

Exercises to Improve Gait and Postural Control in Adults with Schizophrenia: A Scoping Review

Adriane T. Tuminez, PTRP, MPT^{1,2} and Yves Y. Palad, PTRP, EdD¹

¹Department of Physical Therapy, College of Allied Medical Professions, University of the Philippines Manila, Manila, Philippines

²Department of Physical Therapy, College of Rehabilitation Sciences, St. Paul University Iloilo, Iloilo, Philippines

ABSTRACT

Background. Adults with schizophrenia may experience gait and postural control problems, which increase fall risk, limit community participation, and contribute to cardiometabolic comorbidity. Exercise-based interventions are increasingly used in multidisciplinary care; however, the extent and characteristics of programs targeting postural control and gait outcomes in this population are unclear.

Objective. This scoping review aimed to map the available evidence on interventions addressing gait and postural control problems in adults with schizophrenia.

Methods. A scoping review was conducted using the Arksey and O'Malley framework and reported in accordance with PRISMA-ScR guidance. PubMed, PEDro, and CINAHL were searched for studies published from 2012 to 2023 that examined exercise or physical activity interventions in adults with schizophrenia or related psychotic disorders and reported outcomes related to gait and/or postural control. Data were charted on study characteristics, intervention dose (frequency, intensity, type, time), setting and personnel, outcome measures, limitations, and recommendations.

Results. Eighteen (18) studies (n = 591 participants) met the inclusion criteria. Interventions were categorized as technology-based programs (e.g., exergaming/virtual reality), mind-body and dance-based approaches (e.g., yoga, Baduanjin, dance movement therapy, Greek traditional dance), structured aerobic and strength training, and multi-modal programs. Postural control was most commonly assessed using center-of-pressure metrics, the One-Leg Balance Test, and the Timed Up and Go (TUG) test; gait outcomes frequently included the TUG, walking-capacity measures such as the Six-Minute Walk Test, and walking-efficiency outcomes. Most interventions were reported as feasible and generally safe; however, substantial heterogeneity in protocols and outcomes, as well as variable attrition, limited cross-study comparability.

Conclusion. Evidence on exercise interventions to improve gait and postural control in adults with schizophrenia remains limited but is growing. However, heterogeneity in study designs, outcome measures, and intervention protocols limits cross-study comparisons. Future research should prioritize rigorous, adequately powered randomized controlled trials and the validation of schizophrenia-appropriate outcome measures to support evidence-based intervention development and improve mobility and quality of life.

Keywords: balance, exercise, gait, physical therapy, postural control, schizophrenia, scoping review



eISSN 2094-9278 (Online)
Published: October 31, 2026
<https://doi.org/10.47895/amp.v60i20.13760>
Copyright: The Author(s) 2026

Corresponding author: Adriane T. Tuminez, PTRP, MPT
Department of Physical Therapy
College of Rehabilitation Sciences
St. Paul University Iloilo
Gen. Luna St., Iloilo City, Iloilo 5000, Philippines
Email: atuminez@spuililo.edu.ph
ORCID: <https://orcid.org/0009-0008-4130-4840>

INTRODUCTION

Schizophrenia is a severe mental health condition associated with symptoms, including motor problems, that may affect the cognitive functioning, social participation, and quality of life of people living with the illness.¹⁻⁴ The global prevalence of schizophrenia was 23.6 million as of 2019.⁵ In the Philippines, an estimated 300 per 100,000 people (0.3%) are living with schizophrenia.⁶ The burden of this condition has increased because of inadequate quality of care, inaccessible mental health services, and stigma.^{5,7}

The symptoms of schizophrenia include negative and positive symptoms. Negative symptoms reflect a decline in motivation or expression (e.g., avolition or decreased emotional expressiveness), while positive symptoms are experiences that go beyond typical functioning (e.g., delusions, hallucinations, and disorganized behavior).² Individuals with schizophrenia may also exhibit motor symptoms such as dyskinesias, neurological soft signs (NSS) (e.g., motor incoordination and impaired sensory integration), catatonia, parkinsonism, and psychomotor slowing. These symptoms have been linked to structural changes in cortical-basal ganglia, thalamocortical, and cerebellar sensorimotor systems.^{1,8-10}

Postural control and gait abnormalities may be intrinsic to individuals with schizophrenia.¹¹⁻¹³ Existing literature indicates that individuals with schizophrenia exhibit significantly greater postural sway than healthy controls.¹³⁻¹⁵ This may be caused by difficulties estimating the location and movement of their center of mass, impaired sensory-motor integration, or cerebellar abnormalities.¹⁶⁻¹⁹ It could also be linked to self-disorder (e.g., impaired bodily experiences, loss of self-demarcation) and severity of the condition (e.g., positive and negative symptoms, anxiety, extrapyramidal symptoms).^{11,15,20} Other factors such as visual input and medications are also associated with postural control impairments; however, evidence of these associations is conflicting.^{12,13,15,21-24} Impaired postural control has been identified as a factor in causing falls among individuals with schizophrenia, which predisposes them to fractures.²⁵⁻²⁷

Individuals with schizophrenia often exhibit altered gait profiles characterized by reduced gait velocity, increased variation in gait regularity, rigid walking, increased lateral sway, reduced adjustment and integration of limb movements, decreased goal-directed movements, slumped posture, and an ataxic pattern.^{28,29} The reduction of gait velocity is largely attributed to shorter stride length.^{28,30,31} These altered gait performances have also been associated with a range of factors, including reduced lower limb muscular force, impaired dynamic balance, compromised executive function (such as dual-tasking), the severity of the condition's symptoms (e.g., positive and negative symptoms, psychomotor slowing, parkinsonism, and NSS), and self-disorders (e.g., abnormal bodily experiences, weakened self-demarcation, disrupted first-person viewpoint).^{15,28,32-36} Although medications may

exacerbate these deficits, their precise impact remains a subject of debate in the literature.^{13,15,30-32}

The consequences of these gait impairments are significant and can contribute to poor health, as reduced gait speed is the key feature of frailty.³⁷ This frailty status is associated with falls and reduced quality of life among individuals with schizophrenia.³⁸⁻⁴¹ Furthermore, these gait impairments can decrease their functional walking capacity and increase their likelihood of developing metabolic syndromes, further influencing their overall functioning, quality of life, and muscular fitness.⁴²⁻⁴⁸

Physical therapy interventions, such as balance training, resistance training, and aerobic exercise with external cues, have been shown to address gait and postural control issues in older adults and people with neurologic conditions.⁴⁹⁻⁵⁵ Similar benefits have also been reported for Traditional Chinese Medicine exercises, Pilates, yoga, and exergaming (e.g., Wii, Kinect, and virtual reality), as well as combined exercise programs, Square Stepping Exercises, and High-Intensity Functional Exercises.⁵⁶⁻⁶⁸ These effects have been attributed to training specificity and neuroplasticity, improved sensorimotor integration, and increased muscular strength and coordination.^{49,62,63} Therefore, these exercises may also improve postural control and gait in individuals with schizophrenia, potentially reducing fall risk, helping prevent metabolic syndrome, and improving quality of life and functional walking capacity.

The role of the physical therapist, as part of a multi-disciplinary team in psychiatry, has been recognized by national physical therapy organizations.^{69,70} The roles identified include addressing the physical health of patients with mental health conditions using traditional musculoskeletal treatment and a mind-body approach, as well as promoting physical activity and a healthier lifestyle through supervised exercise.^{69,70} However, physical therapy is underutilized because of a lack of confidence in working with patients with mental illness, a limited understanding of the relevance of physical therapy in psychiatry, limited referrals, and patient-specific barriers (such as cost, transportation, and insufficient knowledge about physical therapy services).^{71,72} Despite these barriers, the literature generally agrees that physical therapy interventions, such as moderate-to-vigorous aerobic exercise, yoga, and strengthening exercises, improve psychiatric symptoms, cardiopulmonary fitness, cognition, and quality of life in people with schizophrenia.^{73,74} Furthermore, progressive muscle relaxation reduces psychological stress and anxiety and enhances subjective well-being.⁷³ Yet, there is no synthesized literature on exercises specifically for motor impairments, particularly gait and postural control.

Thus, this study aimed to map the available evidence on exercise interventions that address postural control and gait impairments in adults with schizophrenia. The review addressed the following research question: What evidence is available on exercise interventions targeting gait and postural control in adults with schizophrenia?

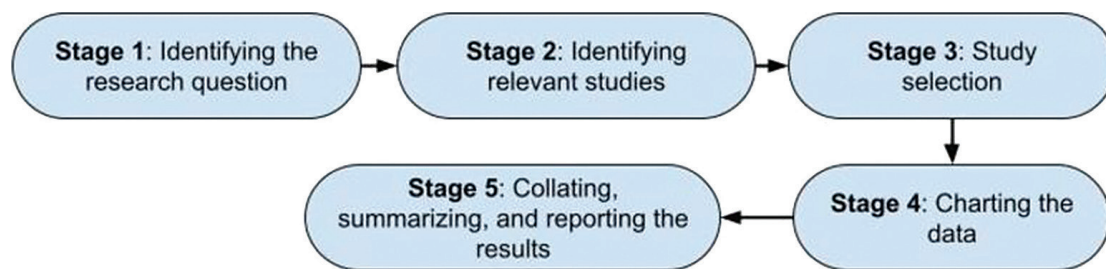


Figure 1. Diagram of the stages of a scoping review according to the framework of Arksey and O'Malley.⁷⁵

MATERIALS AND METHODS

The methodology of this scoping review was guided by the Arksey and O'Malley framework (Figure 1) and reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) by Tricco et al.^{75,76} This scoping review was granted ethics review exemption by the University of the Philippines Manila Research Ethics Board (UPMREB No. 2024-0037-EX).

Identifying the Research Question

This scoping review examined exercise interventions for improving gait and postural control in adults with schizophrenia and addressed the following questions: (1) What types of exercise interventions have been studied for improving gait and postural control in adults with schizophrenia? (2) What outcome measures for postural control and gait have been used in the included studies? (3) What evidence gaps remain and warrant further research?

Identifying Relevant Studies

The following databases were searched for relevant studies: PubMed, a biomedical database covering health and allied disciplines; PEDro, a database of interventional studies and evidence-based clinical practice guidelines relevant to physical therapy; and CINAHL, a database that includes journals for nursing and allied health professionals.⁷⁷⁻⁷⁹ Searches were conducted from December 2023 to February 2024. The following Boolean terms were used across databases: (schizophrenia) AND (exercise OR intervention OR "physical activity" OR training) AND (gait OR walking OR balance OR "postural control" OR "balance control" OR "postural sway") (Appendix). After the database search, reference-list screening of relevant studies was conducted until no additional articles were identified. Records were exported to Google Sheets and checked for duplicates.

Eligibility Criteria

The scoping review used the PICO framework (population, intervention, comparator, and outcome measures) to select relevant studies. The population included adults (>18 years) with schizophrenia or related psychotic disorders

(ICD-10 F20–F29).⁸⁰ Interventions included any exercise or physical activity program used as a physical therapy approach to address the physical health of individuals with mental health conditions.^{69,70} Studies could include a comparator group or none. Outcomes were related to gait performance and postural control. Gait performance outcomes included spatiotemporal parameters, functional mobility, functional walking capacity, and components of gait analysis. These components included observational gait analysis, joint or segment range of motion (kinematics), forces acting on the body (kinetics), muscle activity, foot pressure, and energy expenditure during walking (energetics).⁸¹ Postural control outcomes were defined using the Systems Framework for Postural Control: biomechanical constraints (functional stability limits, strength, static stability), orientation in space (verticality), movement strategies (reactive and anticipatory postural control), control of dynamics (dynamic stability), sensory strategies (sensory integration), cognitive processing (dual-tasking), and emotional influences (fear, confidence, and self-efficacy).^{82,83}

In addition, journal articles were eligible if they: (1) were published from 2012 to December 2023 to capture recent evidence; (2) were written in English; and (3) used an interventional study design (e.g., experimental or quasi-experimental studies, single-subject designs, or case reports). Articles were excluded if the full text was unavailable.

Study Selection

The eligibility criteria were applied to the final search results using a screening form. The first author and an external reviewer, a licensed physical therapist with research experience, independently screened article abstracts. The external reviewer underwent an orientation on the study procedures and the screening form. To ensure consistency, reviewers pilot-tested the form and assessed agreement by independently screening the same three abstracts. Upon achieving 80% inter-rater agreement, the first author screened the remaining abstracts, with results subsequently verified by the external reviewer. If eligibility could not be determined from the abstract, the full text was screened by the first author and verified by the external reviewer. The second author resolved any remaining discrepancies.

