2. The incremental treadmill protocol (Balke and Ware, 1959) was modified. After measuring resting expired gases for 2 min, participants were gradually brought to the selected running speed for the first minute of the test, which was then maintained throughout the duration of the test. The first 4 min of the protocol were performed at 0% grade; thereafter, the treadmill grade was increased by 1%/2 min until volitional fatigue. The primary goal of the test was to encourage the participants to give a maximal effort. The protocol has constants speed with changes in inclination during the test. Directly measured VO_2 was considered when a plateau in the VO_2 curve was detected. The VO_{2peak} was taken and defined as the highest oxygen uptake achieved during the test at exhaustion. The exhaustion was considered when: i) reaching 85–90% of age-predicted maximum heart rate (HR); ii) a plateau in VO_2 (i.e., stabilization, or an increase of less than 2.1 ml kg^{-1} min^{-1} for consumption oxygen, with the load increment) with an increase in workload; iii) a respiratory exchange ratio equal to or greater than 1.10; iv) participants showed symptoms of discomfort and/or signs of high sweating, facial flushing, or if they requested to stop. No manual assistance was provided during any of the testing procedures. A similar test was performed by individuals with schizophrenia in another study (Heggelund et al., 2011).

The measurements of pulmonary gas exchange and heart rate were measured by the computerized metabolic measurement system (Oxycon-Pro®) and the Polar watch (Polar Electro Oy, Kempele, Finland), respectively.

2.8. Statistical analysis

Descriptive statistics including mean, standard deviation (SD), skewness, kurtosis, and minimum and maximum values were examined. The Shapiro–Wilk test was used to examine the skewness and kurtosis levels in the sample data. Participants ($n=5$) using betablocking medication to control hypertension were excluded from HR analyses because betablocking agents could affect the HR response (Chick et al., 1988). The ICC was calculated to objectively assess test–retest reliability between two 6MWT trials (3-day interval) and its associated 95% CI. Paired *t*-test was performed to evaluate the statistically significant improvement in the mean 6MWT between two trials. Independent *t* test was calculated to evaluate differences between individuals who participated in the test–retest reliability and individuals who participated in the validity test. Validity was evaluated by calculating Pearson's *r* correlation between the 6MWT and the VO_{2peak}. Forward stepwise linear regression was used to examine the characteristics (demographical, medication, bone and body composition) that might interfere in the validity coefficient of 6MWT (the correlation between 6MWT and VO_{2peak}). Spearman or Pearson correlations were used when appropriate to compute associations between the 6MWT and anthropometrics measures and other variables. All analyses were completed with SPSS 22.0 (SPSS Inc., Chicago, United States), with a significance level of 0.05.

3. Results

3.1. Participants

A total of 51 outpatients with schizophrenia were enrolled in the study. All participants performed the test–retest for reliability analyses of 6MWT. All individuals were Portuguese natives and all were treated with antipsychotic medication at the moment of the assessments. The participants used the monotherapy antipsychotic medication ($n=33$) and combination of antipsychotics medication ($n=18$). Twenty participants had obesity (World Health Organization, 1995). Table 1 shows data on the characteristics of the participants and Table 2 shows the characteristics of all participants in test–retest.

3.2. 6MWT scores and test–retest reliability

All participants were able to walk for 6 minutes without stopping prematurely. The mean 6MWT score ($n=51$) on the first test was 547.22 ± 70.87 m (Minimum=402.20; Maximum=719.00; Skewness=0.241; Kurtosis=−0.141) and on the retest was 556.25 ± 75.05 m (Minimum=369.00; Maximum=723.00; Skewness=0.240; Kurtosis=−0.038).

Analyses of test–retest reliability of the 6MWT showed that the ICC was equivalent to 0.94 (95% IC=0.90−0.97). Walking distance assessed on the retest was 9.03 ± 4.18 m higher than test ($p=0.55$).

Table 1
Characteristics of study participants ($n=51$).

