

Physical activity in children with juvenile idiopathic arthritis: a review of recent literature

Agnieszka Małgorzata Wosiak , Aleksandra Stasiak , Elżbieta Smolewska 

Department of Paediatric Cardiology and Rheumatology, Central Clinical Hospital of the Medical University of Lodz, Poland

Abstract

Juvenile idiopathic arthritis is the most common rheumatic chronic disease in children, typically characterised by joint pain and swelling, fatigue, stiffness, muscle weakness and movement restrictions. As a consequence, children are exposed to bone atrophy, physical disability, social separation and reduced quality of life. It is believed that early implementation of targeted pharmacological treatment such as nonsteroidal anti-inflammatory drugs, disease-modifying agents and biological therapies is necessary to ensure full recovery. Recent recommendations emphasize the importance of nonpharmacologic treatments, e.g. nutrition, supplements and physical or occupational therapies, as an important component of a complex therapy. In this article, we review recent studies, summarising the impact of different physical interventions on children with juvenile idiopathic arthritis on muscle, bone and psychological function to provide a basis for more detailed recommendations of physical activity for children with arthritis.

Key words: physical activity, movement disorder, rehabilitation in juvenile idiopathic arthritis, juvenile idiopathic arthritis.

Introduction

Juvenile idiopathic arthritis (JIA) is a heterogeneous group of chronic rheumatic diseases that affect children under the age of 16, and the diagnosis is made when joint inflammation persists for at least 6 weeks [1]. The most common symptoms include joint swelling, pain, stiffness, muscle atrophy and weakness, resulting in movement abnormality and physical restrictions [2]. The subclassifications include systemic-onset arthritis, oligoarthritis, polyarthritis rheumatoid factor positive, polyarthritis rheumatoid factor negative, psoriatic arthritis, enthesitis-related arthritis (ERA) and undifferentiated arthritis [1]. The current recommendations suggest an early targeted pharmacological treatment such as nonsteroidal anti-inflammatory drugs, disease-modifying agents (e.g. methotrexate, sulfasalazine, hydroxychloroquine) and biological therapies (e.g. tumour necrosis factor inhibitors, tocilizumab, anakinra, canakinumab, or recently approved secukinumab, baricitinib and tofacitinib) [3–6]. However, recent recommendations also emphasize the role of nonpharmacologic treatments, e.g. nutrition, supplements and physical or occupational therapies [7].

The general physical activity (PA) recommendations for children include 60 minutes of moderate to vigorous activity daily, with vigorous activity performed at least 3 days per week. The same guidelines are applicable and should be implemented by children with JIA [8]. Children with JIA have lower physical fitness [2, 9] and spend less time engaging in moderate-to-vigorous PA [2, 10, 11]. Consequently, joint contracture, muscle weakness and bone atrophy persist [10, 12] and, what is more, it can result in reduced functioning and quality of life (QoL) [12]. That is why, ideally, the physical treatment should be started in the early stage of the disease, before significant functional disability and joint deformity occur [11].

The recommended activities for children with JIA include interventions that maintain or improve joint range of motion (particularly for contractures), improve strength, reverse functional deficits, improve endurance, prevent injury, and promote improved participation in activities of daily living, family routines, and occupations [7]. Therefore, PA such as Pilates, water exercises, bicycle, strengthening and stretching exercises are often proposed [2, 11].

Address for correspondence

Agnieszka Małgorzata Wosiak, Department of Paediatric Cardiology and Rheumatology, Central Clinical Hospital of the Medical University of Lodz, 36/50 Sporna St., 91-738 Lodz, Poland, e-mail: agnieszka.poniecka@umed.lodz.pl

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Despite evidence of positive benefits of PA for children with JIA, the fear of physical therapies still occurs among children and their parents [8, 13]. The success of physical treatment depends on education and detailed instructions how to properly perform exercises as well as on motivational strategies applied to encourage children to participate in PA [8]. It is also important for the clinician to suggest their patients PA that is appropriate for the disease state.

Material and methods

The objective of this article was to compare the impact of various types of PA on JIA. We performed an extensive literature review of PubMed and Scopus databases using “physical activity in children with juvenile idiopathic arthritis” and “rehabilitation in juvenile idiopathic arthritis” as key words. The literature review inclusion criteria included studies that evaluated a physical therapy led exercise intervention in children with JIA. Only articles written in English language and published in the last 20 years were included in the further analysis.

