

## Characteristics and effects of school based physical activity programs for schoolchildren with autism spectrum disorder: A scoping review

### Características y efectos de los programas escolares de actividad física para escolares con trastorno del espectro autista: una revisión de alcance

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**Abstract.** Although benefits have been reported from the practice of physical activity in children with autism spectrum disorder (ASD), to a lesser extent the characteristics of the programs carried out in the school context and their effects on health are known. The objective of this review was to characterize school based physical activity programs and their effects on the health of schoolchildren with ASD. The review was carried out in accordance with the PRISMA statement in the databases, Medline and PsycINFO, between the years 2010 to 2023. A total of 20 articles were analyzed. A total sample of 683 schoolchildren with ASD ( $\bar{x}=10.5$  years and 73.1% male) were included. Schoolchildren with ASD had 98.1% adherence to the programs. The school based physical activity programs were mainly based on aerobic exercises, such as walking, jogging, running, and cycling (45% of the articles) with a duration between 10-16 weeks (55% of the articles), with a frequency of 2-3 times a week (60% of the articles) and with 60-minute sessions (45%). On the other hand, the most studied variables were language and motor skills (60% of the articles) and psychosocial and cognitive function (50% of the articles); together with the variables of physical and nutritional activity, these were where a higher percentage of articles with positive effects were found. The findings suggest a profile of schoolchildren with ASD and the main characteristics of school based physical activity programs in schoolchildren with ASD in terms of their extension, frequency, duration, intensity, location and provider as well as the variables most frequently evaluated and with the greatest positive effects.

**Keywords:** Exercise; Autism Spectrum Disorder; ASD; Cognition; Physical Activity; Scoping Review.

**Resumen.** Si bien se han reportado beneficios de la práctica de actividad física en niños con trastorno del espectro autista (TEA), en menor medida se conocen las características de los programas realizados en el contexto escolar y sus efectos sobre la salud. El objetivo de esta revisión fue caracterizar los programas escolares de actividad física y sus efectos sobre la salud de escolares con TEA. La revisión se realizó de acuerdo con la declaración PRISMA en las bases de datos, Medline y PsycINFO, entre los años 2010 a 2023. Se analizaron un total de 20 artículos. Se incluyó una muestra total de 683 escolares con TEA ( $\bar{x}=10,5$  años y 73,1% varones). Los escolares con TEA tuvieron un 98,1% de adherencia a los programas. Los programas escolares de actividad física se basaron principalmente en ejercicios aeróbicos, como caminar, trotar, correr y andar en bicicleta (45% de los artículos) con una duración entre 10-16 semanas (55% de los artículos), con una frecuencia de 2-3 veces por semana (60% de los artículos) y con sesiones de 60 minutos (45%). Por otro lado, las variables más estudiadas fueron lenguaje y motricidad (60% de los artículos) y función psicosocial y cognitiva (50% de los artículos); junto con las variables de actividad física y nutricional, fueron en estas donde se encontró un mayor porcentaje de artículos con efectos positivos. Los hallazgos sugieren un perfil de los escolares con TEA y las principales características de los programas escolares de actividad física en escolares con TEA en cuanto a su extensión, frecuencia, duración, intensidad, ubicación y proveedor, así como las variables más evaluadas y con mayores efectos positivos.

**Palabras clave:** Ejercicio; Trastorno del espectro autista; TEA; Cognición; Actividad física; Revisión de alcance.

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## Introduction

Autism Spectrum Disorder (ASD) is characterized by difficulties in the development of social skills, restricted interests, repetitive behaviors (Sanchack, 2016), and a readability sedentary lifestyle. In addition, they present deficits in relevant areas of development and schooling such as social interaction, verbal and non-verbal communication, creative play, sensory processing, maintaining eye contact and adapting to noisy environments (Sowa & Meulenbroek, 2012; Maravé-Vivas, Carregui Ballester, Gil-Gómez & Chiva-Bartoll, 2021). According to The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), the diagnostic criteria for ASD are: A. Persistent deficits in social communication and social interaction across multiple contexts, as manifested by the following symptoms, current or past (Deficits in social-emotional reciprocity; Deficits in nonverbal communica-

tive behaviors used in social interaction; Deficits in developing, maintaining, and understanding relationships), B. Repetitive and restricted patterns of behaviors, activities, and interests, which manifest themselves in at least two of the following symptoms, current or past (Stereotyped or repetitive motor movements, use of objects, or speech; Insistence on equality, inflexible adherence to routines or ritualized patterns of verbal and nonverbal behavior; Highly restricted interests, obsessive, which are abnormal in intensity or focus; Sensory hyper- or hypo-reactivity or unusual interest in aspects of the environment), C. The symptoms must be present in the early developmental period, D. The symptoms cause clinically significant disturbances socially, occupationally, or in other important areas of current functioning, and E. These disturbances are not better explained by the presence of an intellectual disability or a global developmental delay (DSM-5, 2014). Reporting an increase in ASD during the last decades, with

a prevalence of 1.5% in developed countries (Sharma et al., 2018; Waye & Cheng, 2018; Rech, Irwin, Rosen, Baldwin & Schenkelberg, 2022). In this sense, schoolchildren with ASD do not achieve the minimum levels of physical activity recommended (i.e. 60 minutes of daily physical activity throughout the week mainly moderate to vigorous intensity aerobic) (WHO, 2020). Besides, there is evidence that indicates that the adolescent population is readability more sedentary than the adult population (Mear & Neumeier, 2015; Pan et al., 2016).

The foregoing is of interest, since metabolic and cardiovascular diseases related to physical inactivity have a high prevalence in the population (Bilder et al., 2013; Croen et al., 2015). In this sense, physical activity is a protection and prevention factor associated with better physical and psychological health (Biddle & Asare, 2011; Hillman & Biggan, 2017), and that plays a crucial role in promoting and maintaining a healthy lifestyle in adolescents with ASD (Fang et al., 2019; Jones et al., 2017). In addition, studies indicate that physical activity has positive effects on the control of stereotypical behaviors (i.e., involuntary, coordinated, non-purposeful and rhythmic movements that are carried out in an identical way in each repetition, as well as improvements in motor skills, social relationships with their schoolmates and inclusiveness (Pérez-Dueñas, 2010; Chiva-Bartoll, Maravé-Vivas, Salvador-García y Valverde-Esteve, 2021). socioemotional, cognitive, and attention functioning in young adults belonging to this population have been observed (Yu et al., 2018; López Díaz, Moreno Rodríguez y López Bastías, 2021). Along these lines, the current literature emphasizes the need to identify and design programs that promote physical activity in the adolescent population with ASD (Liang et al., 2020a; Sorensen & Zarrett, 2014).

As such, the educational context has been proposed as an ideal means for the promotion of physical activity, through various moments of the school day, such as physical education classes, recesses, the school classroom, sports practice, and extracurricular activities, which allow maximizing the functional independence and quality of life in children and young adults with ASD (Langford et al., 2015; Fernández Cabrera, Jiménez Jiménez, Navarro Adelantado y Sánchez López, 2019; Muñoz Moreno, Smith, y Matos Duarte, 2020). In this sense, physical activity programs (i.e. any programs that includes any body movement produced by skeletal muscles that involves expenditure of energy (WHO, 2018)) at school have been suggested as a particularly useful means to develop and increase interest and participation in physical activity in this population (Bremer et al., 2020), allowing the introduction of behavior modification techniques through this type of programs (Fessia et al., 2018). However, the characteristics of physical activity programs that contribute to the comprehensive health of children and young adults with ASD in educational contexts are unknown.

