

## REVIEW PAPER

# Six minutes walk test for individuals with schizophrenia

P. Bernard<sup>1</sup>, A. J. Romain<sup>1</sup>, D. Vancampfort<sup>2</sup>, A. Baillot<sup>3</sup>, E. Esseul<sup>4</sup>, and G. Ninot<sup>1</sup>

<sup>1</sup>Laboratory Epsilon EA 4556, Department of Dynamics of Human Abilities and Health Behaviors, University of Montpellier 1, Montpellier, France, <sup>2</sup>University Psychiatric Centre Catholic University Leuven, Campus Kortenberg, Kortenberg, Belgium, <sup>3</sup>Department of Medicine, Division of Endocrinology, Étienne-LeBel Clinical Research Center of the Centre Hospitalier Universitaire de Sherbrooke, University of Sherbrooke, Sherbrooke, QC, Canada, and <sup>4</sup>St Clement Clinic, St Clément de Rivière, France

### Abstract

**Purpose:** The six-minute walk test (6MWT) is a sub-maximal exercise test measuring the distance that a patient can walk quickly in a period of 6 minutes (6MWD). The objectives of this systematic review are to evaluate the 6MWT's suitability for measuring the impact of an intervention, to compare the 6MWD walked by patients with schizophrenia with data for the general population or matched controls, to identify the determinants of 6MWD and to examine the measurement properties and quality procedures of the 6MWT. **Methods:** Using five databases, we performed a systematic review of full-text articles published through August 2013. **Results:** Sixteen studies met our selection criteria. The assessment of the 6MWT's suitability for measuring the impact of interventions was not made because none of the interventional studies reported a significant increase in 6MWD. The distance walked by adults with schizophrenia seemed generally shorter than that walked by healthy adults. Mean 6MWDs ranged from 421 m to 648 m in the included studies. The 6MWD is usually negatively associated with a higher Body Mass Index, increased cigarette consumption, higher doses of antipsychotic medication and lower physical self-worth in individuals with schizophrenia. The 6MWT demonstrates high reliability. To date, however, its criterion validity has not been investigated. In spite of existing guidelines, the test procedures used in the studies reviewed varied significantly. **Conclusions:** Future physical health monitoring recommendations for patients with schizophrenia should include the 6MWT. Future studies should investigate its predictive role and continue to assess its measurement properties.

### Keywords

6-minute walk test, exercise, functional capacity, physical health, schizophrenia

### History

Received 21 October 2013  
Revised 18 July 2014  
Accepted 21 July 2014  
Published online 7 August 2014

### ► Implications for Rehabilitation

- The Six-Minute Walk Test reliably assesses the functional exercise capacity in patients with schizophrenia.
- The impact of therapeutic interventions on patients, as measured by the 6MWT, cannot be confirmed.
- Clinicians should take into account overweight, antipsychotic medication use and the physical self-perception when considering the functional exercise capacity in schizophrenia.
- Clinicians should follow International standards such as these of the American Thoracic Society when using the Six-Minute Walk Test in patients with severe mental illnesses.

### Introduction

The 6-minute walk test (6MWT) is a sub-maximal standardized aerobic test. It is practical, simple and easy to perform with minimal equipment [1]. The 6MWT provides information regarding the functional exercise capacity of individuals by measuring the distance that they can quickly walk on a flat, hard surface in a period of 6 minutes (6MWD). The main outcome is the distance that a subject can walk within this period. The American Thoracic Society (ATS) has published guidelines for

adults taking the 6MWT in clinical settings [2]. The 6MWT has been studied in various populations including healthy older adults, patients with chronic obstructive pulmonary disease (COPD), adults with heart failure, obese adults and adults with rheumatoid arthritis [3–6]. 6MWT performance appears to improve with therapy and can provide prognosis information [7,8]. For example, a meaningful change in distance walked was obtained after pulmonary rehabilitation (or inhaled corticosteroids treatment) among patients with COPD [8]. Several systematic reviews have investigated the 6MWT's suitability for measuring the impact of therapeutic interventions for patients with rheumatic diseases, chronic heart failure and pulmonary arterial hypertension [5,9–11].

Since metabolic and cardiovascular diseases have become major clinical care and research issues, a growing number of

Address for correspondence: Paquito Bernard, Laboratory Epsilon EA 4556, Dynamics of Human Abilities and Health Behaviors, University of Montpellier 1, 4 boulevard Henri IV, F-34000, France. Tel: 33 467 415 731. Fax: 33 467 415 751. E-mail: paquito.bernard@gmail.com

studies have used the 6MWT to measure functional capacity in individuals with schizophrenia [12]. The prevention of somatic disorders (e.g. obesity, chronic respiratory disease) in this population has generated considerable interest [13]. Furthermore, numerous studies have explored the efficacy of lifestyle interventions (e.g. peer counseling, exercise, weight management) on physical health parameters in adults with schizophrenia [14]. Indeed, in this context, the 6MWT could be used as a sensitive marker of post-intervention functional change. However, little information is available about the actual capacity of the 6MWT to measure the effects of interventions [15].

