Feasibility and acceptability of an exergame intervention for schizophrenia

- Carlos Campos
- Filipa Mesquita
- António Marques
- Maria J. Trigueiro
- Verónica Orvalho
- Nuno B.F. Rocha

Abstract

Objectives

To evaluate the feasibility and acceptability of an exergame intervention as a tool to promote physical activity in outpatients with schizophrenia.

Design

Feasibility/Acceptability Study and Quasi-Experimental Trial.

Method

Sixteen outpatients with schizophrenia received treatment as usual and they all completed an 8-week exergame intervention using Microsoft Kinect® (20 min sessions, biweekly). Participants completed pre and post treatment assessments regarding functional mobility (Timed Up and Go Test), functional fitness performance (Senior Fitness Test), motor neurological soft signs (Brief Motor Scale), hand grip strength (digital dynamometer), static balance (force plate), speed of processing (Trail Making Test), schizophrenia-related symptoms (Positive and Negative Syndrome Scale) and functioning (Personal and Social Performance Scale). The EG group completed an acceptability questionnaire after the intervention.

Results

Attrition rate was 18.75% and 69.23% of the participants completed the intervention within the proposed schedule. Baseline clinical traits were not related to game performance indicators. Over 90% of the participants rated the intervention as satisfactory and interactive. Most participants (76.9%) agreed that this intervention promotes healthier lifestyles and is an acceptable alternative to perform physical activity. Repeated-measures MANOVA analyses found no significant multivariate effects for combined outcomes.

Conclusion

This study established the feasibility and acceptability of an exergame intervention for outpatients with schizophrenia. The intervention proved to be an appealing alternative to physical activity. Future trials should include larger sample sizes, explore patients' adherence to home-based exergames and consider greater intervention dosage (length, session duration, and/or frequency) in order to achieve potential effects.

Keywords

- Exergames;
- Schizophrenia;
- Physical activity;
- Physical fitness;
- Motor function

Introduction

The majority of patients with schizophrenia is known to have a more sedentary lifestyle in comparison to healthy controls (Faulkner et al., 2006 and Lindamer et al., 2008). Physical activity levels are reduced in this population and can be related to impaired health-related quality of life (Martín-Sierra et al., 2011, Vancampfort et al., 2011 and Vancampfort et al., 2011). Furthermore, these individuals show less confidence in their physical abilities, which is associated with a lower participation in physical activities (Vancampfort, Probst, Sweers, et al., 2011).

There is also evidence that patients with schizophrenia have a reduced functional exercise capacity when compared to healthy controls (Vancampfort, Probst, Sweers, et al., 2011). Patients with schizophrenia display impairments in several physical fitness indicators including flexibility (Vancampfort et al., 2013), maximal aerobic capacity, maximal anaerobic power, anaerobic capacity (Ozbulut et al., 2013) and muscular fitness as measured by hand grip (Callison et al., 1971 and Viertiö, 2011), abdominal and leg muscle strength (Vancampfort et al., 2013). Moreover, patients with schizophrenia commonly display motor deficits which have a great impact on the long-term outcome of the disease (Putzhammer & Klein, 2006). The main motor impairments described include a decreased balance and postural control, displayed by postural instability, increased postural sway area and center of pressure displacement (Agarwal and Agarwal, 2014,Kent et al., 2012, Marvel et al., 2004 and Stensdotter et al., 2013); poorer gait performance, comprising shorter stride length and decreased gait velocity

(Putzhammer et al., 2004 and Putzhammer et al., 2005); and higher incidence of motor neurological soft signs, with inferior performance in motor coordination and sequencing tasks (Dazzan and Murray, 2002 and Zakaria et al., 2013).

Currently, there has been a growing interest in the physical rehabilitation of patients with schizophrenia (Hert et al., 2011), with international guidelines emphasizing the role of physical activity in the treatment of this disorder (Lehman et al., 2010, National Institute for Health and Care Excellence, 2014, Scottish Intercollegiate Guidelines Network, 2013 and Vancampfort et al., 2012). Rosenbaum, Tiedemann, Sherrington, Curtis, and Ward (2014) recently completed a systematic review with meta-analysis with psychiatric patients which found a large effect of physical activity on depressive and psychotic symptoms, a moderate effect on aerobic capacity and quality of life and a small effect on anthropometric measures. The effects of exercise in patients with schizophrenia have also been reported in another systematic review, with findings showing that regular exercise programs are feasible for this population and can provide benefits for physical/mental health and well-being of these individuals (Gorczynski & Faulkner, 2010). These authors also reported that current guidelines for lifestyle activity and exercise appear just as acceptable for individuals with schizophrenia. International physical activity guidelines state that any adult, even if diagnosed with schizophrenia, should complete at least 150 min a week of moderate-intensity, or 75 min of moderate-to vigorous-intensity aerobic activity to achieve substantial health improvements (Vancampfort et al., 2012). Exergames have emerged in recent years as promising new tools to promote physical fitness and motor rehabilitation in several populations (Chang et al., 2011, van Diest et al., 2013, Eichhorn et al., 2013, Jansen-Kosterink, 2013, Knights et al., 2014, Lange et al., 2011 and Staiano et al., 2013), being a reliable tool to improve balance and postural control (van Diest et al., 2013), lower limb muscle strength (Chen et al., 2012 and Kim et al., 2013) and other physical fitness measures (Knights et al., 2014 and Staiano et al., 2013). This intervention allows the user to perform video games that involve exercise and are controlled by bodily movements. The application of exergames in patients with psychiatric disabilities has not been fully considered, although there are some findings regarding subjects with schizophrenia. The latter have reported emotional state improvement after an exergame intervention, which reinforces the role of this intervention in people who experience mental health problems (Patsi, Antoniou, Batsiou, Bebetsos, & Lagiou, 2012). Exergames have also been highlighted as an accessible and ideal tool to promote physical activity and promote well-being in older adults with schizophrenia (Leutwyler, Hubbard, Vinogradov, & Dowling, 2012). However, further work is necessary to determine if this intervention is an acceptable and alternative tool to promote physical activity in subjects with schizophrenia from different settings and across several age groups. This study is a quasi-experimental trial which aims to evaluate the feasibility and acceptability of an exergame intervention as a tool to promote physical activity in outpatients with schizophrenia.

Methods

Participants

Participants were recruited from the *Associação Nova Aurora na Reabilitação e Reintegração Psicossocial (ANARP)* socio-occupational center, Porto, Portugal, which provides services to individuals with stable, severe and persistent mental illnesses. The inclusion criteria were the following: patients diagnosed with schizophrenia based on the Diagnostic and Statistical Manual of Mental Disorders IV criteria (American Phychiatric Assocation, 2000) recognized by each patient psychiatrist, aged between 18 and 65 years and clinically stable (no significant changes in medication for at least one month). The patients with severe cognitive impairment (based on Mini Mental State cut off values), neurologic disorders or current substance dependence were excluded from the study.