Results

The literature search resulted in gathering 14 articles from the years 2003 to 2022. The participants in the included studies were children diagnosed with JIA according to the International League of Associations for Rheumatology (ILAR) criteria, in the stable phase of the disease. In 5 publications out of 14, there was no information about diagnostic criteria [13–17]. The age range varied between 5 and 21 years old. Both sexes participated in the studies, with female predominance. The most common subtype of JIA was polyarthritis. Other subtypes such as oligoarticular or ERA were also common (Table I) [13–26]. Various PAs were performed, such as strengthening exercises [16, 20, 23, 24, 26], stretching [13, 20, 26], aerobic [13, 16–18, 23–25], water programmes [14, 15, 21, 22] and Pilates exercise [19], by the participants of the studies. An interesting study was published by Arman et al. [18], where activities of daily living were practised using video-based games. The sports programmes were mostly conducted by physiotherapists. Two studies relied on home-based exercise programmes [23, 26]. The studies focused on reducing pain, improving muscle strength and flexibility, joint mobility, aerobic capacity, bone mineral density and general QoL (Table II).

Pain

One of the most aggravating symptoms of arthritis, leading to disability in patients, is pain. According to several studies, children with JIA report joint pain

even after the implementation of the dedicated treatment [27]. Because of the multifactorial origin of pain in chronic diseases, the treatment should also include compound, interdisciplinary methods [27]. In the presented studies, as long as the pain was subjective, the scientists verified the impact of PA in reducing pain, using recognized scales such as the Numeric Rating Scale (NRS) [17, 18, 20], Childhood Health Assessment Questionnaire (CHAQ) with Visual Analogue Scale (VAS) [13–15, 17–21, 24, 26] and Child Health Questionnaire (CHQ) [14, 24]. The studies showed that PA can have a significant impact on the reduction of pain, independently from selected interventions [13, 15, 18–20, 26]. The biggest difference can be observed in the Takken et al. [14] study, where the control group received no physical intervention and a 22% improvement was observed in the study group's CHAQ scale in comparison to the control group. Sansdetdt et al. [24] observed a small improvement after 12 weeks of activity, but the score in CHAQ and CHQ at baseline was also low. According to Bayraktar, there was no significant improvement after water-running exercises [21].

Muscle strength and flexibility

Muscle strength is lower in children and adolescents with JIA compared to their healthy peers. To prevent this, it is important to start early rehabilitation independently from medical treatment [22, 24]. Different PAs have been studied to improve muscle function in children with JIA. Traditional physiotherapies such as bicycle ergometer, lower extremity muscle stretching, strengthening and proprioceptive-balance exercises [20], as well as home-based exercise programmes which include jumping, handgrip exercises and resistance training, improved muscle strength, while core exercises and exercises with free weights for arms [16, 24] improved ultimate muscle strength. In his study, Houghton [28] however observed a decline in Z-scores for mechanography outcomes. Alternative activities such as water therapy may have a positive impact on muscle strength [28]. In their research, Elnaggar et al. [22] used combined resistive underwater exercises and interferential current on the peak torque of the quadriceps and hamstrings, achieving significant differences in muscle strength after 1 and 3 months of the study. Meanwhile, according to the study by Epps et al. [15], which compared integrated hydrotherapy exercises with land physiotherapy to land therapy alone, both activities had a positive impact on muscle function with lower cost in comparison to traditional physiotherapy. A significant improvement of muscle strength was observed after 12 weeks of experimental use of video-based games for activities of daily living [18]. Muscle strength was measured using

Table 1. Characteristic of participants, additional inclusion and exclusion criteria