Important differences in the distance walked have been observed in studies of healthy subjects [16]. The distance achieved on the walk test (6MWD) is associated with age, weight, height and gender in healthy populations [8]. The examination of such correlates in patients with schizophrenia could improve our understanding of 6MWD variability in this population.

In addition, it is necessary to ascertain whether the 6MWT procedures (based on ATS recommendations) ensure good quality results [1]. This procedure includes three main criteria: location (e.g. straight corridor and length of walking course), instructions, and encouragement (e.g. standardized encouragement) [2].

Thus, the objectives of this systematic review are: first, to evaluate the 6MWT's suitability for measuring the impact of interventions on adults with schizophrenia or schizoaffective spectrum; second, to compare the 6MWD walked by patients with schizophrenia with that walked by general population samples or matched controls; third, to identify the correlates (i.e. reproducible association) and determinants (i.e. predictive relationship) of 6MWD; fourth, to examine the measurement properties and quality procedures of the 6MWT.

## Methods

### Procedure

This systematic review is reported on the basis of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement [17].

### Inclusion and exclusion criteria

To be included in our systematic review, studies had to meet the following criteria:

- (i) Participants. Participants were adults (age  $\geq 18$  years) diagnosed with schizophrenia or schizoaffective disorders (schizoaffective or schizophreniform disorder) based on DSM-IV-TR [18].
- (ii) Outcomes. The primary outcome was the functional capacity of patients as measured by the 6MWT. Secondary outcomes included the measurement properties of the 6MWT, its determinants and its test procedures.
- (iii) Controls. When comparing the 6MWD walked by schizophrenia patients with that walked by other populations, studies involving clinical and non-clinical controls were included.
- (iv) Studies. Randomized clinical trials, controlled trials, and observational studies were included.

We did not exclude trials on the basis of age, nationality or gender of participants.

### Data sources and searches

The following databases were searched: PubMed (January 1965 to August 2013), SPORTDiscus (January 1990 to August 2013), The Cochrane Library (1993 to August 2013), FRANCIS (January 1990 to August 2013) and Physiotherapy Evidence Database

(PEDro; current). Our PubMed search strategy first included MeSH terms related to physical fitness, walk tests and schizophrenia: (“Exercise Test”[MeSh] OR “Heart Failure”[MeSh]) OR “Physical Fitness”[MeSh]) AND “Schizophrenia and Disorders with Psychotic Features”[MeSh] AND (“humans”[MeSH Terms] AND (English[lang] OR French[lang]) AND “adult”[MeSH Terms]). Secondly, the following text algorithm was searched on the PubMed, PEDro and SPORTDiscus databases: schizophren\* AND (“six minute walk test” OR “6 minute walk test” OR “six minute walking test” OR “6 minute walking test” OR “6MWT” OR “fitness test”). The titles and abstracts returned by the databases were initially and independently screened by one reviewer (PB) to determine their appropriateness for this systematic review. After the removal of duplicate studies, full-text articles were analyzed by two independent reviewers (GN, AJR). Descriptive data on participants and study methodology characteristics were recorded by two coders (PB, AJR) and discrepancies were resolved by discussion. One reviewer (PB) examined the 6MWT test procedures.

### Data extraction

Descriptive data were extracted according to (1) year, country, gender ratio, mean age, subgroup, patient status; (2) nature of intervention; (3) 6MWT outcomes: distances walked, measurement properties (i.e. test/retest reliability, criterion validity, minimally detectable change), determinants (i.e. predictive relationship), correlates (i.e. reproducible association) and test procedure (i.e. compared to ATS guidelines criteria). Requests for unreported data (e.g., 6MWT procedure) were made by e-mail to the corresponding authors of several studies [20,21].

## Results

### Search results

Ninety-one studies were retrieved from the databases and 16 were included in our review (see our search flow diagram, Supplementary figure 1).

### Participants

Population data and 6MWDs reported in the selected studies are summarized in Table 1. In total, 662 in- and outpatients with schizophrenia were included in the analyses. The participants ranged in age from 18 to 62 years. Four studies included inpatients and 12 studies focused solely on outpatients. The number of participants was fewer than 20 in seven studies.

### Impact of treatment on 6MWD

Four studies assessed the effect of an exercise intervention (Table 1) on functional capacity as measured by the 6MWT [21–24]. Most were single-arm pilot studies. One was a randomized controlled study [24]. Sample size was smaller than 15 patients in four studies. No significant increase in 6MWD was reported.