Characteristics	Woman ($n=12$)	Men ($n=39$)
	Mean ± SD	Mean ± SD
Age (years)	42.25 ± 7.33	39.18 ± 6.96
Body and bone characteristics		
Weight (Kg)	80.28 ± 17.33	83.70 ± 13.58
Height	1.60 ± 0.65	1.71 ± 0.05
BMI (Kg/m^2)	30.93 ± 5.73	28.50 ± 4.36
Waist Circumference (cm)	109.60 ± 22.59	104.73 ± 7.67
Hip Circumference (cm)	101.17 ± 15.07	101.84 ± 13.13
Hip to ratio (cm)	0.95 ± 0.20	0.96 ± 0.74
BMD (g/cm^2)	1.00 ± 0.29	1.11 ± 0.20
Lean mass (Kg)	41.64 ± 5.71	53.47 ± 5.47
Fat mass (Kg)	35.22 ± 11.65	25.69 ± 9.09
Total fat (%)	43.64 ± 5.47	30.57 ± 6.82
Fat mass (kg/m^2)	13.51 ± 4.06	8.72 ± 2.96
Smoking (cigarettes/day)	8.58 ± 7.77[a]	15.33 ± 10.33[b]
Chlorpromazine	490.26 ± 354.54	361.02 ± 343.68
6MWT (m)	520.03 ± 54.74	555.59 ± 73.72
Systolic BP pre* (mm Hg)	128.58 ± 18.60	129.90 ± 16.08
Systolic BP post* (mm Hg)	122.25 ± 18.48	131.87 ± 20.07
Diastolic BP pre* (mm Hg)	89.83 ± 12.65	91.36 ± 12.16
Diastolic BP post* (mm Hg)	90.83 ± 7.67	92.90 ± 15.71
HR pre* (beats/min)	85.75 ± 17.31	89.28 ± 16.03
HR post* (beats/min)	88.92 ± 17.65	89.81 ± 17.81
Level of PA		
Total minutes PA	198.33 ± 127.64	189.54 ± 176.74
Total minutes of vigorous PA	26.66 ± 34.20	17.82 ± 31.34
Total minutes of moderate PA	66.66 ± 96.40	73.58 ± 94.46
Total minutes of walking	105.00 ± 107.77	98.12 ± 102.62

Data are presented as mean ± standard deviation. BMI=body mass index; BMD=bone mineral density; 6MWT=six minute walk distance; PA=physical activity.

[a] $n=28$.

[b] $n=7$.

Table 2
Characteristics of study participants in test–retest ($n=51$).

Characteristics	Mean ± SD	Correlation with 6MWT	p
Age (years)	39.9 ± 7.10	−0.20	NS
Body and bone characteristics			
Weight (Kg)	82.89 ± 14.43	−0.09	NS
Height	1.69 ± 0.75	0.30	0.03
BMI (Kg/m^2)	29.06 ± 4.77	−0.25	NS
Waist Circumference (cm)	105.88 ± 12.70	−0.19	NS
Hip Circumference (cm)	101.68 ± 13.46	−0.22	NS
Hip to ratio (cm)	0.96 ± 0.11	−0.05	NS
BMD (g/cm^2)	1.09 ± 0.23	0.12	NS
Lean mass (Kg)	27.93 ± 10.46	0.24	NS
Fat mass (Kg)	50.69 ± 7.46	−0.31	NS
Total fat (%)	33.64 ± 8.56	−0.42	0.002
Fat mass (kg/m^2)	9.85 ± 3.81	−0.35	0.010
Smoking (cigarettes/day)[a]	13.75 ± 9.97	−0.34	0.013
Chlorpromazine	391.43 ± 347.11	−0.02	NS
Systolic BP pre (mm Hg)	129.95 ± 15.41	0.08	NS
Systolic BP post (mm Hg)	129.15 ± 17.61	0.09	NS
Diastolic BP pre (mm Hg)	91.32 ± 11.87	0 .01	NS
Diastolic BP post (mm Hg)	91.43 ± 13.00	0 .08	NS
HR pre (beats/min)	92.91 ± 40.58	−0.04	NS
HR post (beats/min)	94.73 ± 53.93	0.00	NS
Level of PA			
Total minutes PA	191.61 ± 165.00	0.27	0.049
Total minutes of vigorous PA	19.90 ± 31.91	0.77	NS
Total minutes of moderate PA	71.96 ± 93.99	0.11	NS
Total minutes of walking	99.74 ± 103.80	0.11	NS

Data are presented as mean ± standard deviation. BMI=body mass index; BMD=bone mineral density; 6MWT=six minute walk distance; PA=physical activity; NS=not significant.

[a] $n=35$.