Based on this background, the following research questions were asked: What are the characteristics of school

based-physical activity programs aimed at students with ASD? and What are the effects of these programs on the health of schoolchildren with ASD? Along these lines, the objective of this scoping review was to characterize school based-physical activity programs and their effects on the health of schoolchildren with ASD. This review will make it possible to identify a profile of the physical activity programs and identify the main variables and procedures that have been applied during the last decade.

## Method

### Search Strategy

This scoping review was carried out according to the guidelines established by the PRISMA statement (Liberati et al., 2009). The PRISMA checklist can be found in the supplementary material (**Table S1**). The manuscript was not registered in PROSPERO. PROSPERO does not currently accept registrations for scoping reviews, literature reviews or mapping reviews.

The search strategy followed the Peer Review of Electronic Search Strategies (PRESS) (McGowan et al., 2016) guidelines. A systematic search was carried out in May 2020 and updated in February 2023, with MeSH terms “Exercise”, “Autistic Disorder”, and “Schools”. The general search syntax was: (“physical activity” OR “exercise” OR “sport”) AND (autism spectrum disorder) AND (school OR school-based programs). The MEDLINE databases were reviewed by PubMed and PsycINFO. The objective was to identify studies that use school based physical activity programs in schoolchildren who present ASD. The search covered the period from 2010 to February 2023. The complete search strategy in all databases is presented in the supplementary material (Table S2).

### Selection of studies and inclusion

Exclusion criteria by gender were not applied (studies conducted in men and women were accepted), but language was considered, and only articles in English were reviewed. Reviews, editorial documents, protocols, or theses were not included. Physical activity programs combined with educational activities or physical activity carried out outside the educational center were not included. The articles selected by title and abstract had to meet the conditions indicated in

Table 1.

Inclusion Criteria	
Criteria	Description
1. Type of Programs	a. School based on physical activity programs, including physical exercise, sports, extracurricular activities.
2. Population	b. Schoolchildren with a diagnosis of autism spectrum disorder. c. Programs carried out at different times
3. Educational Context	within the educational context: classroom, recess, playground, physical education classes...
4. Type of articles	d. Original articles, with experimental or quasi-experimental design.

### Data Extraction

In the first step, identified duplicate articles were removed from the databases using Mendeley software version 1.19.4. Then, two reviewers (CG-A and NU-C) applied the inclusion/exclusion criteria to all titles and abstracts. Articles that met the inclusion criteria were selected, and when decisions could not be made based on the title and abstract alone, the full-text documents were also retrieved. The selected articles were independently verified by the two reviewers (CG-A and NU-C); and when there were discrepancies, a third reviewer made the decision (MC-C). We used a standardized questionnaire to extract the data from the included articles to synthesize the evidence.

### Risk of bias assessment tools and the Consensus on Exercise Reporting Template (CERT) assessment format

We analyzed the risk of bias in all included full-text articles. “The Cochrane Collaboration’s tool for assessing risk of bias in randomized trials” by Higgins et al., (2011) for Randomized Clinical Trials, evaluating the risk of bias in each of the proposed items: (a) Selection bias, (b) Performance bias, (c) Detection bias, (d) Attrition bias and (e) Reporting bias. The only item that was not considered was “Other biases”. The results of this analysis are presented, grouping all the studies analyzed (Table S3) and ROBINS-I (*Risk of Bias in Non-randomized Studies of Interventions*) was used to analyze the risk of bias (Sterne et al., 2016) for non-randomized studies (Table S4). Each article was independently graded by two reviewers (CG-A and NU-C) and scores were compared. When there was a disagreement, a consensus was reached with a third reviewer (MC-C). In addition, the *Consensus on Exercise Reporting Template (CERT)* evaluation form was added to determine the proportion of articles that met the CERT items. In the results section, a description of these analysis was presented, and detailed analysis is in supplemental material (Slade, S.C. et al., 2016) (Table S5).

### Strategy for data synthesis

A narrative synthesis of the findings was provided from the included studies, and the main information is presented in Tables 2, 3, and 4. The results were organized by: general characteristics of the articles (Author, year, country, gender, age, design, and main aim, and adherence, i.e., which can be understood as maintaining a regimen or exercise program for an extended period after an initial phase of adaptation has been completed (Lox et al., 2014)) (Table

Table 2.

General characteristics of the articles

Author, year	Country	Adh (%)	Gender m/f (n°)	Age (Mean)	Design	Main aim
(An et al., 2019)	USA	100	9/5	13,4	QE	To examine the feasibility of a school-based programs using the I Can Do It! national health promotion model to promote healthy behaviors of adolescents with intellectual and developmental disabilities.
(Bahrami et al., 2012)	Iran	100	26/4	9,1	E	To determine whether teaching Kata techniques to children with autism spectrum disorders (ASD) for a longer period leads to consistent reduction of their stereotypical behaviors
(Bahrami et al., 2016)	USA	100	26/4	9,1	E	To examine the long-term effect of Karate techniques training on communication of children with autism ASD.
(Dickinson & Place, 2016)	ENG	100	39/11	15	E	To examine if a computer-based activity program could improve the social functioning of these children.

2), characteristics of physical activity programs for schoolchildren with ASD (Table 3) and main effects on study variables and measurement instruments used (Table 4).

## Results

### Literature review

Figure 1 presents the flow chart for systematic reviews proposed by the PRISMA Declaration. A total of 548 potential articles were identified. Subsequently, after the exclusion of duplicates in the databases, the selection and eligibility criteria were applied. Finally, 20 articles were included for the narrative synthesis in this review (An et al., 2019; Bahrami et al., 2012, 2016; Dickinson & Place, 2016; ElGarhy & Liu, 2016; Hilton et al., 2014; Hinckson et al., 2013; Ito et al., 2017; Lakes et al., 2019; Messiah et al., 2019; Rafie et al., 2017; Schmitz Olin et al., 2017; Sotoodeh et al., 2017; Todd et al., 2010; Tse et al., 2018; Tse et al., 2020; Tse et al., 2021; Yanardag et al., 2013; Zanolini & Solari, 2019; Zhao & Chen, 2018) (Figure 1).

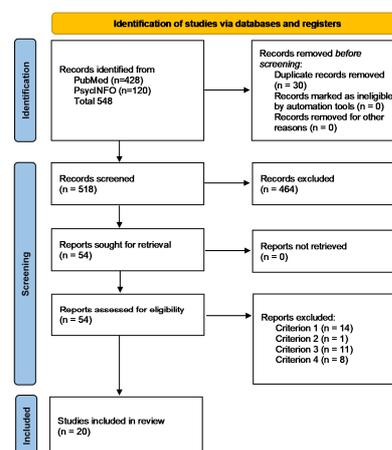


Figure 1. Study selection flow chart according to PRISMA statement (Page et al., 2021).