Authors	JIA characteristic (n)	Division of groups (n)	Age	Sex	Other requirements
Arman et al. [18]	28 polyarthritis 22 oligoarthritis	Experimental group: 25 Control group: 25	6–18 years (mean: 13.16)	F: 84% M: 16%	At least one affected upper limb joint (shoulder, elbow, wrist, or finger joints), ability to read and write in Turkish, diagnosis of JIA at least 6 months before study Exclusion criteria: second rheumatic or another chronic disease, a history of mental deficit or psychological problem, or no familial consent for participation in the study
Azab et al. [19]	40 polyarthritis	Experimental group: 20 Control group: 20	10–15 years (mean age: 11.94)	F: 65% M: 35%	Polyarticular JIA, stable medical treatment Exclusion criteria: contractures or congenital anomalies, history of surgery or systemic disease, or cardiorespiratory co-morbidities and participated in regular exercises or sports activity
Baydoğan et al. [20]	4 polyarthritis RF(+) 12 polyarthritis RF(–) 11 oligoarthritis 3 psoriatic	Experimental group: 15 Control group: 15	6–18 years (mean age: 9.63)	F: 70% M: 30%	Inclusion criteria: involvement with inflammation and/or movement restrictions in the knee, and ability to attend regular training Exclusion criteria: presence of a neurologic disease, decompensated organ failure, intra-articular steroid injection or surgery in any joint, active synovitis, active arthritis psychiatric disease, and inability to understand and follow the prescribed exercise
Bayraktar et al. [21]	6 polyarthritis 10 oligoarthritis 24 ERA 2 systemic	Experimental group: 21 Control group: 21	8–18 years (mean age: 14)	F: 31% M: 69%	Inclusion criteria: involvement related to lower extremities (hip and/or knee and/or ankle) Exclusion criteria: recent surgery/intraarticular injection, an ongoing exercise programme, any cardiovascular and/or pulmonary pathologies, and/or unwillingness of the patient and/or the family to participate in the study
Elmagar et al. [22]	30 polyarthritis	Experimental group: 15 Control group: 15	Age range not provided (mean: 9.9)	No data	Polyarticular onset JIA with only bilateral knee joint involvement in their lower extremities, stable disease, no change in medical treatment course throughout the study, no structural musculoskeletal deformities in lower extremities Exclusion criteria: GC injection, any joint surgery, regular engagement in another exercise programme (aerobic or strengthening exercises), cardiopulmonary disorders, and inability to cooperate and follow instructions during both measurement and treatment sessions
Epps et al. [15]	33 polyarthritis 7 oligoarthritis 12 ERA 1 psoriatic arthritis 10 systemic 15 extended oligoarthritis	Experimental group: 39 Control group: 39	4–19 years (mean: 11.5)	F: 55% M: 45%	Inclusion criteria: diagnosis of JIA at least 3 months before study, stable pharmacotherapy, at least one active joint, core set criteria 1, at least two out of any five of the remaining core set criteria below, the physician global assessment of disease activity > 10 mm on a 100-mm VAS, the parent global assessment of well-being > 10 mm on a 100-mm VAS, CHAQ scores > 0, more than one joint with limited range of motion (joint motion reduced by at least 5° from normative range for age 58), an elevated ESR (> 5 mmHg in children and > 10 mmHg in adolescents) Exclusion criteria: patients suffered from severe systemic disease or any other condition that is unstable, quotidian fevers (daily recurrent fever for at least 2 weeks to > 39°C between spikes) Inability to give informed consent or complete questionnaires owing to language barriers Musculoskeletal surgery within the previous 6 months, neuromuscular condition which increases muscle tone, intensive physiotherapy defined as more than 1 week of daily treatment within the previous 6 months, no access to outpatient physiotherapy or hydrotherapy General hydrotherapy exclusion criteria, such as chlorine allergy
Houghton et al. [16]	2 polyarthritis RF(–) 2 persistent oligoarthritis 2 extended oligoarthritis 3 ERA 2 psoriatic 2 undifferentiated	Experimental group: 13	8–16 years (mean: 13)	F: 54% M: 46%	Exclusion criteria: receiving bisphosphonate treatment (past or planned), participation in high performance sports, training or competition > 3 hours/week, participation > 1 resistance training session per week for the past 4 months, and pregnant or planning pregnancy

Table 1. Cont.