3.3. Associated parameters

Table 2 showed that height; total percent body fat mass and total fat mass were significantly associated with distance walked on the 6MWT. In the same way, smoking behavior was significantly associated to the 6MWT. Higher total minutes of PA per week were significantly associated with a higher 6MWT score. The associated parameters were analyzed using the 6MWT score from the first trial.

3.4. Validity

The participants who accepted to perform the treadmill maximal test were men ($n=13$). However, there were no significant differences on age, anthropometric measures and distance walked (i.e.; BMI, BMD, lean mass, fat mass, hip and waist circumferences and hip to ratio) of this group and the group that performed test–retest reliability ($n=51$) ($p>0.05$). Moreover, there were no significant differences on age, anthropometric measures and distance walked between the group of men that performed the treadmill incremental test ($n=13$) and the men that did not perform the treadmill incremental test ($n=26$) ($p>0.05$). With the exception of height, there were also no significant differences between the men that performed the treadmill incremental test ($n=13$) and the woman that did not perform the treadmill incremental test ($n=12$) ($p>0.05$). Descriptive statistics of the 6MWT of the participants enrolled in the treadmill test are shown in Table 3.

A significant correlation was found between walking distance (6MWT) and VO_{2peak} ($r=0.67$; $p=0.01$; $n=13$). The forward stepwise linear regression showed that 6MWT and VO_{2peak} were related when the analyses was adjusted to height. Table 4 shows the results of forward stepwise linear regression analyses.

Table 3
Clinical characteristics of the participants, 6MWT and physiological variables measured during peak treadmill test ($n=13$).

Characteristics	Mean ± SD
Age	37.92 ± 7.32
Body and bone characteristics	
Weight (Kg)	84.82 ± 9.81
Height (m)	1.70 ± 0.6
BMI (Kg/m^2)	29.22 ± 3.86
Waist Circumference (cm)	105.18 ± 5.56
Hip Circumference (cm)	103.58 ± 9.69
Hip to ratio (cm)	0.98 ± 0.6
BMD (g/cm^2)	1.09 ± 0.11
Lean mass (Kg)	26.53 ± 5.69
Fat mass(Kg)	53.80 ± 5.54
Total fat (%)	9.18 ± 2.26
Fat mass (kg/m^2)	31.80 ± 4.73
Treadmill test	
6MWT (m)	564.73 ± 70.27
HR (beats/min)	157.08 ± 14.85
VO_{2peak} (ml/kg/min)	28.97 ± 4.91
V_E (l/min)	91.77 ± 16.49
RER	1.09 ± 0.06
Smoking (cigarettes/day)[a]	8.00 ± 8.98
Chlorpromazine	387.76 ± 407.36
Systolic BP pre (mm Hg)	129.59 ± 16.52
Systolic BP post (mm Hg)	129.61 ± 19.96
Diastolic BP pre (mm Hg)	91.00 ± 148.12
Diastolic BP post (mm Hg)	92.41 ± 201.36
HR pre (beats/min)	88.45 ± 16.21
HR post (beats/min)	89.60 ± 17.60
Level of PA	
Total minutes PA	188.46 ± 142.20
Total minutes of vigorous PA	22.30 ± 33.94
Total minutes of moderate PA	66.15 ± 87.13
Total minutes of walking	100.00 ± 96.05

Data are presented as mean ± standard deviation. BMI= body mass index; BMD=bone mineral density; VO_{2peak}=peak oxygen uptake; HR=heart rate; V_E=total pulmonary ventilation; RER=respiratory exchange ratio.

[a] $n=7$.

Table 4
Predictive model for the total distance walked in the 6MWT.

	Unstandardized coefficients		T	Sig.	95.0% confidence interval for B	
	B	Std. error			Lower bound	Upper bound
(Constant)	62.405	24.858	2.510	0.031	7.018	117.792
6MWT	0.064	0.014	4.402	0.001	0.031	0.096
Height	−40.613	16.114	−2.520	.030	−76.517	−4.710

Dependent Variable: VO^2.

