Psychiatr. Pol. 2022; 56(4): 837–859
PL ISSN 0033-2674 (PRINT), ISSN 2391-5854 (ONLINE)
www.psychiatriapolska.pl
DOI: https://doi.org/ 10.12740/PP/140053

Physical activity as a therapeutic method for non-pharmacological treatment of schizophrenia: A systematic literature review

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Summary

Aim. The purpose of this systematic review was to classify, compare and characterize selected types of physical activity having a positive impact on the course of the treatment of schizophrenia (including its long-term effects).

Method. The literature review for this work was carried out in the scientific databases: PubMed/MEDLINE, Web of Science and EBSCO. The analysis and further description were developed based on the PRISMA protocol.

Results. During the database analysis, 330 items of potential sources of knowledge were searched for to prepare a literature review on physical activity used in the treatment of schizophrenia. After the verification and qualification process, 17 items were included in the study.

Conclusions. The inclusion of physical activity in the treatment of patients with schizophrenia had a positive effect on the perceived symptoms and ailments related to the course of the disease and supported the return of patients to society

Key words: schizophrenia, physical activity, conservative treatment

Introduction

According to the World Health Organization (WHO), 20 million people worldwide currently suffer from schizophrenia assessed as a chronic and severe mental disorder [1]. Its prevalence varies depending on the type of population. Unfortunately, not every sick person is diagnosed and receives appropriate treatment [2]. It is an illness of a psychotic nature [3]. The symptoms specific to schizophrenia are negative and positive. Negative symptoms pose a challenge to modern psychiatry. These include: affective flattening, alogia (poverty of thoughts), social withdrawal, anhedonia (re-

duced ability to experience pleasure from positive stimuli), avolition (reduction of intentional self-initiated activity) [4, 5]. These symptoms can be divided into primary and secondary. Primary negative symptoms are the basis of the pathological picture in schizophrenia; moreover, their course is stable, they are resistant to the currently used therapeutic procedures and are chronic in nature. Secondary symptoms are the result of various factors and symptoms characteristic of schizophrenia, such as: "positive (psychotic) symptoms, depression, anxiety, side effects of pharmacotherapy, addiction and social deprivation" [4, p. 108]. Positive symptoms, otherwise known as productive symptoms, are typical during an exacerbation of the disease, while during remission, negative (deficit) symptoms are typical [6].

According to DSM-5, schizophrenia is diagnosed on the basis of three leading diagnostic tools, including: WODAS 2.0 (World Health Organization Disability Assessment Schedule), GAF (Global Assessment of Functioning), and SOFAS (Social and Occupational Functioning Assessment Scale) [7]. Schizophrenia exerts an effect on the development of somatic diseases, such as cardiovascular, metabolic and infectious diseases, or cognitive dysfunction [1]. Cognitive abilities are reduced in people suffering from schizophrenia, and they have the features of selectivity and specificity. The weakened domains include executive functions, attention, memory and language. The tests and strategies used in the course of schizophrenia, mentioned later in this work, include:

- MCCB (MATRICS Consensus Cognitive Battery) – a standardized set of tests for the assessment of cognitive functions, consists of 10 tests verifying the functioning of seven cognitive domains, which include: information processing speed, attention/vigilance, problem solving, verbal learning, visual learning, working memory, and social cognition [7]. Used to assess the improvement of cognitive performance in the course of schizophrenia in clinical trials. Adapted to multiple neurocognitive examinations, good in terms of psychometrics, e.g., in terms of sensitivity to the severity of neurocognitive disorders [8].
- BACS (Brief Assessment of Cognition in Schizophrenia) – a simplified set of tests to assess cognitive functions in schizophrenia. Contains six subtests related to the six weakened domains of cognitive functions in schizophrenia (motor speed, verbal learning, verbal memory, working memory, attention, executive functions), related simultaneously to functional changes in schizophrenics. The test is quick (it takes 25 to 30 minutes) and easy to carry out (it can be performed by specialists in various fields of medicine) [9].
- PANSS (Positive and Negative Syndrome Scale) – a standardized research tool to assess the frequency and severity of positive and negative symptoms, as well as total psychopathology in schizophrenia. It lists 30 symptoms, which should be assigned a point value from a 7-point scale of severity, where 1 means absent symptom, and 7 means symptom of extreme intensity. The higher the index, the more severely the symptom of the disease is felt by the patient. One of the most frequently used scales in the assessment of the symptomatology of schizophrenia [9].
- MCII (Mental Contrasting and Implementation Intentions) – a type of effective and easy to apply strategy conducive to the implementation of intended activities.