Authors	JIA characteristic (n)	Division of groups (n)	Age	Sex	Other requirements
Sieczkowska et al. [23]	Mean disease time (years): 5.20	Not provided	10–19 years (mean: 14.5)	F: 80% M: 20%	Beside patients with JIA, in the study patients diagnosed with JSLE participated (we did not include those in the research) Exclusion criteria: cardiovascular involvement (e.g., arrhythmias, arterial hypertension, heart failure, conduction disturbances, myocarditis, or pericarditis), undernourishment, kidney or pulmonary chronic diseases, or engagement in any form of exercise for at least 3 months prior to and during the study
Sandstedt et al. [24]	29 polyarthritis 15 oligoarthritis 4 ERA or psoriatic arthritis	Experimental group: 33 Control group: 21	9–21 years (mean: 13.9)	F: 76% M: 24%	Inclusion criteria: polyarticular or extended oligoarticular arthritis, treated with methotrexate, TNF-blockers and/or prednisone, and in need of repeated GC injections of joints in the lower extremities
Sandstedt et al. [25]	31 polyarthritis 17 oligoarthritis 6 ERA or psoriatic arthritis	Experimental group: 33 Control group: 21	9–21 years (mean: 13.9)	F: 74% M: 26%	Inclusion criteria: children with polyarticular onset form or severe oligoarticular onset form, being treated with methotrexate, TNF blockers, and/or prednisone (12–58 mg), and requiring repeated GC injections in the foot, knee, or hip
Singh-Grewal et al. [13]	34 polyarthritis 7 persistent oligoarthritis 11 extended oligoarthritis 7 systemic 11 ERA 8 psoriatic arthritis 2 other	Experimental group: 41 Control group: 39	8–16 years (mean: 11.6)	F: 80% M: 20%	Stable rheumatologic condition and unlikely to require modification of therapy during the study Exclusion criteria: significant cardiac, pulmonary, or metabolic comorbidity; if they had moderate or severe hip pain while walking (judged by the patient as 3 on a 4-point scale), engaged in 3 hours per week of extracurricular PA, excluding physiotherapy pool, inability to cooperate with training or testing
Sule et al. [17]	34 polyarthritis	Experimental group: 17 Control group: 16	10–18 years (mean: 15)	F: 35% M: 65%	Stable medical therapy and GC free for 1 month prior to study enrolment. Exclusion criteria: pregnant or breast feeding, in an active flare of arthritis, had cardiac or pulmonary disease, cognitive impairment
Takken et al. [14]	29 polyarthritis 23 oligoarthritis 2 systemic	Experimental group: 27 Control group: 27	5–13 years (mean: 8.77)	F: 70% M: 30%	Inclusion criteria: a phase of remission without medication of no longer than 6 months in the absence of joint pain, tenderness and/or morning stiffness, and an erythrocyte sedimentation rate within normal limits. All patients had received a local and/or systemic arthritis-related therapy consisting of nonsteroidal anti-inflammatory drugs and/or disease-modifying anti-rheumatic drugs and/or immunosuppressive medication and/or GCs in the last 6 months prior to inclusion Exclusion criteria: a systemic disease with fever, low haemoglobin level and a general feeling of malaise; exercise contraindication by a medical specialist; a recipient of a bone marrow transplant; and not feeling confident in water
Tarakci et al. [26]	46 polyarthritis 30 oligoarthritis 4 systemic 1 psoriatic arthritis	Experimental group: 43 Control group: 38	5–17 years (mean: 10.42)	F: 54% M: 46%	Inclusion criteria: a stable dosage and continue taking their prescribed medical treatment regularly throughout the study Exclusion criteria: presence of active joints in the exacerbation period, neurological disease, metabolic disorder, decompensated organ failure, intra-articular GCs injection or surgery in any joint, > 2 hours habitual regular weekly exercise (aerobic exercises such as swimming/cycling, callisthenic exercise, or strengthening exercise), and inability to cooperate with exercise or measurement

CHAQ – Child Health Questionnaire, ERA – enthesitis-related arthritis, ESR – erythrocyte sedimentation rate, F – female, GC – glucocorticosteroid, JIA – juvenile idiopathic arthritis, M – male, n – number, RF – rheumatoid factor, TNF – tumor necrosis factor, VAS – Visual Analogue Scale.

Table II. Summary of sample size, activity intervention, evaluated parameter and outcomes