### Overview of included articles

Of the total of articles, the period with the highest frequency of publication was between the years 2016 to 2019 with 14 of 20 articles. Of a total of eight countries, the United States was the country with the highest frequency of articles found (8 of the 18 articles). A total of 683 schoolchildren with an average age of 10.5 years completed the school physical activity programs (n=499; 73.1% male), achieving a total adherence of 98.1% (Table 2).

(ElGarhy & Liu, 2016)	USA	100	23/5	5,5	E	To examine the effects of a psychomotor programs program on body awareness and psychomotor concepts for students with ASD.
(Hilton et al., 2014)	USA	100	5/2	10	QE	To investigate the effects of a pilot 30-session Makoto arena training programs, a light and sound speed-based exergame, on response speed, executive function, and motor skills in school-aged children with ASD.
(Hinckson et al., 2013)	NZ	100	10/7	11,5	QE	To determine the effectiveness of a program in managing weight, through changes in physical activity and nutrition behaviors in overweight and obese New Zealand children and youth with intellectual disability or autism.
(Ito et al., 2017)	Japan	89	14/18	13,7	QE	To identify the factors affecting the performance of dance exercise in students with intellectual deficiency.
(Lakes et al., 2019)	USA	100	4/4	8,5	QE	To examine qualitative characteristics of and individual responses to a music and movement programs (Creatively Able) for children with ASD.
(Messiah et al., 2019)	USA	100	214/83	14,1	QE	To determine the effects of Fit2Play, a park-based afterschool programme on cardio-vascular/fitness health outcomes among youth with intellectual disability, were pro- spective assessed
(Rafie et al., 2017)	Iran	100	11/9	10,3	E	To examine the effect of selected physical exercise on Perceptual-motor skills in adolescents with autism.
(Schmitz Olin et al., 2017)	USA	100	-/-	13	QE	To quantify the acute effect of exercise and to assess the influence of duration and intensity on the frequency of stereotypical behaviors in children with ASD.
(Sotoodeh et al., 2017)	Iran	100	-/-	11,2	E	To examine the effect of yoga training program on the severity of autism in children with High Function Autism.
(Todd et al., 2010)	USA	100	2/1	16	QE	To investigate the effect of a self-regulation instructional strategy on sustained cycling, which included self-monitoring, goal setting, and self-reinforcement
(Tse et al., 2018)	China	100	22/8	10,2	E	To examine the underlying mechanism by considering the theoretical operant nature of stereotypical behaviors.
(Tse, 2020)	China	97%	23/4	9,7	E	To examine the effect of physical exercise (jogging) on emotional regulation and behavioral functioning in children with ASD.
(Tse et al., 2021)	China	94%	50/12	9,8	E	The purpose of this study was to compare the effect of cognitive engagement exercise (learning to ride a bicycle) and non-cognitive engagement exercise (stationary cycling) on executive function in children with ASD.
(Yanardag et al., 2013)	Turkey	100	2/1	7	QE	To investigate the effectiveness of the video prompting procedure on teaching aquatic play skills and to determine the effects of aquatic exercise training on the motor performance of children with ASD.
(Zanobini & Solari, 2019)	Italy	100	19/6	5,5	E	To analyze the effectiveness of a swimming program on interpersonal skills, autistic mannerisms, and aquatic abilities in children with ASD.
(Zhao & Chen, 2018)	China	82	-/-	6,5	E	To investigate the effects of structured physical activity program on social interaction and communication of children with ASD.

-: It does not specify or apply. USA: United States. NZ: New Zealand. ENG: England. Adh (%): Adherence to the programs. Gender M/F: Number of participants by male (m) / female (f) gender belonging to the final sample of the programs. Design. E: Experimental. QE: Quasi-experimental. autism spectrum disorder: ASD.

### **Risk of bias assessment tools and the Consensus on Exercise Reporting Template (CERT) assessment format**

Risk of bias in nine randomized trials was assessed using The Cochrane Collaboration's tool for assessing risk of bias in randomized trials. The risk of bias was included for each of the items proposed by the Cochrane Collaboration's tool. A high percentage of articles had a low risk of bias in the selection bias for the sequence generation (91%), as well as for the attrition bias (100%) and reporting bias (100%). In contrast, a high percentage of articles with unclear risk in performance bias (82%) and high risk in detection bias (91%) and allocation concealment (82%) were observed (Table S3). In addition, risk of bias for nine non-randomized studies was assessed using ROBINS-I. In the overall risk of bias, 6 articles had a moderate risk of bias, 2 a low risk of bias and 1 a serious risk of bias (Table S4).

Regarding the level of compliance of the CERT items, eleven out of nineteen items compliant (rated "yes" on the CERT items) in at least 75% of the articles (C1 = 100%, C2=100%, C3= 94%, C4=100%, C7a=100%, C7b=100%, C9=100%, C10 =100%, C12=90%, C13=90%, and C16b=85%). The items categories with

the highest level of compliance were those included in the materials (one item, C1), provider (one items, C2), location (one items, C12), and dosage (one item, C13) categories (Table S5).

### **Characteristics of school based physical activity programs**

Of the total articles, the duration and frequency of the programs implemented most frequently was between 10-16 weeks (11 articles), two or three times a week (12 articles). In addition, the duration of sessions most frequently was 60 minutes per session (9 articles). The place of school programs where it was used most frequently was the school and special schools (7 and 9 articles, respectively) and the higher education center (4 articles). In 15 of 20 articles, the school programs were carried out by a specialized professional (psychologist, speech pathologist, or differential educator). The type of physical activity implemented consisted mainly of aerobic exercises (9 articles), (e.g., walking, jogging, running, and cycling) that trained motor skills. In addition, 7 articles included sports which were more frequently activities in the water environment, or swimming (4 articles), multi-sport (2 articles), and karate (2 articles) (Table 3).

Table 3.