This study was approved by the Scientific Committee of the *School of Allied Health Technologies - Polytechnic Institute of Porto* and by the directive board of ANARP. All participants signed a consent form and there was no financial compensation for participation. Details of enrollment into the trial are described in Fig. 1. Forty-six patients were assessed for eligibility and eight did not meet the inclusion criteria (three clinical unstable; two with neurologic disease diagnosis; one with severe cognitive impairment; two were discharged from the institution). Six of the eligible participants were not interested in participating in the study. Therefore, 32 participants were recruited and assigned to either the exergame intervention group (EG; n = 16) or the treatment-as-usual group (TAU; n = 16). Group allocation of participants was based on participants' availability to attend the exergame sessions biweekly. Three participants did not complete the intervention. No significant differences were found between groups regarding socio-demographic, clinical and physical characteristics (Table 1).

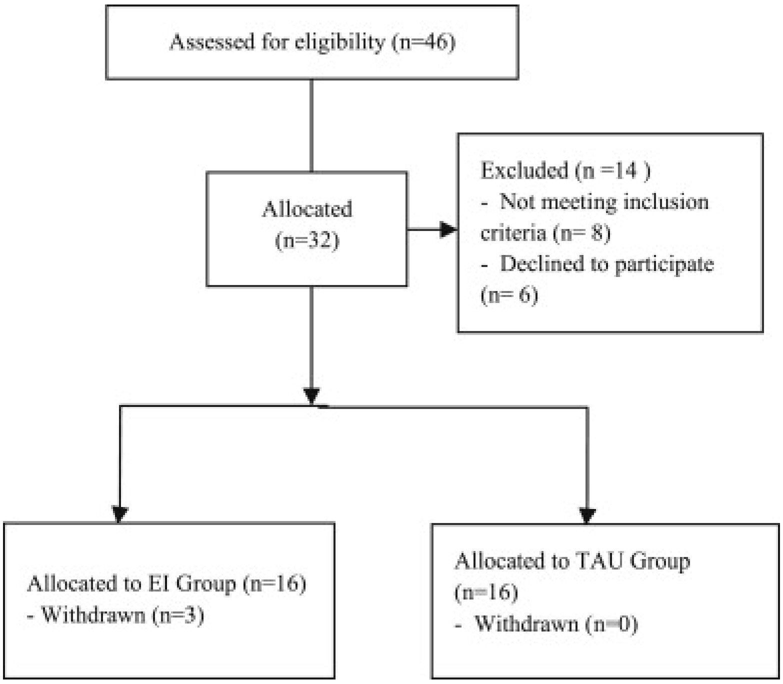

Fig. 1.

Participants flow diagram according to CONSORT Statement.

Table 1.
Summary of participant characteristics at baseline.

Characteristics	EG (n = 13) *M (SD)*	TAU (n = 16) *M (SD)*	*p*
Gender (M/F)	10/3	11/5	0.697[a]
Age (years)	39.77 (9.2)	39.00 (5.60)	0.794[b]
Educational level			0.847[c]
< 9	3	3	
9–12 years	8	10	
College education	2	3	
Marital status			1.000[c]
Single	11	14	
Married	0	1	
Divorced	2	1	
Length of illness (years)	17.15 (9.17)	11.88 (9.16)	0.135[b]
Chlorpromazine equivalent dose (mg/day)	483.58 (448.66)	341.28 (281.65)	0.787[d]
Body Mass Index	25.72 (4.75)	27.57 (5.33)	0.339[b]
Baecke score	4.29 (2.00)	3.48 (2.16)	0.305[b]

a *Fisher's* exact test.

b Two-tailed *student t*-test.

c *Chi-square* test.

d *Mann–Whitney U* test.

Table 2.
Game performance data regarding completed levels and trial per level (mean and standard deviation).

Game scenarios	Completed levels *M (SD)*	Trials per level *M (SD)*
Grape Harvest (20 levels)	12.92 (4.87)	3.13 (1.63)
Grape Run (20 levels)	17.00 (5.16)	2.39 (2.39)
Grape Stomp (20 levels)	15.61 (4.13)	3.53 (1.73)
Full Game (60 levels)	45.54 (12.18)	3.01 (1.02)

Table 3.
Participants acceptability/usability rating.

Intervention satisfaction	Disagree	Neutral	Agree
I would like to use Exergames often	0 (0%)	7 (53.8%)	6 (46.2%)
I would use Exergames without the need of technical assistance	11 (84.6%)	1 (7.7%)	1 (7.7%)
If I have access to Exergames, I will use them	0 (0%)	3 (23.1%)	10 (76.9%)
I am satisfied with this type of intervention	0 (0%)	0 (0%)	13 (100%)
I would recommend Exergames to a friend	1 (7.7%)	1 (7.7%)	11 (84.6%)
Exergames are interactive	0 (0%)	1 (7.7%)	12 (92.3%)
Exergames are fun to use	2 (15.4%)	2 (15.4%)	9 (69.2%)
This intervention promotes an healthier lifestyle	2 (15.4%)	1 (7.7%)	10 (76.9%)
This intervention is an acceptable alternative to perform physical activity	1 (7.7%)	2 (15.4%)	10 (76.9%)
I found session duration suitable	1 (7.7%)	2 (15.4%)	10 (76.9%)
I found intervention frequency suitable	0 (0%)	2 (15.4%)	11 (84.6%)
I found intervention length suitable	1 (7.7%)	2 (15.4%)	10 (76.9%)
Game characteristics			
I found the game to be very complicated	6 (46.2%)	4 (30.8%)	3 (23.1%)
I am satisfied with game control	1 (7.7%)	2 (15.4%)	10 (76.9%)
I found game functioning to be acceptable	2 (15.4%)	1 (7.7%)	10 (76.9%)
I felt confident and comfortable using the game	1 (7.7%)	1 (7.7%)	11 (84.6%)
Whenever I failed a level, I could easily found a strategy to complete it	1 (7.7%)	3 (23.1%)	9 (69.2%)

Game screen components were clearly visible	2 (15.4%)	3 (23.1%)	8 (61.5%)
It was easy to learn to use the game	2 (15.4%)	4 (30.8%)	7 (53.8%)
Specific intervention effects			
I experienced symptoms improvement	0 (0%)	8 (61.5%)	5 (38.5%)
I experienced daily functioning improvement	2 (15.4%)	6 (46.2%)	5 (38.5%)
I experienced speed of processing improvement	1 (7.7%)	6 (46.2%)	6 (46.2%)
I felt that the game improved my overall motor functioning	2 (15.4%)	6 (46.2%)	5 (38.5%)
I experienced muscle strength improvement	1 (7.7%)	6 (46.2%)	6 (46.2%)
I experienced balance improvement	2 (15.4%)	4 (30.8%)	7 (53.8%)
I experienced endurance improvement	0 (0%)	3 (23.1%)	10 (76.9%)
I experienced flexibility improvement	1 (7.7%)	5 (38.5%)	7 (53.8%)
I experienced motor coordination improvement	0 (0%)	6 (46.2%)	7 (53.8%)

Instruments

Participants of both groups were evaluated twice, before and after the intervention (up to two weeks after the intervention). Assessment procedures were completed by two blinded evaluators which had previous training applying the selected instruments. Clinical and functional outcomes were assessed by each participants' reference clinician. Each assessment period concluded by the blind evaluators ranged from 45 to 60 min and was ideally performed in one visit, although some participants needed two visits because of their personal agendas. Selected instruments consisted of feasibility/acceptability indicators and motor functioning, cognitive performance, clinical and functional scales, which were all administered in the native language of the participants (Portuguese).