Authors	Sample size	Intervention	Exclusions	Evaluated parameters	Outcomes
Arman et al. [18]	62 JIA patients	Group 1 (control group): activities of daily living were practiced using real materials from daily life Group 2 (experimental group): activities of daily living were practiced using video-based games (Xbox 360 Kinect) for 3 days/week for 8 weeks	12 patients left the treatment for various reasons	NRS; CHAQ; dynamometer measured upper limb muscle, grip, and pinch strengths; Canadian Occupational Performance Measure, and Duruoz Hand Index	After treatment in both groups, significant changes were found in NRS, muscle strength, grip strength, CHAQ, Canadian Occupational Performance Measure, and Duruoz Hand Index ($p < 0.05$). Group 2 was statistically superior to group 1 in changes of almost all upper limb muscle strength, palmar pinch strength, Canadian Occupational Performance Measure satisfaction, and Duruoz Hand Index scores ($p < 0.05$)
Azab et al. [19]	40 JIA patients	Group 1 (experimental group): Pilates exercises (25 min each session, 3 sessions each week over 3 months) plus the conventional physical therapy programme (40 min per session, 3 sessions each week over 3 months) Group 2 (control group): conventional physical therapy (40 min per session, 3 sessions each week over 3 months)	3 children did not complete the study (1 from experimental group and 2 from the control group)	VAS; CHAQ; PedsQL; graded cardiopulmonary fitness was assessed by cardiopulmonary exercise test; peak oxygen uptake (peak VO_2), maximum heart rate (HR_{max}), and breath-by-breath minute ventilation (VE) were assessed using an electromagnetic cycle ergometer with electronic braking (ER900; Ergoline, Bitt, Germany), according to the McMaster incremental cycle protocol	Pain ($p = 0.001$), cardiorespiratory markers (all $p < 0.05$), functional ability ($p = 0.002$), and overall quality of life ($p = 0.007$) improved significantly in the experimental groups compared to the control group
Baydogan et al. [20]	36 JIA patients	Group 1: an exercise programme that included bicycle ergometer, lower extremity muscle stretching, and strengthening exercises Group 2: bicycle ergometer and lower extremity muscle stretching as in group 1 and additional proprioceptive-balance exercises All participants completed 36 supervised sessions of their respective programme in a 12-week period	No data	NRS; PROM of knee flexion and extension assessed by goniometer; a portable handheld dynamometer (Lafayette, LA) estimated muscular strength; FRT measured static balance; FBT evaluated postural balance control; CHAQ; 10-meter walking test; 10-stair climbing test	The intragroup analysis showed statistically significant improvements ($p < 0.001$) in all outcome measures except for muscle strength in the hip and ankle after strengthening exercises in Group 1 Statistically significant improvements ($p < 0.001$) were found in all outcome measures after the proprioceptive-balance exercises in Group 2 The intergroup analysis showed statistically significant improvements in all outcome measures in Group 2 except for scores of NRS-resting, NRS-activity, CHAQ, PROM, and muscle strength of hip extension and knee flexion ($p < 0.01$)
Bayraktar et al. [21]	42 JIA patients	Group 1 (exercise group): water-running, moderate-intensity exercise (60–70%), two times/week Group 2 (control group): no additional treatment other than the prescribed medication	3 patients (exercise group: 2, control group: 1) could not be assessed due to a temporary disorder of the oxygen analyser	VAS; ROM; aerobic exercise capacity (cycle ergometer); anaerobic exercise capacity (Wingate test)	Anaerobic exercise capacity was found to be improved in the exercise group ($p = 0.002$); the magnitude of the changes related to anaerobic exercise capacity was higher in the exercise group ($p = 0.024$). No changes were detected related to aerobic exercise capacity in any of the groups ($p > 0.05$)

Table II. Cont.

Authors	Sample size	Intervention	Exclusions	Evaluated parameters	Outcomes
Elnaggar et al. [22]	30 JIA patients	Group 1 (study group): resistive underwater exercises and interferential current therapy Group 2 (control group): traditional physical therapy programme The children participated actively on a regular basis three times a week for 45 minutes per session for 3 successive months	12 patients did not take part in randomization	Evaluation of peak torque of quadriceps and hamstring was carried out using the HUMAC NORM, CSMi 2009, USA Testing and Rehabilitation System, which is HUMAC computer software coupled with a proven mechanical 3 pro multi-joint systems design of the CYBEX NORM	In the control group, all measures showed significant differences ($p < 0.05$) after 1 month except peak torque of left quadriceps and pain levels, and significant differences were found after 3 months ($p < 0.05$) in all. In the study group, all measures showed significant differences after 1 and 3 months ($p < 0.05$), and there were significant differences between groups after 1 and 3 months in favour of the study group ($p < 0.05$)
Epps et al. [15]	101 children with JIA	Group 1: land-based physiotherapy Group 2: combination of hydrotherapy and land-based physiotherapy Both groups received 16 1-hour treatment sessions over 2 weeks followed by local physiotherapy attendances for 2 months	23 of these patients lost eligibility or withdrew consent before intervention	CHAQ; VAS; physicians' global assessment of disease activity; parents' global assessment of overall well-being; number of joints with limited ROM; number of active joints and erythrocyte sedimentation rate; HRQoL using the EQ-5D and QALYs; cardiovascular fitness, isometric muscle strength and patient satisfaction	Two months after intervention, 47% of patients in the combined group (Group 2) and 61% patients in the land group (Group 1) had improved disease with 11 and 5% with worsened disease, respectively. The analysis showed no significant differences in mean costs and QALYs between the two groups. The combined group had slightly lower mean costs ($-\pounds 6.91$) and lower mean QALYs (-0.0478 , 95% CI: from -0.11294 to 0.0163 based on 1,000 bootstrap replications). All secondary measures demonstrated a mean improvement in both groups, with the combined group showing greater physical improvements
Houghton et al. [16]	24 JIA patients	Group 1: a 6-month home-based exercise programme involving jumping and handgrip exercises, resistance training and one group exercise session per month	11 children did not complete 6-month programme	Lumbar spine bone mass assessed with dual energy X-ray absorptiometry; high-resolution peripheral quantitative computed tomography assessed distal tibia and radius bone microarchitecture; jumping mechanography, dynamometry measured strength muscle function; clinical outcomes (joint assessment, function, health-related quality of life) at baseline, 6 and 12 months. Adherence was assessed using weekly activity logs	Fatigue improved, but there were no other sustained improvements in muscle, bone or clinical outcomes. Adherence to the exercise programme was low (47%) and decreased over time