Data Charting

The following data were collected and charted from eligible studies: (1) author(s), year of publication, study location, and study design; (2) study objectives; (3) participant characteristics (e.g., total number of participants, sex, diagnosis, and medication status); (4) intervention characteristics (frequency, intensity, type, and time [FITT], comparator, progression, and personnel delivering the intervention); (5) outcome measures for gait performance and postural control and balance; and (6) study limitations (e.g., methodological limitations, adverse events, attrition rate, and reasons for dropout) and recommendations.

The data-charting process began with pilot testing to calibrate the reviewers and assess the reliability of the data-charting form.⁷⁶ The same individuals who screened the articles independently charted data from three eligible studies using the form. The reviewers then discussed the results and revised the form as needed to ensure that it captured all relevant information. Once at least 80% agreement across the form items was achieved, the first author charted the remaining studies, and the external reviewer verified the extracted data for accuracy and credibility.

Synthesis

This stage involved assembling, summarizing, and reporting findings to address the research questions.⁷⁵

Screening results, including the number of included and excluded studies and reasons for exclusion, were summarized in a flow diagram. Data describing each article, outcome measures used, the number of studies examining each intervention for each outcome, and the evidence mapped for each outcome were synthesized in tables and figures. In accordance with scoping review methodology, a formal critical appraisal of the included studies was not conducted.

RESULTS

A total of 667 records were identified through database and reference-list searches. Following the removal of duplicates, 370 records were screened by title and abstract, and 336 were excluded. Full-text assessment was performed for 34 articles, of which 16 were excluded (e.g., non-English, missing relevant outcomes, or insufficient participant data; Figure 2). Ultimately, 18 studies met the inclusion criteria for this scoping review.

Study Characteristics and Participants

The 18 included articles comprised eight randomized controlled trials (RCTs), four pilot or feasibility studies, three quasi-experimental studies, two clinical trials, and one single-subject design.⁸⁴⁻¹⁰¹ Most studies were conducted in Asia (e.g., Taiwan (n = 3), Japan (n = 2), South Korea

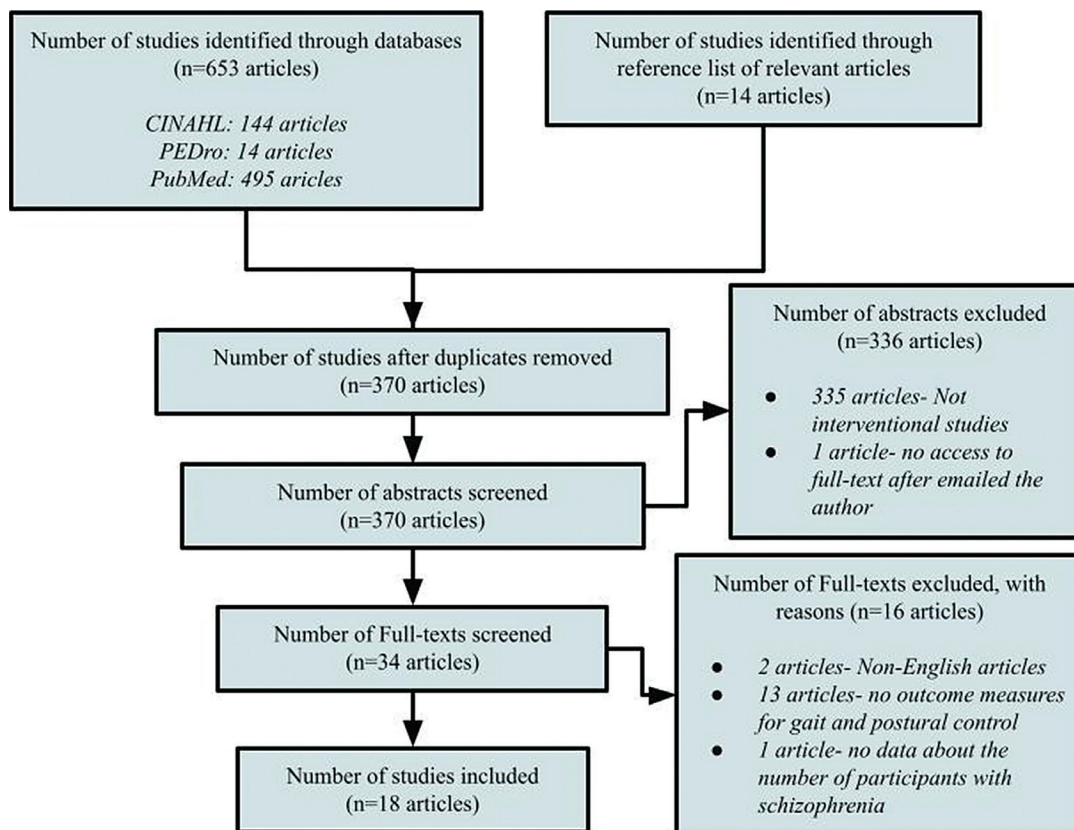


Figure 2. Study flow diagram.

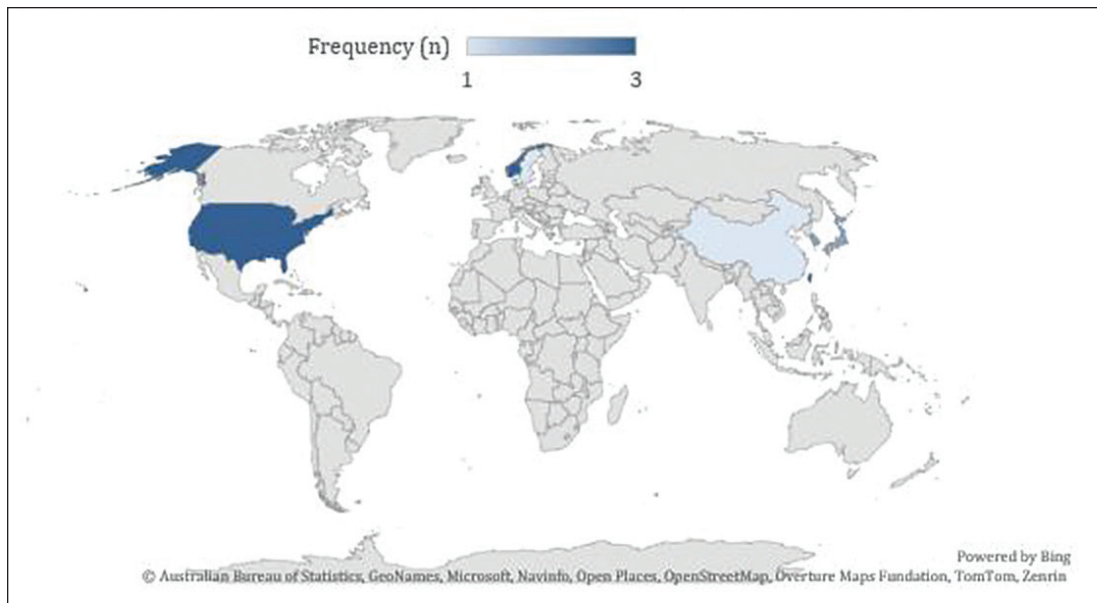


Figure 3. Map of studies included in the scoping review, by country of origin.

($n = 2$), and China ($n = 1$)) and Europe (e.g., Denmark ($n = 1$), Greece ($n = 1$), Norway ($n = 3$), Portugal ($n = 1$), and Sweden ($n = 1$)), while three studies were conducted in North America (United States)^{96,97,101} (Figure 3).⁸⁴⁻¹⁰¹ Ten studies were conducted in hospitals, five in outpatient facilities/clinics or community-based rehabilitation centers, one in a laboratory, and two in mixed settings.⁸⁴⁻¹⁰¹ Across the included studies, 591 participants with schizophrenia were enrolled, with ages ranging from 19 to 80 years. Sixteen studies reported that participants were receiving antipsychotic medication.^{84-86,88-95,97-101} Table 1 summarizes key study characteristics, including participant descriptions and study objectives.

Exercise Interventions

An overview of interventions from the included studies is presented in Table 2. Interventions were grouped into four domains: technology-based programs ($n = 5$) (e.g., exergaming/virtual reality); mind-body ($n = 4$) and dance-based approaches ($n = 2$) (e.g., yoga, Baduanjin, dance movement therapy, and Greek traditional dance); structured aerobic and strength training ($n = 9$) (e.g., maximal strength training using a leg-press machine, elastic-band resistance training, speedwork training using a stationary recumbent bicycle, aerobic treadmill training, stationary bicycle ergometer training, and walking); and multimodal programs ($n = 2$) (e.g., circuit training with functional movements and physical activity combined with basic body awareness therapy and cognitive psychotherapy⁸⁹).⁸⁴⁻¹⁰¹ Across the included studies, interventions were most often delivered twice per week ($n = 9$) or three times per week ($n = 6$), with three studies reporting once-weekly sessions.⁸⁴⁻¹⁰¹ Session duration typically ranged from 20 to 60 minutes ($n = 13$), although

one study reported 90-minute sessions.^{84-88,91-98,101} Most interventions lasted 8 to 12 weeks ($n = 12$), two studies lasted 6 weeks, and four studies lasted 6 to 12 months.⁸⁴⁻¹⁰¹

Intervention intensity was not explicitly reported in many studies ($n = 10$).^{84,86-89,91-93,96,98} When reported, strength training was commonly prescribed using one-repetition maximum (1RM) (85%–90%) ($n = 3$), while aerobic intensity was described using target heart rate (e.g., Karvonen method) or maximum heart rate (50%–90%) ($n = 6$).^{90,94,95,97,99-100} Borg's rating of perceived exertion scale was used for strengthening, and Baduanjin exercise (moderate to hard) ($n = 2$), and one study reported resistance intensity in watts.^{85,95,101} Interventions were delivered by a range of professionals, most commonly exercise physiologists and trained personnel.^{84-86,90,93,94,96-101} Most studies compared interventions with treatment as usual (TAU) or routine medical/psychosocial care ($n = 6$), while five studies had no control group.^{84,86-89,91-94,98,101} Active comparators included self-administered exercise, brisk walking, balance exercises, stretching, recreation, and non-active/computer video games.^{85,90,95-97,99,100}

The review identified a range of tools used to evaluate intervention effects on postural control and gait, including performance-based measures, objective laboratory assessments, and self-report scales (Table 3). Across studies, postural control outcomes aligned most often with the postural control systems framework domains of biomechanical constraints, movement strategies, control of dynamics, and sensory strategies. The Timed Up and Go (TUG) test was the most frequently used performance-based measure ($n = 4$), followed by the One-Leg Balance Test/Unipedal Stance Test ($n = 3$), the Berg Balance Scale (BBS) ($n = 2$), and the Foot Up-and-Go test from the Senior Fitness Test

Table 1. Summary of the Characteristics of Included Articles

Author, Year of Publication, Country	Study design, Setting	Objectives	Participants
Campos, Mesquita, Marques, Trigueiro, Orvalho, Rocha⁸⁴ 2015 Portugal	Quasi-experimental trial Socio-occupational center	"To evaluate the feasibility and acceptability of an exergame intervention as a tool to promote physical activity in outpatients with schizophrenia."	Diagnosis: Schizophrenia (DSM-IV) Total = 32 participants (IG: n = 16; CG: n = 16) IG: ● Age: 39.77 y.o. (± 9.2) ● Sex: M (n = 10); F (n = 3); not mentioned (n = 3) CG: ● Age: 39 y.o. (± 5.60) ● Sex: M (n = 11); F (n = 5) (+) Antipsychotic medications
Chen, Huang, Lee, Hsieh, Lee, and Lin⁸⁵ 2022 Taiwan	RCT Hospital	"To examine the efficacy of Baduanjin exercise vs. brisk walking on physical fitness, cognitive function, and dual-task performance in middle-aged patients with schizophrenia."	Diagnosis: Schizophrenia (DSM-V) Total = 48 participants (IG: n = 24; CG: n = 24) IG: ● Age: 50.63 y.o. (± 6.11) ● Sex: M (n = 12); F (n = 12) CG: ● Age: 50.92 y.o. (± 7.81) ● Sex: M (n = 12); F (n = 12) (+) Antipsychotic medications
Chen, Yeh, Tsai, Chang, Yu, Hsu⁸⁶ 2016 Taiwan	Exploratory study Community-based setting	"To examine the efficacy of a group participating in Baduanjin on the health of individuals with SMI and the feasibility/acceptability of using short message service (SMS) reminder strategies to prompt continued exercise during a follow-up period."	Diagnosis: Schizophrenia (DSM-IV) Total = 16 participants ● Age: 38.9 y.o. (± 9.6) ● Sex: M (n = 8); F (n = 3); not mentioned (n = 5) (+) Medications
Chien, Chern, Wang, Yang⁸⁷ 2022 Taiwan	Quasi-experimental study Hospital	"To examine the effects of combining traditional multitask training (TMT) and video games--a new form of multitask training (video game multitask training, VGMT) --on cognition and motor control performance in people with SSD."	Diagnosis: Schizophrenia or schizoaffective disorder (DSM-IV) Total = 28 participants ● Age: 59.61 y.o. (± 11.46) ● Sex: M (n = 12); F (n = 13); not mentioned (n = 3) Medications were not mentioned
Guan, Zhou, Li, Pan, Zou, Meng, Guan, Zhang, Li, LiWei, Zhang, Li, Han, Li, and Xiu⁸⁸ 2023 China	RCT Hospital	"To investigate the efficacy of a 12-week DMT intervention in bone mineral density and balance ability in patients with SZ."	Diagnosis: Schizophrenia (DSM-V) Total = 60 participants (IG: n = 30; CG: n = 30) IG: ● Age: 55.4 y.o. (± 3.7) ● Sex: M (n = 30); F (n = 0) CG: ● Age: 55.3 y.o. (± 3.9) ● Sex: M (n = 30); F (n = 0) (+) Medications
Jo, Rossow-Kimball, Park, Lee⁹³ 2018 South Korea	Single-subject design Hospital	"To examine the effects of virtual reality exercise (VRE) using Nintendo Wii-Fit on physical fitness."	Diagnosis: Schizophrenia Total = 2 participants ● Age: 61 y.o. (pt. A) and 53 y.o. (pt. B) ● Sex: M (n = 2); F (n = 0) (+) Received medical routine
Kaltsatou, Kouidi, Fountoulakis, Sipka, Theochari, Kandylis, and Deligiannis⁹⁴ 2015 Greece	RCT Sports medicine laboratory	"To examine the effects of an eight-month exercise training programme with Greek traditional dancing on functional capacity and quality of life in patients with schizophrenia."	Diagnosis: Schizophrenia (DSM-IV) Total = 31 participants (IG: n = 16; CG: n = 15) IG: ● Age: 59.5 y.o. (± 19.6) ● Sex: M (n = 14); F (n = 2) CG: ● Age: 60.4 y.o. (± 8.6) ● Sex: M (n = 11); F (n = 4) (+) Antipsychotic medications