### 6MWD comparisons: patients with schizophrenia versus control groups

Three studies compared the 6MWD walked by schizophrenia patients with the 6MWD walked by age- and gender-matched healthy adults [25–27]. Patients with schizophrenia walked a shorter distance than healthy adults. Vancampfort et al. [25,26] found an average distance of  $573.1 \text{ m} \pm 115.5$  in 60 adults with schizophrenia, compared to  $710.6 \text{ m} \pm 108.4$  in 40 healthy adults, respectively. Furthermore, in a sample of 80 schizophrenia patients and 40 healthy adults, Vancampfort et al. [27] also

Table 1. Six-Minute Walk Distance in included studies.

Study	Country	Age M ( $\pm$ )	Gender ratio ( $\text{♀}/\text{♂}$ )	Intervention	6MWT (t1) M ( $\pm$ ) meter	6MWT (t2) M ( $\pm$ ) meter	I/O
[21]	USA	52.1*	8/2	Treadmill walking, 30 min, 3 S/W, 16 W	Intervention 430† No intervention 421†	Intervention 476† No intervention 438†	I
[22]	USA	47.9 $\pm$ 0.6	6/4	Dance, 60 min, 1 S/W, 10W	464 $\pm$ 16.7	470 $\pm$ 20.5	I
[23]	Canada	44.6 $\pm$ 2.6	8/5	Resistance + treadmill, 90 min, 2S/W, 12W	Intervention 535.9 $\pm$ 17.1 No intervention 513 $\pm$ 31.0	Intervention 563.7 $\pm$ 35.0 No intervention 484.2 $\pm$ 31.0	I
[24]	Australia	45.9 $\pm$ 10.1	6/2	Aerobic training + treadmill, 30 min, 2S/W, 24W	432.1 $\pm$ 68.2	427.5 $\pm$ 48.5	O
[19]	Canada	24†	8/2		†		O
[48]	USA	†	2/9		428.8 $\pm$ 84.2		I
[20]	Australia	†	0/6		†		O
[12]	Belgium	37.4 $\pm$ 10.1	24/47		564 $\pm$ 107.5		O
[33]	Belgium	40.5 $\pm$ 9.2	20/20		558.5 $\pm$ 112.2		O
[29]	Belgium	Without MetS 35.0 $\pm$ 10.9 With MetS 36.2 $\pm$ 9.4	37/69		Without MetS 610 $\pm$ 93.7 With MetS 527 $\pm$ 108.9		O
[25]	Belgium	Healthy weight 35.5 $\pm$ 10.5 Overweight 41 $\pm$ 9.35 Obese 39.9 $\pm$ 10.9	22/38		615.8 $\pm$ 92.4 580.2 $\pm$ 116.0 450.6 $\pm$ 97.7		O
[32]	Belgium	LPSCPF 36.5 $\pm$ 10.6 HPSCPF 34.3 $\pm$ 8.0	9/29		538.0 $\pm$ 89.5 648.0 $\pm$ 68.6		O
[27]	Belgium	36.8 $\pm$ 10.0	25/55		583.6 $\pm$ 140.7		O
[28]	Belgium	Without pre-diabetes 34.5 $\pm$ 10.5 Pre-diabetic 38.0 $\pm$ 8.5 Diabetic 40.3 $\pm$ 10.9	37/69		590.7 $\pm$ 101.8 552.0 $\pm$ 131.9 500.3 $\pm$ 76.9		O
[26]	Belgium	38.1 $\pm$ 10.4	22/38		573.5 $\pm$ 115.5		O
[34]	Belgium	34.6 $\pm$ 9.7	25/68		587.30 $\pm$ 98.4		O

M = Mean,  $\pm$  = Standard Deviations, † = Standard Deviations not available, ♀ = female, ♂ = male, 6MWT (t1) = 6 min Walk Test before intervention or sole assessment, 6MWT (t2) = 6 min Walk Test after intervention, NS = No significant difference, MetS = metabolic syndrome, HPSCPF = high perceived sports competence and perceived physical fitness, LPSCPF = low perceived sports competence and perceived physical fitness, S/W = session per week, W = weeks, I = Inpatient, O = Outpatient

observed that the 6MWD walked by patients with schizophrenia was shorter of 17.9% ( $p < 0.001$ ) with an effect size of  $d = -1.01$  (95%CI:  $-0.57$  to  $-1.37$ ).

Below or above-standard Body Mass Index (BMI), diabetes and the presence of metabolic syndrome (MetS) are reported to negatively influence 6MWD. Vancampfort et al. [25] compared mean 6MWDs for each BMI category. The results showed that overweight patients walked a shorter mean distance than patients at normal weight (580.2 m versus 615.8 m,  $p < 0.001$ ) [25]. Furthermore, the authors also observed that obese patients walked shorter mean distances than overweight patients (450.6 m  $\pm$  97.7,  $p < 0.02$ ) [25]. A similar result was obtained among diabetic adults compared to adults without diabetes [28]. However, no significant difference was identified for adults with pre-diabetes (defined as fasting blood glucose 6.1–6.9 mmol/L).