When self-regulatory mechanisms are used, it becomes possible to solve problems related to achieving the goal, e.g., starting work, overcoming problems and obstacles during work. The discussed action strategy consists of the following key elements: defining the goal/wish, visualizing the future positive effects of achieving the goal, comparing the expected positive effect of the intended action with the greatest difficulty in achieving it, presenting helpful tools/instruments in achieving the goal and determining when, where and how the goal is to be achieved. Due to changes in cognitive and motivational processes, it becomes possible to increase the effectiveness of action in critical situations and create associations between the goal, obstacles to its achievement and the instruments necessary for its implementation to achieve the intended action. The patient's systolic blood pressure increases and he becomes energized. Taking into account the current scientific reports and the application of the above-mentioned strategy, e.g., in patients suffering from chronic pain or in populations with impaired cognitive functions, it may also be effective in schizophrenics to increase physical activity [10].

Treatment of schizophrenia aims to alleviate the symptoms of the disease, but it does not eliminate the factors underlying the etiopathogenetic basis of schizophrenia, which is classified as incurable. Treatment should be initiated immediately after diagnosis; it is a long-term procedure, sometimes for the rest of the patient's life [3]. The treatment of schizophrenia can be divided into pharmacological and non-pharmacological. The mainstay of treatment of patients with schizophrenia is pharmacological treatment. Six areas are taken into account when selecting drugs [11]:

- first-episode schizophrenia;
- acute exacerbation;
- relapse prevention and maintenance care;
- treatment-resistant schizophrenia;
- clozapine-resistant schizophrenia;
- specific domains of symptoms [11].

The most commonly used drugs are antipsychotic drugs (APDs), for example, olanzapine, risperidone, quetiapine, amisulpride, ziprasidone, and aripiprazole [11]. There are two stages of treatment, referred to as early treatment (alleviation of acute symptoms of the disease, improvement in functioning in society) and late treatment (balancing deficiencies and dysfunctions, determining the scope of assistance).

One of the classifications of the types of non-pharmacological treatment in schizophrenia distinguishes:

- neurorehabilitation,
- psychoeducation,
- psychotherapy,
- physical activity,
- artistic activity [12].

Alternative non-pharmacological methods of treating schizophrenia are acupuncture, music therapy and psychotherapy. According to Bosch et al. [13], acupuncture is

a method of treating sleep disorders and negative symptoms of chronic schizophrenia. As suggested by Geretsegger et al. [14] in their work, music therapy is an element supporting basic therapy, improving the general mental state, social functioning and quality of life. The psychotherapeutic methods used include cognitive-behavioral therapy (it causes a slight and non-permanent improvement in functioning) [15], an intervention based on mindfulness (related to the improvement of clinical parameters in the course of schizophrenia, increasing motivation) [16] or positive psychotherapy of psychosis (a new method based on the "subjectivity of the human individual" – creating and living in symbiosis with one's own identity, self-development, reading one's own experiences and emotional states) [17].

The most effective non-pharmacological intervention remains a combination intervention as part of "lifestyle psychiatry", which consists of four components:

(1) physical exercise;
(2) a wholesome way of nutrition;
(3) quitting smoking;
(4) an adequate amount of sleep [18-20].

The leading forms of non-pharmacological support to basic treatment remain diet therapy and physical activity [17].

Diet therapy

Psychiatric dietetics is still a relatively new field of dietetics. Existing reports suggest an improvement in health in the neurological, cognitive and emotional areas in the course of psychiatric diseases, including schizophrenia.

In people suffering from schizophrenia, certain eating patterns can be identified [21]. Such people are characterized by the use of a diet based on unhealthy, convenient and highly processed food with an easy-to-chew structure. Their meals are characterized by irregularity – omitting selected meals, accumulation of most of the food consumed in the evening hours. Moreover, one study indicated a greater percentage of people with psychosis among vegetarians who may be deficient in vitamins, especially vitamin B12 [21]. The diet of people suffering from schizophrenia is also characterized by a greater supply of refined sugars, total fat consumption, and lower consumption of omega-3 and omega-6 fatty acids, fruits and vegetables, and thus a smaller amount of vitamins and minerals in the diet (B vitamins – B6, B12; folic acid, vitamin C, as well as zinc and selenium). Schizophrenics are at greater risk of allergies and food intolerances due to the poor composition of the intestinal microbiome and phytochemicals (L-theanine, sulforaphane, and resveratrol). Nutritional intervention in these patients should consist in providing deficient dietary components mentioned earlier and amino acids (serine, lysine, glycine, tryptophan) [21]. Another study points to under-consumption of fish and over-consumption of alcohol by people diagnosed with schizophrenia, suggesting another intervention to improve the quality of life and cognitive functions in these people [18].

Physical activity

The World Health Organization published recommendations for physical activity in 2020 depending on age group and health status. A novelty is the separation of recommendations for physical activity for people suffering from chronic diseases. According to the WHO [22], one should:

- "engage in muscle-strengthening activities at moderate or greater intensity involving all major muscles on 2 or more days a week";
- "perform varied multicomponent physical activity that emphasizes functional balance and strength training at moderate or greater intensity on 3 or more days a week";
- "increase moderate–intensity aerobic exercise to more than 300 minutes or do more than 150 minutes of vigorous–intensity aerobic physical activity or an equivalent combination of moderate – and vigorous–intensity activity throughout the week" [22, p. 53].