Feasibility and acceptability

Attrition rate and intervention attendance were recorded in order to assess feasibility. Game performance indicators were also considered through the annotation of completed levels and number of trials per level. Acceptability was assessed through a self-report 28-item questionnaire, comprised of adapted items from other feasibility studies (Ben-Zeev et al., 2014 and Williams et al., 2010). Participants were asked to rate their agreement (Disagree, Neutral or Agree) with a series of statements about the intervention (Table 4for all items).

Table 4
Comparisons between the pre- and post-intervention scores for each group (mean, standard deviation and Cohen's d).

	EG group (n = 13)			TAU group (n = 16)		
	Pre *M (SD)*	Pos *M (SD)*	*Within group d*	Pre *M (SD)*	Pos *M (SD)*	*Within group d*
TUG	8.508(2.211)	9.094(1.590)	0.32	8.702(0.984)	8.471(1.316)	0.21
SFT						
Chair Stand	11.000(3.488)	10.385(2.142)	0.22	11.938(2.489)	12.625(2.553)	0.28
Arm Curl	11.4615(3.886)	11.846(3.078)	0.11	13.000(4.926)	14.250(3.786)	0.29
Two Min Step	58.308(20.613)	62.461(16.195)	0.23	66.375(22.160)	71.812(19.941)	0.27
Chair Sit & Reach	−8.077(11.694)	−10.654(10.491)	0.24	−7.125(12.049)	−4.969(11.297)	0.19
Back Scratch	−12.923(9.987)	−11.423(10.916)	0.15	−9.688(11.965)	−5.094(9.191)	0.57
Foot Up &Go	5.480(0.946)	5.509(0.796)	0.03	5.101(0.941)	5.213(0.875)	0.13
Hand grip strength						
Dominant Arm	34.064(9.254)	33.385(9.063)	0.08	34.631(13.361)	34.996(14.723)	0.03
Non Dominant Arm	32.933(8.312)	31.615(11.044)	0.14	32.154(12.692)	32.310(13.270)	0.01
Force plate – eyes open						
Total Trajectory Length	22.493(8.303)	25.729(11.919)	0.33	19.542(4.672)	19.837(7.422)	0.05
Total Average Speed	0.748(0.276)	0.856(0.396)	0.33	0.650(0.156)	0.660(0.247)	0.05
X Axis Maximum Extent	1.579(0.655)	1.851(1.081)	0.32	1.202(0.515)	0.990(0.482)	0.44
Y Axis Maximum Extent	1.979(0.706)	2.604(1.095)	1.08	2.154(0.883)	2.207(0.874)	0.30
Force plate - eyes closed						
Total Trajectory Length	30.412(11.840)	29.893(11.313)	0.05	24.854(7.242)	24.814(7.134)	0.03
Total Average Speed	1.012(0.394)	0.995(0.376)	0.05	0.827(0.241)	0.826(0.238)	0.00
X Axis Maximum Extent	1.919(0.844)	1.945(1.412)	0.02	1.326(0.479)	1.207(0.450)	0.27
Y Axis Maximum Extent	2.519(0.943)	2.609(1.303)	0.08	2.319(0.650)	2.243(0.630)	0.12
TMT A	47.712(17.622)	47.672(14.248)	0.00	45.025(12.333)	44.203(10.78)	0.07
TMT B	133.896(83.582)	145.969(80.264)	0.15	91.094(35.549)	101.141(35.57)	0.29
BMS	5.731(3.113)	4.962(4.230)	0.22	5.031(3.845)	3.188(3.596)	0.51
PSP	52.62(14.563)	58.77(16.203)	0.42	64.63(13.079)	65.06(15.472)	0.03
PANSS						
Positive	14.15(4.180)	14.69(6.993)	0.1	14.63(6.490)	14.75(5.710)	0.02
Negative	16.92(6.171)	17.69(7.005)	0.12	13.75(5.209)	15.88(5.667)	0.4
General Psychopathology	33.00(7.059)	33.38(8.771)	0.05	31.81(10.477)	31.44(9.223)	0.04
Total	64.08(15.261)	65.77(21.155)	0.1	60.19(19.729)	62.06(18.635)	0.1

Physical activity and motor functioning

Baecke Modified Physical Activity Questionnaire

This questionnaire was used to measure habitual physical activity levels (Baecke et al., 1982 and Voorrips et al., 1991). The selected version is completed through an interview which addresses three domains: domestic, sports and leisure activities. The first domain is scored based on ten 5-point Likert scale questions about usual domestic activities. In the following domains patients describe the sports and leisure activities they usually perform. Each activity is scored based on a formula which contemplates the intensity (e.g. Sitting, standing, walking, with or without weight load), frequency (hours per week) and periodicity (number of months per year) of each activity. The subscores of the three domains (domestic, sports and leisure) are summed and provide the global psychical activity score for each participant (Voorrips et al., 1991).

Timed Up and Go Test (TUG)

This test was used to assess functional mobility (Podsiadlo & Richardson, 1991). The test is scored based on the time it takes participants to stand up from a chair, walk 3 m, turn around, walk back to the chair, and sit down again (Podsiadlo & Richardson, 1991).

Senior Fitness Test (SFT)

The instrument has 6 subtests which were used to assess functional fitness performance (Rikli & Jones, 2013). To complete the test participants must perform 6 functional movement tasks:

- Chair Stand (lower body strength) - number of full stands completed in 30 s with arms folded across chest;

- Arm Curl (upper body strength) - number of bicep curls completed in 30 s holding a weight (2.3 Kg for women and 3.6 Kg for men) in a sitting position;

- Two Minute Step (aerobic endurance) - Number of full steps completed in 2 min, without moving from the starting position, and raising each knee to a point midway between the patella and iliac crest. The score is the number of times the right knee reaches the required height.

- Chair Sit & Reach (lower body flexibility) – seated, the participant must extend a leg and reach toward his toes. The test is rated according to the number of cm between the middle fingers and toes;

- Back Scratch (upper body flexibility) – one hand reaches over shoulder and one up the middle back. The test is rated according to the number of cm between the middle fingers of both hands;

- Foot Up & Go (agility/dynamic balance) – participants have two trials to get up from a seated position, walk 2.44 m, turn and return to seated position as fast as they can. The test is scored based on the time of the fastest trial.