Three studies have explored the impact of MetS on 6MWD. Mean 6MWD was shorter for schizophrenia patients with MetS than for those without MetS, 527.6 m  $\pm$  108.9 versus 610.0 m  $\pm$  93.7 ( $p < 0.001$ ) [29], 491.4 m  $\pm$  75.3 versus 633.2 m  $\pm$  92.1 ( $p < 0.001$ ) [27] and 475.9 m  $\pm$  101.7 versus 608 m  $\pm$  85.4 [26], respectively.

To determine the effect of the level of perceived sports competence and perceived physical fitness (PSCPF, high versus low) [30,31] on 6MWD, Vancampfort et al. [32] compared the distances walked by individuals with schizophrenia ( $n = 38$ ). The authors reported a longer distance for participants with higher levels of PSCPF (648.0 m  $\pm$  68.6 versus 538.0 m  $\pm$  89.5,  $p < 0.001$ ).

### 6MWD correlates

Correlates associated with 6MWD were explored in eight studies [12,23,25–27,29,33,34]. Fifty-one correlates are listed in

Table 2. Negatively associated correlates included high BMI, cigarette consumption, high chlorpromazine (or equivalent) levels and low physical self-perception. Positively associated correlates included physical activity overall activity, sports) as assessed with a questionnaire. However, results were contradictory on duration of illness, while other factors, such as systolic-diastolic blood pressure and age, were clearly not associated with 6MWT performance.

Two studies reviewed the potential determinants of 6MWD using multiple stepwise regression analysis. Vancampfort et al. [27] showed that muscular fitness, BMI, the presence of MetS and physical activity were independent predictors of walking capacity (model 1). Furthermore, Vancampfort et al. [25] also reported that BMI, smoking behaviour, involvement in sports, physical self-worth and perceived sports competence, as well as perceived physical condition and perceived body attractiveness, were all independent predictors of 6MWD (model 2). Both Model 1 and 2 explained the 71.8% and 59.4% variance of 6MWT performance, respectively [25].

### 6MWT measurement properties and quality procedures

The 6MWT's measurement properties were examined in one study of 71 adults with schizophrenia (47 men, 37.4  $\pm$  10.1 years, BMI = 26.0  $\pm$  5.3 kg/m<sup>2</sup>) [12]. The 6MWT was repeated within 3 days (trial 1–2). Test–retest reliability was reported as high, with an Intraclass Correlation Coefficient (ICC) between the two 6MWT instances of 0.96 (CI 95% of 0.94–0.98) and a correlation coefficient between 6MWDs (trials 1–2) of 0.97 ( $p < 0.001$ ) [12]. The criterion validity of the association between the 6MWT and other exercise tests (e.g. Shuttle Walk Test, Cycle Ergometer test, Balke Treadmill Graded Exercise Test) was not explored in the included studies on adults with schizophrenia.

Table 2. Correlates of Six-Minute Walk Distance in adults with schizophrenia.

Correlates	Related with 6MWT	Unrelated with 6MWT	Studies reporting assoc.
<b>Demographic</b>			
BMI (kg/m <sup>2</sup> )	−0.561 [25], −0.44** [29], −0.40** [34], −0.52*** [12], −0.48** [33], −0.61** [27]		6/6
Age (years)	−0.24* [12]	[25] [27,33,34]	1/5
Smoking (cig/day)	−0.343 [25], −0.36** [34], −0.31** [12]	[27]	3/4
<b>Physical activity</b>			
Beacke	0.354 [33]		
Leisure PA sports	0.42**† [29], 0.37* [33] 0.58** [25], 0.60**†, 0.58** [33]	[25]	2/3 3/3
IPAQ total PA	0.64** [27]		1/1
IPAQ walking minutes	0.56 ** [27]		1/1
IPAQ moderate PA minutes		[27]	0/1
IPAQ vigorous PA minutes	0.376* [27]		1/1
IPAQ Met-minutes/week	0.69** [27]		1/1
Baseline 6MWD		[23]	0/1
Standing broad jump (cm)	0.68** [27]		1/1
<b>Pain/Fatigue</b>			
Hip pain	−0.437 [25]		1/1
Foot pain	−0.438 [25]		1/1
Back pain		[25]	0/1
Knee pain		[25]	0/1
Musculoskeletal pain	−0.40** [25]		1/1
Dyspnoea		[25]	0/1
Borg Scale		[12]	0/1
<b>Anthropometrics measures</b>			
WC	−0.43**† [25]		1/1
Systolic blood pressure (mmHg)		†[12,29]	0/2
Diastolic blood pressure (mmHg)		†[29,34]	0/2
HR	−0.33** [12]		
HDL (mg/dL)		†[29]	0/1
Triglycerides (mg/dL)		†[29]	0/1
Glucose (mg/dL)		†[29]	0/1
<b>Psychiatric characteristics</b>			
Chlorpromazine equivalents	−0.38** [34], −0.37** [12], −0.42** [27]		3/3
EPS		[27]	0/1
GAF	0.59** [34]		1/1
PECC total	−0.46** [34]		1/1
PECC positive symp		[27,34]	0/2
PECC negative symp	−0.45** [34]	[27]	1/2
PECC cognitive symp	−0.319 [34]	[27]	1/2
PECC depression	−0.48** [34]	[27]	1/2
PECC excitement		[27,34]	0/2
Duration of illness (years)	0.3910 [33]	[27]	1/1
<b>Psychological measures</b>			
Depression score <sup>a</sup>		[23]	0/1
<i>Physical Self Esteem (PSPP)</i>			
Sport Competence	−0.55** [25]		1/1
Body Attractiveness	−0.4011 [25]		1/1
<b>Physical Strength</b>			
Physical Self-worth	−0.49** [25]	[25]	0/1
<i>Qol (RAND-36)</i>			
Physical Functioning	0.46** [33]		1/1
Social Functioning		[33]	0/1
Physical Role limitations		[33]	0/1
Emotional Role limitations		[33]	0/1
Mental Health		[26,33]	0/2
Vitality	0.4012 [33]		1/1
Bodily pain	0.41** [33]		1/1
Mental component score		[33]	1/0
Physical component score	0.42** [33], 0.43** [26]		2/2