Current literature reports show a significant relationship between physical activity and the improvement of the clinical picture in the course of schizophrenia – positive and negative symptoms, quality of life, functioning, cognitive functions, plasticity of the hippocampus and its volume in the brain and remission of symptoms related to depression. It is beneficial to combine physical training with cognitive training [23-25]. A systematic review conducted by Tumiel et al. [26] shows that physical activity including aerobic training with complementary resistance training is crucial in people with schizophrenia due to the fact that these people are highly exposed to the development of risk factors for metabolic and cardiovascular diseases. The literature review by Lebieck et al. [27] also provides information on the possible positive impact of physical activity on both cardiovascular and respiratory fitness as well as cognitive functions and psychopathological symptoms of the disease. Importantly, the authors indicate that there is no evidence of adverse effects resulting from physical activity interventions in schizophrenia patients [27]. Regular physical activity as a proven form of therapy supplementing the treatment of schizophrenia is described in the study of Stubbs et al. [28], which is the position of the European Psychiatric Association. The authors indicate that monitored physical activity improves cognitive functions and affects positive and negative symptoms of schizophrenia.

Aim

The purpose of this systematic review was to classify, compare and characterize selected physical activities that have a positive impact on the course of the treatment of schizophrenia (including its long-term effects).

Material and methods

In order to conduct a methodologically correct and high-quality systematic review of the literature, the PRISMA protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was used. [29]. The review of the scientific databases for the purposes of this study was carried out from November to December 2020.

Search strategy

Literature search for the systematic literature review was conducted in three scientific databases: PubMed/MEDLINE, Web of Science and EBSCO. The language of the publications was limited to English, French and Polish. The key words: schizophrenia, schizophrenia symptoms, physical activity, physical training, physical exercises, were used to search each of the above-mentioned scientific databases, taking into account linguistic changes. An example of a search strategy is presented in Table 1. Bibliographies of searched items and the rest of the sources were manually searched.

Table 1. **Sample search strategy**

Scientific base	Keywords
PubMed/MEDLINE	(1) Schizophrenia
	(2) Schizophrenia symptoms
	(3) Symptoms of schizophrenia
	(4) (1) OR (2) OR (3)
	(5) physical activity
	(6) physical training
	(7) physical exercises
	(8) (5) OR (6) OR (7)
	(9) (4) AND (8)

Inclusion and exclusion criteria

The items found were verified and qualified for further analysis if they met the following inclusion criteria: randomized controlled study, observation period equal to or longer than three months, control group composed of people with schizophrenia. Articles were excluded from the review if the inclusion criteria were not met and if they were published before 2015. Any misunderstandings between the authors regarding the inclusion of individual works were resolved by consensus following a discussion.

Results

Selection of works

Searching scientific databases, bibliographies of found items and other potential sources yielded 330 items. After verifying the full texts of papers, applying the inclusion and exclusion criteria, 17 articles were qualified for the final analysis, which is the qualitative analysis. Figure 1 shows a diagram of the workflow of found papers broken down into individual stages of work verification.

Description of the included works

All qualified studies were randomized controlled studies, which included a total population of 1,206 people. The most common age group subjected to the training intervention was the age group between 30 and 50 years of age. Most of the studies followed the study group and the control group within 3 months from the start of the intervention, while the follow-up longer than 6 months was carried out only in 4 of