Table 1. Summary of the Characteristics of Included Articles (*continued*)

Author, Year of Publication, Country	Study design, Setting	Objectives	Participants
Kim, Song, So, Lee, Song, Kim ⁹⁵ 2014 South Korea	Pilot study Hospital	"To investigate the effect of a combined exercise program on circulating BDNF expression and the relationship between BDNF and improvements in physical fitness."	Diagnosis: Schizophrenia (DSM-IV) Total = 40 participants (IG: n = 25; CG: n = 15) IG: ● Age: 48.7 y.o. (± 9.9) ● Sex: not mentioned CG: ● Age: 50.7 y.o. (± 12.0) ● Sex: not mentioned (+) Stable medications
Leutwyler, Hubbard, Cooper, Dowling ⁹⁶ 2018 United States of America	RCT An outpatient community treatment center, a transitional residential facility, and a locked inpatient facility.	"To describe the impact of a videogame-based physical activity program using the Kinect for Xbox 360 game system on walking speed in adults with schizophrenia."	Diagnosis: Schizophrenia or schizoaffective disorder Total = 40 participants (IG: n = 20; CG: n = 20) IG: ● Age: 37 y.o. (± 6.8) ● Sex: M (n = 11); F (n = 9) CG: ● Age: 38 y.o. (± 11.6) ● Sex: M (n = 13); F (n = 7) Medications were not mentioned
Massa, Alrohaibani, Mammino, Bello, Taylor, Cuthbert, Fargotstein, Coulter, Boatright, Nocera and Duncan ⁹⁷ 2020 United States of America	Randomized parallel group clinical trial Hospital or surrounding community center	"Assessed cognitive and physical function change as well as a change in BDNF among SCZ after aerobic exercise."	Diagnosis: Schizophrenia Total = 38 participants (IG: n = 21; CG: n = 17) IG: ● Age: 52.52 y.o. (± 6.66) ● Sex: M (n = 16); F (n = 5) CG: ● Age: 53.18 y.o. (± 10.27) ● Sex: M (n = 15); F (n = 2) (+) Antipsychotic medications
Nygård, Brobakken, Lydersen, Güzey, Morken, Heggelund, Wang ⁹⁹ 2023 Norway	RCT Hospital	"To investigate effects of strength training with adherence support in a collaborative care model."	Diagnosis: Schizophrenia or related psychotic disorder (F20-F29) Total = 48 participants (IG: n = 25; CG: n = 23) IG: ● Age: 34 y.o. (± 10) ● Sex: M (n = 17); F (n = 8) CG: ● Age: 36 y.o. (± 12) ● Sex: M (n = 11); F (n = 12) (+) Antipsychotic medications
Nygård, Brobakken, Taylor, Reitan, Güzey, Morken, Lydersen, Vedul-Kjelsås, Wang, Heggelund ¹⁰⁰ 2021 Norway	RCT Hospital	"To investigate whether 12 weeks of maximal strength training (MST) could (a) restore FGC and functional performance to the level of healthy references, (b) increase patient activation and quality of life, and (c) explore associations between symptom severity, defined daily dose of medication, illness duration, level of patient activation, and improvements in FGC and functional performance."	Diagnosis: Schizophrenia or related psychotic disorder (F20-F29) Total = 48 participants (IG: n = 25; CG: n = 23) ● Age: 35 y.o. (± 11) ● Sex: M (n = 28); F (n = 20) (+) Antipsychotic medications
Uygur and Dinzeo ¹⁰¹ 2021 United States of America	A single-group repeated-measures design Community mental health agency	(1) To evaluate the adherence and acceptability of speedwork training in individuals with schizophrenia; (2) to assess the test-retest reliability of motor assessments that are novel to schizophrenia research; (3) to evaluate the effectiveness of speedwork training in improving parkinsonian motor symptoms; and (4) psychiatric symptoms in individuals with schizophrenia.	Diagnosis: Schizophrenia or schizoaffective disorder Total = 13 participants ● Age: 45.4 y.o. (± 14) ● Sex: M (n = 8); F (n = 5) (+) Antipsychotic medications

IG – intervention group; CG – control group; DSM – Diagnostic and Statistical Manual of Mental Disorders; M – male; F – female; y.o. – years old; $\pm$ – standard deviation; RCT – randomized controlled trial; pt – patient.

Table 2. Overview of Interventions

Author	Frequency	Intensity	Type	Time	Comparator	Facilitator
<i>Campos et al.</i> ⁸⁴	2x/week	Not mentioned	Exergame using Microsoft Kinect	20 minutes for 8 weeks	TAU	Researcher with a background in OT
<i>Chen, Huang, et al.</i> ⁸⁵	2x/week	10-item Borg rating scale- Moderate to Hard	Baduanjin exercise + usual medical and psychosocial treatment	60 minutes for 12 weeks	Brisk walking + usual medical and psychosocial treatment	OT and nurses
<i>Chen, Yeh, et al.</i> ⁸⁶	2x/week	Not mentioned	Baduanjin exercise + SMS reminder (home-based)	90 minutes for 8 weeks	None	Researcher with experience in teaching Baduanjin exercise
<i>Chien et al.</i> ⁸⁷	2x/week	Not mentioned	Multitasking training (Stage 1: real-world and goal-oriented tasks; Stage 2: exergame using Xbox-Kinect)	40 minutes for 12 weeks (each stage)	None	OT
<i>Guan et al.</i> ⁸⁸	2x/week	Not mentioned	Dance Movement Therapy	60 minutes for 12 weeks	TAU	Dance movement therapist
<i>Gyllensten et al.</i> ⁸⁹	1x/week	Not mentioned	Physical activity, basic body awareness therapy, walking, and strength training with structured exercise motivation + cognitive psychotherapy and/or supportive counselling, and skills training and daily activity balance	Duration was not mentioned; 6 months	None	PT, OT, nurse, social worker
<i>Heggelund et al.</i> ⁹⁰	3x/week	85-90% of 1RM	MST using a leg press machine + Traditional therapy	4 sets of 4 repetitions for 8 weeks	Playing computer games (Xbox) for 36 minutes + Traditional therapy	Exercise physiologist
<i>Ikai, Uchida, Mizuno et al.</i> ⁹¹	2x/week	Not mentioned	Chair yoga + routine treatment	20 minutes for 12 weeks	TAU	Hatha yoga therapist and OT
<i>Ikai, Uchida, Suzuki, et al.</i> ⁹²	1x/week	Not mentioned	Yoga therapy + ambulatory treatment	60 minutes for 8 weeks	TAU	One of the investigators has a master's degree in yoga
<i>Jo et al.</i> ⁹³	3x/week	Not mentioned	Virtual reality exercise using the Nintendo Wii-Fit software	35 minutes for 8 weeks	None	Primary researcher and two graduate students
<i>Kaltsatou et al.</i> ⁹⁴	3x/week	60%–70% of individual maximum heart rate (220-age)	Greek traditional dancing	60 minutes for 8 months	psychotherapy and continue the usual sedentary lifestyle	Physical exercise instructor
<i>Kim et al.</i> ⁹⁵	3x/week	Strengthening: Borg's RPE (12-13/ somewhat hard); Aerobic: 60% of the individual VO2 max (THR)	Combined aerobic (walking) and strengthening using an elastic band	60 minutes for 12 weeks	continue their routine daily activities and perform stretching (static and dynamic), dancing, and recreation activity once a week for 1 hour	Not mentioned
<i>Leutwyler et al.</i> ⁹⁶	1x/week	Not mentioned	Active video game using Kinect for the Xbox 360 game system	30 minutes for 6 weeks	non-active video games using the Xbox 360 system (without the Kinect sensor) using remote controls	The principal investigator and her research staff

Table 2. Overview of Interventions (*continued*)

Author	Frequency	Intensity	Type	Time	Comparator	Facilitator
<i>Massa et al.</i> ⁹⁷	3x/week	Karvonen method of THR (50-80%)	Aerobic exercise using a stationary bicycle ergometer	20-45 minutes for 12 weeks	Stretching and balance exercise	Instructor with a degree in exercise physiology and/or Personal Training certification through ACSM
<i>Midtgaard et al.</i> ⁹⁸	3x/week	Not mentioned	Group-based, multifaceted exercise training (circuit training with functional movements)	60 minutes for 8 weeks	TAU	Trained PT and exercise physiologist
<i>Nygård, Brobakken, Lydersen et al.</i> ⁹⁹	2x/week	~90% of 1RM (strength) and ~85-90% of peak heart rate (aerobic)	Supervised aerobic interval training (AIT) using a treadmill and MST using a leg press	4 sets of 4 repetitions (MST); 4 series of 4 minutes (AIT) for 1 year	Self-administered AIT and MST using a leg press	Experienced personnel at the training clinic and/or exercise physiologists
<i>Nygård, Brobakken, Taylor et al.</i> ¹⁰⁰	2x/week	~90% of 1RM (strength) and ~85-90% of peak heart rate (aerobic)	Supervised AIT using a treadmill and MST using a leg press	4 sets of 4 repetitions (MST); 4 series of 4 minutes (AIT) for 12 weeks	AIT and MST using a leg press (two supervised sessions, with the remaining sessions self-administered)	Experienced personnel at the training clinic and/or exercise physiologists
<i>Uygur and Dinzeo</i> ¹⁰¹	2x/week	Lowest resistance (power of <100 watts), speed was as fast as possible (comfort level)	Speedwork training using a stationary recumbent bicycle	30 minutes for 6 weeks	None	Experienced trainer

TAU – treatment-as-usual; OT – occupational therapist/therapy; PT – physical therapist/physiotherapist; SMS – short message service; 1RM – one repetition maximum; MST – maximal strength training; THR – target heart rate; VO2 max – maximal oxygen consumption; ACSM – American College of Sports Medicine; RPE – rate of perceived exertion

Table 3. Overview of Outcome Measures

Postural Control							
Tool (n, number of studies)	Psychometric properties	Biomechanical constraints	Orientation in space	Movement strategies	Control of dynamics	Sensory strategies	Cognitive processing
<i>Center of pressure (COP)-related measures with eyes open, eyes closed, Romberg ratio, and Functional reach test using force plate and clinical stabilometric platform (n = 4)</i> ^{84,87,91,92}	Not mentioned	✓		✓	✓	✓	
<i>Timed Up & Go Test (TUG) (n = 4)</i> ^{84,85,87,101}	Moderate to excellent relative and good absolute test-retest reliability among adults with schizophrenia. ¹⁰¹	✓		✓	✓		
<i>One-leg balance test or Unipedal stance test (with eyes open and eyes closed) (n = 3)</i> ^{86,95,100}	Not mentioned	✓				✓	
<i>Single-leg flamingo test (n = 1)</i> ⁹⁸	Not mentioned	✓					
<i>Senior Fitness Test (SFT) (Foot Up and Go) (n = 2)</i> ^{84,93}	Reliable and valid among older adults ⁹³	✓		✓	✓		
<i>Berg Balance Scale (BBS) (n = 2)</i> ^{88,94}	Reliable and valid among older adults ⁸⁸	✓		✓	✓	✓	
<i>Timed Up & Go Test (TUG) with motor & cognitive dual task (n = 1)</i> ⁸⁵	Not mentioned	✓		✓	✓		✓