BMI = Body Mass Index, WC = Waist circumference (cm), † = after adjusting for age and smoking behavior, Beacke = Baecke Physical Activity Questionnaire, GAF = Global Assessment of Functioning, PECC = Psychosis Evaluation tool for Common Use by Caregivers, HR = Heart Rate, HDL = High-Density Lipoprotein, EPS = Extrapyramidal side-effects, IPAQ = International Physical Activity Questionnaire, PA = Physical Activity, MET = Metabolic Equivalent Task, PSPP = Physical Self-Perception Profile, Qol = Quality of life, RAND-36 = Short Form Health Survey (36).

a = Mental Health Inventory, EPS = Extrapyramidal side-effects,

\* =  $p < 0.05$ , \*\* =  $p < 0.001$

Table 3. ATS guidelines compared to actual 6MWT procedures.

Study	Location		Instructions				Encouragement	
	Straight Corridor	Length Walking Course (m)	Pre-testing period	'Walk as far as possible without jogging or running'	Turning around the cones	Practice test	Standardized	Phrases ATS-guidelines
ATS-Guidelines	Y	30	Y	Y	Y	Opt	Y	Y
[19]	-	-	-	-	-	-	-	-
[21]		60 (oval)						
[48]		60 (oval)		Y				
[20]		Treadmill						
[22]	Y	15.2						
[23]	Y	30	Y	Y	Y	Y	Y	Y
[24]	Y	20		Y				
[12]	Y	25	Y	Y	Y	Y	Y	Y
[33]	Y	25	Y	Y	Y		Y	Y
[29]	Y	25	Y	Y	Y	Y	Y	Y
[25]	Y	25	Y	Y	Y	Y	Y	Y
[32]	Y	25	Y	Y	Y	Y	Y	Y
[27]	Y	25	Y	Y	Y		Y	Y
[28]	Y	25	Y	Y	Y		Y	Y
[26]	Y	25	Y	Y	Y		Y	Y
[34]	Y	25	Y	Y	Y		Y	Y

Y = Yes, Shaded cell = Criteria not respected, Opt = optional, - = details not available.

A useful statistical estimate is Minimal Detectable Change (MDC). MDC can also help clinicians interpret the distance walked by patients after an intervention. Vancampfort et al. [12] reported an MDC of 56.2 m and 50.2 m for men and women, respectively. The MDC was calculated using a distributional method, by multiplying the standard error of measurement by 1.96 (for more information, see [35]).

We also reviewed the 6MWT procedures used in the included studies in light of the ATS guidelines; our review is summarized in Table 3. Walking courses ranged from 15.2 m to 60 m. Most studies used a walking course longer than 25 m. Nine studies followed the criteria set by the ATS guidelines. In the study by Archie et al. [19], the test procedure was not described.

## Discussion

The 6MWT is used to measure a patient's response to a therapeutic physical activity intervention or physical rehabilitation. In our review, we found that response to intervention was evaluated in 4 studies involving various types of exercise. None of the studies found any significant increase in 6MWD. The absence of a comparator and the small sample sizes may have limited the interpretation of patients' responses to intervention as measured by the 6MWT for individuals with schizophrenia. However, the absence of significant changes in 6MWT performance may be also explained by the duration of the exercise interventions and intensity of exercise sessions. Indeed, longer training regimens duration ( $\geq 24$  weeks) and interval training with high intensity (85–95% of heart rate) improve the indicators of functional exercise capacity in adults with schizophrenia [36–38]. For instance, in a single-arm study of adults with serious mental illness, a significant increase in 6MWD (i.e. a mean change of  $31.7 \text{ m} \pm 54.9$ ) was observed after a 24-week weight management intervention [36]. In contrast, only one study had a length of intervention of 24 weeks and moderate exercise intensity was used among studies involving interventions.