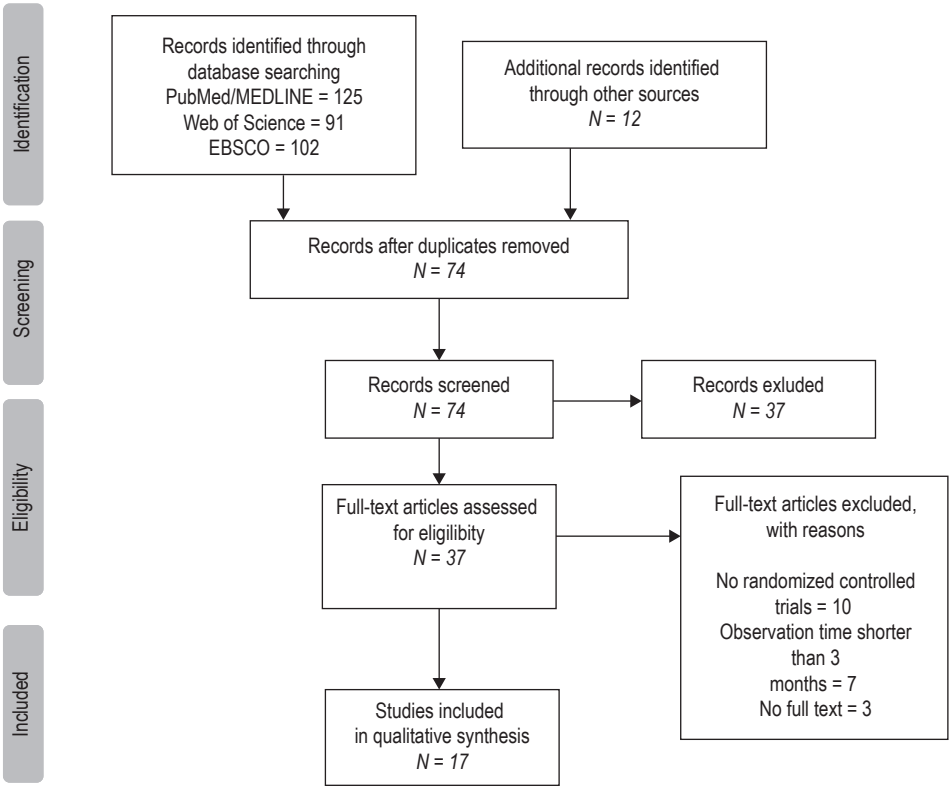

Figure 1. **Workflow diagram used for the review**

the studies qualified for the final analysis. The frequency of training, which was conducted in the study groups, most often included 3 trainings during the week, and the entire training period was typically 12 weeks. Most of the qualified studies concerned the improvement of fitness, cardiovascular parameters and motor deficits [30-37]. Seven articles focused on the assessment of cognitive and social functions, as well as motivation and perseverance [10, 32-34, 36, 38, 39], while the assessment of the severity of symptoms on the PANSS scale was examined in five articles [40-44]. Two studies also assessed changes in the volume of the hippocampus [36, 45]. The results are included in Table 2.

Discussion

Selected types of physical activity in patients with schizophrenia

In people with schizophrenia, the course of the disease and symptoms of apathy, decreased initiative and motivation make it difficult to maintain regularity in taking up activity. Therefore, it seems reasonable to create solutions supporting the regularity of physical exercise in people diagnosed with schizophrenia. The confirmation of the above is the research conducted by Brobakken et al. [30], in which, in addition to the 12-month regular interval training, the study group was provided with a system informing about the upcoming training (by means of SMS text message or a telephone call), as well as a series of lectures on the health-promoting effects of physical activity. The effectiveness of the intervention is demonstrated by a statistically significant improvement in VO_{2max} and HR_{max} values compared to the control group [30].

The use of high-intensity interval training to improve cognitive functions was the subject of research by Bang-Kittilsen et al. [38]. Both the study group and the control group showed a statistically significant improvement in some of the MCCB battery test subscales. However, high-intensity interval training has not been shown to improve cognitive function more than the use of active video games. Comparing the two groups, the authors did not observe statistically significant differences, although they explained it with a relatively short observation period and the need to conduct research on a larger population [38]. Shimada et al. [33] also assessed the effect of physical training on the improvement of cognitive functions. The group of people who received standard treatment was compared with the group that received 12 weeks of aerobic training in addition to standard treatment. The authors found no statistically significant differences between the groups after serving the 12-week training, although the observation time of the respondents was quite short and covered only the training period. It is noteworthy that no adverse reactions related to exercise intolerance were observed among the study group [33]. Improvement of cognitive functions after 12 weeks of aerobic training was also observed in the study by Kimhy et al. [34]. A comparative analysis of the study group and the control group showed that a statistically significant improvement concerned the function of social competence and the function of visual learning.

Table 2. **Summary of physical activity interventions in schizophrenia**

No.	Source	Characteristics of the population		Intervention	Observation period	Main results
		N	Age			
1.	Brobakken et al., 2020 [30]	B = 25 C = 23	B = 34(30-38)* C = 36(31-41)*	A single training session, which included aerobic treadmill training, lasted 35 minutes and consisted of a 5-minute warm-up (at 70% HR_{max}), followed by 4 rounds of walking/running at 85-95% of HR_{max}, between which there was an active break of 3 minutes. The training session ended with a 5-minute cool down (at the level of 70% HR_{max}). The intensity was increased by 0.1 km/h or by 1% of the incline of the treadmill to the ground. Training sessions were performed twice a week for a year. In the study group, patients were reminded about the training session by telephone or SMS messages and each session was supervised. In the control group, only 2 sessions were supervised, while the rest were based on previous patient instruction.	12 months	In the control group, a statistically significant increase in VO_{2max} and HR_{max} was observed after 3, 6 and 12 months of training in comparison to the control group. There were no statistically significant changes in the value of the respiratory exchange index and the value of oxygen pulse in the study group and the control group.