Table II. Cont.

Authors	Sample size	Intervention	Exclusions	Evaluated parameters	Outcomes
Sieczkowska et al. [23]	30 JIA patients and 21 JSLE patients	A home-based exercise programme consisted of a 12-weeks, three times a week aerobic and bodyweight exercise training programme	4 JSLE and 4 JIA patients discontinued due to lost interest in the intervention, personal reasons or did not complete the follow-up questionnaires – the patients were not included in final evaluation	SDQ; PedsQL; PSQI	The home-based exercise training programme was suitable for and well-accepted by adolescents with JSLE and JIA. The mean (95% confidence interval) of SDQ, PedsQL domains, and PSQI scores did not significantly change from baseline to after intervention ($p > 0.05$)
Sandstedt et al. [24]	54 JIA patients	Group 1: exercise group – a training programme 3 times a week for 12 weeks. The exercise programme consisted of rope skipping, muscle strength, core exercises and exercises with free weights for arms; PA in leisure time outside the programme was also documented in an activity diary Group 2: control group (no intervention)	10 dropouts from the control group after the randomization, as they had preferred to belong to the exercise group 6 dropouts after the first test occasion due to the families' lack of time	A handheld Grip-it device assessed muscle strength; heart rate and pain perception measured with step-test for fitness; CHAQ and CHQ	For the exercise group, muscle strength in hip and knee extensors increased after the 12-week exercise programme and was maintained in knee extensors at follow-up. There was no change in fitness tested with the individually adapted step-test. The CHQ questionnaire showed that pain was common in the exercise group and in the control group. There were only small changes in the CHAQ and CHQ after the training period
Sandstedt et al. [25]	54 JIA patients	Group 1: an exercise programme – 100 two-footed jumps with a rope, muscle strength core exercises and a load (0.5–2 kg) for the arms and shoulders, and 10 × 3 repetitions 3 times a week for 12 weeks Group 2: control group Physical exercise in leisure time outside the programme was documented in both groups	5 patients from the exercise group and 1 from the control group, were more heavily medicated and/or had long disease duration	BMD and bone mineral content were assessed with DXA and DXA Laser Calscan for the heel at the start and after 3 and 6 months	BMD values in total body, but not Z-score, increased significantly ($p = 0.012$) in the exercise group
Singh-Grewal et al. [13]	80 JIA patients	Group 1 (experimental group) – high-intensity aerobics (cardio-karate) Group 2 (control group): qigong (a gentle relaxation programme similar to tai chi) Both groups undertook a 12-week exercise programme consisting of 1 supervised session and 2 unsupervised sessions per week	11 patients (6 from the experimental group and 5 from the control group) due to lack of time	Exercise testing measuring submaximal oxygen uptake at 3 km/hour ($VO_{2\text{submax}}$) as the primary outcome; maximal oxygen uptake and peak power at the beginning and end of the programme; CHAQ	There was no difference in $VO_{2\text{submax}}$ or any other exercise testing measures between the groups through the study period and no indication of improvement. Both groups showed significant improvements in CHAQ with no difference between the groups. Adherence was higher in the control group than the experimental group

Table II. Cont.