In spite of these results, given the relatively low number of studies and amount of data available to date on the 6MWT's suitability for measuring the impact of interventions, we cannot offer a definite conclusion on the use of this test in that respect on patients with schizophrenia.

Our review data also show that the 6MWD walked by adults with schizophrenia seemed generally shorter than that covered by healthy adults. This finding corroborates the results of Nilson et al. [39] and Heggelund et al. [40], who reported that the physical fitness in adults with schizophrenia is more impaired. In fact, in terms of functional capacity, adults with schizophrenia generally exhibit lower cardiopulmonary fitness (i.e. higher respiratory quotient on submaximal workloads and lower calculated  $\text{VO}_2\text{-max}$ ) than the general population [39]. Another possible explanation for the poorer 6MWT performance of schizophrenia patients is their impaired gait pattern, characterized by a reduction of velocity and stride length at free gait [41]. Interestingly, the 6MWD walked by outpatients was also shorter.

Among 6MWT correlates, objective and subjective (e.g. perceived body attractiveness) factors were identified. BMI and daily cigarette consumption were negatively associated with walking distance. These results are consistent with the factors found in healthy subjects [16]. Furthermore, a higher level of physical activity (assessed by questionnaire) was positively associated with 6MWT performance. This observation is in line with those made in earlier studies on COPD patients [1,42].

More specifically, for individuals with schizophrenia, the mean daily equivalent dosage of chlorpromazine was negatively associated with 6MWD [12,27,34]. However, these results should be interpreted with caution, because gait velocity is lower in adults with schizophrenia treated with conventional neuroleptics than in patients treated with olanzapine. On the other hand, the associations between schizophrenic symptoms (assessed with the Psychosis Evaluation tool for Common Use by Caregivers) and the 6MWT were not clear. Repeated significant associations were not found between 6MWD and the following categories of symptoms: negative (e.g. blunted affect), depressive (e.g. guilt feelings), cognitive (e.g. poor attention) and excitatory (e.g. excitement) [28,34].

The association between age and 6MWT performance was not significant in four studies. This could be explained by a recruitment bias because participants with schizophrenia are generally younger in clinical studies [43]. Moreover, in samples of adults with schizophrenia, weight status appeared to have a negative impact on 6MWD [25]. These results were consistent with those of other studies on adults without psychiatric disorders

[44,45]. Pires et al. [46] showed that the distance walked significantly decreased with increasing BMI in normal weight, overweight and obese adults, who walked  $565.45 \text{ m} \pm 101.56$ ,  $492.93 \text{ m} \pm 73.18$ , and  $457.35 \text{ m} \pm 92.18$ , respectively. It is also important to note that studies using multivariate analysis identified psychological (e.g. body attractiveness) and behavioural factors (e.g. smoking) as predictors of 6MWD [25,34].

As a fourth aim we explored the psychometric properties of the 6MWT, we found that the 6MWT is a very reliable walk test ( $\text{ICC} > 0.95$ ). However, no data were available on its criterion validity. Further research should therefore focus on this aspect. For example, future studies could explore the association between 6MWD and  $\text{VO}_2$  peak obtained by maximal treadmill exercise testing in individuals with schizophrenia.

MDC was investigated in one study [12] and the calculated values were 56.2 m and 50.2 m. However, calculations were made using the distributional method. Using a discriminative method often yields different results [47]. Generally, authors followed ATS recommendations for the use of the 6MWT on individuals with schizophrenia, but interventional studies lacked a quality procedure. The test procedure was clearly described in only one study [23]. In a study of Beebe et al. [21], the experimenters used a continuous oval path. As reported [48], this design probably increased the walking distance by 28.1 m. The issue of the quality of the test procedure therefore limits the determination of the suitability of the 6MWT as an appropriate post-intervention measurement instrument.

### Limitations

Several limitations to our systematic review need to be acknowledged. First, the sample sizes of the clinical studies included were very small. Second, Table 2, which shows physical activity correlates for patients with schizophrenia, is solely based on cross-sectional studies; therefore, inferring causal relationships between the hypothesized correlates and physical activity is precluded. Third, the correlate studies mainly used Belgian samples.

### Future research

Future research should concentrate on the investigation of the 6MWT's criterion validity and MDC, with larger samples of adults with schizophrenia and a discriminative analysis method (i.e. anchor-based analyses) [49]. It would be interesting to further compare the distance walked by inpatients and outpatients, and to identify common determinants. Further research might also explore the predictive role of 6MWD on clinical factors (e.g. psychiatric symptoms, global functioning, quality of life or hospitalization) in individuals with schizophrenia.

### Conclusion

When performed according to the standardized testing protocol, the 6MWT shows excellent reliability for assessing functional capacity in adults with schizophrenia. Consequently, this test should be included in future physical health monitoring recommendations for patients with schizophrenia.