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2.	Bang-Kittilsen et al., 2021 [38]	B = 43 C = 39	B = 36.6±14.3 C = 37.5±13.8	Both the test group and the control group participated in 24 training sessions, each lasting 45 minutes (2 sessions per week for 12 weeks). In the study group, the training session consisted of an 8-minute warm-up followed by a 4-minute run/walk (or cycling on an ergometer if unable to walk/run on the treadmill) with an intensity of 85-95% of HR_{max}, between which there were 3 minutes of active rest. The training session ended with a 5-minute cool down. In the comparison group, the training sessions consisted of active video gaming. The subjects had a choice of playing tennis, golf or bowling.	7 months	Improvement in cognitive functioning was observed in both study groups. Statistically significant results were observed in the cognitive function domains of information processing speed, attention/vigilance, working memory and visual learning. There were no statistically significant differences between the test group and the control group.
3.	Andersen et al., 2020 [31]	B = 43 C = 39	B = 36.6±14.3 C = 37.5±13.8	Both the test group and the control group participated in 2 training sessions per week. In the study group, the training sessions were of high-intensity and consisted of an 8-minute warm-up, followed by a 4-minute run/walk (or cyclo-ergometer cycling if walking/running on a treadmill was not possible) with an intensity of 85-95% of HR_{max}, between which there was a 3-minute active break. The training sessions ended with a 5-minute cool down. In the comparison group, the training session consisted of active video gaming (playing tennis, golf or bowling).	3 months	After 12 weeks of training, no statistically significant differences were observed in the values of VO_{2max} and other parameters determining the efficiency of the respiratory system in both groups. Moreover, no statistically significant differences were observed between the test group and the control group.

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4.	Su et al., 2016 [32]	B = 30 C = 27	B = 37.64±8.23 C = 36.68±8.33	Interventions in both groups included 3 training sessions within a week for 3 months. In the study group, a single training session consisted of a 5-minute warm-up, 30 minutes of aerobic exercise with the intensity of 55-69% HR_{max}, adjusted to the age and abilities of the subject and a 5-minute cool down. In the control group, the training session consisted of a 3-minute warm-up, 25 minutes of stretching and balance exercises, and 2 minutes of cooling down. A trainer was present in both groups during the training session.	6 months	A statistically significant improvement in the speed of information processing and mindfulness was observed in the study group compared to the control group. However, this improvement had taken place after the end of the training period, and 3 months after the end of the training, no statistically significant differences between the groups were observed. Both after 3 months from the start of the study, and 3 months after the end of the training period, no statistically significant differences were observed in VO_{2max} values in both groups.
5.	Shimada et al., 2019 [33]	B = 16 C = 16	BI	Standard treatment and aerobic exercises were used in the study group, while only standard treatment was used in the control group. Standard treatment included meetings with a psychiatrist, pharmacotherapy and the care of an occupational therapist. Aerobic exercise sessions included 60-minute training at the level of 60-80% VO_{2max} performed twice a week for 3 months.	3 months	There were statistically significant differences between the groups only in the scales of the BACS questionnaire, demonstrating the improvement of cognitive functions in the study group.

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6.	Massa et al., 2020 [39]	B = 21 C = 17	B = 52.52±6.66 C = 53.18±10.27	The participants were subjected to 12-week training, with the frequency of 3 training sessions per week. In the study group, the training session included training on a bicycle ergometer. The training intensity was initially 50% of heart rate reserve, but was increased at a rate of 5% of heart rate reserve per week to 80% heart rate reserve. The duration of the training session was initially 20 minutes, but was increased by 5 minutes per week until the 45-minute training session was reached. Stretching exercises and balance exercises were performed in the control group, lasting the same amount of time as in the control group.	5 months	In the 400-meter walk test, a statistically significant decrease in speed was observed in both groups, while the decrease in the control group was greater than in the test group. In the study group, a statistically significant improvement in cognitive functions was observed in all subscales of the MCCB battery test compared to the control group. In the case of the remaining scales and tests, no statistically significant changes were observed.
7.	Wang et al., 2018 [40]	B = 33 C = 29	B = 38.30±8.34 C = 38.72±8.62	The participants were subjected to a 12-week training period in which training sessions were held at least 3 times a week under the supervision of a trainer. In the test group, aerobic training was used, where a single training session consisted of a 5-minute warm-up, a 30-minute main part and a 5-minute cool down. In the control group, training consisting of stretching and balance exercises was used, where a single training session lasted about 30 minutes.	6 months	A statistically significant decrease in the intensity of negative symptoms and improvement of the score on the general psychopathology scale in the study group both after the completion of the 12-week training session and after 3 months from the end of the intervention, compared to the control group.

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8.	Kimhy et al., 2015 [34]	B = 16 C = 17	B = 36.56±10.37 C = 37.24±9.85	The test group was subjected to standard treatment with a 12-week training period in which training sessions were held 3 times a week under the supervision of a trainer with an initial intensity of 60% HR_{max} increasing every 5% per week until an intensity of 75% HR_{max} was achieved. A single training session consisted of a 10-minute warm-up, 45-minute main part and 5-minute relaxation. The main part consisted of exercises on a treadmill, stationary bike or active video games. Standard treatment was applied in the control group.	3 months	A statistically significant increase in cognitive functioning was observed in the study group compared to the control group, especially in the function of social competence and visual learning. Moreover, a statistically significant improvement in the VO_{2max} value was observed in the test group.
9.	Ho et al., 2016 [35]	B = 51 C = 51	B = 52.4±9.6 C = 54.7±8.0	Each of the groups participating in the study underwent a 12-week training period, during which the subjects trained once a week for 60 minutes. Part of the study group performed tai-chi training, which was instructed by trainers. The rest of the study group performed aerobic training. The training intensity in both groups was maintained at 50-60% VO_{2max}. Pharmacotherapy was used in the control group and physical activities of choice were encouraged.	9 months	In the tai-chi group, a statistically significant decrease in motor deficits and cortisol levels was observed. Both tai-chi and aerobic training led to a statistically significant improvement in motor coordination. There were no differences between the type of training performed.