Brief Motor Scale

This scale was used to assess motor neurological soft signs (Jahn et al., 2006). This scale is categorized into two sub-scales. The first subscale has 5 items which require the performance of motor coordination tasks (e.g. foot tapping, gaze impersistence, bilateral rhythm tapping). The second displays 5 items which involve motor sequencing tasks (e.g. rhythm production, pronation/supination, finger-thumb-opposition). Total score ranges from 0 to 20, with 0 being the worst possible score (Jahn et al., 2006).

Digital dynamometer

The DHD-1 model from Saehan was used to measure hand grip strength. The subjects compress a handle between the thena/hypothenar eminences and all the other fingers, except the thumb, and the display will provide the maximum force recorded in each trial (Amaral, Mancini, & Júnior, 2012). This instrument was applied according to the procedure described by Roberts et al. (2011). This equipment allows to record strength values between 0 and 90 Kg, with a resolution of 0.1 Kg and an accuracy of ±1% of the full scale.66 e 68.

Force plate

The emed®-a50 model from Novel was used to measure static balance. Participants stand on the platform in either static or dynamic conditions and the investigator receives information about their center of pressure (COP) displacement (Chaudhry, Bukiet, Ji, & Findley, 2011). This equipment collects data at 60 Hz, has a resolution of 2 sensors/cm2 and a pressure threshold of 10 kPa. The assessment procedure was based on Duarte and Freitas (2010). Participants positioned both feet on the plate, barefooted, and were instructed to look at a wall 3 m ahead for 60 s. One trial was completed with eyes open and another with eyes closed. Output from the data collected provided the following data: total trajectory length (total distance covered by COP), total average speed (average speed of COP displacement), x axis maximum extent (maximum medial-lateral COP displacement) and y maximum extent (maximum anterior-posterior COP displacement). The data presented represents the most stable 30 s.

Cognitive performance

The Trail Making Test A & B was also included to assess changes in processing speed, visual attention and cognitive flexibility (Reitan & Wolfson, 1995). Part A consists in connecting 25 numbers in numerical order. In Part B participants must switch between the numerical mode and the alphabetic mode by connecting 25 numbers and characters. The score is the total time needed to finish the tasks. To keep the assessment schedule brief, we did not include any additional neurocognitive testing.

Functional and clinical outcomes

Functioning was determined using the Personal and Social Performance Scale (PSP;Brissos et al., 2010 and Morosini et al., 2000). The PSP is scored based on a structured interview which includes 4 domains: socially useful activities, personal and social relationships, self-care and disturbing/aggressive behavior. Each domain is classified as absent, mild, manifest, marked, severe or very severe. The final score is calculated based on predefined criteria which take into account the rating of each domain and can be between 1 and 100. The severity of schizophrenia-related symptoms was assessed using the Positive and Negative Syndrome Scale (PANSS; Kay, Fiszbein, & Opler, 1987). This scale is based on a semi structured interview as well as the reports from family members or health professionals which have contact with the patient. A total of 30 items is rated based on the information gathered from these methods. The items are divided into three domains: positive symptoms, negative symptoms and general psychopathology. Each item is rated from 1 to 7, with 1 meaning absence of symptoms and 7 extremely severe symptoms. Total score ranges between 30 and 210.

Intervention

All intervention sessions were delivered in the ANARP facilities. EG group participants attended an initial session where basic game controls were introduced. Participants started the intervention protocol consisting of 20 min game sessions, performed biweekly, throughout an 8 week period. Game performance was controlled using the Microsoft Kinect® equipment, with the actual game being developed on the Move4Health project, led by Porto Interactive Center and the Laboratório de Reabilitação Psicossocial. The exergame intervention protocol consisted of a series of 20 levels for each game scenario so that the game was adjusted to each participants' individual skills. Levels gradually increased in degree of difficulty in several parameters including speed of processing, agility, range of motion, balance and aerobic endurance. The game was originally created for the elderly and gameplay occurs along three scenarios related to grape harvest:

Grape Harvest (Fig. 2)

Participants had to use their upper limbs to catch the grapes that appear on the screen. The required movements were shoulder flexion, abduction and hyperextension and elbow flexion. As the degree of difficulty increased, participants had to perform wider range of motions and larger weight transfers to complete the task;

Fig. 2.
Grape Harvest scenario: participants complete upper limb motions to catch the grapes that appear on the screen.

Grape Run (Fig. 3)

The screen displayed an avatar carrying a basket of grapes while facing several obstacles. As the avatar moves forward, the participants must complete trunk movements (flexion, left and right inclination) in order to avoid the obstacles presented. The harder levels required the participant to step so that the avatar maintains its walk across the trail. As the degree of difficulty increased, the obstacles appeared closer to each other and a wider range of motion was necessary to avoid them. The length of the trail increase would also demand more aerobic resistance from the participants.

Fig. 3.
Grape Run scenario: use of trunk movements (flexion and inclination) in order to avoid the obstacles presented.

Grape Stomping (Fig. 4)

The avatar was displayed in a grape press as several grapes appear in different positions. The participants had to accurately stomp the grapes by performing lower limb movements, mainly flexion and abduction as well as knee flexion. As the levels got more difficult, grapes remained less time on the screen. Also, the distance between grapes increased, requiring more mobility from the participants.

Fig. 4.
Grape Stomp scenario: subjects had to accurately stomp the grapes by performing lower limb movements.

Statistical analysis

Descriptive statistics were used to characterize game performance indicators (completed level and trials per level) and acceptability items. Pearson correlation coefficients were used to examine the association between lengths of illness, chlorpromazine equivalent dose and outcomes measures with game performance indicators. To test for intervention effects a repeated-measures *MANOVA* was calculated with participants' group as the between-group factor (EG vs TAU), assessment point as the within-group measure variable (Pre- and Post-) and all the intervention outcomes as dependent variables. *Pillai's Trace* was selected as the *F* ratio outcome. Within-group effect sizes were calculated with *Cohen's d.* An effect size ≥0.20 was considered small, while an effect size ≥0.50 was considered medium and an effect size ≥0.80 was considered large (Cohen, 1988). All statistic tests were applied with a significance level of 0.05.

Results

Feasibility

Attrition rate was 18.75% with only three participants withdrawing from the intervention. Participants that dropped out of the study mentioned that their availability had changed (two participants started attending educational activities outside the center; one participant started to provide daily care to a family member). Furthermore, 69.23% finished the intervention sessions within the proposed schedule. Information regarding game performance is presented in Table 2. Participants completed an average of 45.54 ± 12.18 game levels, with 84.62% of the participants concluding more than half of the projected levels. Length of illness, chlorpromazine equivalent dose and PANSS total score were not significantly correlated with the number of completed levels (r = -0.340;p = 0.255; r = −0.317; p = 0.292; r = −0.303, p = 0.314, respectively) and trials per level (r = 0.266; p = 0.380; r = 0.298; p = 0.322; r = 0.381; p = 0.199, respectively).