Characteristics of school based physical activity programs

Author, year	DI (week)	SW (days)	DS (min)	IP	RP	Description of the school based physical activity programs
(An et al., 2019)	16	1	60-70	SCH	INS	Walk, jog, or run. Students' favorite activities, such as, for example, basketball, dance, soccer, jump rope, sprinting, and volleyball.
(Bahrami et al., 2012)	16	4	30-90	HEC	SP	"Kata" exercises as part of karate practice.
(Bahrami et al., 2016)	16	4	30-90	HEC	SP	"Kata" exercises as part of karate practice.
(Dickinson & Place, 2016)	36	3	15	SCH	HP, SP	Through the Nintendo Wii video game console, sports such as athletic races, and water activities such as swimming, were simulated during physical education classes.
(ElGarhy & Liu, 2016)	11	3	40	RC	INS	Activities related to body awareness and concepts, such as touching body parts with eyes open and closed or responding to verbal instructions.
(Hilton et al., 2014)	4	3	2	HEC	INS	Sessions of Makoto arena, which consisted of hitting luminous objects with a ball as fast as possible, each session progressively increasing in difficulty.
(Hinckson et al., 2013)	10	2	60	SS	SP	Generate physical activity and low intensity games (walking), physical activity in the aquatic environment (swimming) that include family participation.
(Ito et al., 2017)	16	2	20	SCH	HP	Dance guided by a dance instructor in physical education classes. It included the participation and cooperation of teachers. The music included phrases such as "I appreciate my family" so that the students could think about the people involved with them during the exercises.
(Lakes et al., 2019)	4	2	45	HEC	SP	During after-school hours, dance was performed under the guidance of an instructor. Where they had to develop a story that was physically expressed to music.
(Messiah et al., 2019)	96	5	60	Park	SP	Physical activity that incorporated multi sports such as soccer, kickball, flag ball, and Sports Play and Active Recreation for Kids (SPARK).
(Rafie et al., 2017)	8	3	45	SCH	SP	Physical activity that included perceptual-motor training and development of motor skills, such as: body awareness, bilateral motor balance, motor coordination and vasomotor performance.
(Schmitz Olin et al., 2017)	-	3	60	Gym	SP, INS	Low or high intensity continuous aerobic physical activity performed on a cycling ergometer, treadmill or elliptical.
(Sotoodeh et al., 2017)	8	-	30	SS	SP	Yoga sessions guided by an instructor that included different postures and body awareness typical of the discipline.
(Todd et al., 2010)	16	3	30	SS	SP	Circuit of 30 to 75 meters of cycling on asphalt that included movements in different directions and turns.
(Tse et al., 2018)	12	2	20	SS	SP	Physical activity that consisted of a game with a "10-inch Little Tikes" ball where the aim was to maintain a pitch frequency according to work time.
(Tse, 2020)	12	4	30	SS	SP	Physical activity that consisted of a jogging intervention.
(Tse et al., 2021)	2	5	60	SS	INS	Physical activity including a learning to ride a bicycle program or stationary cycling.
(Yanardag et al., 2013)	12	3	60	Gym	SP	Physical activity in an aquatic environment (pool) where they had to carry out activities and exercises guided through videos.
(Zanobini & Solari, 2019)	20	1	30	SCH	SP	Physical activity in an aquatic environment (pool) where they had to carry out activities such as familiarization with the aquatic environment, technique, and swimming exercises.
(Zhao & Chen, 2018)	12	2	60	SS	SP	Physical activity in teams guided by teachers that included ball throwing work.

REF: References. DI: Duration of program. SW: Sessions per week. DS: Duration of sessions. IP: Program place. GC: Game Center. RC: Rehabilitation Center. SS: Special School. SCH= School. HEC= Higher Education Center. RP: Responsible Professional. SP: Specialized Professional. HP: Health Professional. INS: Instructor.

### Measurement instruments and main effects of school based physical activity programs on schoolchildren health with ASD

The variables were grouped into 5 categories. The first group corresponds to the physical activity variables (which included physical activity level and intensity, physical and cardiorespiratory fitness, calories, and dance performance), present in 5 articles and positive effects were found in 4 of them. The second group was of body composition variables (which included BMI, waist-hip circumference, and skin folds) present in 3 articles and did not present positive effects. The third group were the psychosocial and cognitive function variables (which included social functioning and family, manifestations related to physical

activity capacities in children, social, physical and health behaviors, autistic behaviors and social response, social interaction, emotion regulation, behavioral functioning, and executive function) present in 10 articles with positive effects found in 8 of them. The fourth group were the nutritional status (which included water and vegetable consumption, nutritional behavior, and confectionery consumption) present in 2 articles and finding positive effects in both, and the fifth group were language and motor skills (which included, speech, language, communication, body awareness, spatial and body concepts, motor aptitude, aquatic skills, basic language, learning skills, and stereotypical behaviors) present in 12 articles and positive effects were found in 11 of them (Table 4).

Table 4.

Main effects on study variables and measurement instruments used

Author, year	Study variables				Measurement tools
	Physical Activity	Body Composition	Psychosocial and cognitive function	Nutritional status	
(An et al., 2019)	Physical activity level ↑(b)	BMI =, WHC =	-	Consumption of water and vegetables ↑(b)	Self-report questionnaires (a), standardized procedures (b)
(Bahrami et al., 2012)	-	-	-	-	Stereotypical behaviors ↓ Gilliam Autism Rating Scale (GARS-2)
(Bahrami et al., 2016)	-	-	-	-	Communication Gilliam Autism Rating Scale (GARS-2)

					deficit ↓	
(Dickinson & Place, 2016)	-	-	Social and family functioning ↑ (a)(b)	-	-	Self-report questionnaires (a), Family Adaptation and Cohesion Assessment Scales (FACES IV) (b)
(ElGarhy & Liu, 2016)	-	-	-	-	Body and spatial awareness and body concepts ↑	Self-report questionnaire
(Hilton et al., 2014)	-	-	Behavioral manifestations of physical activity abilities in children ↑(a)	-	Motor ability ↑(b)	Executive Function Behavioral Score (SHORT) (a) and Motor Aptitude Test (BOT-2) (b)
(Hinckson et al., 2013)	Physical activity level ↑ (a) and Fitness ↑(b)	BMI=(c), WHC=(c)	-	Nutritional behavior ↑ (a), Confectionery consumption ↓(a)	-	Self-report questionnaire (a), six-minute walk test (6MWT) (b), standardized procedures (c).
(Ito et al., 2017)	Calorie usage score ↑ (a), Dance performance ↑ (b).	-	-	-	-	accelerometer (a), evaluation according to specific criteria through video analysis (b)
(Lakes et al., 2019)	-	-	Enjoy the physical activity ↑ (a), Participant engagement and self-regulation during the program sessions ↑ (b)	-	-	Physical Activity Enjoyment Scale (PACES) (a), Revised Repetitive Behavior Scale (RBS-R) (b)
(Messiah et al., 2019)	Cardiorespiratory fitness ↑ (a), muscular endurance (c)↑, flexibility (b)↑	BMI =, Skin folds=	Health and wellness behaviors and knowledge ↑ (d)	-	-	Progressive Aerobic Cardiovascular Endurance Running Test (PACER) (a), sit-and-reach test (b), standardized procedures (c), EmpowerMe4Life scale (d)
(Rafie et al., 2017)	-	-	-	-	Motor skills ↑	Bruininks-Oseretsky Motor Competition Test [BOTMP]
(Schmitz Olin et al., 2017)	Physical activity intensity ↓(a,b)	-	-	-	Stereotypical behaviors ↓ (c)	HR Monitor (a), OMNI scale (b), evaluation according to specific criteria through video analysis (c)
(Sotoodeh et al., 2017)	-	-	- Social, physical and health behaviors =	-	Speech, language, communication =	Autism Treatment Evaluation Checklist (ATEC)
(Todd et al., 2010)	-	-	Self-control self-regulation ↑, physical activity self-efficacy =	-	Motor skills (distance and time on the circuit) ↑	Field notes
(Tse et al., 2018)	-	-	-	-	Stereotypical behaviors ↓	Gilliam Autism Rating Scale (GARS-3)
(Tse, 2020)	-	-	Emotion regulation ↑ (a), Emotional and behavioral functioning ↓ (b)	-	-	Emotion regulation Checklist (ERC) (a), Child behavior checklist (CBCL) (b).
(Tse et al., 2021)	-	-	Planning ↑(a), working memory ↑(b), (c),(d), flexibility ↑(e), inhibition ↑(f)	-	-	Tower of London test (TOL) (a), forward digit span (FDS) (b), Backward digit span (BDS) (c), Corsi block tapping task (CBTT) (d), Stroop Color and Word Test (SCWT) (e), Go/No-go (GNG) (f)
(Yanardag et al., 2013)	-	-	-	-	Movement ability in water ↑	Video analysis by researchers
(Zanobini & Solari, 2019)	-	-	Autistic behaviors ↓(b), social response ↑ (c)	-	Aquatic skills ↑	Humphries Assessment of Aquatic Readiness (HAAR) (a), Autism Behavioral Checklist (ABC) (b), Social Response Scale (SRS) (c).
(Zhao & Chen, 2018)	-	-	Social interaction and communication = (b)	-	Basic Language and Learning Skills ↑ (a -	The Assessment of Basic Language and Learning Skills (ABLLS-R) (a), Qualification of the system of improvement of social skills Scales (SSIS-RS) were used (b)

REF: References. Effects on study variables. ↑: positive effects. ↓: negative effects. =: no effects: Body composition. BMI: Body mass index. WHC: Waist hip circumference.