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10.	Kang et al., 2016 [41]	B = 118 C = 126	B = 46.4±11.9 C = 45.4±12.3	In the study group, apart from pharmacotherapy, social skills training and tai-chi training were conducted. Only pharmacological treatment was used in the control group. The training session in the study group lasted 45 minutes and was carried out twice a month for 12 months.	12 months	In the study group, after 12 months of tai-chi training, a statistically significant improvement was shown in all the PANSS questionnaire values. No statistically significant changes were observed in the control group.
11.	Woodward et al., 2018 [36]	B = 12 C = 15	B = 30.1±6.9 C = BI	The test group and the control group were subjected to a 12-week physical training, which was carried out 3 times a week. In the study group, aerobic training was used, which consisted of a 10-minute warm-up, a 10-minute main part and a cool down. The intensity was 40-59% HR_{max}. In the control group, a 30-minute weight-bearing training was conducted, also preceded by a warm-up and finished with a cool down.	3 months	In both groups, after 12 weeks of training, a statistically significant improvement in social function was observed in the SOFAS questionnaire. Moreover, a statistically significant increase in the volume of the hippocampus was observed. There was no statistically significant improvement in VO_{2max} value.
12.	Papiol et al., 2019 [45]	B_1 = 20 B_2 = 23 C = 21	BI	The first study group (B1), which included people diagnosed with schizophrenia, underwent endurance training with the use of cycloergometers. The second study group (B2) consisted of healthy people subjected to training as in group B1. In the control group, which included people diagnosed with schizophrenia, a moderate level of physical activity was performed using table soccer. In each group, physical activity included three 30-minute training sessions a week for 3 months.	3 months	In group B1, a statistically significant increase in the volume of the hippocampus area was observed. In the B2 group, no statistically significant changes were observed within the hippocampus, similarly as in the control group.

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13.	Svatkova et al., 2015 [37]	B = 33 C = 48	B = 28.8±7.4 C = 27.7±6.4	Interventions in both groups included physical exercises lasting 1 hour, performed twice a week over a period of 6 months. The study group used physical exercises and occupational therapy (painting, reading, computer classes). Healthy people were also divided into 2 groups (physical exercise or life-as-usual). Physical activity was monitored for 24 hours with the help of SenseWear Armbands and a questionnaire.	6 months	There was a statistically significant increase in FA (a measure of brain connectivity) and a statistically significant increase in cardiovascular capacity in the group of aerobic exercisers.
14.	Silva et al., 2015 [42]	B_1 = 12 B_2 = 9 C = 13	B_1 = 32.91±2.28 B_2 = 33.55±2.63 C = 33.36±12.19	The study group was divided into two subgroups: B1, performing strength training, and B2, performing endurance training. Both subgroups participated in a 20-week training period. Training sessions were held twice a week. Depending on the age and health of the subjects, increasing the intensity and type of exercise was done individually. The control group was subjected to standard pharmacological treatment.	5 months	There were statistically significant changes in groups B1 and B2 in the value of the PANSS questionnaire. Group B1 showed a decrease in the intensity of negative symptoms and an increase in the strength value during the test of pressing the weight over the chest.
15.	Curcic et al., 2017 [43]	B = 40 C = 40	B = 39.95±9.51 C = 41.75±9.45	The study group, apart from pharmacological treatment, participated in the training 4 times a week. A single training session lasted 45 minutes and consisted of: a 5-minute warm-up, 30-minute brisk walking or jogging, and 10 minutes of cooling down. Only pharmacological treatment was used in the control group.	3 months	After 12 weeks, the study group showed a statistically significant increase in the VO_{2max} value compared to the value before the start of training and compared to the control group. A difference was also observed in the overall score of the PANSS questionnaire in favor of the study group.

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16.	Sailer et al., 2015 [10]	B = 19 C = 17	30.89±11.41 ***	Both the test group and the control group underwent running training. A single workout lasted 40 minutes and consisted of a 5-minute warm-up, 30 minutes of running and 5 minutes of cooling down. In the study group, goals were set using the MCII method, while in the control group, no goals were set. Progress was assessed every 2 weeks from the start of the study and compared to the pre-study results.	4 months	It was observed that the use of the MCII method increased the motivation, attendance and perseverance of the study group compared to the control group.
17.	Loh et al., 2015 [44]	B = 52 C = 52	B = 46±14 C = 53±11	In the study group, walking training was conducted 3 times a week for three months with progressive intensity, where in the first month a single training session lasted 30 minutes and consisted of a 5-minute warm-up, 20 minutes of walking and 5 minutes of cooling down. However, in the third month, the main part of the training lasted 40 minutes. Standard treatment was applied in the control group.	3 months	After three months, statistically significant changes in the symptoms included in the PANSS questionnaire were observed, i.e., reduction of negative symptoms and improvement in the overall score.