### Declaration of interest

The authors report no declarations of interest.

### References

- Enright PL. The six-minute walk test. *Resp Care* 2003;48:783–5.
- ATS. ATS statement: guidelines for the six-minute walk test. *Am J Resp Crit Care Med* 2002;166:111–17.
- Hulens M, Vansant G, Claessens AL, et al. Predictors of 6-minute walk test results in lean, obese and morbidly obese women. *Scand J Med Sci Sp* 2003;13:98–105.
- Pankoff B, Overend T, Lucy S, et al. Reliability of the six-minute walk test in people with fibromyalgia. *Arthritis Care Res* 2000;13:291–5.
- Olsson LG, Swedberg K, Clark AL, et al. Six minute corridor walk test as an outcome measure for the assessment of treatment in randomized, blinded intervention trials of chronic heart failure: a systematic review. *Eur Heart J* 2005;26:778–93.
- Troosters T, Gosselink R, Decramer M. Six minute walking distance in healthy elderly subjects. *Eur Resp J* 1999;14:270–4.
- Miyamoto S, Nagaya N, Satoh T, et al. Clinical correlates and prognostic significance of six-minute walk test in patients with primary pulmonary hypertension. Comparison with cardiopulmonary exercise testing. *Am J Resp Crit Care Med* 2000;161:487–92.
- Rasekaba T, Lee AL, Naughton MT, et al. The six-minute walk test: a useful metric for the cardiopulmonary patient. *Inter Med J* 2009;39:495–501.
- Avouac J, Kowal-Bielecka O, Pittrow D, et al. Validation of the 6 min walk test according to the OMERACT filter: a systematic literature review by the EPOSS-OMERACT group. *Ann Rheu Dis* 2010;69:1360–3.
- De Feo S, Tramarin R, Lorusso R, et al. Six-minute walking test after cardiac surgery: instructions for an appropriate use. *Eur J Cardio Prev Rehab* 2009;16:144–9.
- Savarese G, Paolillo S, Costanzo P, et al. Do changes of 6-minute walk distance predict clinical events in patients with pulmonary arterial hypertension? A meta-analysis of 22 randomized trials. *J Am Coll Card* 2012;60:1192–201.
- Vancampfort D, Probst M, Sweers K, et al. Reliability, minimal detectable changes, practice effects and correlates of the 6-min walk test in patients with schizophrenia. *Psychiatry Res* 2011;187:62–7.
- Marder SR, Essock SM, Miller, et al. Physical health monitoring of patients with schizophrenia. *Am J Psychiatry* 2004;161:1334–49.
- Faulkner G, Cohn T, Remington G. Interventions to reduce weight gain in schizophrenia. *Cochrane Database Syst Rev* 2007;(1):CD005148. doi: 10.1002/14651858.CD005148.pub2.
- Mokkink LB, Terwee CB, Patrick DL, et al. The COSMIN study reached international consensus on taxonomy, terminology, and definitions of measurement properties for health-related patient-reported outcomes. *J Clin Epidemiol* 2010;63:737–45.
- Casanova C, Celli BR, Barria P, et al. The 6-min walk distance in healthy subjects: reference standards from seven countries. *Eur Resp J* 2011;37:150–6.
- Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Med* 2009;6:e1000100.
- American Psychiatric Association. Diagnostic and statistical manual of mental disorders: DSM-IV-TR. Washington, DC: American Psychiatric Pub; 2000.
- Archie S, Wilson JH, Osborne S, et al. Pilot study: access to fitness facility and exercise levels in olanzapine-treated patients. *Can J Psychiatry* 2003;48:628–32.
- Fogarty M, Happell B, Pinikahana J. The benefits of an exercise program for people with schizophrenia: a pilot study. *Psychiatr Rehabil J* 2004;28:173–6.
- Beebe L, Tian L, Morris N, et al. Effects of exercise on mental and physical health parameters of persons with schizophrenia. *Issues Ment Health Nurs* 2005;26:661–76.
- Hackney ME, Earhart G. Social partnered dance for people with serious and persistent mental illness: a pilot study. *J Nerv Ment Dis* 2010;198:76–8.
- Marzolini S, Jensen B, Melville P. Feasibility and effects of a group-based resistance and aerobic exercise program for individuals with severe schizophrenia: a multidisciplinary approach. *Ment Health Phys Act* 2009;2:29–36.
- Dodd KJ, Duffy S, Stewart JA, et al. A small group aerobic exercise programme that reduces body weight is feasible in adults with severe chronic schizophrenia: a pilot study. *Disabil Rehabil* 2010;33:1222–9.
- Vancampfort D, Probst M, Sweers K, et al. Relationships between obesity, functional exercise capacity, physical activity participation and physical self-perception in people with schizophrenia. *Acta Psychiatr Scand* 2011;123:423–30.