Table 3. Overview of Outcome Measures (*continued*)

Postural Control								
Tool (n, number of studies)	Psychometric properties	Biomechanical constraints	Orientation in space	Movement strategies	Control of dynamics	Sensory strategies	Cognitive processing	Emotional influences
<i>Activities-specific Balance Confidence Scale (n = 1)</i> ⁸⁷	Excellent test-retest reliability, internal consistency, and construct validity in community-dwelling older adults. ⁸⁷							✓
<i>Four Square Step Test (4SST) (n = 1)</i> ¹⁰¹	Moderate to excellent relative and good absolute test-retest reliability among adults with schizophrenia. ¹⁰¹	✓		✓	✓			
<i>Functional Reach Test (FRT) (n = 1)</i> ¹⁰¹	Moderate to excellent relative and good absolute test-retest reliability among adults with schizophrenia. ¹⁰¹	✓		✓	✓			
<i>Modified Falls Efficacy Scale (MFES) (n = 1)</i> ⁹¹	Not mentioned							✓
Gait								
Tool (n, number of studies)	Psychometric properties	Biomechanical constraints	Walking capacity	Energetics	Kinetics	Kinematics	Muscle activity	Spatio-temporal
<i>Timed Up & Go Test (TUG) (n = 4)</i> ^{84,85,87,101}	Moderate to excellent relative and good absolute test-retest reliability among adults with schizophrenia. ¹⁰¹	✓						
<i>Six-minute Walk Test (6MWT) (n = 3)</i> ^{85,89,94}	Acceptable validity and reliability among adults with schizophrenia. ^{85,89}		✓					✓
<i>Walking efficiency test using metabolic device (n = 3)</i> ^{90,99,100}	Not mentioned			✓				
<i>10-Meter Walk Test (10mW) (n = 2)</i> ^{93,101}	Moderate to excellent relative and good absolute test-retest reliability among adults with schizophrenia. ¹⁰¹							✓
<i>Timed 3-Meter Walk Test of the Short Physical Performance Battery (SPPB) (n = 1)</i> ⁹⁶	Valid and reliable test among older adults. ⁹⁶							✓
<i>Timed 400-Meter Walk Test (n = 1)</i> ⁹⁷	Not mentioned							✓

(SFT) (n = 2).^{84-88,93-95,100,101} Other measures included the Four-Square Step Test (4SST) (n = 1) and the Functional Reach Test (FRT) (n = 1).¹⁰¹ Center-of-pressure (COP) measures were the most frequently used laboratory-based postural control outcomes (n = 4).^{84,87,91,92} One study used a dual-task TUG to assess cognitive processing during a balance task, and two studies used self-report scales to assess balance self-efficacy and confidence (Modified Falls Efficacy Scale [MFES] (n = 1) and the Activities-specific Balance Confidence Scale [ABC] (n = 1)).^{85,87,91}

Gait outcomes were predominantly assessed in terms of functional mobility and spatiotemporal characteristics. The TUG test was frequently used to measure functional mobility (n = 4).^{84,85,87,101} Walking capacity was measured using the Six-Minute Walk Test (6MWT) (n = 3).^{85,89,94} Walking speed and step-related outcomes were assessed using the 10-Meter Walk Test (10mW) (n = 2), the Timed 3-Meter Walk Test from the Short Physical Performance Battery (SPPB) (n = 1), and the Timed 400-Meter Walk Test (n = 1).^{93,96,97,101}

Reporting of psychometric properties for outcome measures in adults with schizophrenia was inconsistent across the included studies. The TUG, 4SST, FRT, and 10mWT tests were reported to have moderate to excellent relative and good absolute test-retest reliability.¹⁰¹ The 6MWT was cited as having acceptable validity and reliability.^{85,89} For several tools (e.g., BBS, ABC scale, the timed 3-Meter Walk Test of the SPPB, and the SFT), authors cited psychometric properties established in older adult populations rather than in adults with schizophrenia.^{87,88,93,96} For other tools, psychometric properties were not reported in the included studies.

Distribution of Studies According to Interventions and Outcomes

The included studies employed a variety of exercise modalities, and the emphasis on specific outcomes varied across intervention types. Figure 4 summarized the distribution of studies by intervention type and outcomes. Technology-based interventions most commonly assessed gait outcomes ($n = 5$), while three studies assessed postural control outcomes.^{84,87,90,93,96} Similarly, studies on structured aerobic and strength training placed more emphasis on gait ($n = 5$) than on postural control ($n = 3$).^{90,95,97,99-101} Mind-body interventions ($n = 4$) focused more on postural control, with one study assessing gait outcomes.^{85,86,91,92} Evidence for dance-based and multimodal interventions was limited. Two dance-based studies assessed postural control, while one assessed gait.^{88,94} One multimodal study assessed postural control and one assessed gait outcomes.^{89,98}

Acceptability, Attendance, and Adverse Events

Acceptability was explicitly reported in only three studies. Campos et al. reported that over 90% of participants rated the exergame intervention as interactive and satisfactory.⁸⁴

Chen, Yeh, et al. noted that 80% of participants valued the support materials for home-based Baduanjin exercise, and the use of SMS reminders appeared to slightly improve daily participation.⁸⁶ Uygur and Dinzeo reported that participants found speedwork training enjoyable, with a manageable time commitment and level of difficulty.¹⁰¹

Attendance rates varied across interventions, and only 13 studies reported them. Several studies reported high attendance ($>80\%$), including Chen, Huang, et al. (94%), Heggelund et al. (85% in the experimental group), Ikai, Uchida, Suzuki, et al. (87%), Kaltsatou et al. (86.7% in the experimental group), Massa et al. (90.3%), and Uygur and Dinzeo (92%).^{85,90,92,94,97,101} Uygur and Dinzeo attributed the high attendance to incentives and supervision. In contrast, other studies reported lower attendance, including Campos et al. (69.23%) and Midtgaard et al. (43%; range: 9%–96%).^{84,98} Chen, Yeh, et al. observed a gradual decline in attendance after the first week of a Baduanjin program, with an overall average attendance of 72%.⁸⁶

Participant attrition across the 18 studies varied widely, ranging from 0% to 60.53%. Table 4 summarizes attrition for each study and the reported reasons for dropout. Retention was high in only a few studies, such as Jo et al. and Kaltsatou et al. (0%) and Guan et al.^{88,93,94} (3.33%). Most studies ($n = 8$) reported moderate attrition (5%–20%), while seven studies reported high attrition ($>20\%$), led by Massa et al. (60.53%) and Midtgaard et al. (48%).^{84-87,89-92,95-101}

Of the 18 included studies, 11 reported safety data. Most of these studies ($n = 7$) reported no accidents, injuries, or adverse events during the study period.^{85,86,91,94,99-101} Mild adverse effects were reported in two studies, including transient muscle soreness and fatigue following yoga and circuit training.^{92,98} Massa et al. reported physical sequelae associated with aerobic exercise, although the specific nature of these events was not described.⁹⁷ Reasons for dropout

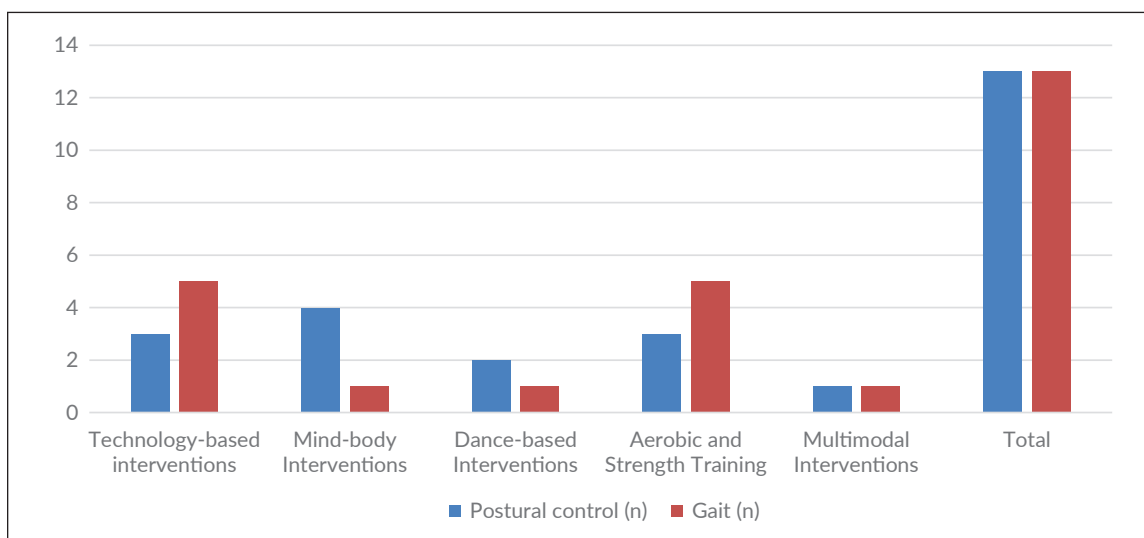


Figure 4. Distribution of studies according to exercises and outcomes.

Table 4. Attrition Rate and Reasons for Attrition

Level of Attrition (n, number of studies)	Studies (Attrition rate, %)	Key Reasons for Attrition (n, number of participants)
None (0%) (n = 2)	Jo et al. ⁹³ , Kaltsatou et al. ⁹⁴	<ul style="list-style-type: none"> • None
Low (<5%) (n = 1)	Guan et al. ⁸⁸ (3.33%)	<ul style="list-style-type: none"> • Marked fluctuations in psychotic symptoms (n = 1) • Discharged from the hospital (n = 1)
Moderate (5-20%) (n = 8)	Campos et al. ⁸⁴ (18.75% in EG; 9.38% total sample), Chen, Huang, et al. ⁸⁵ (6.26%), Chien et al. ⁸⁷ (17.21%), Gyllensten et al. ⁸⁹ (12.5%), Heggelund et al. ⁹⁰ (18.75%), Ikai, Uchida, Mizuno et al. ⁹¹ (8.93%), Ikai, Uchida, Suzuki, et al. ⁹² (10.20%), Kim et al (10%). ⁹⁵	<ul style="list-style-type: none"> • Relocation (n = 5)^{85,89,91,92} • Declined to participate or withdrawal of consent (n = 4)^{85,87,92} • Schedule conflict or availability was changed (n = 4)⁸⁴⁻⁸⁵ • Discharged (n = 3)⁹⁰⁻⁹¹ • Relapse (n = 2)^{91,92} • Unstable psychiatric symptoms (n = 1)⁸⁷ • MSK diagnosis (n = 1)⁸⁷ • Disappeared (n = 1)⁹⁰ • <80% of training sessions (n = 1)⁹⁰ • Hospitalization for physical comorbidity (n = 1)⁹² • Personal reasons or for health reasons unrelated to the study (specific number of participants are unknown)⁹⁵
High (>20%) (n = 7)	Chen, Yeh, et al. ⁸⁶ (31.25%), Leutwyler et al. ⁹⁶ (30%), Massa et al. ⁹⁷ (60.53%), Midtgaard et al. ⁹⁸ (48%), Nygård, Brobakken, Lydersen et al. ⁹⁹ (31.25%), Nygård, Brobakken, Taylor et al. ¹⁰⁰ (25%), Uygur and Dinzeo (23.08%). ¹⁰¹	<ul style="list-style-type: none"> • Lack of motivation (n = 19)⁹⁹⁻¹⁰⁰ • Stop showing up for appointments (n = 17)⁹⁷ • Incomplete (n = 11)⁹⁶ • Withdraw from participation (n = 10)^{97-98,101} • Time conflict (n = 6)^{86,98} • Noncompliance (n = 5)⁹⁶⁻⁹⁷ • Not contactable (n = 4)⁹⁸ • Psychiatric hospitalization (n = 4)⁹⁹⁻¹⁰⁰ • Not feeling fit for the intervention (n = 3)⁹⁸ • Unstable psychiatric symptoms (n = 3)^{86,101} • Somatic hospitalization (n = 2)⁹⁹⁻¹⁰⁰ • Death from drug overdose (n = 2)⁹⁹⁻¹⁰⁰ • Transportation issues (n = 2)⁹⁷ • Physical sequelae from exercise paradigm (n = 1)⁹⁷ • Not willing to repeat the test (n = 1)⁹⁸ • No longer interested (n = 1)¹⁰¹