## Discussion

### Main findings

The main findings of this scoping review indicate that the 20 articles included a total sample of 683 schoolchildren with ASD (73.1% male) and with an average age of

10.5 years. The schoolchildren with ASD had an adherence to the program of 98.1%. The studies were carried out mainly in primary or special schools (56% of the articles) and guided by a specialized professional (75%). The school based physical activity programs were mainly based on aerobic exercises, such as walking, jogging, running,

and cycling (45% of the articles), with a duration between 10-16 weeks (55% of the articles), with a frequency of 2-3 times a week (60% of the articles), and with 60-minute sessions (45%). The most studied variables were language and motor skills (60% of the articles) and psychosocial and cognitive function (50% of the articles). Together with the variables of physical and nutritional activity, they were where a higher percentage of articles with positive effects was found.

### ***Findings of the review and contrast with the existing evidence***

#### *Characteristics of school based physical activity programs*

It has been suggested a low participation of students diagnosed with ASD in school spaces aimed at performing physical activity. In this regard, Recent evidence has shown that children and adolescents with ASD are less physically active than their typical development peers (Liang et al., 2020b). However, based on this, it is analyzed and affirmed that physical activity improves the health and quality of life of the population evaluated. The quality of the comprehensive school programs of physical education and / or physical activity can play a much more significant role for those students who present ASD, since the environment that exists in the school context can offer the opportunity to promote the development of skills and / or essential skills for students to be more active and energetic and, at the same time, to be able to make a transcendent contribution to the general levels of physical exercise in the school population (Bremer et al., 2020).

The school is a primary space to promote and carry out programs aimed at increasing the participation of physical activity, exercise, or sport since the integral development of the students is promoted and / or strengthened mainly in the educational establishment due to their extensive performance in it during the year. Before this, Bremer et al. (2020) points out that through the opportunity to be more active in educational centers, it is possible to encourage and / or favor students who present ASD to develop safety and enjoyment skills, to be more active outside of school. Likewise, these physical exercises, carried out in educational establishments, contribute to the general levels of physical activity, being able to contribute to the students to comply with the physical activity guidelines.

However, with respect to the main characteristics of the programs, the highest percentage of professionals responsible for the evaluation corresponds to qualified personnel, followed by instructors and, finally, personnel from the health area. On the other hand, the total program time most used was 16 weeks (6 of 24). Regarding the weekly sessions, the majority were carried out in 2 or 3 sessions, with an average time of 67 minutes, with 60 minutes being the most used period. Regarding the components of the programs, they were grouped into 3 categories: physical exercises, corresponding to different voluntary body movements; sports activities that considered

those sports subject to established norm and / or rules, and finally, recreational activities corresponding to activities of entertainment, distraction and fun.

The time within a program is essential to meet objectives and develop skills, as highlighted by Schmitz, et al., (2017) through their study, based on participants selected by the presentation of self-stimulation and other inappropriate behaviors. Results show that shorter and less intense periods of exercise were more effective in reducing stereotypical behaviors, while the more exhaustive exercise session led to an increase in frequency (Schmitz Olin et al., 2017).

#### *Effects of school based physical activity programs in school-children health with ASD*

Regarding the effects or results obtained in responses to the programs, they showed as evidence a major decrease in stereotypical behaviors, as supported by Bahrami, Moheda, Marandi & Abedi (2012) through the analysis of the participation of students in karate techniques for a period of 4 months, exhibiting a reduction of stereotypical behaviors in the diagnosed students. Likewise, it occurs with the involvement of the students in dance sessions and choreography twice a week (Bahrami et al., 2012; Lakes et al., 2019).

On the other hand, motor development as a sequential and continuous process demands the development of motor skills in students with ASD, what might be needed to create spaces where they can enhance these skills. In the studies by Colebourn, Golub-Victor & Paez (2017), El-Garhy & Liu (2016), and Hilton et al. (2014) they show a range of activities that favor the increase, improvement or progression of these skills, such as throwing games, movement of the body and arms, catching the ball, hitting objects, and running in a training period between 30 to 60 minutes, obtaining a significant improvement in perceptual motor skills, upper limb coordination, visual motor control, balance, speed, dexterity, and strength (Colebourn et al., 2017; ElGarhy & Liu, 2016).

In relation to body composition, specifically body mass index, An, DuBose, Decker & Hatala (2019) after the participation of the students for 4 months in the program "I can't do it", not only analyzes the program from a purely physical perspective through exercises, but also shows information on the increase in nutritional variables, such as the consumption of water and healthy foods (An et al., 2019). Performing basic exercises that involve consistent strength training, such as squats and push-ups, directly improve health and physical condition, as well as activities such as walking and playing soccer for 60 minutes, causing improvements in blood pressure, walking distance, moderate physical activity, and progressions in body mass index, fitness, and cardiovascular health (heallessiah et al., 2019).

Finally, in reference to the evaluation of social variables, we showed that eight studies carried out programs aimed at evaluating the communication deficit, social functioning, participation, socialization, among others,

where in most of the results obtained there were improvements and progression. Bahrami, Movahedi, Marandi & Sorensen (2016) through their appreciation of the participation of students with an ASD diagnosis in karate technique sessions, with an estimate of 30 to 90 minutes, four times a week, results in a significant reduction in the communication deficit (Bahrami et al., 2016). The same occurs with the assessment provided by the authors Miltenberger & Charlop (2014) where games such as handball and four tables promote speech, group play and participation. The inquiries regarding the social sphere, carried out by the different authors, propose that programs based on activities where social interaction is required among its participants, such as swimming, soccer, table tennis, and athletics between 15 to 60 minutes are effective in increasing these skills (Miltenberger & Charlop, 2014).

### Limitations of this study

First, we highlight that the review does not comprise a meta-analysis of the included studies. The synthesis of the information presented has a qualitative approach, which generates a limitation to determine the effectiveness of physical activity programs in health outcomes of schoolchildren with ASD.

Second, experimental and quasi experimental studies were included, thus showing great heterogeneity in methodological quality and a high risk of bias.

Third, despite efforts to conduct comprehensive searches, this review may not have found all relevant studies. This may be due to the variability in the search terms used, the lack of access to certain databases or the lack of publication of some studies. Besides, only articles written in English were considered, which could have hidden articles published in other languages or in places where English is not a primary or commonly spoken language such as Latin America or the Caribbean.

