



The Effect of Sports Activities on Motor and Social Skills in Autistic Children and Adolescents: a Systematic Narrative Review

A. Levante^{1,2} · C. Martis¹ · G. Antonioli¹ · M. Dima³ · L. Duma¹ · M. Perrone¹ · L. Russo⁴ · F. Lecciso^{1,2}

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Abstract

Background The main traits of Autism Spectrum Disorder (ASD) are difficulties in social communication and interactions. Autism is frequently related to motor impairments. In the last decades, to develop and promote the social and motor skills of autistic people, several sports training programmes have been designed. In the present systematic narrative review, we aimed at providing an overview of studies evaluating the effectiveness of these sports training programmes to synthesize their strengths and weaknesses.

Method To formulate the eligibility criteria for the systematic review, the PICO protocol was used. The PRISMA protocol was applied to four databases for the search strategy. 30 papers were reviewed, and their main features were tabulated and critically discussed.

Results Findings highlighted that 8 types of sports were applied to autistic individuals and that the majority of them were focused on two individual sports (i.e., swimming and horseback riding). In sum, findings revealed that sports training programmes provided positive benefits both on motor/social skills as well as on autistic traits (e.g., repetitive behaviours) and individual functioning. The narrative synthesis revealed also that future studies should enroll more autistic females and preschoolers. To encourage the social inclusion of autistic individuals, a group of typically developing peers should be involved in future sports training programmes.

Discussion In conclusion, professionals trained on autistic traits and knowledgeable in the target sport are required; consultations with the autistic community as guidance for designing novel sports training programmes are recommended.

Keywords Autism Spectrum Disorder · Narrative Review · Team Sport · Individual Sport · Social Skill · Motor Skill

Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder characterised by communication and social interaction deficits as well as a pattern of repetitive behaviours and restricted activities/interests [1]. Autistic individuals often show difficulties in social relations

[2–5], impairments in socio-emotional reciprocity [6], and poor interest in peers [7]. They also show stereotypes and ritualised patterns of behaviours [5] and hyper- and/or hypo-reactivity to environmental sensory inputs.

Although not included in diagnostic criteria, fine and gross motor difficulties [8•, 9], lack of postural control [10, 11], unstable balance [12], gait cycle abnormalities [13], hypotonia [14], and lack of motor coordination [15, 16] are shown by autistic individuals. A large number of studies [17–22] reported that motor difficulties may be one of the signs of risk for the early detection of autism. These motor difficulties are present since childhood [8•, 23, 24] and they persist into adulthood [25].

Due to the complexity and pervasiveness of the autistic disorder, recent research [26] suggested that combined strategies [e.g., the STAR programme; [26]] may be successful to reduce and mitigate autistic symptomatology. For instance, psychological interventions

✉ A. Levante
annalisa.levante@unisalento.it

¹ Department of Human and Social Sciences, University of Salento, Lecce, Italy

² Lab of Applied Psychology, Department of Human and Social Sciences, University of Salento, Lecce, Italy

³ Centro Sportivo Universitario, Lecce, Italy

⁴ Department of Mental Health, Unit of Infancy and Adolescent Neuropsychiatric, Local Health Service, Taranto, Italy

devoting attention to the enhancement of socio-communicative skills could be supported by other activities (e.g., speech therapy) involving other social partners. In this vein, sports training designed for autistic individuals can be used as a vehicle to improve their socio-communicative skills [27, 28] promoting and generalising the skills learned in therapeutic settings.

The positive cascade effects of sports activity on cognitive functioning and mental/medical health in typically developing individuals were demonstrated [29, 30]. Regarding autistic people, the positive impact of sports activity was reported in terms of reduced motor difficulties [31], improvement of cognitive functioning [32, 33], and emotional/behavioural adjustment [34–36].

Although the gains of sports activities for autistic individuals concerning motor [37–40] and social skills [41, 42, 43, 44] were demonstrated, their effective engagement in sports activities met two interrelated barriers. The first one is related to the motor difficulties (e.g., difficulties in balance, gait, speed, and motor control) that prevent their involvement in sports. For instance, their clumsiness makes them slow in carrying out motor tasks [45] warding off the fulfilment of the performance. The second barrier concerns the social and communicative difficulties which lead autistic individuals to not spontaneously engage themselves in sports activities, specifically when other peers are involved. By these two obstacles, a vicious cycle arises which negatively encourages their social withdrawal [46].