EG – experimental group

were categorized as clinical, personal, and logistical factors. Clinical issues included unstable psychiatric symptoms, musculoskeletal diagnoses, exercise-related physical sequelae, health reasons, relapse, and hospitalization.^{86-88,91,92,95,97,99-101} In higher-attrition studies, personal factors were prominent, including low motivation or interest, withdrawal of consent, non-attendance or inability to contact participants, perceived unfitness for the intervention, incomplete attendance, noncompliance, and other personal reasons.^{85,87,90,92,95-101} Logistical barriers included scheduling conflicts, transportation issues, and hospital discharge.^{84-86,88,90,91,97,98}

Limitations and Recommendations from Included Studies

Table 5 outlined the primary methodological limitations and targeted recommendations for future research across the four intervention categories. Small cohort size was the most frequently cited limitation across intervention types.^{86-95,97,101} Several authors also reported inadequate blinding or used non-RCT methodologies (e.g., lack of control groups or non-random allocation).^{84,86-93,101} Heterogeneous participant characteristics were noted as a limitation in multimodal and mind-body/dance-based studies.^{85,89,91,92} Inadequate

intervention dosage was identified in technology-based, mind-body/dance-based, and aerobic/strength training studies.^{86,90,92,94,96} For technology-based interventions, studies also noted limited reporting of fall frequency outcomes and technical issues with exergames (e.g., poor functioning or researcher-operated systems).^{84,87} In contrast, aerobic and strength training studies frequently reported limited assessment of clinical mental health outcomes, neuromuscular changes, and cerebrospinal fluid (CSF) biomarkers, which limited physiological insight.^{95,100} Finally, mind-body and dance-based intervention studies cited short follow-up periods, single-site designs, and unclear physiological mechanisms underlying observed benefits.^{85,91,92,94}

To strengthen the evidence base, authors emphasized the need for large-scale randomized controlled trials (RCTs) with adequate follow-up periods.^{84-87,89,92,97-99,101} A recurring recommendation across intervention categories was to investigate optimal dosing and to conduct longer trials.^{85,91,92,96,99} Several studies also recommended expanding research to multiple settings and exploring patient-led interventions, particularly for exergaming.^{84,85,98,101} In addition, future studies should incorporate a broader range of outcomes, including neuromusculoskeletal measures (e.g.,

Table 5. Synthesis of Study Limitations and Recommendations according to Intervention

Type of Intervention	Common limitations identified (n, number of studies)	Recommendations noted from included studies for future research (n, number of studies)
Technology-based	<ul style="list-style-type: none"> • Small sample size (n = 3).^{87,90,93} • Lack of placebo and control group (n = 2).^{84,87} • Decreased intervention frequency (n = 1).⁹⁶ • The technology was mainly operated by the researchers and had poor game functioning (n = 1).⁸⁴ • Lack of effects on fall frequency (n = 1).⁸⁷ • Use of quasi-experimental (n = 1)⁸⁴ and single-subject designs (n = 1).⁹³ 	<ul style="list-style-type: none"> • Consider exergames that can be completely controlled by patients either in a laboratory or home-based setting (n = 1).⁸⁴ • Conduct larger-scale studies to compare exergaming with other physical activity interventions for effectiveness and adherence (n = 1).⁸⁴ • Explore the feasibility and patients' adherence to home-based exergaming (n = 1).⁸⁴ • Investigate the optimal dosing (FITT) (n = 1).⁸⁴ • Prioritize future randomized controlled trials with adequate follow-up (n = 1).⁸⁷ • The Activities-specific Balance Confidence (ABC) Scale should be conducted in unfamiliar situations (n = 1).⁸⁷ • Investigate effects on the prefrontal and motor cortex and the impact on fall incidence (n = 1).⁸⁷ • Implement longer programs with more frequent sessions to assess mobility and health outcomes like blood pressure and body mass index (n = 1).⁹⁶
Mind-body and Dance-based interventions	<ul style="list-style-type: none"> • Small sample sizes (n = 5).^{86,88,91,92,94} • Lack of double-blind designs or control groups (n = 4).^{86,88,91,92} • Short intervention durations with lack of long-term follow-up (n = 4).^{86,91,92,94} • Insufficient dosage and heterogeneous participant characteristics (different diagnoses/medications) (n = 2).^{91,92} • Single-site study or enclosed in an outpatient department (n = 2).^{85,94} • The physiologic mechanism of the intervention remains to be elucidated (n = 2).^{91,92} • Participant characteristics may moderate treatment response (n = 1).⁸⁵ • All participants were male (n = 1).⁸⁸ • Potential bias from increased attention given to exercise groups compared to controls (n = 1).⁹² 	<ul style="list-style-type: none"> • Conduct multi-site research with larger, more diverse sample sizes (n = 3).^{85-86,92} • Investigate the optimal dosing (frequency, intensity, and duration) (n = 2).^{85,91} • Include "maintenance packages" to facilitate long-term retention of the intervention (n = 1).⁸⁵ • Use clinical outcomes such as risk of falls, fracture risk, risk ratio for disability, and quality of life (n = 1).⁸⁸ • Assess improvements in cognitive functions and social interaction alongside physical stability (n = 1).⁸⁸ • Determine the physiological mechanisms behind the benefits of intervention (n = 1).⁹¹ • Longer trials are warranted (n = 1).⁹² • Need for further investigations on the potential benefits of intervention in patients with psychiatric disorders (n = 1).⁹¹
Aerobic and Strength training	<ul style="list-style-type: none"> • Small sample sizes and issues with retention (high attrition in some cases) (n = 4).^{90,95,97,101} • Lack of evaluation for clinical mental conditions or neural/muscular measurements for more in-depth information (n = 2).^{95,100} • Lack of control group (n = 1).¹⁰¹ • Allocation was not randomized in one study (n = 1).⁹⁰ • Short intervention periods and lack of blinded assessment (n = 1).⁹⁰ • Implementation of the intervention in a structured setting and the use of incentives (n = 1).¹⁰¹ • Biomarkers (like BDNF) are often measured only in circulating levels (blood) rather than CSF (n = 1).⁹⁵ 	<ul style="list-style-type: none"> • Prioritize future randomized controlled trials with larger samples and include other populations within psychiatry (n = 3).^{97,99,101} • Include neural, muscular, skeletal, immunologic, and metabolic measurements for more in-depth data on physical capacity and to better understand the effects of intervention in psychiatric populations (n = 2).^{97,100} • Combine strength and endurance training with sustainable lifestyle interventions (diet and smoking habits) (n = 1).⁹⁹ • Investigate the optimal dosing (e.g., increased frequency) (n = 1).⁹⁹ • Evaluate clinical outcomes using standard scores (e.g., PANSS or BPRS) in conjunction with physiological data (n = 1).⁹⁵ • Further evaluate acceptability and effectiveness of the interventions across different settings and comparison groups (n = 1).¹⁰¹
Multimodal	<ul style="list-style-type: none"> • Cross-sectional (n = 1).⁸⁹ • Small sample size, and patients had multiple and varied diagnoses (n = 1).⁸⁹ • Problems in recruitment due to some assessments used (n = 1).⁸⁹ • Limited recruitment and high retention rates.⁹⁸ 	<ul style="list-style-type: none"> • Prioritize future large-scale, multi-site randomized controlled trials (n = 2).^{89,98} • Incorporate more "recovery-related" measures rather than focusing strictly on objective physiological metrics (n = 1).⁹⁸

FITT – Frequency, Intensity, Type, Time; SMS – Short Message Service; BDNF – Brain-Derived Neurotrophic Factor; PANSS – Positive and Negative Syndrome Scale; BPRS – Brief Psychiatric Rating Scale

prefrontal cortex activity), psychiatric symptom scales (e.g., PANSS/BPRS), cognitive outcomes, disability and fracture risk, fall incidence, and recovery-oriented patient-reported outcomes.^{87,88,95,97,98,100} Finally, studies should include more diverse participant samples to better understand whether intervention effects vary across populations.

DISCUSSION

Gait and balance impairments contribute to mobility issues among individuals with schizophrenia. These impairments have been linked to metabolic syndrome, negative symptoms, lower cognitive functioning, and reduced quality of life.¹⁰² Therefore, the primary goal of this scoping review was to map the existing evidence on exercise interventions designed to improve gait and postural control in adults with schizophrenia. This review highlights what is currently known and what remains uncertain.

The mapped interventions reflect two parallel priorities in schizophrenia care: improving physical health and supporting engagement. Technology-based programs, such as exergaming, may be used to increase patients' engagement and willingness to participate in training tasks.^{84,87} This may be relevant given that this population is known to have motivational barriers.⁹⁰⁻¹⁰¹ In contrast, mind-body and dance-based approaches may target physical health (e.g., postural control) because they integrate balance, body awareness, coordinated movements, and a range of postures, while aerobic and strength training align with cardiometabolic health and mobility.^{85,86,88,90-92,94,95,101} The lack of detailed reporting on intervention dosage hinders the development of a robust, cumulative evidence base. Although many studies include frequency, session duration, and total program length, intensity was frequently omitted.^{84,86-89,91-93,96,98} Without clear descriptions of FITT variables, it is difficult to replicate programs or compare interventions across settings. Future studies should prioritize transparent reporting to facilitate translation into physical therapy and multidisciplinary care.

Outcome selection across studies indicates a heavy emphasis on clinically practical functional assessments (e.g., the TUG and 6MWT), which promotes realistic application but may limit insight into underlying mechanisms. Balance tools frequently focus on specific domains of postural control, leaving other domains (e.g., emotional influences, orientation in space, and cognitive processing) underexplored. Functional mobility and walking-capacity assessments dominate gait outcomes, but comprehensive biomechanical measures are less common, limiting understanding of which specific gait abnormalities respond to exercise. Furthermore, most studies rely on psychometric properties established in older adults rather than those validated specifically for schizophrenia.^{87,88,93,96} The lack of standardized, population-specific outcome measures hinders meaningful synthesis and obstructs the formulation of definitive, evidence-based therapeutic guidelines.

Variation in attendance and attrition in exercise programs was highlighted in the literature and indicates the influence of symptom fluctuation, motivation, and logistical barriers on participation. Systematic reporting of acceptability, adherence strategies, and adverse events is essential for real-world implementation. Occupational therapists, exercise physiologists, nurses, trained personnel, and investigators often facilitated exercise delivery, while physical therapists' involvement was notably limited. Physical therapists (PTs) are essential members of multidisciplinary teams due to their expertise in movement science, gait analysis, and functional restoration.^{103,104} Future studies should explore physiotherapist-led delivery approaches to improve reproducibility and expand PT-related literature in psychiatric settings.

This scoping review highlights several gaps that limit the development of evidence-informed guidance for gait and postural control interventions in schizophrenia. Small sample sizes, variable intervention methods, inadequate long-term follow-up and blinding, incomplete dosing, and inconsistent outcome and psychometric reporting all contribute to reduced cross-study comparability.

Future Directions

Future research should focus on establishing the optimal frequency, intensity, and duration (FITT principle) of PT-led exercise modalities for achieving meaningful and long-term gains in motor function. It is also critical to evaluate balance and gait tests specifically for people with schizophrenia, rather than relying on data from older adult groups. Gait examinations should include not only functional tests but also biomechanical outcomes such as kinematics, kinetics, muscle activation, and spatiotemporal factors like stride and step length. To further understand how exercise affects motor function and fall risk, researchers should investigate underlying mechanisms, such as biomarkers and brain changes in the prefrontal and motor cortex. Large-scale, multi-site randomized controlled trials with longer follow-up and more diverse populations are needed to strengthen the evidence base and support the development of clinical guidelines.

Limitations

This scoping review has several limitations. First, only published articles from 2012 to December 2023 were included, and grey literature was excluded. Although this may have limited the pool of eligible studies, the review focused on recent peer-reviewed evidence to support evidence-informed practice. Second, only three databases were searched; however, these databases index a wide range of health-related literature. Finally, a formal critical appraisal of the evidence was not performed, as the goal was to map the evidence rather than determine the quality of individual studies. Therefore, findings should be interpreted as an evidence map rather than a statement of effectiveness.

CONCLUSION

Evidence regarding exercise interventions for gait and postural control in schizophrenia is currently limited, though the field is expanding. It includes technology-based programs, mind-body/dance-based interventions, aerobic and strength training, and multimodal approaches. However, significant heterogeneity in study designs, intervention procedures, and outcome measures, combined with incomplete reporting of intensity, psychometric characteristics, adherence, and adverse events, impedes comparability and the formulation of clear, evidence-based interventions. Future research should prioritize adequately powered and methodologically rigorous trials, standardized and schizophrenia-appropriate outcome measures for gait and postural control, and more detailed reporting of intervention dose, physical therapist involvement, and implementation outcomes to support translation into practice and improve mobility and quality of life in this population.

Acknowledgment

The authors thank Anna Mae Usero-Consing, MPT for her contribution as an external reviewer.