Fourth, the highest risk of bias reported by the Cochrane tool was related to performance bias and detection bias. Both biases are associated with difficulty in masking participants and study staff. These biases increase the risk that the knowledge of the intervention received will affect the results, which could lead to a systematic error in the application of school based on physical activity programs. It is relevant to highlight that numerous investigations indicate the low methodological quality of the studies; other studies mention a high risk of bias in at least one domain evaluated.

Fifth, it is possible that new articles could be published after the search ended in February 2023.

Finally, it is relevant to indicate that the results of this review may not be generalizable to all schoolchildren with ASD, educational centers or physical activity programs. Therefore, it is important to consider the limitations and conditions in which the research found was conducted when interpreting the results of this review.

### Clinical and research implications

The results obtained in this scoping review suggest that physical activity plays an important role in the well-being and development of schoolchildren with ASD.

School is the privileged place where schoolchildren develop in a constant way. In this context, this review shows that school based on physical activity programs can promote benefits in physical development, language and communication skills, emotional well-being, socialization, attention, executive functions, as well as in the reduction of problematic behaviors. We highlight the progression of motor skills, exhibiting an evident decrease in stereotypical behaviors commonly attributed to this disorder, as well as the parameters most commonly used in the studies are presented. Hence, we believe that these findings could be useful to professionals working with schoolchildren with ASD for a safe and timely prescription of future school based on physical activity programs.

It is important that parents and caregivers working with teachers and health professionals can identify, select, and promote appropriate and effective physical activities, exercises, or sports for each schoolchild with ASD.

Considering that most of the physical activity programs were carried out by specialized professionals (speech-language pathologist, psychologist, physical therapist, physical education teacher or differential educator) and that they were carried out in special schools, it is highly relevant that these professionals are trained in the prescription of physical exercise.

Additionally, we allow ourselves to deliver the following suggestions to professionals who develop these physical activity programs in school contexts a) communicate with parents and educational team to adapt the contents of the program, b) create safe and structured environments that provide confidence for the realization of physical activity routines, c) provide clear and positive feedback so that students with ASD know if they are doing the activities well and feel motivated to continue participating, and d) be flexible and patient in the design and content of the programs, since all students with ASD are unique and may have different needs and ways of learning.

### Future lines of research

The authors of this review encourage researchers to investigate the effects of physical activity-based school programs on the health of schoolchildren with ASD. It is suggested to analyze whether there are elements or conditions in school that promote physical activity in schoolchildren with ASD (example: health and education professionals who work directly with schoolchildren with ASD, availability of time and spaces for physical activity, use of school uniform). It is suggested to study if there are policies or educational programs that promote physical activity programs in schoolchildren with ASD for example, active breaks, curricular content adapted to develop them active-

ly). Finally, it is suggested to analyze if there are signs and symptoms of ASD that benefit more from physical activity programs.

## Conclusions

The 20 studies included in this scoping review showed a profile of schoolchildren with ASD and the main characteristics of school based physical activity programs in schoolchildren with ASD in terms of their extension, frequency, duration, intensity, location and provider. This review showed the variables and instruments most frequently used in research on schoolchildren diagnosed with ASD.

In addition, this review synthesizes the main positive effects of physical activity divided into 5 categories; physical activity, body composition, psychosocial and cognitive function, nutritional status, and language and motor skills.

## Authors' contributions

CG-A, NU-P, MC-C and RZ-L proposed and designed the review and drafted the manuscript. CG-A, NU-P, MC-C and RZ-L conducted the searches, reviewed the findings, and discussed and agreed studies to be included. AT, AR, DR-M, MC-A, CO and IC contributed to the manuscript. All authors have read, commented on and approved the final manuscript.

## Compliance with Ethical Standards

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## References

\*Articles included in scoping review

- \*An, J., DuBose, K. D., Decker, J. T., & Hatala, L. E. (2019). A school-based mentoring program developing healthy behaviors of adolescents with intellectual and developmental disabilities: A pilot feasibility study. *Disability and Health Journal*, *12*(4), 727–731. <https://doi.org/10.1016/j.dhjo.2019.03.012>
- American Psychiatric Association (2013). Diagnostic and statistical manual of mental disorders (5th ed.). <https://doi.org/10.1176/appi.books.9780890425596>
- \*Bahrami, F., Movahedi, A., Marandi, S. M., & Abedi, A. (2012). Kata techniques training consistently decreases stereotypy in children with autism spectrum disorder. *Research in Developmental Disabilities*, *33*(4), 1183–1193. <https://doi.org/10.1016/j.ridd.2012.01.018>
- \*Bahrami, F., Movahedi, A., Marandi, S. M., & Sorensen, C. (2016). The Effect of Karate Techniques Training on Communication Deficit of Children with Autism Spectrum Disorders. *Journal of Autism and Developmental Disorders*, *46*(3), 978–986. <https://doi.org/10.1007/s10803-015-2643-y>

- Biddle, S. J. H., & Asare, M. (2011). Physical activity and mental health in children and adolescents: A review of reviews. *In British Journal of Sports Medicine*, *45*(11), 886–895. <https://doi.org/10.1136/bjsports-2011-090185>
- Bilder, D., Botts, E. L., Smith, K. R., Pimentel, R., Farley, M., Viskochil, J., McMahon, W. M., Block, H., Ritvo, E., Ritvo, R.-A., & Coon, H. (2013). Excess Mortality and Causes of Death in Autism Spectrum Disorders: A Follow up of the 1980s Utah/UCLA Autism Epidemiologic Study. *Journal of Autism and Developmental Disorders*, *43*(5), 1196–1204. <https://doi.org/10.1007/s10803-012-1664-z>
- Bremer, E., Martin Ginis, K. A., Bassett-Gunter, R. L., & Arbour-Nicitopoulos, K. P. (2020). Factors Associated with Participation in Physical Activity Among Canadian School-Aged Children with Autism Spectrum Disorder: An Application of the International Classification of Functioning, Disability and Health. *International Journal of Environmental Research and Public Health*, *17*(16), 5925. <https://doi.org/10.3390/ijerph17165925>
- Colebourn, J. A., Golub-Victor, A. C., & Paez, A. (2017). Developing Overhand Throwing Skills for a Child with Autism with a Collaborative Approach in School-Based Therapy. *Pediatric Physical Therapy*, *29*(3), 262–269. <https://doi.org/10.1097/PEP.0000000000000405>
- Chiva-Bartoll, O., Maravé-Vivas, M., Salvador-García, C., & Valverde-Esteve, T. (2021). Impact of a physical education service-learning programme on ASD children: A mixed-methods approach. *Children and Youth Services Review*, *126*(106008), 106008. <https://doi.org/10.1016/j.childyouth.2021.106008>
- Croen, L. A., Zerbo, O., Qian, Y., Massolo, M. L., Rich, S., Sidney, S., & Kripke, C. (2015). The health status of adults on the autism spectrum. *Autism*, *19*(7), 814–823. <https://doi.org/10.1177/1362361315577517>
- \*Dickinson, K., & Place, M. (2016). The Impact of a Computer-Based Activity Program on the Social Functioning of Children with Autistic Spectrum Disorder. *Games for Health Journal*, *5*(3), 209–215. <https://doi.org/10.1089/g4h.2015.0063>
- \*ElGarhy, S., & Liu, T. (2016). Effects of psychomotor intervention program on students with autism spectrum disorder. *School Psychology Quarterly*, *31*(4), 491–506. <https://doi.org/10.1037/spq0000164>
- Fang, Q., Aiken, C. A., Fang, C., & Pan, Z. (2019). Effects of Exergaming on Physical and Cognitive Functions in Individuals with Autism Spectrum Disorder: A Systematic Review. *Games for Health Journal*, *8*(2), 74–84. <https://doi.org/10.1089/g4h.2018.0032>
- Fessia, Gabriel, Manni, Diego, Contini, Liliana, & Astorino, Francisco. (2018). Estrategias de actividad física planificada en autismo: revisión sistemática. *Revista de Salud Pública*, *20*(3), 390-395. <https://doi.org/10.15446/rsap.v20n3.63040>
- Fernández Cabrera, J. M., Jiménez Jiménez, F., Navarro Adelantado, V., & Sánchez López, C. R. (2019). Cambios en el autoconcepto del alumnado con y sin discapacidad motriz a partir de una intervención docente inclusiva en Educación Física (Changes in self-concept of students with and without motor disabilities after an inclusive