Acceptability

Participants' responses to the acceptability questionnaire are presented in Table 3. Over 90% of the participants rated the exergames intervention as satisfactory and interactive. Moreover, 76.9% of the participants agreed that this intervention promotes a healthier lifestyle and is an acceptable alternative to perform physical activity. Only a minority of the participants (7.7%) did not agree with session duration and intervention length. It also is noteworthy that 84.6% of the participants would not use this type of equipment without technical assistance. In relation to game characteristics, 76.9% of the participants were satisfied with game control and game functioning, while 84.6% felt confident in their performance using the game. Over 90% of the participants reported that they experienced at least 1 specific intervention effect. Participants highlighted the effects on endurance (76.9%), balance, flexibility and motor coordination (53.8% for the 3 motor functions).

Preliminary efficacy

The EG group and the TAU group did not significantly differ at baseline in any of the outcome measures, except for X Axis Maximum Extent with Eyes Closed ($t = -2.385; p = 0.024$) and PSP score ($t = 2.311$; $p = 0.027$). Descriptive data pre- and post-intervention for both groups and within-group effect sizes are presented in Table 4. Repeated-measures MANOVA analyses found no significant multivariate effects for combined outcomes across participants' groups ($V = 0.804$; F (24.4) = 0.682; $p = 0.757$), assessment time point ($V = 0.839$; F (24.4) = 0.643; $p = 0.643$) and the interaction between participants' group and assessment time point ($V = 0.821$; F (24.4) = 0.764; $p = 0.705$). Univariate between-group analyses showed significant differences between participants' groups regarding X Axis Maximum Extent with Eyes Open (F (1.27) = 8.072; $p = 0.008$), X Axis Maximum Extent with Eyes Closed (F (1.27) = 6.809; $p = 0.015$) and TMT B (F (1.27) = 4.470; $p = 0.044$). This means that the EG participants had a significantly worse performance on both outcomes. However, within group analysis indicated that there were no significant improvements in either group over time on any of the outcomes (F (1.27) = 0.041; $p = 0.841$; F (1.27) = 0.061; $p = 0.807$; F (1.27) = 1.447; p = 0. 239). None of the remaining outcome measures displayed significant univariate between group differences. Within-group univariate analysis indicated that Back Scratch score, Negative Symptoms and BMS score were significantly different between baseline and reassessment (F (1.27) = 5.597, $p = 0.025$; F (1.27) = 4.530; $p = 0.043$; F(1.27) = 5.072; p = 0. 033), irrespective of participants' group. For these 3 outcomes, small and medium within group effect sizes were found on the EG and TAU group, respectively. There was no significant interaction between participants group and assessment time points for any of the outcomes.

Discussion

Firstly, this study provides evidence for the feasibility of conducting exergame intervention trials for outpatients with schizophrenia. Researchers were able to implement a rather demanding exergame intervention protocol (biweekly sessions during a two month period) and to conduct an intensive set of assessments in order to explore the potential benefits of the intervention. It is safe to state that these findings relate to the possibility of conducting more robust studies in larger groups of outpatients with schizophrenia in the future.

This study also established that exergames can be a feasible and acceptable intervention in outpatients with schizophrenia. Participants displayed a low attrition rate (18.75%) and high session attendance. Attrition rate was similar or inferior to the values reported in exergame interventions for individuals with subsyndromal depression (14%;Rosenberg et al., 2010), in exercise therapy for individuals with severe mental illness (0–33%; Pearsall, Smith, Pelosi, & Geddes, 2014) or in aerobic interval training for young adults with psychotic disorders (36%; Abdel-Baki, Brazzini-Poisson, Marois, Letendre, & Karelis, 2013). High levels of attendance could be explained by the fact that patients with schizophrenia deal with exergames with enthusiasm and a positive mental state (Patsi et al., 2012).

All the participants reported being satisfied with the intervention, which is consistent with previous results found in older patients with schizophrenia (Leutwyler et al., 2012). These findings are particularly important since this measure has been associated with increased adherence to exercise programs (Annesi and Mazas, 1997, Hagberg et al., 2009 and Rhodes et al., 2009). It is also a common indicator used by researchers to validate exergame acceptability for several populations (Agmon et al., 2011, Barry et al., 2014, Chao et al., 2013, Franco et al., 2012, Rosenberg et al., 2010 and Yong Joo et al., 2010). Participants have also found this intervention a feasible alternative to perform physical activity and to promote healthier lifestyles. Moreover, patients with schizophrenia state that this type of intervention promotes their willingness to participate in physical activity and to reduce unhealthy habits (Patsi et al., 2012). Game performance indicators also show that the exercises appear to be adjusted to participants' motor competency. Participants must feel that they are skilled at performing the proposed tasks in order to stay engaged in exergaming intervention (Leutwyler et al., 2012). No significant correlations were found between clinical characteristics and game performance indicators, which can provide evidence that this intervention package is wide-ranging and suitable to outpatients with schizophrenia (Ben-Zeev et al., 2014).

Another important finding was that almost all the participants reported improvement in at least one of the specific intervention effects, highlighting the development of endurance, motor coordination, flexibility and balance related skills. Patients with schizophrenia report a reduced confidence in their physical capacities (Vancampfort et al., 2011 and Vancampfort et al., 2011), but our findings suggest that exergames could counteract this trend. Improved confidence in their motor abilities may increase the likelihood of their involvement in physical activity. This study presents itself as a feasibility and acceptability assessment, with a small sample size and a reduced power to detect significant intervention efficacy. Several outcomes were assessed and no significant effects were found for any of them. Intervention dosage may be another factor that limited the intervention effects (40 min per week). The exergame session duration, frequency of exergaming sessions and total intervention duration may not have provided a sufficient stimulus to result in improvements in the EG group. The major limitation found regarding acceptability was the fact that most participants reported that they would not use this exergame without technical support, which places a substantial limitation to the dissemination of this intervention. It is important to understand that exergaming was developed for users to practice physical activity in their homes', with no need for supervision or trained coaches. However, the latter findings could be potentially explained by two main reasons. First, the technology was mainly operated by the researchers (game scenarios and levels were selected directly on the PC) which can explain why participants did not feel they were skilled enough to use this intervention independently. Future studies should consider exergames completely controlled by patients either in a laboratory context or even using a home-based program. Secondly, a substantial number of participants also reported poor game functioning. This has been associated with lower game performance (especially in patients with reduced functional ability) and higher frustration while using exergames (Chao et al. 2013). Thereby, game selection is another crucial factor in exergame studies for outpatients with schizophrenia. Proper game functioning has to be guaranteed in order to maximize patients' adherence and willingness to utilize the equipment independently. Furthermore, future research should address if exergaming has any advantages over other physical training interventions, by comparing the acceptability and adherence of outpatients with schizophrenia to this intervention in comparison to other types of physical activity. The feasibility and acceptability findings suggest that this intervention should be more thoroughly studied in people with schizophrenia. Despite the costs associated with equipment purchase and the need for technical support for some of the subjects, exergames could provide a low resource dependent intervention to promote physical activity in this population. Moreover, as familiarity with game consoles increases and the recent generation of young adults grows hand-in-hand with videogames, the opportunity for patients with schizophrenia to use exergames, in a home-based approach, will increase.