26. Vancampfort D, Probst M, Scheewe T, et al. Lack of physical activity during leisure time contributes to an impaired health related quality of life in patients with schizophrenia. *Schizophr Res* 2011; 129:122–7.
27. Vancampfort D, Probst M, De Herdt A, et al. An impaired health related muscular fitness contributes to a reduced walking capacity in patients with schizophrenia: a cross-sectional study. *BMC Psychiatry* 2013;13:5.
28. Vancampfort D, De Herdt A, Sweers K, et al. Diabetes, physical activity participation and exercise capacity in patients with schizophrenia. *Psychiatry Clin Neurosci* 2013;67:451–6.
29. Vancampfort D, Sweers K, Probst M, et al. Association of the metabolic syndrome with physical activity performance in patients with schizophrenia. *Diabetes Metab* 2011;37:318–23.
30. Hansson L, Middelboe T, Merinder L, et al. Predictors of subjective quality of life in schizophrenic patients living in the community. A Nordic Multicentre Study. *Int J Soc Psychiatry* 1999; 45:247–58.
31. Weinberg D, Shahar G, Noyman G, et al. Role of the self in schizophrenia: a multidimensional examination of short-term outcomes. *Psychiatry Interp Biol Proc* 2012;75:285–97.
32. Vancampfort D, Hert MD, Maurissen K, et al. Physical activity participation, functional exercise capacity and self-esteem in patients with schizophrenia. *Int J Therapy Rehabil* 2011;18:222–30.
33. Martín-Sierra A, Vancampfort D, Probst T, et al. Walking capacity is associated with health related quality of life and physical activity level in patients with schizophrenia: a preliminary report. *Actas Españolas Psiquiatría* 2011;39:211–16.
34. Vancampfort D, Probst M, Scheewe T, et al. The functional exercise capacity is correlated with global functioning in patients with schizophrenia. *Acta Psychiatry Scand* 2012;125:382–7.
35. Wyrwich KW, Tierney WM, Wolinsky FD. Further evidence supporting an SEM-based criterion for identifying meaningful intra-individual changes in health-related quality of life. *J Clin Epidemiol* 1999;52:861–73.
36. Daumit G, Dalcin AT, Jerome GJ, et al. A behavioral weight-loss intervention for persons with serious mental illness in psychiatric rehabilitation centers. *Int J Obesity* 2010;35:1114–23.
37. Heggelund J, Nilsberg GE, Hoff J, et al. Effects of high aerobic intensity training in patients with schizophrenia—a controlled trial. *Nord J Psychiatry* 2011;65:269–75.
38. Abdel-Baki A, Brazzini-Poisson V, Marois F, et al. Effects of aerobic interval training on metabolic complications and cardio-respiratory fitness in young adults with psychotic disorders: a pilot study. *Schizophr Res* 2013;149:112–15.
39. Nilsson BM, Olsson RM, Oman, et al. Physical capacity, respiratory quotient and energy expenditure during exercise in male patients with schizophrenia compared with healthy controls. *Eur Psychiatry* 2012;27:206–12.
40. Heggelund J, Hoff J, Helgerud J, et al. Reduced peak oxygen uptake and implications for cardiovascular health and quality of life in patients with schizophrenia. *BMC Psychiatry* 2011;11:188.
41. Putzhammer A, Heindl B, Broll K, et al. Spatial and temporal parameters of gait disturbances in schizophrenic patients. *Schizophr Res* 2004;69:159–66.
42. Pitta F, Troosters T, Spruit MA, et al. (2005). Characteristics of physical activities in daily life in chronic obstructive pulmonary disease. *Am J Resp Crit Care Med* 2004;171:972–7.
43. Hofer A, Hummer M, Huber R, et al. Selection bias in clinical trials with antipsychotics. *J Clin Psychopharmacol* 2000;20: 699–702.
44. Larsson U, Reynisdottir S. The six-minute walk test in outpatients with obesity: reproducibility and known group validity. *Physiol Res Inter* 2008;13:84–93.
45. Olczyk J, Kokoszko A, Lewiński A, et al. Quality of life and exercise capacity in obesity and growth hormone deficiency. *Neuro Endocrinol Lett* 2010;31:700–7.
46. Pires SR, Oliveira AC, Parreira VF, et al. Six-minute walk test at different ages and body mass indexes. *Braz J Phys Ther* 2007;11: 131–4.
47. Mathai SC, Puhana MA, Lam D, et al. The minimal important difference in the 6-minute walk test for patients with pulmonary arterial hypertension. *Am J Resp Crit Care Med* 2012;186: 428–33.
48. Sciarba F, Criner G, Lee S, Mohsenifar Z, et al. Six-minute walk distance in chronic obstructive pulmonary disease: reproducibility and effect of walking course layout and length. *Am J Resp Crit Care Med* 2003;167:1522–7.
49. Crosby RD, Kolotkin RL, Williams GR. Defining clinically meaningful change in health-related quality of life. *J Clin Epidemiol* 2003;56:395–407.

Supplementary material available online

Supplementary figure 1