- teaching intervention in P. *Retos*, 36, 138–145. <https://doi.org/10.47197/retos.v36i36.67717>
- Higgins, J. P. T., Altman, D. G., Gøtzsche, P. C., Jüni, P., Moher, D., Oxman, A. D., Savovic, J., Schulz, K. F., Weeks, L., Sterne, J. A. C., Cochrane Bias Methods Group, & Cochrane Statistical Methods Group. (2011). The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ (Clinical Research Ed.)*, 343(oct18 2), d5928. <https://doi.org/10.1136/bmj.d5928>
- Hillman, C. H., & Biggan, J. R. (2017). A review of childhood physical activity, brain, and cognition: Perspectives on the future. In *Pediatric Exercise Science*, 29(2), 170–176. <https://doi.org/10.1123/pes.2016-0125>
- \*Hilton, C. L., Cumpata, K., Klohr, C., Gaetke, S., Artner, A., Johnson, H., & Dobbs, S. (2014). Effects of exergaming on executive function and motor skills in children with autism spectrum disorder: A pilot study. *American Journal of Occupational Therapy*, 68(1), 57–65. <https://doi.org/10.5014/ajot.2014.008664>
- \*Hinckson, E. A., Dickinson, A., Water, T., Sands, M., & Penman, L. (2013). Physical activity, dietary habits and overall health in overweight and obese children and youth with intellectual disability or autism. *Research in Developmental Disabilities*, 34(4), 1170–1178. <https://doi.org/10.1016/j.ridd.2012.12.006>
- \*Ito, Y., Hiramoto, I., & Kodama, H. (2017). Factors affecting dance exercise performance in students at a special needs school. *Pediatrics International*, 59(9), 967–972. <https://doi.org/10.1111/ped.13338>
- Jones, R. A., Downing, K., Rinehart, N. J., Barnett, L. M., May, T., McGillivray, J. A., Papadopoulos, N. V., Skouteris, H., Timperio, A., & Hinkley, T. (2017). Physical activity, sedentary behavior and their correlates in children with autism spectrum disorder: A systematic review. In *PLoS ONE*, 12(2), e0172482. <https://doi.org/10.1371/journal.pone.0172482>
- \*Lakes, K. D., Neville, R., Vazou, S., Schuck, S. E. B., Stavropoulos, K., Krishnan, K., Gonzalez, I., Guzman, K., Tavakoulia, A., Stehli, A., & Palermo, A. (2019). Beyond Broadway: Analysis of Qualitative Characteristics of and Individual Responses to Creatively Able, a Music and Movement Intervention for Children with Autism. *International Journal of Environmental Research and Public Health*, 16(8), 1377. <https://doi.org/10.3390/ijerph16081377>
- Langford, R., Bonell, C., Jones, H., Poulou, T., Murphy, S., Waters, E., Komro, K., Gibbs, L., Magnus, D., & Campbell, R. (2015). The World Health Organization's Health Promoting Schools framework: A Cochrane systematic review and meta-analysis. In *BMC Public Health*, 15(1), 130. <https://doi.org/10.1186/s12889-015-1360-y>
- Liang, X., Li, R., Wong, S. H. S., Sum, R. K. W., & Sit, C. H. P. (2020). Accelerometer-measured physical activity levels in children and adolescents with autism spectrum disorder: A systematic review. In *Preventive Medicine Reports*, 19(101147), 101147. <https://doi.org/10.1016/j.pmedr.2020.101147>
- Lox, C. L., Ginis, K. A. M., & Petruzzello, S. J. (2016). The psychology of exercise: Integrating theory and practice (4th Edition). Routledge. López Díaz, J. M., Moreno Rodríguez, R., & López Bastías, J. L. (2021). Análisis del impacto de un programa deportivo en niños con Trastorno del Espectro del Autismo (Analysis of the impact of a sport program on children with Autism Spectrum Disorder). *Retos*, 39, 98–105. <https://doi.org/10.47197/retos.v0i39.74841>
- Maravé-Vivas, M., Carregui Ballester, J., Gil-Gómez, J., & Chiva-Bartoll, Òscar. (2021). Hacia la inclusión del alumnado con TEA en educación física: investigación-acción en un programa piloto (Towards the inclusion of students with ASD in physical education: action-research in a pilot programme). *Retos*, 42, 66–76. <https://doi.org/10.47197/retos.v42i0.85845>
- McGowan, J., Sampson, M., Salzwedel, D. M., Cogo, E., Foerster, V., & Lefebvre, C. (2016). PRESS Peer Review of Electronic Search Strategies: 2015 Guideline Statement. *Journal of Clinical Epidemiology*, 75, 40–46. <https://doi.org/10.1016/j.jclinepi.2016.01.021>
- Menear, K. S., & Neumeier, W. H. (2015). Promoting Physical Activity for Students with Autism Spectrum Disorder: Barriers, Benefits, and Strategies for Success. *Journal of Physical Education, Recreation & Dance*, 86(3), 43–48. <https://doi.org/10.1080/07303084.2014.998395>
- \*Messiah, S. E., D'Agostino, E. M., Patel, H. H., Hansen, E., Mathew, M. S., & Arheart, K. L. (2019). Changes in cardiovascular health and physical fitness in ethnic youth with intellectual disabilities participating in a park-based afterschool programme for two years. *Journal of Applied Research in Intellectual Disabilities*, 32(6), 1478–1489. <https://doi.org/10.1111/jar.12642>
- Miltenberger, C. A., & Charlop, M. H. (2014). Increasing the athletic group play of children with autism. *Journal of Autism and Developmental Disorders*, 44(1), 41–54. <https://doi.org/10.1007/s10803-013-1850-7>
- Muñoz Moreno, A., Smith, E., & Matos Duarte, M. (2020). Una Experiencia de Inclusión Educativa en el Aula de Expresión Corporal con Alumnado Universitario (An Educational Inclusion Experience in a Body Expression course with undergraduate students). *Retos*, 37, 702–705. <https://doi.org/10.47197/retos.v37i37.68438>
- Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Ghanaville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., McGuinness, L. A., ... Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ (Clinical research ed.)*, 372, n71. <https://doi.org/10.1136/bmj.n71>
- Pan, C. Y., Tsai, C. L., Chu, C. H., Sung, M. C., Ma, W. Y., & Huang, C. Y. (2016). Objectively Measured Physical Activity and Health-Related Physical Fitness in Secondary School-Aged Male Students with Autism Spectrum Disorders. *Physical Therapy*, 96(4), 511–520. <https://doi.org/10.2522/ptj.20140353>
- Pérez-Dueñas, B. (2010). Estereotipias primarias en pediatría. *Anales de Pediatría Continuada*, 8(3), 129–134. [https://doi.org/10.1016/S1696-2818\(10\)70023-8](https://doi.org/10.1016/S1696-2818(10)70023-8)