Additional limitations of this study include the use of a quasi-experimental design and the lack of placebo condition, which limited control for non-specific elements of the intervention program.

In summary, this study is the first to establish the feasibility and acceptability of an exergame intervention for outpatients with schizophrenia. This intervention proved to be an appealing alternative to physical activity for outpatients with schizophrenia. Future trials should include larger samples and explore patients' adherence to home-based exergames. Moreover, researchers should consider frequency, intensity and duration of the exergame activity in order to meet the physical activity guidelines and achieve outcome improvements.

References

Abdel-Baki et al., 2013

A. Abdel-Baki, V. Brazzini-Poisson, F. Marois, E. Letendre, A.D. Karelis

Effects of aerobic interval training on metabolic complications and cardiorespiratory fitness in young adults with psychotic disorders: a pilot study

Schizophrenia Research, 149 (1–3) (2013), pp. 112–115 http://dx.doi.org/10.1016/j.schres.2013.06.040

Agarwal and Agarwal, 2014

N.K. Agarwal, S.K. Agarwal

Postural instability in patients with schizophrenia

Medical Science, 6 (20) (2014), pp. 47–50

Agmon et al., 2011

M. Agmon, C.K. Perry, E. Phelan, G. Demiris, H.Q. Nguyen

A pilot study of Wii Fit exergames to improve balance in older adults

Journal of Geriatric Physical Therapy, 34 (4) (2011), pp. 161–167http://dx.doi.org/10.1519/JPT.0b013e3182191d98

Amaral et al., 2012
J.F. Amaral, M. Mancini, J.M.N. Júnior
Comparison of three hand dynamometers in relation to the accuracy and precision of the measurements

Brazilian Journal of Physical Therapy, 16 (3) (2012), pp. 216–224

American Phychiatric Assocation, 2000
American Phychiatric Assocation
Diagnostic and statistical manual of mental disorders: DSM-IV-TR

(4th ed.)Author, Washington (2000)

Annesi and Mazas, 1997
J.J. Annesi, J. Mazas
Effects of virtual reality-enhanced exercise equipment on adherence and exercise-induced feeling states

Perceptual and Motor Skills, 85 (3 Pt 1) (1997), pp. 835–844

Baecke et al., 1982
J.A. Baecke, J. Burema, J.E. Frijters
A short questionnaire for the measurement of habitual physical activity in epidemiological studies

American Journal of Clinical Nutrition, 36 (5) (1982), pp. 936–942

Barry et al., 2014
G. Barry, B. Galna, L. Rochester
The role of exergaming in Parkinson's disease rehabilitation: a systematic review of the evidence

Journal of NeuroEngineering and Rehabilitation, 11 (33) (2014), pp. 1–10http://dx.doi.org/10.1186/1743-0003-11-33

Ben-Zeev et al., 2014
D. Ben-Zeev, C.J. Brenner, M. Begale, J. Duffecy, D.C. Mohr, K.T. Mueser
Feasibility, acceptability, and preliminary efficacy of a smartphone intervention for schizophrenia

Schizophrenia Bulletin (2014) http://dx.doi.org/10.1093/schbul/sbu033

Brissos et al., 2010
S. Brissos, F. Palhavã, J.G. Marques, S. Mexia, A.L. Carmo, M. Carvalho, *et al.*
The Portuguese version of the Personal and Social Performance Scale (PSP): reliability, validity, and relationship with cognitive measures in hospitalized and community schizophrenia patients

Social Psychiatry and Psychiatric Epidemiology, 45 (7) (2010) http://dx.doi.org/10.1007/s00127-011-0412-6

Callison et al., 1971
D.A. Callison, H.F. Armstrong, L. Elam, R.L. Cannon, C.B. Paisley, H.E. Himwich
The effects of aging on schizophrenic and mentally defective patients: visual, auditory, and grip strength measurements

The Journals of Gerontology, 26 (2) (1971), pp. 137–145

Chang et al., 2011
Y.J. Chang, S.F. Chen, J.D. Huang
A Kinect-based system for physical rehabilitation: a pilot study for young adults with motor disabilities

Research in Developmental Disabilities, 32 (6) (2011), pp. 2566–2570http://dx.doi.org/10.1016/j.ridd.2011.07.002

Chao et al., 2013
Y.Y. Chao, Y.K. Scherer, Y.W. Wu, K.T. Lucke, C.A. Montgomery
The feasibility of an intervention combining self-efficacy theory and Wii Fit exergames in assisted living residents: a pilot study

Geriatric Nursing, 34 (5) (2013), pp. 377–382 http://dx.doi.org/10.1016/j.gerinurse.2013.05.006

Chaudhry et al., 2011
H. Chaudhry, B. Bukiet, Z. Ji, T. Findley
Measurement of balance in computer posturography: comparison of methods – a brief review

Journal of Bodywork and Movement Therapies, 15 (1) (2011), pp. 82–91http://dx.doi.org/10.1016/j.jbmt.2008.03.003

Chen et al., 2012
P.Y. Chen, S.H. Wei, W.L. Hsieh, J.R. Cheen, L.K. Chen, C.L. Kao
Lower limb power rehabilitation (LLPR) using interactive video game for improvement of balance function in older people

Archives of Gerontology and Geriatrics, 55 (3) (2012), pp. 677–682http://dx.doi.org/10.1016/j.archger.2012.05.012

Cohen, 1988
J. Cohen
Statistical power analysis for the behavioral sciences

(2nd ed.)Laurence Erlbaum Associates, New Jersey (1988)

Dazzan and Murray, 2002
P. Dazzan, R.M. Murray
Neurological soft signs in first-episode psychosis: a systematic review

British Journal of Psychiatry, 181 (2002), pp. 50–57

van Diest et al., 2013
M. van Diest, C.J. Lamoth, J. Stegenga, G.J. Verkerke, K. Postema
Exergaming for balance training of elderly: state of the art and future developments

Journal of NeuroEngineering and Rehabilitation, 10 (2013), p. 101 http://dx.doi.org/10.1186/1743-0003-10-101

Duarte and Freitas, 2010
M. Duarte, S.M.S.F. Freitas
Revisão sobre posturografia baseada em plataforma de força para avaliação do equilíbrio

Brazilian Journal of Physical Therapy, 14 (3) (2010), pp. 183–192

Eichhorn et al., 2013
S. Eichhorn, V. Koller, U. Schreiber, A. Mendoza, M. Krane, R. Lange
Development of an exergame for individual rehabilitation of patients with cardiovascular diseases

Australasian Physical & Engineering Sciences in Medicine, 36 (4) (2013), pp. 441–447http://dx.doi.org/10.1007/s13246-013-0223-z

Faulkner et al., 2006

G. Faulkner, T. Cohn, G. Remington

Validation of a physical activity assessment tool for individuals with schizophrenia