Statement of Authorship

Both authors certified fulfillment of ICMJE authorship criteria.

Author Disclosure

Both authors declared no conflicts of interest.

Funding Source

This study was funded by the authors.

REFERENCES

- Walther S, Strik W. Motor symptoms and schizophrenia. *Neuropsychobiology*. 2012;66(2):77-92. doi: 10.1159/000339456. PMID: 22814247.
- Black DW, Grant JE. DSM-5 guidebook: the essential companion to the diagnostic and statistical manual of mental disorders, 5th Edition [Internet]. Washington (DC): American Psychiatric Association Publishing; 2014 [cited 2023 Jan 16]. pp. 71-74. Available from: <https://research.ebsco.com/linkprocessor/plink?id=9ae5a2f1-fcdf-31ca-89f1-f0958403a9ed>.
- Nadesalingam N, Chapellier V, Lefebvre S, Pavlidou A, Stegmayer K, Alexaki D, et al. Motor abnormalities are associated with poor social and functional outcomes in schizophrenia. *Compr Psychiatry*. 2022 May;115:152307. doi: 10.1016/j.comppsych.2022.152307. PMID: 35303585.
- Pieters LE, Nadesalingam N, Walther S, van Harten PN. A systematic review of the prognostic value of motor abnormalities on clinical outcome in psychosis. *Neurosci Biobehav Rev*. 2022 Jan;132:691-705. doi: 10.1016/j.neubiorev.2021.11.027. PMID: 34813828.
- GBD 2019 Mental Disorders Collaborators. Global, regional, and national burden of 12 mental disorders in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Psychiatry*. 2022 Feb;9(2):137-150. doi: 10.1016/S2215-0366(21)00395-3. PMID: 35026139; PMCID: PMC8776563.
- Kemp CG, Concepcion T, Ahmed HU, Anwar N, Baingana F, Bennett IM, et al. Baseline situational analysis in Bangladesh, Jordan, Paraguay, the Philippines, Ukraine, and Zimbabwe for the WHO special initiative for mental health: universal health coverage for mental health. *PLoS One*. 2022 Mar 22;17(3):e0265570. doi: 10.1371/journal.pone.0265570. PMID: 35316294; PMCID: PMC8939830.
- He H, Liu Q, Li N, Guo L, Gao F, Bai L, et al. Trends in the incidence and DALYs of schizophrenia at the global, regional and national levels: results from the global burden of disease study 2017. *Epidemiol Psychiatr Sci*. 2020 Jan 13;29:e91. doi: 10.1017/S2045796019000891. PMID: 31928566; PMCID: PMC7214712.
- Walther S, van Harten PN, Waddington JL, Cuesta MJ, Peralta V, Dupin L, et al. Movement disorder and sensorimotor abnormalities in schizophrenia and other psychoses - European consensus on assessment and perspectives. *Eur Neuropsychopharmacol*. 2020 Sep;38:25-39. doi: 10.1016/j.euroneuro.2020.07.003. PMID: 32713718.
- Walther S. Psychomotor symptoms of schizophrenia map on the cerebral motor circuit. *Psychiatry Res*. 2015 Sep 30;233(3):293-8. doi: 10.1016/j.psychres.2015.06.010. PMID: 26319293.
- Hirjak D, Meyer-Lindenberg A, Kubera KM, Thomann PA, Wolf RC. Motor dysfunction as research domain in the period preceding manifest schizophrenia: a systematic review. *Neurosci Biobehav Rev*. 2018 Apr;87:87-105. doi: 10.1016/j.neubiorev.2018.01.011. PMID: 29410313.
- Feldman R, Schreiber S, Pick CG, Been E. Gait, balance and posture in major mental illnesses: depression, anxiety and schizophrenia. *Austin Med Sci [Internet]*. 2020 Jan 20 [cited 2023 Feb 10];5(1):[about 1 p.]. Available from: <https://austinpublishinggroup.com/medical-sciences/fulltext/ams-v5-id1039.php>
- Morera-Salazar DA, Serna-Salazar AM, Pérez-Parra JE, Agudelo-Cardona N, Díaz-Restrepo D, Hurtado-Valencia M, et al. Postural control in schizophrenia: a retrospective cohort study. *Clin Schizophr Relat Psychoses*. 2021 Jan 1;15(1):1-7.
- Presta V, Paraboschi F, Marsella F, Lucarini V, Galli D, Mirandola P, et al. Posture and gait in the early course of schizophrenia. *PLoS One*. 2021 Jan 19;16(1):e0245661. doi: 10.1371/journal.pone.0245661. PMID: 33465166; PMCID: PMC7815098.
- Akbaş E, Ünver B, Erdem EU. Postural stability, gait, and plantar pressure alterations in schizophrenia patients. *J Exerc Ther Rehab*. 2020 Jan 10;6(3):131-9.
- Tonna M, Lucarini V, Lucchese J, Presta V, Paraboschi F, Marsella F, et al. Posture, gait and self-disorders: an empirical study in individuals with schizophrenia. *Early Interv Psychiatry*. 2023 May;17(5):447-61. doi: 10.1111/eip.13340. PMID: 37156494.
- Stensdotter AK, Lorås HW, Fløvig JC, Djupsjöbacka M. Postural control in quiet standing in patients with psychotic disorders. *Gait Posture*. 2013 Sep;38(4):918-22. doi: 10.1016/j.gaitpost.2013.04.017. PMID: 23726427.
- Teng YL, Chen CL, Lou SZ, Wang WT, Wu JY, Ma HI, et al. Postural stability of patients with schizophrenia during challenging sensory conditions: implication of sensory integration for postural control. *PLoS One*. 2016 Jun 29;11(6):e0158219. doi: 10.1371/journal.pone.0158219. PMID: 27355830; PMCID: PMC4927090.
- Bernard JA, Mittal VA. Cerebellar-motor dysfunction in schizophrenia and psychosis-risk: the importance of regional cerebellar analysis approaches. *Front Psychiatry*. 2014 Nov 25;5:160. doi: 10.3389/fpsy.2014.00160. PMID: 25505424; PMCID: PMC4243486.
- Kim DJ, Moussa-Touks AB, Bolbecker AR, Apthorp D, Newman SD, O'Donnell BF, et al. Cerebellar-cortical dysconnectivity in resting-state associated with sensorimotor tasks in schizophrenia. *Hum Brain Mapp*. 2020 Aug 1;41(11):3119-32. doi: 10.1002/hbm.25002. PMID: 32250008; PMCID: PMC7336143.
- Henriksen M, Nordgaard J. Schizophrenia as a disorder of the self. *J Psychopathol*. 2014 Jul 6;20:435-41.
- Kent JS, Hong SL, Bolbecker AR, Klaunig MJ, Forsyth JK, O'Donnell BF, et al. Motor deficits in schizophrenia quantified by nonlinear analysis of postural sway. *PLoS One*. 2012;7(8):e41808. doi: 10.1371/journal.pone.0041808. PMID: 22870250; PMCID: PMC3411581.

22. Matsuura Y, Fujino H, Hashimoto R, Yasuda Y, Yamamori H, Ohi K, et al. Standing postural instability in patients with schizophrenia: relationships with psychiatric symptoms, anxiety, and the use of neuroleptic medications. *Gait Posture*. 2015 Mar;41(3):847-51. doi: 10.1016/j.gaitpost.2015.03.006. PMID: 25813604.
23. Koreki A, Tsunoda K, Suzuki T, Hirano J, Watanabe K, Kashima H, et al. Clinical and demographic characteristics associated with postural instability in patients with schizophrenia. *J Clin Psychopharmacol*. 2011 Feb;31(1):16-21. doi: 10.1097/JCP.0b013e318205e192. PMID: 21192138.
24. Nygård M, Brobakken MF, Roel RB, Taylor JL, Reitan SK, Güzey IC, et al. Patients with schizophrenia have impaired muscle force-generating capacity and functional performance. *Scand J Med Sci Sports*. 2019 Dec;29(12):1968-79. doi: 10.1111/sms.13526. PMID: 31359490.
25. Tsuji Y, Akezaki Y, Mori K, Yuri Y, Katsumura H, Hara T, et al. Factors inducing falling in schizophrenia patients. *J Phys Ther Sci*. 2017 Mar;29(3):448-51. doi: 10.1589/jpts.29.448. PMID: 28356628; PMCID: PMC5361007.
26. Aso K, Okamura H. Association between Falls and balance among inpatients with schizophrenia: a preliminary prospective cohort study. *Psychiatr Q*. 2019 Mar;90(1):111-6. doi: 10.1007/s11126-018-9609-0. PMID: 30328019.
27. Stubbs B, Gaughran F, Mitchell AJ, De Hert M, Farmer R, Soundy A, et al. Schizophrenia and the risk of fractures: a systematic review and comparative meta-analysis. *Gen Hosp Psychiatry*. 2015 Mar-Apr;37(2):126-33. doi: 10.1016/j.genhosppsych.2015.01.004. PMID: 25666994.
28. Martin L, Stein K, Kubera K, Troje NF, Fuchs T. Movement markers of schizophrenia: a detailed analysis of patients' gait patterns. *Eur Arch Psychiatry Clin Neurosci*. 2022 Oct;272(7):1347-64. doi: 10.1007/s00406-022-01402-y. PMID: 35362775; PMCID: PMC9508056.
29. Jeon HJ, Cho MJ, Cho SJ, Kim SU, Park SK, Kwon JS, et al. Quantitative analysis of ataxic gait in patients with schizophrenia: the influence of age and visual control. *Psychiatry Res*. 2007 Aug 30;152(2-3):155-64. doi: 10.1016/j.psychres.2006.09.001. PMID: 17512059.
30. Putzhammer A, Heindl B, Broll K, Pfeiff L, Perfahl M, Hajak G. Spatial and temporal parameters of gait disturbances in schizophrenic patients. *Schizophren Res*. 2004 Aug 1;69(2-3):159-66. doi: 10.1016/s0920-9964(03)00090-2. PMID: 15469189.
31. Putzhammer A, Perfahl M, Pfeiff L, Hajak G. Gait disturbances in patients with schizophrenia and adaptation to treadmill walking. *Psychiatry Clin Neurosci*. 2005 Jun;59(3):303-10. doi: 10.1111/j.1440-1819.2005.01375.x. PMID: 15896224.
32. Tsuji Y, Akezaki Y, Katsumura H, Hara T, Sawashita Y, Kakizaki H, et al. Factors affecting walking speed in schizophrenia patients. *Prog Rehabil Med*. 2019 Jan 31;4:20190003. doi: 10.2490/prm.20190003. PMID: 32789250; PMCID: PMC7365212.
33. Lallart E, Jouvent R, Herrmann FR, Beauchet O, Allali G. Gait and motor imagery of gait in early schizophrenia. *Psychiatry Res*. 2012 Aug 15;198(3):366-70. doi: 10.1016/j.psychres.2011.12.013. PMID: 22445069.
34. Lallart E, Jouvent R, Herrmann FR, Perez-Diaz F, Lallart X, Beauchet O, et al. Gait control and executive dysfunction in early schizophrenia. *J Neural Transm (Vienna)*. 2014 Apr;121(4):443-50. doi: 10.1007/s00702-013-1111-0. PMID: 24201834.
35. Nuoffer MG, Lefebvre S, Nadesalingam N, Alexaki D, Gama DB, Wüthrich F, et al. Psychomotor slowing alters gait velocity, cadence, and stride length and indicates negative symptom severity in psychosis. *Schizophrenia (Heidelb)*. 2022 Dec 30;8(1):116. doi: 10.1038/s41537-022-00324-x. PMID: 36585399; PMCID: PMC9803648.
36. Martin LAL, Melchert D, Knack M, Fuchs T. Relating movement markers of schizophrenia to self-experience-a mixed-methods study. *Front Psychiatry*. 2023 Jun 21;14:1212508. doi: 10.3389/fpsy.2023.1212508. PMID: 37415694; PMCID: PMC10319999.
37. Fried LP, Tangen CM, Walston J, Newman AB, Hirsch C, Gottdiener J, et al; Cardiovascular Health Study Collaborative Research Group. Frailty in older adults: evidence for a phenotype. *J Gerontol A Biol Sci Med Sci*. 2001 Mar;56(3):M146-56. doi: 10.1093/gerona/56.3.m146. PMID: 11253156.
38. Pearson E, Siskind D, Hubbard RE, Gordon EH, Coulson EJ, Warren N. Frailty and severe mental illness: a systematic review and narrative synthesis. *J Psychiatr Res*. 2022 Mar;147:166-75. doi: 10.1016/j.jpsychires.2022.01.014. PMID: 35051715.
39. Tsai MT, Lee SM, Chen HK, Wu BJ. Association between frailty and its individual components with the risk of falls in patients with schizophrenia spectrum disorders. *Schizophr Res*. 2018 Jul;197:138-43. doi: 10.1016/j.schres.2018.01.023. PMID: 29395605.
40. Wang MY, Liu IC, Chiu CH. Clinical decision path for identifying recurrent falls in late middle-aged and older patients with chronic schizophrenia. *J Nurs Res*. 2021 Jun 29;29(5):e167. doi: 10.1097/JNR.0000000000000444. PMID: 34183567.
41. Yang C, Hou X, Ma X, Wu D. Frailty among inpatients with schizophrenia: status, influencing factors, and their correlation with quality of life. *Front Psychiatry*. 2023 Jan 4;13:1067260. doi: 10.3389/fpsy.2022.1067260. PMID: 36684022; PMCID: PMC9846125.
42. Vancampfort D, Probst M, Sweers K, Maurissen K, Knapen J, De Hert M. Relationships between obesity, functional exercise capacity, physical activity participation and physical self-perception in people with schizophrenia. *Acta Psychiatr Scand*. 2011 Jun;123(6):423-30. doi: 10.1111/j.1600-0447.2010.01666.x. PMID: 21219266.
43. Bernard P, Romain AJ, Vancampfort D, Baillot A, Esseul E, Ninot G. Six minutes walk test for individuals with schizophrenia. *Disabil Rehabil*. 2015;37(11):921-7. doi: 10.3109/09638288.2014.948136. PMID: 25098595.
44. Efthymiou D, Zekakos DX, Papatriantafyllou E, Ziagkas E, Petrelis AN, Vassilopoulou E. Gait alterations in the prediction of metabolic syndrome in patients with schizophrenia: a pilot study with PODOSmart insoles. *Front Psychiatry*. 2022 Jan 27;13:756600. doi: 10.3389/fpsy.2022.756600. PMID: 35153872; PMCID: PMC8829465.
45. Papanastasiou E. The prevalence and mechanisms of metabolic syndrome in schizophrenia: a review. *Ther Adv Psychopharmacol*. 2013 Feb;3(1):33-51. doi: 10.1177/2045125312464385. PMID: 23983991; PMCID: PMC3736963.
46. Martín-Sierra A, Vancampfort D, Probst M, Bobes J, Maurissen K, Sweers K, et al. Walking capacity is associated with health related quality of life and physical activity level in patients with schizophrenia: a preliminary report. *Actas Esp Psiquiatr*. 2011 Jul-Aug;39(4):211-6. PMID: 21769744.
47. Vancampfort D, Probst M, Scheewe T, Knapen J, De Herdt A, De Hert M. The functional exercise capacity is correlated with global functioning in patients with schizophrenia. *Acta Psychiatr Scand*. 2012 May;125(5):382-7. doi: 10.1111/j.1600-0447.2011.01825.x. PMID: 22235778.
48. Vancampfort D, Probst M, Scheewe T, De Herdt A, Sweers K, Knapen J, et al. Relationships between physical fitness, physical activity, smoking and metabolic and mental health parameters in people with schizophrenia. *Psychiatry Res*. 2013 May 15;207(1-2):25-32. doi: 10.1016/j.psychres.2012.09.026. PMID: 23051886.
49. Palheta de Lima K, Nascimento da Silva C, Ferreira de Seixas N, de Santana Maneschy M, Nascimento Lima B, Vilela Junior G, et al. Effect of resistance training on balance and postural control in people with Parkinson's: a systematic review. *Rev Cient Soc Esp Enferm Neurol (English Ed.)*. 2022;56:19-29. doi: 10.1016/j.sedeng.2021.05.002.
50. Salari N, Hayati A, Kazemini M, Rahmani A, Mohammadi M, Fatahian R, et al. The effect of exercise on balance in patients with stroke, Parkinson, and multiple sclerosis: a systematic review and meta-analysis of clinical trials. *Neurol Sci*. 2022 Jan;43(1):167-85. doi: 10.1007/s10072-021-05689-y. PMID: 34709478.
51. Zhang SL, Liu D, Yu DZ, Zhu YT, Xu WC, Tian E, et al. Multisensory exercise improves balance in people with balance disorders: a systematic review. *Curr Med Sci*. 2021 Aug;41(4):635-48. doi: 10.1007/s11596-021-2417-z. PMID: 34403086.