4. Discussion

The first goal of this study was to explore the test–retest reliability of the 6MWT and to identify the associated parameters that contribute to the variability of the distance walked during the 6MWT in outpatients with schizophrenia. This study was the first

one to assess the criterion validity of the 6MWT in men with schizophrenia. The preliminary findings demonstrated that the 6MWT is both reproducible and reliable, indicating that it can be used to quantify the functional exercise capacity in this population. We found adequate values of ICC (0.94) similarly to Vancampfort et al. (2011b) and no significant differences were found in the 6MWT test–retest. These results are in line with findings in populations with different diseases (Casey et al., 2012; Hanson et al., 2012; Vanhelst et al., 2013). In addition, we did not find significant differences in age, anthropometric measures and distance walked between the group of men that performed the treadmill incremental test ($n=13$) and the men that did not perform the treadmill incremental test ($n=26$), as well as the men that performed the treadmill incremental test ($n=13$) and the woman ($n=12$). Because of this, we suggest that the test is reliable for this group.

The mean distance on the 6MWT of our sample was lower (test=547.2; retest=556.2) when compared to the outcome of the participants (test=564.0; retest=572.1) of Vancampfort et al. (2011b). Possibly, these discrepancies may be related with the differences in the levels of activity/inactivity across different European countries. World Health Organization (2006) stated that the highest proportions of participants that participated in PA were found in the northern countries of Europe and the lowest in the southern ones.

On the basis of our results, we can conclude that the 6MWT is a valid tool to assess functional exercise capacity in men with schizophrenia, as there was a significant correlation between 6MWT and VO_{2peak}. These results are in line with findings in populations with different diseases (i.e., Down Syndrome, Ischemic Heart Disease, Traumatic Brain Injury) (Roberts et al., 2006; Vis et al., 2009; Mossberg and Fortini, 2012). However, future studies should determine whether present results are also applicable to female patients. In addition, the analyses adjusted for height, through linear regression analyses, showed an increase of correlation coefficient. Future studies that aim to develop a prediction equation to estimate VO_{2peak} through of 6MWT in individuals with schizophrenia should consider the height as an important variable.

Regarding the associated parameters that contributed to the variability of the distance walked during the 6MWT we found a negative association between total percent body fat mass and 6MWT. Smoking addiction was also associated to a worse functional exercise capacity which is in accordance with Vancampfort et al., (2011b). Individuals with schizophrenia who smoke are known to exercise less, to have other unhealthy life habits and consequently are more likely to suffer a cardiovascular event (Bobes et al., 2010).

The present study was the first to demonstrate that more minutes of PA per week were significantly associated with the 6MWT. It is known that individuals with schizophrenia are sedentary (Faulkner et al., 2006; Lindamer et al., 2008) and have a reduced functional exercise capacity (Vancampfort et al., 2011a). Therefore, our findings support the idea of 6MWT correlate with PA participation (Gardner et al., 2006; Vancampfort et al., 2011c).

The 6MWT is reliable for assessing functional exercise capacity in outpatients with schizophrenia and valid for men with schizophrenia. This clinical tool is well-suited to assess functional exercise capacity in clinical trials and psychiatric care.

A limitation of the present study was the small sample size available for the validity procedures that made the development of a statistically sound multiple regression models not possible. Moreover, the validity procedures focused only in men. Therefore, further research should increase the sample size and include both genders in order to develop an equation to predict the distance walked of the 6MWT in individuals with schizophrenia. Secondly, the extrapyramidal side-effects were not assessed. More research is needed to understand the influence of antipsychotics on one's functional exercise capacity (Vancampfort et al., 2011b). Lastly, future studies should develop comparative analyses between individuals with schizophrenia and health control group as well as investigate the 6MWT according to gender, age and anthropometric categories (weight, BMI, circumference).

Contributors

EG carried out the study. EG, TB, MP, GS and RC drafted the manuscript. EG, JCR and GS carried the statistical analysis. TB, MP, GS, JCR and RC contributed to the execution of the study, and to the manuscript writing.

Competing interests

The authors declare that there is no conflict of interest.