Schizophrenia Research, 82 (2–3) (2006), pp. 225–231

Franco et al., 2012

J.R. Franco, K. Jacobs, C. Inzerillo, J. Kluzik

The effect of the Nintendo Wii Fit and exercise in improving balance and quality of life in community dwelling elders

Technology and Health Care, 20 (2) (2012), pp. 95–115 http://dx.doi.org/10.3233/THC-2011-0661

Gorczynski and Faulkner, 2010

P. Gorczynski, G. Faulkner

Exercise therapy for schizophrenia

Schizophrenia Bulletin, 36 (4) (2010), pp. 665–666 http://dx.doi.org/10.1093/schbul/sbq049

Hagberg et al., 2009

L.A. Hagberg, B. Lindahl, L. Nyberg, M.L. Hellénius

Importance of enjoyment when promoting physical exercise

Scandinavian Journal of Medicine & Science in Sports, 19 (5) (2009), pp. 740–747http://dx.doi.org/10.1111/j.1600-0838.2008.00844.x

Hert et al., 2011

M.d. Hert, C.U. Correll, J. Bobes, M. Cetkovich-Bakmas, D. Cohen, I. Asai, *et al.*

Physical illness in patients with severe mental disorders. I. Prevalence, impact of medications and disparities in health care

World Psychiatry, 10 (1) (2011), pp. 52–77

Jahn et al., 2006

T. Jahn, R. Cohen, W. Hubmann, F. Mohr, I. Kohler, R. Schlenker, *et al.*

The Brief Motor Scale (BMS) for the assessment of motor soft signs in schizophrenic psychoses and other psychiatric disorders

Psychiatry Research, 142 (2–3) (2006), pp. 177–189 http://dx.doi.org/10.1016/j.psychres.2002.12.002

Jansen-Kosterink, 2013

S.M. Jansen-Kosterink, R.M. Huis In 't Veld, C. Schönauer, H. Kaufmann, H.J. Hermens, M.M. Vollenbroek-Hutten

A serious exergame for patients suffering from chronic musculoskeletal back and neck pain: a pilot study

Games for Health Journal, 2 (5) (2013), pp. 299–307 http://dx.doi.org/10.1089/g4h.2013.0043

Kay et al., 1987

S.R. Kay, A. Fiszbein, L.A. Opler

The positive and negative syndrome scale (PANSS) for schizophrenia

Schizophrenia Bulletin, 13 (2) (1987), pp. 261–276

Kent et al., 2012

J.S. Kent, S.L. Hong, A.R. Bolbecker, M.J. Klaunig, J.K. Forsyth, B.F. O'Donnell, *et al.*

Motor deficits in schizophrenia quantified by nonlinear analysis of postural sway

PLoS One, 7 (8) (2012), p. e41808 http://dx.doi.org/10.1371/journal.pone.0041808

Kim et al., 2013

J. Kim, J. Son, N. Ko, B. Yoon

Unsupervised virtual reality-based exercise program improves hip muscle strength and balance control in older adults: a pilot study

Archives of Physical Medicine and Rehabilitation, 94 (5) (2013), pp. 937–943http://dx.doi.org/10.1016/j.apmr.2012.12.010

Knights et al., 2014

S. Knights, N. Graham, L. Switzer, H. Hernandez, Z. Ye, B. Findlay, *et al.*

An innovative cycling exergame to promote cardiovascular fitness in youth with cerebral palsy: a brief report

Developmental Neurorehabilitation (2014), pp. 1–6 http://dx.doi.org/10.3109/17518423.2014.923056

Lange et al., 2011

B. Lange, C.Y. Chang, E. Suma, B. Newman, A.S. Rizzo, M. Bolas

Development and evaluation of low cost game-based balance rehabilitation tool using the Microsoft Kinect sensor

Conf Proc IEEE Eng Med Biol Soc, 2011 (2011), pp. 1831–1834http://dx.doi.org/10.1109/IEMBS.2011.6090521

Lehman et al., 2010

A.F. Lehman, J.A. Lieberman, L.B. Dixon, T.H. McGlashan, A.L. Miller, D.O. Perkins, *et al.*

Practice guideline for the treatment of patients with schizophrenia United States

American Phychiatric Association (2010)

Leutwyler et al., 2012

H. Leutwyler, E.M. Hubbard, S. Vinogradov, G.A. Dowling

Videogames to promote physical activity in older adults with schizophrenia

Games for Health Journal, 1 (5) (2012), pp. 381–383 http://dx.doi.org/10.1089/g4h.2012.0051

Lindamer et al., 2008

L.A. Lindamer, C. McKibbin, G.J. Norman, L. Jordan, K. Harrison, S. Abeysinhe, *et al.*

Assessment of physical activity in middle-aged and older adults with schizophrenia

Schizophrenia Research, 104 (1–3) (2008), pp. 294–301 http://dx.doi.org/10.1016/j.schres.2008.04.040

Martín-Sierra et al., 2011

A. Martín-Sierra, D. Vancampfort, M. Probst, J. Bobes, K. Maurissen, K. Sweers, *et al.*

Walking capacity is associated with health related quality of life and physical activity level in patients with schizophrenia: a preliminary report

Actas espanolas de psiquiatria, 39 (4) (2011), pp. 211–216

Marvel et al., 2004

C.L. Marvel, B.L. Schwartz, R.B. Rosse

A quantitative measure of postural sway deficits in schizophrenia

Schizophrenia Research, 68 (2–3) (2004), pp. 363–372 http://dx.doi.org/10.1016/j.schres.2003.09.003

Morosini et al., 2000

P.L. Morosini, L. Magliano, L. Brambilla, S. Ugolini, R. Pioli

Development, reliability and acceptability of a new version of the DSM-IV Social and Occupational Functioning Assessment Scale (SOFAS) to assess routine social functioning

Acta Psychiatrica Scandinavica, 101 (4) (2000), pp. 323–329

National Institute for Health and Care Excellence, 2014

National Institute for Health and Care Excellence

Psychosis and schizophrenia in adults: Treatment and management

Author, United Kingdom (2014)

Ozbulut et al., 2013

O. Ozbulut, A. Genc, E. Bagcioglu, K.S. Coskun, T. Acar, O.A. Alkoc, *et al.*

Evaluation of physical fitness parameters in patients with schizophrenia

Psychiatry Research, 210 (3) (2013), pp. 806–811 http://dx.doi.org/10.1016/j.psychres.2013.09.015

Patsi et al., 2012

C. Patsi, P. Antoniou, S. Batsiou, E. Bebetsos, K. Lagiou

Exergames and their effect on emotional state in people with schizophrenia

Balkan Military Medical Review, 15 (4) (2012), pp. 275–281

Pearsall et al., 2014

R. Pearsall, D.J. Smith, A. Pelosi, J. Geddes

Exercise therapy in adults with serious mental illness: a systematic review and meta-analysis

BMC Psychiatry, 14 (2014), p. 117 http://dx.doi.org/10.1186/1471-244X-14-117

Podsiadlo and Richardson, 1991

D. Podsiadlo, S. Richardson

The timed “Up & Go”: a test of basic functional mobility for frail elderly persons