* – min.-max. value; ** – IQR; *** – common value for the test group and the control group; B – test group; C – control group; HR_{max} – maximum heart rate; VO_{2max} – maximal aerobic capacity; BACS – Brief Assessment of Cognition in Schizophrenia; MCCB – MATRICS Consensus Cognitive Battery; PANSS – Positive and Negative Syndrome Scale; SOFAS – Social and Occupational Functioning Assessment Scale; MCII – Mental Contrasting and Implementation Intentions; FA – measure of brain connectivity of physical training on the improvement of cognitive functions.

Moreover, a statistically significant increase in the VO_{2max} value was observed in the test group after the end of the training cycle [34]. Using the medical data of people from the Bang-Kittilsen et al. [38] study, Andersen et al. [31] analyzed the results of VO_{2max}, FEV1, FVC, MEF50 measurements. No statistically significant differences between the groups were observed after completion of the 12-week intervention [31], similarly as in the study by Bang-Kittilsen et al. [38]. The authors claim that research on the influence of interval training on endurance parameters should last longer than the accepted 12 weeks. They also indicate the need to increase the frequency of training sessions and the number of intervals during training, and also point to the possibility of no improvement resulting from the type of medications taken [31, 38]. The study of Su et al. [32] also indicates the need for a multi-week physical training intervention. The authors showed no statistically significant differences in the values of VO_{2max} and HR_{max} between the study group that was subjected to 12 weeks of aerobic training and the group that performed only stretching and balance exercises. A similar relationship in the lack of differences between the groups was observed in the analysis of cognitive functions assessed with the use of the MCCB test [32]. The research of Mass et al. [39] also unequivocally indicates that interventions involving the implementation of aerobic training should last many months rather than weeks. The reason is the inconclusive results of the 400-meter walk test, because both groups showed a decrease in walking speed after 12 weeks of training compared to the state before the intervention. It is worth noting, however, that the study was completed by only 40% of the respondents, although the authors do not associate this fact with poor tolerance of physical effort. The only statistically significant results in the field of research on cognitive functions include the analysis of the MCCB tests, which showed that the study group showed improvement in contrast to the control group after 12 weeks of intervention [39]. The influence of aerobic training on the severity of schizophrenia symptoms was investigated in the work of Wang et al. [40]. The assessment of symptoms was performed using the PANSS questionnaire. A statistically significant improvement was observed in the form of a decrease in the intensity of negative symptoms in the group subjected to aerobic training – both directly after the end of the intervention and 3 months after its completion. The statistically significant result also applied to the total PANSS score [40].

In another body of research, Silva et al. [42] showed that in patients with schizophrenia, resistance training and concurrent endurance training should be used in order to improve muscle strength as well as physical, functional and mental health. In their study carried out on a group of 34 subjects, the impact of strength resistance training of individual muscle groups (N = 12) and running training with the use of a treadmill (N = 9) was considered. In both cases, the presented forms of activity had an impact on reducing the amount of antipsychotic drugs taken by patients and reducing the frequency of schizophrenia symptoms based on the PANSS scale. A weakness of the study was the small sample size and the differences in doses of the drug [42]. Two datasets investigated the effects of jogging on reducing and alleviating symptoms of schizophrenia [10, 43]. Both studies found a positive effect of this physical activity on the physical and mental health of patients. Sailer et al. [10] also used in their re-

search the MCII theory (Mental Contrasting with Implementation Intentions), which consists in setting goals and obstacles in achieving them. Consequently, it forces the respondents to find a way to eliminate the obstacle in order to achieve the goal. This method supports the achievement of goals through unconscious cognitive and motivational processes [10, 43]. If the test groups are not able to jog, tests based on walking training were also introduced. The study by Loh et al. [44] initially qualified 252 people; after introducing the exclusion criterion age >65 years old, 137 people were disqualified and 11 did not consent to participate in the study. In the final three--month study, 104 subjects participated, divided equally by randomization into the test group in the walking exercise program (N = 52) and the group with standard treatment (N = 52). When training 3 times a week with gradual extension of training sessions, a decrease in schizophrenia symptoms, an improvement in the quality of life during the research and a better well-being of the respondents was demonstrated [44]. The same conclusions were put forward by Curcic et al. [43] in their study, in which the participants engaged either in running or brisk walking for 45 minutes 4 times a week. All studies using both walking and running in the research methodology showed positive effects of such training on patients with schizophrenia. The authors agree that these physical activities are easy and inexpensive to implement. The articles show that walking for at least 30 minutes three times a week has significant results in the prevention and treatment of schizophrenia comorbidities and can help people reintegrate into society.