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References

American Thoracic Society, 2002. ATS statement: guidelines for the six-minute walk test. Am. J. Respir. Crit. Care Med. 166, 111–117.
American Thoracic Society, American College of Chest Physicians, 2003. ATS/ACCP statement on cardiopulmonary exercise testing. Am. J. Respir. Crit. Care Med., 211–277.
Balke, B., Ware, R.W., 1959. An experimental study of physical fitness of Air Force personnel. US Armed Forces Med. J. 10, 675–688.
Beebe, L.H., Harris, R.F., 2013. Description of physical activity in outpatients with schizophrenia spectrum disorders. Int. J. Ment. Health Nurs. 22, 430–436.
Beebe, L.H., Tian, L., Morris, N., Goodwin, A., Allen, S.S., Kuldau, J., 2005. Effects of exercise on mental and physical health parameters of persons with schizophrenia. Issues Ment. Health Nurs. 26, 661–676.
Bernard, P., Ninot, G., 2012. Bénéfices des activités physiques adaptées dans la prise en charge de la schizophrénie : revue systématique de la littérature. L'Encéphale 38, 280–287.
Bernard, P., Romain, A.J., Vancampfort, D., Baillot, A., Esseul, E., Ninot, G., 2014. Six minutes walk test for individuals with schizophrenia. Disabil. Rehabil., 1–7.
Blouin, M., Binet, M., Bouchard, R.-H., Roy, M.-A., Després, J.-P., Alméras, N., 2009. Improvement of metabolic risk profile under second-generation antipsychotics: a pilot intervention study. Can. J. Psychiatry 54, 275–279.
Bobes, J., Arango, C., Garcia-Garcia, M., Rejas, J., 2010. Healthy lifestyle habits and 10-year cardiovascular risk in schizophrenia spectrum disorders: an analysis of the impact of smoking tobacco in the CLAMORS schizophrenia cohort. Schizophr. Res. 119, 101–109.
Borg, G.A.V., 1982. Psychophysical bases od perceived exertion. Med. Sci. Sports Exerc. 14, 377–381.
Campo, L.A., Chilingaryan, G., Berg, k, Paradis, B., Mazer, B., 2006. Validity and relibility af the modified shuttle walk test in patients with chronic obstrutive pulmonary didease. Arch. Phys. Med. Rehabil. 87.
Casey, A.F., Wang, X., Osterling, K., 2012. Test-retest reliability of the 6-minute walk test in individuals with down syndrome. Arch. Phys. Med. Rehabil. 93, 2068–2074.
Chick, T.W., Halperin, A.K., Gacek, E.M., 1988. The effect of antihypertensive medicantions on exercise performance: a review. Med. Sci. Sports Exerc. 20, 447–454.
Craig, C.L., Marshall, A.L., Sjöström, M., Bauman, A.E., Booth, M.L., Ainsworth, B.E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J.F., 2003. International physical activity questionnaire: 12-country reliability and validity. Med. Sci. Sports Exerc. 35, 1381.
De Hert, M., Schreurs, V., Vancamprfot, D., Van Winkel, R., 2009. Metabolic