Authors	Sample size	Intervention	Exclusions	Evaluated parameters	Outcomes
Sule et al. [17]	33 JIA patients	Group 1 (exercise group): 1–2 times per week for 12 weeks slow speed resistance exercise with individualized instruction by a certified trainer Group 2 (control group): performed home-based aerobic exercise 3 days per week for 12 weeks	In the exercise group, 9/17 (53%) completed any exercise training; of these 9 subjects, 5 (55%) completed all 12 weeks of the protocol In the control group, 8/16 (50%) reported compliance with the recommended aerobic exercise training at least 1 time per week Only 2 subjects (12%) reported exercising more than once per week	Total body lean and fat mass were measured using DXA; measurement of body weight, height, BMI; aerobic fitness was assessed by peak oxygen uptake (VO_2 peak) during cycle ergometry; a Cardinal Health V_{max} metabolic system was used to assess oxygen uptake while subjects pedalled on a stationary bicycle; isometric muscle strength measured with Biodex unit; Pain Rating Scale, Kids Fatigue Severity Scale; CHAQ	There was no significant difference between pre- and post-measurements in any category in the exercise group. There was also significantly elevated body fat in both groups with only 17% in the control group and 23% in the exercise group meeting the recommended value
Takken et al. [14]	54 JIA patients	Group 1 (experimental group): aquatic exercise programme, 1 hour a week, supervised by an instructed community physical therapist Group 2 (control group): assessment only	1 patient after 75% of programme (included in final analysis)	CHAQ; CHQ; JAFAS; JAQQ Joint status (number of tender and swollen joints and the range of motion), joint mobility with Paediatric Escala Paulista de Medicina ROM; MXT and a submaximal 6-minute walk test measured the physical fitness	Group 1 improved 27% in CHAQ score, while Group 2 improved only 5%. The effects were not significant Slight decline in JAQQ score in Group 2 (–15%), compared to stable throughout in Group 1 (0% change) – differences between the 2 groups were not statistically significant. The experimental group (Group 1) showed a small improvement over time on the physical and psychological CHQ summaries, while the control group (Group 2) decreased slightly or remained stable. These changes almost reached statistical significance. The aquatic group showed slight improvements in the 6-minute walk test (3%) compared to the control (0%), though these differences were not statistically significant. VO_2 peak remained stable during the training period for both groups
Tarakci et al. [26]	81 JIA patients	Group 1: a 12-week individually planned land-based home exercise programme (including ROM, strengthening, stretching, and posture exercises) once a week at the hospital for 4 days per week Group 2: control group – waiting list until the end of the study	4 patients left the exercise group and 8 patients left the control group before the end of the study	6-minute walk test; CHAQ; VAS; PedsQL	Statistically significant improvements ($p < 0.001$) were found in all the outcome measures in the exercise group (Group 1). The VAS score decreased significantly ($p < 0.01$) in the control group (Group 2) after 12 weeks. Other than the VAS score ($p > 0.05$), the changes in the other outcome measures ($p < 0.001$) were significant in favour of Group 1

BMD – bone mineral density, BMI – body mass index, CHAQ – Childhood Health Assessment Questionnaire, CHQ – Child Health Questionnaire, DXA – dual-energy X-ray absorptiometry, FBT – Flamingo Balance Test, FRT – Functional Reach Test, HRQoL – Health-Related Quality of Life, JAFAS – Juvenile Arthritis Functional Assessment Scale, JAQQ – Juvenile Arthritis Quality of Life Questionnaire, JIA – juvenile idiopathic arthritis, JSLE – juvenile systemic lupus erythematosus, MXT – maximal exercise test, NRS – Numerical Rating Scale, PA – physical activity, PedsQL – Paediatric Quality of Life Inventory, PROM – Passive Range of Motion, PSQI – Pittsburgh Sleep Quality Index, QALYs – quality-adjusted life years, ROM – range of motion, SDQ – Strengths and Difficulties Questionnaire, VAS – Visual Analogue Scale.

different techniques such as dynamometers, handheld and grip devices, and isometric strength measuring devices. Range of motion (ROM) and flexibility are other important muscle functions that are reduced in patients with JIA and can be easily improved by stretching [15, 20] or aquatic exercises [14]. Most of the studies report improved muscle strength and function following regular PA, highlighting the importance of physical therapy in JIA patients.

Aerobic capacity

The results of the meta-analysis conducted by Taken et al. [9] suggest that patients with JIA have a significantly lower maximal oxygen capacity (VO_2 peak), which can be related directly to lower physical fitness compared to healthy children. Low aerobic capacity can lead to further deconditioning, including even cardiovascular diseases [29].