Designing sports training programmes promoting motor and social skills simultaneously may be the primary effort of the field of research on this topic. Thus, providing a narrative synthesis of the studies evaluating the effectiveness of sports training was deemed to be most adequate. To the best of our knowledge, only one narrative review on this topic has been carried out [47]. Although this review afforded an important contribution to the issue, several limitations may be highlighted. To be accurate, only four studies [48–51] on soccer were reviewed by searching three databases. In addition, only studies published during a short time range of publication were extracted (i.e., 2016–2019). Although this narrative review considered the effectiveness of team sports, whose benefits are undeniable [52], it did not cover the relevant literature on the topic adequately.

With this in mind, we conceived the current narrative review to synthesise studies published in the last 13 years (2010–2022) evaluating the effectiveness of sports training programmes designed for autistic children and adolescents. We searched only for studies aimed at improving both motor and social skills of participants. The main purpose of the present review was to extract their main strengths and weaknesses to encourage and provide recommendations for future research.

Method

Search Strategy

Despite the narrative nature of the current review, two standardised protocols were applied. To extract studies to review, the Preferred Reporting Items for Systematic Review and Meta-Analysis [PRISMA; 53]. Furthermore, the methodology used followed a published protocol [54]. To define the eligibility criteria the PICO protocol was applied.

The electronic search was carried out using four databases (Education Resources Information Center, PubMed, Scopus, and Web of Science). The keywords combined by boolean operators were: ‘autis*’ OR ‘autis* condition’ OR ‘Asperger’ AND ‘sport*’, ‘individual sport*’, ‘team sport*’, ‘exercise’, ‘physical exercise’, ‘football’, ‘basketball’, ‘handball’, ‘swimming’, ‘horseback riding’, ‘martial art*’, ‘athletics’, ‘golf’, ‘social skill*’, ‘motor skill*’.

The PICO protocol was used to examine the content of the reviewed papers. To be accurate:

- Population:** children and adolescents with autism aged ≤ 18 years;
- Intervention:** studies evaluating the effectiveness of the sports training programmes;
- Comparison:** differences between the group who trained in the sports and who did not;
- Outcome:** motor and social skills.