Journal of the American Geriatrics Society, 39 (2) (1991), pp. 142–148

Putzhammer et al., 2004

A. Putzhammer, B. Heindl, K. Broll, L. Pfeiff, M. Perfahl, G. Hajak

Spatial and temporal parameters of gait disturbances in schizophrenic patients

Schizophrenia Research, 69 (2–3) (2004), pp. 159–166 http://dx.doi.org/10.1016/S0920-9964(03)00090-2

Putzhammer and Klein, 2006

A. Putzhammer, H.E. Klein

Quantitative analysis of motor disturbances in schizophrenic patients

Dialogues in Clinical NeuroSciences, 8 (1) (2006), pp. 123–130

Putzhammer et al., 2005

A. Putzhammer, M. Perfahl, L. Pfeiff, G. Hajak

Gait disturbances in patients with schizophrenia and adaptation to treadmill walking

Psychiatry and Clinical Neurosciences, 59 (3) (2005), pp. 303–310 http://dx.doi.org/10.1111/j.1440-1819.2005.01375.x

Reitan and Wolfson, 1995

R.M. Reitan, D. Wolfson

Category test and trail making test as measures of frontal-lobe functions

The Clinical Neuropsychologist, 9 (1) (1995), pp. 50–56 http://dx.doi.org/10.1080/13854049508402057

Rhodes et al., 2009

R.E. Rhodes, D.E. Warburton, S.S. Bredin

Predicting the effect of interactive video bikes on exercise adherence: an efficacy trial

Psychology Health and Medicine, 14 (6) (2009), pp. 631–640http://dx.doi.org/10.1080/13548500903281088

Rikli and Jones, 2013

R.E. Rikli, C.J. Jones

Development and validation of criterion-referenced clinically relevant fitness standards for maintaining physical independence in later years

Gerontologist, 53 (2) (2013), pp. 255–267 http://dx.doi.org/10.1093/geront/gns071

Roberts et al., 2011

H.C. Roberts, H.J. Denison, H.J. Martin, H.P. Patel, H. Syddall, C. Cooper, *et al.*

A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach

Age and Ageing, 40 (4) (2011), pp. 423–429 http://dx.doi.org/10.1093/ageing/afr051

Rosenbaum et al., 2014

S. Rosenbaum, A. Tiedemann, C. Sherrington, J. Curtis, P.B. Ward

Physical activity interventions for people with mental illness: a systematic review and meta-analysis

Journal of Clinical Psychiatry (2014) http://dx.doi.org/10.4088/JCP.13r08765

Rosenberg et al., 2010

D. Rosenberg, C.A. Depp, I.V. Vahia, J. Reichstadt, B.W. Palmer, J. Kerr, *et al.*

Exergames for subsyndromal depression in older adults: a pilot study of a novel intervention

The American Journal of Geriatric Psychiatry, 18 (3) (2010), pp. 221–226http://dx.doi.org/10.1097/JGP.0b013e3181c534b5

Scottish Intercollegiate Guidelines Network, 2013

Scottish Intercollegiate Guidelines Network

Management of schizophrenia

Author, Edinburgh (2013)

Staiano et al., 2013

A.E. Staiano, A.A. Abraham, S.L. Calvert

Adolescent exergame play for weight loss and psychosocial improvement: a controlled physical activity intervention

Obesity (Silver Spring), 21 (3) (2013), pp. 598–601 http://dx.doi.org/10.1038/oby.2012.143

Stensdotter et al., 2013

A.-K. Stensdotter, H.W. Loras, J.C. Fløvig, M. Djupsjobacka
Postural control in quiet standing in patients with psychotic disorders
Gait&Posture, 38 (2013), pp. 918–922 http://dx.doi.org/10.1016/j.gaitpost.2013.04.017

Vancampfort et al., 2012
D. Vancampfort, M. De Hert, L.H. Skjerven, A.L. Gyllensten, A. Parker, N. Mulders, *et al.*
International organization of physical therapy in mental health consensus on physical activity within multidisciplinary rehabilitation programmes for minimising cardio-metabolic risk in patients with schizophrenia
Disability and Rehabilitation, 34 (1) (2012), pp. 1–12 http://dx.doi.org/10.3109/09638288.2011.587090

Vancampfort et al., 2013
D. Vancampfort, M. Probst, T. Scheewe, A. De Herdt, K. Sweers, J. Knapen, *et al.*
Relationships between physical fitness, physical activity, smoking and metabolic and mental health parameters in people with schizophrenia
Psychiatry Research, 207 (1–2) (2013), pp. 25–32 http://dx.doi.org/10.1016/j.psychres.2012.09.026

Vancampfort et al., 2011
D. Vancampfort, M. Probst, T. Scheewe, K. Maurissen, K. Sweers, J. Knapen,*et al.*
Lack of physical activity during leisure time contributes to an impaired health related quality of life in patients with schizophrenia
Schizophrenia Research, 129 (2–3) (2011), pp. 122–127 http://dx.doi.org/10.1016/j.schres.2011.03.018

Vancampfort et al., 2011
D. Vancampfort, M. Probst, K. Sweers, K. Maurissen, J. Knapen, M. De Hert
Relationships between obesity, functional exercise capacity, physical activity participation and physical self-perception in people with schizophrenia
Acta Psychiatrica Scandinavica, 123 (6) (2011), pp. 423–430 http://dx.doi.org/10.1111/j.1600-0447.2010.01666.x

Viertiö, 2011

S. Viertiö

Functional limitations and quality of life in schizophrenia and other psychotic disorders

National Institute for Health and Welfare (THL), Helsinki, Finland (2011)

Voorrips et al., 1991

L.E. Voorrips, A.C. Ravelli, P.C. Dongelmans, P. Deurenberg, W.A. Van Staveren

A physical activity questionnaire for the elderly

Medicine & Science in Sports & Exercise, 23 (8) (1991), pp. 974–979

Williams et al., 2010

M.A. Williams, R.L. Soiza, A.M. Jenkinson, A. Stewart

EXercising with Computers in Later Life (EXCELL) – pilot and feasibility study of the acceptability of the Nintendo(R) WiiFit in community-dwelling fallers

BMC Research Notes, 3 (2010), p. 238 http://dx.doi.org/10.1186/1756-0500-3-238

Yong Joo et al., 2010

L. Yong Joo, T. Soon Yin, D. Xu, E. Thia, C. Pei Fen, C.W. Kuah, *et al.*

A feasibility study using interactive commercial off-the-shelf computer gaming in upper limb rehabilitation in patients after stroke

Journal of Rehabilitation Medicine, 42 (5) (2010), pp. 437–441 http://dx.doi.org/10.2340/16501977-0528

Zakaria et al., 2013

H. Zakaria, N. Jaafar, A. Baharudin, N. Ibrahim, M. Midin

Motor neurological soft signs among patients with schizophrenia: a clinical significance

Sains Malaysiana, 42 (3) (2013), pp. 381–388