Aerobic capacity can be evaluated by several different tests such as a 10-meter and 6-minute walking test, a 10-stair climbing test, an electromagnetic cycle ergometer, a Wingate test, a maximal exercise test or a cardiopulmonary exercise test, measuring submaximal and maximal oxygen uptake. Almost any type of PA may be beneficial in improving cardiorespiratory fitness, among which Pilates exercises, water-running programmes, bicycle ergometer exercises, home-exercises including ROM, strengthening, stretching, and posture exercises should be mentioned [19–21, 26]. Although activity programmes with aerobic training are safe and may result in notable improvement in PA, intensive programmes do not seem to provide any additional benefits and are less tolerated by children with JIA [13]. Therefore, mild to moderate aerobic activity should be recommended for children with JIA.

Bone health

The combined effects of disease severity, glucocorticosteroid use, low muscle mass and physical inactivity in children with JIA may result in decreased bone mineral density (BMD), reduced peak bone mass, and an increased risk of fractures [16, 25, 30, 31]. Although it is well known that PA has a positive impact on muscle strength and bone density in general [31, 32], only two studies have demonstrated improvement in BMD after the training programme was registered [22, 25]. Correct bone health parameters at the beginning of the study [16, 25], as well as low involvement in the training programme [17], should be considered as the possible reason. More studies are needed to suggest recommendations for improving bone health by PA in patients with JIA.

Quality of life

Chronic pain, severe disease activity and functional disability, accompanied by social isolation, cause worse assessment of the QoL [33]. Although studies to date have not confirmed an improvement in QoL as a result of an exercise programme in children and adolescents with JIA [11], it can be hypothesized that because of reduction of pain, improvement of muscle strength, acquisition of skills, confidence, and social connections during physical training, PA should have a positive impact on QoL [2].

Questionnaires such as the Paediatric Quality of Life Inventory and Juvenile Arthritis Quality of Life Questionnaire and calculations such as quality-adjusted life years should be applied. A hydrotherapy programme, aquatic fitness training, Pilates exercises, and land-based home exercise programme improved the QoL of patients with JIA [14, 15, 19, 26]. Although no differences were found in the quantitative tools in research by Sieczkowska et al. [23], the patients perceived that the programme improved several aspects of their mental and physical health.

Study limitations

Most studies required stable disease status and continued drug treatment but did not specify which medications were applied. While most studies divided participants into an experimental and control group, one study was conducted only with an experimental group, and one study did not provide any information. While most studies provided diversity in terms of gender, age and JIA subtypes, some studies had incomplete data. Although most participants were diagnosed with JIA according to ILAR criteria, 5 publications did not provide diagnostic criteria. Although the studies were well designed and most of the results were statistically significant, dropouts from the programmes were reported in some cases, undermining the reliability of the results. In addition, a limitation of this review was the limited number of articles available on the topic of PA in patients with JIA, which indicates the need for more research and education on this topic.

Conclusions

Until recently, the role of rehabilitation in the treatment of children with JIA was underestimated. Subsequent studies prove the positive impact of PA on pain, muscle strength and flexibility, joint mobility, aerobic capacity, bone density and general QoL in children with JIA. Moreover, it is believed that PA may have a possible anti-inflammatory effect on PA via the reduction of con-

centration of interleukin-6 or even may be useful in mitigating both sleep disturbances and obstructive sleep apnoea in children with JIA.

In 2021 the American College of Rheumatology published recommendations with nonpharmacological therapies in JIA, in which physical and occupational therapy are conditionally recommended regardless of concomitant pharmacologic treatment. Due to the generally low quality of evidence, the recommendations are conditional and should be individually selected by clinicians and the patient/caregiver. The fear of PA is a big obstacle for parents and children with JIA to initiate and maintain engagement in a PA programme. It is important to provide detailed information such as how, when, and why to engage in PA, what interventions are most effective and to ensure the safety of rehabilitation.

To prevent low commitment and quick withdrawal from rehabilitation, new technologies, such as video-based games or smartwatches, may be helpful and could encourage children to perform regular PA.

Various types of PA seem to be appropriate for children with JIA. The Ottawa Panel's recommendations published in 2016 suggest the use of structured exercises and PA such as Pilates, cardio-karate and home and aquatic exercises among children and adolescents (21 years and younger) living with JIA.

The final choice should be based on the type and severity of the disease, local and financial opportunities and preferences of children and their parents.

Future research should concentrate on searching for motivating strategies to increase long-term engagement in PA. It is important to study different PA tailored to the severity of the disease.

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