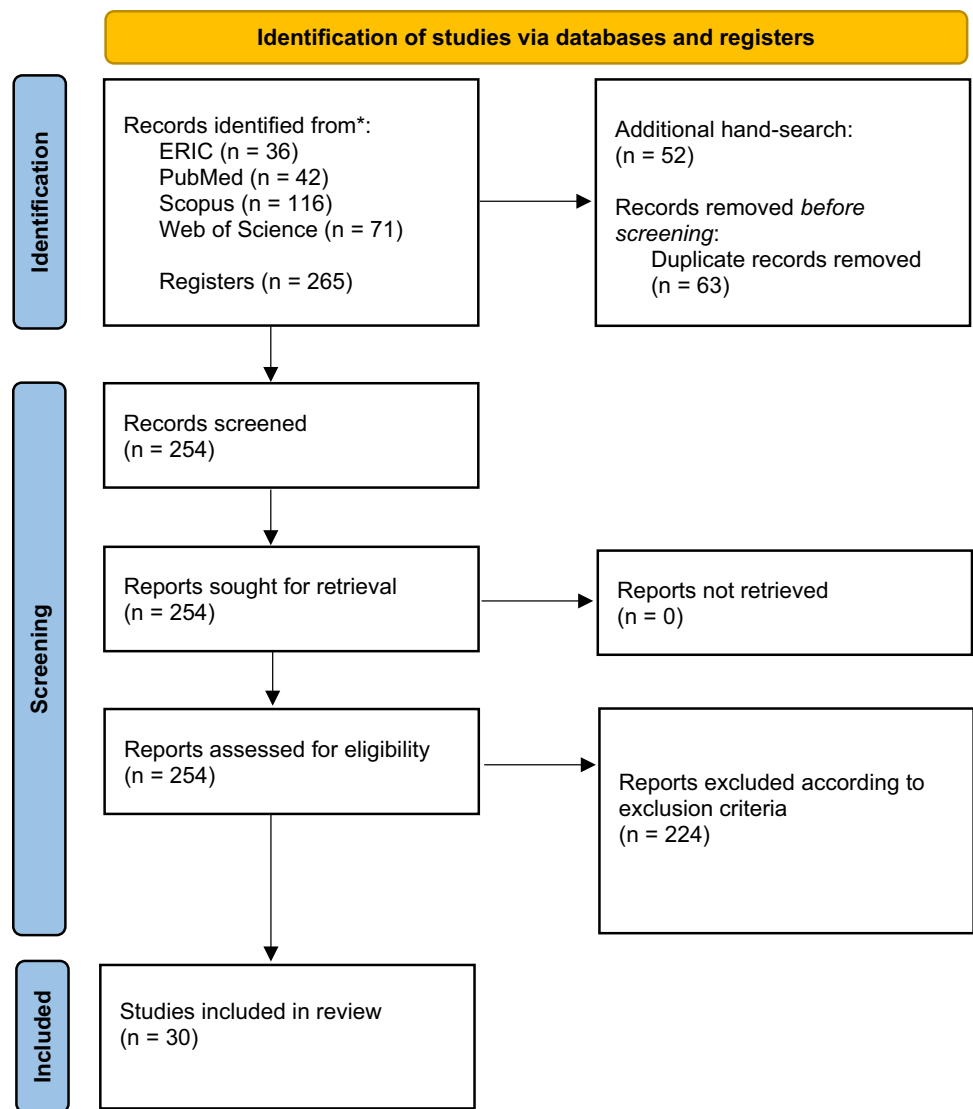
According to the protocol, a set of predefined inclusion criteria were: (i) studies investigating the effectiveness of individual and team sports involving autistic children and adolescents; (ii) studies that evaluate the effectiveness of individual and team sports involving autistic children and adolescents focused on social skills and motor simultaneously; (iii) year of publication ranging from 2010–2022; (iv) published paper in peer-reviewed journals; (v) paper written in English. Exclusion criteria were defined as follows: (i) studies focused on sports training involving autistic adults (age > 18 years) or only typically developing (TD) individuals; (ii) studies examining the effectiveness of the psychomotor intervention; (iii) studies aimed at investigating the effectiveness of individual and team sports only on motor skills in the autistic population; (iv) dissertation and conference papers; (v) publications that are not in peer-reviewed journals.

The selection multi-step procedure for which studies were included in the review has been summarised in Fig. 1.

Selection of the Studies

The second author (CM) carried out the electronic search, extracted 265 records from all databases, and tabulated them in an Excel file. An additional hand search was performed to incorporate another 52 records according to the reference lists

Fig. 1 PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only. *Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/registers). From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. <https://doi.org/10.1136/bmj.n71>. For more information, visit: <http://www.prisma-statement.org/>



of reviewed studies. The first (AL) and the second author (CM) screened the records independently to remove the duplicates (n=63) and, according to the pre-defined inclusion and exclusion criteria, they removed 224 papers. The agreement between authors was high (Cohen’s $k=0.90$). In case of disagreement, the last author (FL) arbitrated. Finally, 30 papers (marked with ● in the reference list) were included in the narrative review [8●, 41●, 42●, 43●, 55●, 56●, 57●, 58●, 59●, 60●, 61●, 62●, 63●, 64●, 65●, 66●, 67●, 68●, 69●, 70●, 71●, 72●, 73●, 74●, 75●, 76●, 77●, 78●, 79●, 80●].

Data Synthesis

The paragraph on the results was structured in 5 sections according to the main information reported in Table 1. Firstly, we described the content of the Table. Then, we summarised the main findings regarding the countries where the studies

were carried out, the type of sport considered, and the participants’ characteristics. The third section consists of the training information and the studies’ purposes. The fourth one included the studies’ design and measures administered. The last section consisted of the synthesis of the main studies’ findings.

Results

Table 1 summarises all information regarding the included papers according to two criteria. Firstly, we grouped the sports in alphabetical order (i.e., athletics, basketball, football, golf, handball, horseback riding, martial arts, and swimming), and secondly, for each sport, we grouped the papers chronologically (from newest publication to oldest one) and in alphabetical order of the first author’s name for papers published in the same year.