52. Li X, He J, Yun J, Qin H. Lower limb resistance training in individuals with Parkinson's disease: an updated systematic review and meta-analysis of randomized controlled trials. *Front Neurol*. 2020 Nov 13;11:591605. doi: 10.3389/fneur.2020.591605. PMID: 33281732; PMCID: PMC7691593.
53. Chiu HL, Yeh TT, Lo YT, Liang PJ, Lee SC. The effects of the Otago exercise programme on actual and perceived balance in older adults: a meta-analysis. *PLoS One*. 2021 Aug 6;16(8):e0255780. doi: 10.1371/journal.pone.0255780. PMID: 34358276; PMCID: PMC8345836.
54. Farrell JW 3rd, Merkas J, Pilutti LA. The effect of exercise training on gait, balance, and physical fitness asymmetries in persons with chronic neurological conditions: a systematic review of randomized controlled trials. *Front Physiol*. 2020 Nov 12;11:585765. doi: 10.3389/fphys.2020.585765. PMID: 33281619; PMCID: PMC7688661.
55. Forte R, Tocci N, De Vito G. The impact of exercise intervention with rhythmic auditory stimulation to improve gait and mobility in Parkinson disease: an umbrella review. *Brain Sci*. 2021 May 22;11(6):685. doi: 10.3390/brainsci11060685. PMID: 34067458; PMCID: PMC8224645.
56. Wu M, Tang Q, Wang L, Zhang M, Song W, Teng L, et al. Efficacy of traditional chinese exercise in improving gait and balance in cases of parkinson's disease: a systematic review and meta-analysis. *Front Aging Neurosci*. 2022 Jun 30;14:927315. doi: 10.3389/fnagi.2022.927315. PMID: 35847669; PMCID: PMC9285003.
57. Zheng X, Wu X, Liu Z, Wang J, Wang K, Yin J, et al. The influences of tai chi on balance function and exercise capacity among stroke patients: a meta-analysis. *Evid Based Complement Alternat Med*. 2021 Feb 24;2021:6636847. doi: 10.1155/2021/6636847. PMID: 33708256; PMCID: PMC7932789.
58. Wang R, Zhou H, Wang YC, Chang XL, Wang XQ. Benefits of tai chi quan on neurodegenerative diseases: a systematic review. *Ageing Res Rev*. 2022 Dec;82:101741. doi: 10.1016/j.arr.2022.101741. PMID: 36220604.
59. Donatoni da Silva L, Shiel A, McIntosh C. Effects of Pilates on the risk of falls, gait, balance and functional mobility in healthy older adults: a randomised controlled trial. *J Bodyw Mov Ther*. 2022 Apr;30:30-41. doi: 10.1016/j.jbmt.2022.02.020. Epub 2022 Feb 18. PMID: 35500977.
60. Rodríguez-Fuentes G, Silveira-Pereira L, Ferradáns-Rodríguez P, Campo-Prieto P. Therapeutic effects of the Pilates method in patients with multiple sclerosis: a systematic review. *J Clin Med*. 2022 Jan 28;11(3):683. doi: 10.3390/jcm11030683. PMID: 35160134; PMCID: PMC8836864.
61. de Faria J, Sousa LR, Dorácio ACP, Pereira MP, Moraes R, Crozara LF, et al. Multicomponent and mat Pilates training increased gait speed in individuals with parkinson's disease when walking and carrying a load: a single-blinded randomized controlled trial. *Physiother Res Int*. 2023 Oct;28(4):e2031. doi: 10.1002/pri.2031. PMID: 37395268.
62. Ban M, Yue X, Dou P, Zhang P. The effects of yoga on patients with parkinson's disease: a meta-analysis of randomized controlled trials. *Behav Neurol*. 2021 Jul 5;2021:5582488. doi: 10.1155/2021/5582488. PMID: 34285724; PMCID: PMC8275425.
63. Liu H, Xing Y, Wu Y. Effect of Wii Fit Exercise with balance and lower limb muscle strength in older adults: a meta-analysis. *Front Med (Lausanne)*. 2022 May 6;9:812570. doi: 10.3389/fmed.2022.812570. PMID: 35602499; PMCID: PMC9120538.
64. Chen Y, Zhang Y, Guo Z, Bao D, Zhou J. Comparison between the effects of exergame intervention and traditional physical training on improving balance and fall prevention in healthy older adults: a systematic review and meta-analysis. *J Neuroeng Rehabil*. 2021 Nov 24;18(1):164. doi: 10.1186/s12984-021-00917-0. PMID: 34819097; PMCID: PMC8611920.
65. Zhang J, Luximon Y, Pang MYC, Wang H. Effectiveness of exergaming-based interventions for mobility and balance performance in older adults with parkinson's disease: systematic review and meta-analysis of randomised controlled trials. *Age Ageing*. 2022 Aug 2;51(8):1-11. doi: 10.1093/ageing/afac175. PMID: 35930726.
66. Begde A, Jain M, Hogervorst E, Wilcockson T. Does physical exercise improve the capacity for independent living in people with dementia or mild cognitive impairment: an overview of systematic reviews and meta-analyses. *Aging Ment Health*. 2022 Dec;26(12):2317-2327. doi: 10.1080/13607863.2021.2019192. PMID: 34951548; PMCID: PMC9662184.
67. Yeh SW, Lin LF, Chen HC, Huang LK, Hu CJ, Tam KW, et al. High-intensity functional exercise in older adults with dementia: a systematic review and meta-analysis. *Clin Rehabil*. 2021 Feb;35(2):169-181. doi: 10.1177/0269215520961637. PMID: 33040592.
68. Wang YH, Liu YH, Yang YR, Wang RY. Effects of square-stepping exercise on motor and cognitive function in older adults - a systematic review and meta-analysis. *Geriatr Nurs*. 2021 Nov-Dec;42(6):1583-93. doi: 10.1016/j.gerinurse.2021.10.022. PMID: 34773911.
69. Stubbs B, Soundy A, Probst M, De Hert M, De Herdt A, Vancampfort D. Understanding the role of physiotherapists in schizophrenia: an international perspective from members of the International Organisation of Physical Therapists in Mental Health (IOPTMH). *J Ment Health*. 2014 Jun;23(3):125-9. doi: 10.3109/09638237.2013.869574. PMID: 24410100.
70. Pope C. Recovering mind and body: a framework for the role of physiotherapy in mental health and well-being. *J Public Ment Health*. 2009 Sep 17;8(2):36-9. doi: 10.1108/17465729200900012.
71. Heywood SE, Connaughton J, Kinsella R, Black S, Bicchi N, Satchell J. Physical therapy and mental health: a scoping review. *Phys Ther*. 2022 Nov 6;102(11):1-16. doi: 10.1093/ptj/pzac102. PMID: 35926073.
72. Andrew E, Briffa K, Waters F, Lee S, Fary R. Physiotherapists' views about providing physiotherapy services to people with severe and persistent mental illness: a mixed methods study. *J Physiother*. 2019 Oct;65(4):222-9. doi: 10.1016/j.jphys.2019.08.001. PMID: 31521550.
73. Vera-García E, Mayoral-Cleries F, Vancampfort D, Stubbs B, Cuesta-Vargas AI. A systematic review of the benefits of physical therapy within a multidisciplinary care approach for people with schizophrenia: an update. *Psychiatry Res*. 2015 Oct 30;229(3):828-39. doi: 10.1016/j.psychres.2015.07.083. PMID: 26254795.
74. Stubbs B, Vancampfort D, Hallgren M, Firth J, Veronese N, Solmi M, et al. EPA guidance on physical activity as a treatment for severe mental illness: a meta-review of the evidence and position statement from the European Psychiatric Association (EPA), supported by the International Organization of Physical Therapists in Mental Health (IOPTMH). *Eur Psychiatry*. 2018 Oct;54:124-44. doi: 10.1016/j.eurpsy.2018.07.004. PMID: 30257806.
75. Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol*. 2005 Feb 1;8(1):19-32. doi: 10.1080/1364557032000119616.
76. Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann Intern Med*. 2018 Oct 2;169(7):467-73. doi: 10.7326/M18-0850. PMID: 30178033.
77. National Center for Biotechnology and Information (NCBI). PubMed overview [Internet]. Bethesda (MD): U.S. National Library of Medicine; [updated 2025 Mar 11; cited 2025 Mar 15]. Available from: <https://pubmed.ncbi.nlm.nih.gov/about/>.
78. PEDro. Who we are [Internet]. Sydney: University of Sydney, Institute for Musculoskeletal Health; 2020 [cited 2025 Jan 5]. Available from: <https://pedro.org.au/english/about/who-we-are/>.
79. EBSCO. CINAHL Database [Internet]. Ipswich (MA): EBSCO Information Services, Inc.; 2025 [cited 2025 Jan 5]. Available from: <https://www.ebsco.com/products/research-databases/cinahl-database>.
80. World Health Organization. The ICD-10 Classification of Mental and Behavioural Disorders: clinical descriptions and diagnostic guidelines [Internet]. Geneva: World Health Organization; 1992 [cited 2025 Nov 2]. 370 p. Available from: https://cdn.who.int/media/docs/default-source/classification/other-classifications/9241544228_eng.pdf.
81. Chambers HG, Sutherland DH. A practical guide to gait analysis. *J Am Acad Orthop Surg*. 2002 May-Jun;10(3):222-31. doi: 10.5435/00124635-200205000-00009. PMID: 12041944.