Research on the influence of tai chi training on the improvement of motor coordination and improvement of cognitive skills was carried out on a group of people with diagnosed schizophrenia. A study by Ho et al. [35] included the selection of a group of patients with schizophrenia using tai chi training and a control group of patients performing training based on physical exercises of choice. In both cases, the common denominator was the achievement of 50-60% of VO_{2max} monitored with a pulse oximeter during training in the patients of both groups and a cycle of 2 trainings per week over a period of 3 months. As in the research by Kang et al. [41], tai chi training was based on the Wu-style Cheng-form Tai-chi chuan system based on 22 movements. When analyzing the results of Ho et al. [35], a statistically significant decrease in the motor deficit and blood cortisol level was observed. Both the tai chi intervention and exercises of choice led to a statistically significant decrease in motor coordination deficit. Referring to the improvement of cognitive skills, studies by Kang et al. [41] proved that practicing tai chi training and adhering to the social skills development program has a statistically significant influence on the change of the PANSS value, including improvement of positive symptom scores, negative symptoms and psychological quality of life.

The role of physical activity in the functioning of the central nervous system in patients with diagnosed schizophrenia

In a broad clinical perspective, schizophrenia is associated with neurocognitive disorders as well as cardiovascular and metabolic complications. The introduction

of physical activity to the therapeutic process may be an additional factor improving the functioning of patients suffering from schizophrenia. An argument supporting the above-mentioned statement may be the study conducted by Woodward et al. [36] whose main aim was to determine the influence of physical activity on the increase of hippocampal plasticity. In the study, the patients were divided into two groups: an aerobic training group (49% – 70% HR_{max}) and a weight-bearing training group for a period of 12 weeks. The effectiveness of the conducted intervention is evidenced by a statistically significant improvement in both groups of social functioning according to the SOFAS scale. A statistically significant increase in hippocampal volume was also noted without statistically significant changes in VO_{2max} capacity. Papiol et al. [45] also assessed changes in the volume of the hippocampal field resulting from physical activity in patients with schizophrenia. Individuals with schizophrenia playing table soccer were compared with the group of patients performing aerobic exercises (50% – 70% HR_{max}), as well as healthy people performing the same type of aerobic exercise. As in the case of the research by Woodward et al. [36] respondents performed three 30-minute training sessions a week. It should be noted that in patients with schizophrenia who conducted aerobic training, a statistically significant increase in the volume of the hippocampal field signal was noticed, which indicates an increase in its volume. In the case of healthy participants, no statistically significant changes were observed, as was the case with the group playing table soccer.

The impact of aerobic training on neurocognitive skills was investigated in the work of Kimhy et al. [34]. Participants were randomized to the group attending aerobic training or the control group receiving standard treatment with exercises of choice. As in the case of the research by Woodward et al. [36] and the experience of Papiol et al. [45], the patients conducted training with the intensity of 60% HR_{max}, and training sessions were conducted three times a week. Kimhy et al. [34] observed a statistically significant improvement in VO_{2max} compared to the control group, as well as a statistically significant improvement in cognitive skills in aerobic training. Also, Svatkova et al. [37] investigated the potential influence of a psychological intervention including aerobic training on the formation of neural connections in the central nervous system. The intervention lasted six months, and the subjects were assigned to groups using physical exercises and group activities (art classes). A statistically significant increase in FA (refractive anisotropy) and a statistically significant increase in cardiovascular and respiratory efficiency were noticed in the aerobic training group.

Limitations of the research

This systematic literature review has several limitations. One of them is the linguistic restriction, which limited the search for articles to Polish, English and French. In this way, papers published in Spanish and Asian languages were omitted, which could have met the criteria of this review. Another limitation is the focus of the authors only on the influence of physical activity on the condition of patients with schizophrenia, ignoring the influence of pharmacotherapy on the psychomotor performance of the study

population. Moreover, the high level of heterogeneity of the included papers means that it is not possible to carry out a meta-analysis of the results of the selected studies.

Conclusions

1. General physical activity performed by patients with schizophrenia is associated with the alleviation of the perceived symptoms of the disease and the improvement of patients' well-being.
2. Trainings conducted in the form of group classes support people with schizophrenia in terms of interpersonal integration and in returning to fulfilling social functions.
3. In the case of patients suffering from schizophrenia struggling with deficits in motor coordination at the same time, it is proposed to use training based on tai chi principles. However, in groups of patients who have difficulties remembering information and articulating social needs, it is recommended to use aerobic training involving at least 60% of HRmax.
4. The recommended procedure is to introduce physical activity into the standard treatment of patients with schizophrenia, which reduces the risk of comorbidities such as abdominal obesity, improves blood pressure and metabolic parameters, as well as reduces the perception of symptoms typical of this illness.

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