syndrome in people with schizophrenia: a review. World Psychiatry 8, 15–22.
Dodd, K.J., Duffy, S., Stewart, J.A., Impey, J., Taylor, N., 2011. A small group aerobic exercise programme that reduces body weight is feasible in adults with severe chronic schizophrenia: a pilot study. Disabil. Rehabil. 33, 1222–1229.
Elmahgoub, S.S., Van de Velde, A., Peersman, W., Cambier, D., Calders, P., 2012. Reproducibility, validity and predictors of six-minute walk test in overweight and obese adolescents with intellectual disability. Disabil. Rehabil. 34, 846–851.
Enright, P.L., 2003. The six-minute walk test. Respir. Care 48, 783–785.
Faulkner, G., Biddle, S., 1999. Exercise as an adjunct treatment for schizophrenia: a review of the literature. J. Ment. Health 8, 441–457.
Faulkner, G., Cohn, T., Remington, G., 2006. Validation of a physical activity assessment tool for individuals with schizophrenia. Schizophr. Res. 82, 225–231.
Fogarty, M., Happell, B., Pinikahana, J., 2004. The benefits of an exercise program for people with schizophrenia: a pilot study. Psychiatr. Rehabil. J. 28, 173–176.
Gardner, A.W., Montgomery, P.S., Parker, D.E., 2006. Metabolic syndrome impairs physical function, health-related quality of life, and peripheral circulation in patients with intermittent claudication. J. Vasc. Surg. 43, 1191–1196.
Gardner, D.M., Murphy, A.L., O'Donnell, H., Centorrino, F., Baldessarini, R.J., 2010. International consensus study of antipsychotic dosing. Am. J. Psychiatry 167, 686–693.
Gomes, E., Bastos, T., Probst, M., Ribeiro, J.C., Silva, G., Corredeira, R., 2014. Effects of a group physical activity program on physical fitness and quality of life in individuals with schizophrenia. Ment. Health Phys. Act., 1–8.
Hanson, L.C., McBurney, H., Taylor, N.F., 2012. The retest reliability of the six-minute walk test in patients referred to a cardiac rehabilitation programme. Physiother. Res. Int. 17, 55–61.
Heggelund, J., Nilsberg, G.E., Hoff, J., Morken, G., Helgerud, J., 2011. Effects of high aerobic intensity training in patients with schizophrenia: a controlled trial. Nord. J. Psychiatry 65, 269–275.
Kalman, D., Morissette, S.B., George, T.P., 2005. Co-morbidity of smoking in patients with psychiatric and substance use disorders. Am. J. Addic. 14, 106–123.
Langenfeld, H., Schneider, B., Grimm, W., Beer, M., Michaela, Knoche, Riegger, G., Koghsiek, K., 1990. The six-minute walk—an adequate exercise test for pacemaker patients? Pacing Clin. Electrophysiol. 13, 1761–1765.
Leucht, S., Burkard, T., Henderson, J., Maj, M., Sartorius, N., 2007. Physical illness and schizophrenia: a review of the literature. Acta Psychiatr. Scand. 116, 317–333.
Lindamer, L.A., McKibbin, C., Norman, G.J., Jordan, L., Harrison, K., Abeyesinhe, S., Patrick, K., 2008. Assessment of physical activity in middle-aged and older adults with schizophrenia. Schizophr. Res. 104, 294–301.
Martín-Sierra, A., Vancampfort, D., Probst, M., Bobes, J., Maurissen, K., Sweers, K., De Schepper, E., De Hert, M., 2011. La capacidad de marcha está asociada a la calidad de vida (relacionada con la salud) y nivel de actividad física en pacientes con esquizofrenia: estudio preliminar. Actas Esp. Psiquiatr. 39, 211–216.
Marzolini, S., Jensen, B., Melville, P., 2009. Feasibility and effects of a group-based resistance and aerobic exercise program for individuals with severe schizophrenia: A multidisciplinary approach. Ment. Health Phys. Act. 2, 29–36.
Mezzani, A., Agostoni, P., Cohen-Solal, A., Corrà, U., Jegier, A., Kouidi, E., Mazic, S., Meurin, P., Piepoli, M., Simon, A., Laethem, C.V., Vanhees, L., 2009. Standards for the use of cardiopulmonary exercise testing for the functional evaluation of cardiac patients: a report from the exercise physiology section of the European association for cardiovascular prevention and rehabilitation. Eur. J. Cardiovasc. Prev. Rehabil. 16, 249–267.
Mossberg, K.A., Fortini, E., 2012. Responsiveness and validity of the six-minute walk test in individuals with traumatic brain injury. Phys. Ther. 92, 726–733.
Newcomer, J.W., 2004. Metabolic risk during antipsychotic treatment. Clin. Ther. 26, 1936–1946.
Nieman, D., 1950. Exercise Testing and Prescription: a Health Related Approach.
Nilsson, B.M., Olsson, R.M., Oman, A., Wiesel, F.A., Ekselius, L., Forslund, A.H., 2012. Physical capacity, respiratory quotient and energy expenditure during exercise in male patients with schizophrenia compared with healthy controls. Eur. Psychiatry 27, 206–212.