82. Sibley KM, Beauchamp MK, Van Ooteghem K, Straus SE, Jaglal SB. Using the systems framework for postural control to analyze the components of balance evaluated in standardized balance measures: a scoping review. *Arch Phys Med Rehabil*. 2015 Jan;96(1):122-132.e29. doi: 10.1016/j.apmr.2014.06.021. PMID: 25073007.
83. Adkin AL, Carpenter MG. New insights on emotional contributions to human postural control. *Front Neurol*. 2018 Sep 21;9:789. doi: 10.3389/fneur.2018.00789. PMID: 30298048; PMCID: PMC6160553.
84. Campos C, Mesquita F, Marques A, Trigueiro MJ, Orvalho V, Rocha NBF. Feasibility and acceptability of an exergame intervention for schizophrenia. *Psychol Sport Exerc*. 2015 Mar 3;19:50-58. doi: 10.1016/j.psychsport.2015.02.005.
85. Chen CR, Huang YC, Lee YW, Hsieh HH, Lee YC, Lin KC. The effects of Baduanjin exercise vs. brisk walking on physical fitness and cognition in middle-aged patients with schizophrenia: a randomized controlled trial. *Front Psychiatry*. 2022 Oct 5;13:983994. doi: 10.3389/fpsyt.2022.983994. PMID: 36276319; PMCID: PMC9579429.
86. Chen MD, Yeh YC, Tsai YJ, Chang YC, Yu JW, Hsu CH. Efficacy of Baduanjin exercise and feasibility of mobile text reminders on follow-up participation in people with severe mental illness: an exploratory study. *J Psychiatr Pract*. 2016 May;22(3):241-9. doi: 10.1097/PRA.000000000000158. PMID: 27123805.
87. Chien TY, Chern JS, Wang SP, Yang Y. Effects of multitask training on cognition and motor control in people with schizophrenia spectrum disorders. *PLoS One*. 2022 Jun 30;17(6):e0264745. doi: 10.1371/journal.pone.0264745. PMID: 35771832; PMCID: PMC9246115.
88. Guan H, Zhou Z, Li X, Pan Y, Zou Z, Meng X, et al. Dance/movement therapy for improving balance ability and bone mineral density in long-term patients with schizophrenia: a randomized controlled trial. *Schizophrenia (Heidelb)*. 2023 Jul 31;9(1):47. doi: 10.1038/s41537-023-00373-w. PMID: 37524713; PMCID: PMC10390548.
89. Gyllenstein AL, Oveesson MN, Hedlund L, Ambrus L, Tornberg Å. To increase physical activity in sedentary patients with affective- or schizophrenia spectrum disorders: a clinical study of adjuvant physical therapy in mental health. *Nord J Psychiatry*. 2020 Jan;74(1):73-82. doi: 10.1080/08039488.2019.1669706. PMID: 31560246.
90. Heggelund J, Morken G, Helgerud J, Nilsberg GE, Hoff J. Therapeutic effects of maximal strength training on walking efficiency in patients with schizophrenia: a pilot study. *BMC Res Notes*. 2012 Jul 3;5:344. doi: 10.1186/1756-0500-5-344. PMID: 22759719; PMCID: PMC3568714.
91. Ikai S, Uchida H, Mizuno Y, Tani H, Nagaoka M, Tsunoda K, et al. Effects of chair yoga therapy on physical fitness in patients with psychiatric disorders: a 12-week single-blind randomized controlled trial. *J Psychiatr Res*. 2017 Nov;94:194-201. doi: 10.1016/j.jpsychires.2017.07.015. PMID: 28750232.
92. Ikai S, Uchida H, Suzuki T, Tsunoda K, Mimura M, Fujii Y. Effects of yoga therapy on postural stability in patients with schizophrenia-spectrum disorders: a single-blind randomized controlled trial. *J Psychiatr Res*. 2013 Nov;47(11):1744-50. doi: 10.1016/j.jpsychires.2013.07.017. PMID: 23932244.
93. Jo G, Rossow-Kimball B, Park G, Lee Y. Effects of virtual reality exercise for Korean adults with schizophrenia in a closed ward. *J Exerc Rehabil*. 2018 Feb 26;14(1):39-48. doi: 10.12965/jer.1835168.584. PMID: 29511651; PMCID: PMC5833966.
94. Kaltsatou A, Kouidi E, Fountoulakis K, Sipka C, Theochari V, Kandyli D, et al. Effects of exercise training with traditional dancing on functional capacity and quality of life in patients with schizophrenia: a randomized controlled study. *Clin Rehabil*. 2015 Sep;29(9):882-91. doi: 10.1177/0269215514564085. PMID: 25525065.
95. Kim HJ, Song BK, So B, Lee O, Song W, Kim Y. Increase of circulating BDNF levels and its relation to improvement of physical fitness following 12 weeks of combined exercise in chronic patients with schizophrenia: a pilot study. *Psychiatry Res*. 2014 Dec 30;220(3):792-6. doi: 10.1016/j.psychres.2014.09.020. PMID: 25446461.
96. Leutwyler H, Hubbard E, Cooper BA, Dowling G. Impact of a pilot videogame-based physical activity program on walking speed in adults with schizophrenia. *Community Ment Health J*. 2018 Aug;54(6):735-9. doi: 10.1007/s10597-017-0208-6. PMID: 29127562.
97. Massa N, Alrohaibani A, Mammino K, Bello M, Taylor N, Cuthbert B, et al. The effect of aerobic exercise on physical and cognitive outcomes in a small cohort of outpatients with schizophrenia. *Brain Plast*. 2020 Oct 1;5(2):161-74. doi: 10.3233/BPL-200105. PMID: 33282679; PMCID: PMC7685675.
98. Midtgaard J, Schnor H, Bjerre ED, Jespersen T, Jelsøe N, Frølund N, et al. Exercise training complementary to specialized early intervention in patients with first-episode psychosis: a feasibility randomised trial. *Pilot Feasibility Stud*. 2021 Aug 19;7(1):162. doi: 10.1186/s40814-021-00900-5. PMID: 34412705; PMCID: PMC8375206.
99. Nygård M, Brobakken MF, Lydersen S, Güzey IC, Morken G, Heggelund J, et al. Strength training integrated in long term collaborative care of patients with schizophrenia. *Schizophr Res*. 2023 Oct;260:67-75. doi: 10.1016/j.schres.2023.08.017. PMID: 37625226.
100. Nygård M, Brobakken MF, Taylor JL, Reitan SK, Güzey IC, Morken G, et al. Strength training restores force-generating capacity in patients with schizophrenia. *Scand J Med Sci Sports*. 2021 Mar;31(3):665-678. doi: 10.1111/sms.13863. PMID: 33113211.
101. Uygur M, Dinzeo TJ. Acceptability and effectiveness of a novel cycling training on the parkinsonian motor and psychiatric symptoms in individuals with schizophrenia: a pilot study. *Complement Ther Med*. 2021 Sep;61:102760. doi: 10.1016/j.ctim.2021.102760. PMID: 34274448.
102. Cuoco F, Agostoni G, Lesmo S, Sapienza J, Buonocore M, Bechi M, et al. Get up! Functional mobility and metabolic syndrome in chronic schizophrenia: effects on cognition and quality of life. *Schizophr Res Cogn*. 2022 Mar 2;28:100245. doi: 10.1016/j.scog.2022.100245. PMID: 35251942; PMCID: PMC8892146.
103. World Physiotherapy. Policy statement: Description of physiotherapy [Internet]. London: World Physiotherapy; 2023 [cited 2025 Dec 14]. Available from: <https://world.physio/sites/default/files/2024-01/PS-2023-Description.pdf>.
104. Gustavson AM, Falvey JR, Jankowski CM, Stevens-Lapsley JE. Public health impact of frailty: role of physical therapists. *J Frailty Aging*. 2017;6(1):2-5. doi: 10.14283/jfa.2017.1. PMID: 28244550; PMCID: PMC5446186.

APPENDIX

Search Result Hits

Database: CINAHL

Search Terms	Number of Hits
EXERCISE AND SCHIZOPHRENIA AND GAIT	3
EXERCISE AND SCHIZOPHRENIA AND WALK	37
EXERCISE AND SCHIZOPHRENIA AND BALANCE	17
EXERCISE AND SCHIZOPHRENIA AND "POSTURAL BALANCE"	2
EXERCISE AND SCHIZOPHRENIA AND "POSTURAL CONTROL"	0
EXERCISE AND SCHIZOPHRENIA AND "POSTURAL STABILITY"	0
TRAINING AND SCHIZOPHRENIA AND GAIT	4
TRAINING AND SCHIZOPHRENIA AND WALK	8
TRAINING AND SCHIZOPHRENIA AND "POSTURAL CONTROL"	1
TRAINING AND SCHIZOPHRENIA AND "POSTURAL STABILITY"	0
TRAINING AND SCHIZOPHRENIA AND BALANCE	26
PHYSICAL ACTIVITY AND SCHIZOPHRENIA AND GAIT	5
PHYSICAL ACTIVITY AND SCHIZOPHRENIA AND WALK	25
PHYSICAL ACTIVITY AND SCHIZOPHRENIA AND "POSTURAL CONTROL"	0
PHYSICAL ACTIVITY AND SCHIZOPHRENIA AND "POSTURAL STABILITY"	0
PHYSICAL ACTIVITY AND SCHIZOPHRENIA AND BALANCE	16
TOTAL:	144

Database: PEDro

Search Terms	Number of Hits
EXERCISE AND SCHIZOPHRENIA AND GAIT	0
EXERCISE AND SCHIZOPHRENIA AND WALK	3
EXERCISE AND SCHIZOPHRENIA AND BALANCE	5
EXERCISE AND SCHIZOPHRENIA AND "POSTURAL BALANCE"	0
EXERCISE AND SCHIZOPHRENIA AND "POSTURAL CONTROL"	0
EXERCISE AND SCHIZOPHRENIA AND "POSTURAL STABILITY"	0
TRAINING AND SCHIZOPHRENIA AND GAIT	0
TRAINING AND SCHIZOPHRENIA AND WALK	1
TRAINING AND SCHIZOPHRENIA AND "POSTURAL CONTROL"	0
TRAINING AND SCHIZOPHRENIA AND "POSTURAL STABILITY"	0
TRAINING AND SCHIZOPHRENIA AND BALANCE	3
PHYSICAL ACTIVITY AND SCHIZOPHRENIA AND GAIT	0
PHYSICAL ACTIVITY AND SCHIZOPHRENIA AND WALK	2
PHYSICAL ACTIVITY AND SCHIZOPHRENIA AND "POSTURAL CONTROL"	0
PHYSICAL ACTIVITY AND SCHIZOPHRENIA AND "POSTURAL STABILITY"	0
PHYSICAL ACTIVITY AND SCHIZOPHRENIA AND BALANCE	0
TOTAL:	14

Database: PubMed

Search Terms	Number of Hits
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND (exercise)) AND (schizophrenia) AND (gait)	7
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND (exercise)) AND (schizophrenia) AND (walk*)	95
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND (exercise)) AND (schizophrenia) AND (balance)	36
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND (exercise)) AND (schizophrenia) AND ("Postural Balance")	6
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND (exercise)) AND (schizophrenia) AND ("postural control")	1
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND (exercise)) AND (schizophrenia) AND ("postural stability")	2
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND (training)) AND (schizophrenia) AND (gait)	19
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND (training)) AND (schizophrenia) AND (walk*)	106
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND (training)) AND (schizophrenia) AND ("postural control")	5
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND (training)) AND (schizophrenia) AND ("postural stability")	1
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND (training)) AND (schizophrenia) AND (balance)	142
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND ("physical activity")) AND (schizophrenia) AND (gait)	3
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND ("physical activity")) AND (schizophrenia) AND (walk*)	55
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND ("physical activity")) AND (schizophrenia) AND ("postural control")	1
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND ("physical activity")) AND (schizophrenia) AND ("postural stability")	0
((("2012"[Date - Publication] : "2023"[Date - Publication])) AND ("physical activity")) AND (schizophrenia) AND (balance)	16
TOTAL:	495