- \*Rafie, F., Ghasemi, A., Zamani Jam, A., & Jalali, S. (2017). Effect of exercise intervention on the perceptual-motor skills in adolescents with autism. *Journal of Sports Medicine and Physical Fitness*, 57(1-2), 53–59. <https://doi.org/10.23736/S0022-4707.16.05919-3>
- Rech, J. P., Irwin, J. M., Rosen, A. B., Baldwin, J., & Schenkelberg, M. (2022). Comparison of physical activity between children with and without autism spectrum disorder: A systematic review and meta-analysis. *Adapted Physical Activity Quarterly: APAQ*, 39(4), 456–481. <https://doi.org/10.1123/apaq.2021-0152>
- Sanchack, K. E., & Thomas, C. A. (2016). Autism spectrum disorder: Primary care principles. *American Family Physician*, 94(12), 972–979.
- \*Schmitz Olin, S., McFadden, B. A., Golem, D. L., Pellegrino, J. K., Walker, A. J., Sanders, D. J., & Arent, S. M. (2017). The Effects of Exercise Dose on Stereotypical Behavior in Children with Autism. *Medicine and Science in Sports and Exercise*, 49(5), 983–990. <https://doi.org/10.1249/MSS.0000000000001197>
- Sharma, S. R., Gonda, X., & Tarazi, F. I. (2018). Autism Spectrum Disorder: Classification, diagnosis and therapy. In *Pharmacology & Therapeutics*, 190, 91–104. <https://doi.org/10.1016/j.pharmthera.2018.05.007>
- Slade, S. C., Dionne, C. E., Underwood, M., Buchbinder, R., Beck, B., Bennell, K., Brosseau, L., Costa, L., Cramp, F., Cup, E., Feehan, L., Ferreira, M., Forbes, S., Glasziou, P., Habets, B., Harris, S., Hay-Smith, J., Hillier, S., Hinman, R., ... White, C. (2016). Consensus on Exercise Reporting Template (CERT): Modified Delphi study. *Physical Therapy*, 96(10), 1514–1524. <https://doi.org/10.2522/ptj.20150668>
- Sorensen, C., & Zarrett, N. (2014). Benefits of Physical Activity for Adolescents with Autism Spectrum Disorders: A Comprehensive Review. *Review Journal of Autism and Developmental Disorders*, 1(4), 344–353. <https://doi.org/10.1007/s40489-014-0027-4>
- \*Sotoodeh, M. S., Arabameri, E., Panahibakhsh, M., Kheiroddin, F., Mirdoozandeh, H., & Ghanizadeh, A. (2017). Effectiveness of yoga training program on the severity of autism. *Complementary Therapies in Clinical Practice*, 28, 47–53. <https://doi.org/10.1016/j.ctcp.2017.05.001>
- Sowa, M., & Meulenbroek, R. (2012). Effects of physical exercise on autism spectrum disorders: A meta-analysis. In *Research in Autism Spectrum Disorders*, 6(1), 46–57. <https://doi.org/10.1016/j.rasd.2011.09.001>
- Sterne, J. A., Hernán, M. A., Reeves, B. C., Savović, J., Berkman, N. D., Viswanathan, M., Henry, D., Altman, D. G., Ansari, M. T., Boutron, I., Carpenter, J. R., Chan, A.-W., Churchill, R., Deeks, J. J., Hróbjartsson, A., Kirkham, J., Jüni, P., Loke, Y. K., Pigott, T. D., ... Higgins, J. P. (2016). ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. *BMJ (Clinical Research Ed.)*, 355, i4919. <https://doi.org/10.1136/bmj.i4919>
- \*Todd, T., Reid, G., & Butler-Kisber, L. (2010). Cycling for students with ASD: Self-regulation promotes sustained physical activity. *Adapted Physical Activity Quarterly*, 27(3), 226–241. <https://doi.org/10.1123/apaq.27.3.226>
- \*Tse, C. Y. A., Pang, C. L., & Lee, P. H. (2018). Choosing an Appropriate Physical Exercise to Reduce Stereotypic Behavior in Children with Autism Spectrum Disorders: A Non-randomized Crossover Study. *Journal of Autism and Developmental Disorders*, 48(5), 1666–1672. <https://doi.org/10.1007/s10803-017-3419-3>
- \*Tse, A. C. Y. (2020). Brief Report: Impact of a Physical Exercise Intervention on Emotion Regulation and Behavioral Functioning in Children with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders*, 50(11), 4191–4198. <https://doi.org/10.1007/s10803-020-04418-2>
- \*Tse, A. C. Y., Anderson, D. I., Liu, V. H. L., & Tsui, S. S. L. (2021). Improving Executive Function of Children with Autism Spectrum Disorder through Cycling Skill Acquisition. *Medicine and Science in Sports and Exercise*, 53(7), 1417–1424. <https://doi.org/10.1249/mss.0000000000002609>
- Waye, M. M. Y., & Cheng, H. Y. (2018). Genetics and epigenetics of autism: A Review. In *Psychiatry and Clinical Neurosciences*, 72(4), 228–244. <https://doi.org/10.1111/pcn.12606>
- World Health Organization. (2019). *Global action plan on physical activity 2018–2030: More active people for a healthier world*. World Health Organization. <https://apps.who.int/iris/handle/10665/272722>
- World Health Organization. (2020). *WHO guidelines on physical activity and sedentary behaviour*. World Health Organization. <https://www.who.int/publications/i/item/9789240015128>
- \*Yanardag, M., Akmanoglu, N., & Yilmaz, I. (2013). The effectiveness of video prompting on teaching aquatic play skills for children with autism. *Disability and Rehabilitation*, 35(1), 47–56. <https://doi.org/10.3109/09638288.2012.687030>
- Yu, C. C. W., Wong, S. W. L., Lo, F. S. F., So, R. C. H., & Chan, D. F. Y. (2018). Study protocol: a randomized controlled trial study on the effect of a game-based exercise training program on promoting physical fitness and mental health in children with autism spectrum disorder. *BMC Psychiatry*, 18(1), 56. <https://doi.org/10.1186/s12888-018-1635-9>
- \*Zanobini, M., & Solari, S. (2019). Effectiveness of the Program “Acqua Mediatrix di Comunicazione” (Water as a Mediator of Communication) on Social Skills, Autistic Behaviors and Aquatic Skills in ASD Children. *Journal of Autism and Developmental Disorders*, 49(10), 4134–4146. <https://doi.org/10.1007/s10803-019-04128-4>
- \*Zhao, M., & Chen, S. (2018). The Effects of Structured Physical Activity Program on Social Interaction and Communication for Children with Autism. *BioMed Research International*, 2018, 1–14. <https://doi.org/10.1155/2018/1825046>