Richardson, C.R., Faulkner, G., McDevitt, J., Skrinar, G.S., Hutchinson, D.S., Piette, J.D., 2005. Integrating physical activity into mental health services for persons with serious mental illness. Psychiatr. Serv. 56, 324–331.
Roberts, E., Li, F.K.W., Sykes, K., 2006. Validity of the 6-minute walk test for assessing heart rate recovery after an exercise-based cardiac rehabilitation programme. Physiotherapy 92, 116–121.
Saha, S., Chant, D., McGrath, J., 2007. A systematic review of mortality in schizophrenia. Arch. Gen. Psychiatry 64, 1123–1131.
Solway, S., Brooks, D., Lacasse, Y., Thomas, S., 2001. A qualitative systematic overview of the measurement properties of functional walk tests used in the cardiorespiratory domain. Chest 119, 256–270.
Stokes, C., Peet, M., 2004. Dietary sugar and polyunsaturated fatty acid consumption as predictors of severity of schizophrenia symptoms. Nutr. Neurosci. 7, 247–249.
Tandon, R., Nasrallah, H.A., Keshavan, M.S., 2010. Schizophrenia, "just the facts" 5. Treatment and prevention. Past, present, and future. Schizophr. Res., 1–23.
Vancampfort, D., Guelinckx, H., De Hert, M., Stubbs, B., Soundy, A., Rosenbaum, S., De Schepper, E., Probst, M., 2014. Reliability and clinical correlates of the Astrand–Rhyming sub-maximal exercise test in patients with schizophrenia or schizoaffective disorder. Psychiatry Res. 220, 778–783.
Vancampfort, D., Knapen, J., Probst, M., Scheewe, T., Remans, S., De Hert, M., 2012a. A systematic review of correlates of physical activity in patients with schizophrenia. Acta Psychiatr. Scand. 125, 352–362.
Vancampfort, D., Probst, M., De Herdt, A., Corredeira, R.M.N., Carraro, A., De Wachter, D., De Hert, M., 2013. An impaired health related muscular fitness contributes to a reduced walking capacity in patients with schizophrenia: a cross-sectional study. BMC Psychiatry 13, 1–8.
Vancampfort, D., Probst, M., Scheewe, T., Knapen, J., De Herdt, A., De Hert, M., 2012b. The functional exercise capacity is correlated with global functioning in patients with schizophrenia. Acta Psychiatr. Scand. 125, 382–387.
Vancampfort, D., Probst, M., Sweers, K., Maurissen, K., Knapen, J., De Hert, M., 2011a. Relationships between obesity, functional exercise capacity, physical activity participation and physical self perception in people with schizophrenia. Acta Psychiatr. Scand., 1–8.
Vancampfort, D., Probst, M., Sweers, K., Maurissen, K., Knapen, J., De Hert, M., 2011b. Reliability, minimal detectable changes, practice effects and correlates of the 6-min walk test in patients with schizophrenia. Psychiatry Res. 187, 62–67.
Vancampfort, D., Sweers, K., Probst, M., Maurissen, K., Knapen, J., Minguet, P., De Hert, M., 2011c. Association of the metabolic syndrome with physical activity performance in patients with schizophrenia. Diabetes Metab. 37, 318–323.
Vanhelst, J., Fardy, P.S., Salleron, J., Beghin, L., 2013. The six-minute walk test in obese youth: reproducibility, validity, and prediction equation to assess aerobic power. Disabil. Rehabil. 35, 479–482.
Vis, J.C., Thoonsen, H., Duffels, M.G., de Bruin-Bon, R.A., Huisman, S.A., van Dijk, A.P., Hoendermis, E.S., Berger, R.M., Bouma, B.J., Mulder, B.J., 2009. Six-minute walk test in patients with down syndrome: validity and reproducibility. Arch. Phys. Med. Rehabil. 90, 1423–1427.
Vittaca, M., Paneroni, M., Comini, L., Bianchi, L., 2013. Efficacy of six months physical activity on exercise capacity in patients with mental disorders (resident in a community servise). Minerva psychiatr. 54, 71–82.
Walter, S.D., Eliasziw, M., Donner, A., 1998. Sample size and optimal designs for reliability studies. Stat. Med. 17, 101–110.
Wani, R.A., Dar, M.A., Margoob, M.A., Rather, Y.H., Haq, I., Shah, M.S., 2015. Diabetes mellitus and impaired glucose tolerance in patients with schizophrenia, before and after antipsychotic treatment. J. Neurosci. Rural Pract. 6, 17–22.
Winklbaur, B., Ebner, N., Sachs, G., Thau, K., Fischer, G.S., 2006. Substance abuse in patients with schizophrenia. Dialogues Clin. Neurosci. 8, 37–43.
World Health Organization, 1995. Physical status: the use and interpretation of anthropometry, Switzerland.
World Health Organization, 2006. Physical activity and health in Europe: evidence for action, Denmark.
World Health Organization, 2008. The Global Burden of Disease: 2004 Update. World Health Organization, Geneva.
World Health Organization, 2012. Mental health, World Health Organization. World Health Organization home, < http://www.who.int/mental_health/management/schizophrenia/en/ > (acessed 2015.02.02).