Table 1 Descriptive information on studies included in the systematic review

Sport targeted in the study	Author(s), year	Journal	Country where the study has been conducted	Sample descriptive information M(sd)	Training information	Study purposes	Measures administered	Study results
<i>Athletics</i>								
1	Jimeno, 2019 [79•]	The Educational and Developmental Psychologist	Australia	N = 4 (males = 2); Age range = 10 – 16 years; M(sd) = ns	One day per week for 8 weeks (1 h/ session)	Motor and social skills Others outcomes: quality of life	Pre-test: PedsQL4.0 Follow-up: PedsQL4.0	Motor skills: improvement in global motor skills Social skills: improvement in global social skills
<i>Basketball</i>								
2	Yang et al., 2021 [76•]	International Journal of Environmental Research and Public Health	China	N = 30 (males = 25); Age range = 3–6 years Experimental group N = 15 (males = 12); M(sd) = 4.67 (0.70) years Control group N = 15 (males = 13); M(sd) = 5.03 (0.55) years	Five days per week for 12 weeks (40 min/ session)	Social skills Other outcomes executive control network	Pre-test: demographic questionnaires Post-test: SRS-2; fMRI	Social skills: improvement in social communication and social cognition No significant difference in social motivation, autistic mannerisms, and social awareness before and after sport training Other outcomes: improvement in functional connectivity of the executive control network
3	Cai et al., 2020 [77•]	Journal of Human Kinetics	China	N = 30 (males = 26); Age range: 3–6 years Experimental group N = 15 (males = 14); M(sd) = 5.03 (.64) years Control group N = 15 (males = 12); M(sd) = 4.56 (.84) years	Five weekly session for 12 weeks (40 min/ session)	Motor and social skills Other outcomes: sleep problems, eating style, physical fitness	Structural features: CARS; CSHQ; CEBQ Pre-test: China's Manual of Physical Fitness [81]; SRS-2 Post-test: China's Manual of Physical Fitness [81]; SRS-2	Motor skills: improvement in speed-agility performances and increased muscle strength Social skills: improvement in social cognition and communication skills Other outcomes: decrease of autistic mannerisms

Table 1 (continued)

Sport targeted in the study	Author(s), year	Journal	Country where the study has been conducted	Sample descriptive information M(sd)	Training information	Study purposes	Measures administered	Study results	
4	Wang et al., 2020 [64•]	Brain Sciences	China	N = 33 (males = 28); Age range: 3–6 years; M(sd) = 4.9 (.7) years Experimental group N = 18 (males = 15); M(sd) = ns (ns) Control group N = 15 (males = 13); M(sd) = ns (ns)	Five weekly sessions for 12 weeks (40 min/session)	Social skills Other outcomes: executive functions, autistic symptoms	Structural features: CARS; CSHQ; CEBC Pre-test: CHEXI; SRS – 2; RBS – R Post-test: CHEXI; SRS – 2; RBS – R	Social skills: improvement in social communication skills Other outcomes: improvement in working memory; decrease of repetitive behaviours	
5	Alp & Akin, 2019 [67•]	Journal of Education and Training Studies	Turkey	N = 2 (males = 2); Age = 10 years old; M(sd) = ns (ns)	One week of observation and sixteen weeks of application	Social skills	Event recording from observation-based recording systems	Social skills: improvement in nonverbal communication skills	
<i>Football</i>									
6	Howells et al., 2022 [72•]	Journal of Autism and Developmental Disorders	Australia	N = 35 (males = 32); Age range = 5–12 years; M(sd) = 8.01 (1.90) years Experimental group N = 16 (males = 14); M(sd) = 8.01 (1.90) years Control group N = 19 (males = 18); M(sd) = 8.73 (2.33) years	One day per week for an average of 13 sessions (60 to 90 min/session)	Motor and social skills	Pre-test: SRS-2; VABS-3; MABC-2 Post-test: MABC-2	Motor skills: the experimental group showed an improvement in global motor skills, aiming, and catching No significant improvement in the control group was found No change in manual dexterity was found in either group Social skills: high levels of social skills were associated with high gains in motor skills	
7	Lopez-Diaz et al., 2021 [55•]	Behavioral Sciences	Spain	N = 16 (males = 16); Age range = 6–10 years; M(sd) = 7 (1.42) years	Two weekly sessions of training for a total of 34 one-hour sessions	Social skills	Pre-test: CHIS; TOS Post-test: CHIS; TOS	Social skills: global improvement	

Table 1 (continued)

Sport targeted in the study	Author(s), year	Journal	Country where the study has been conducted	Sample descriptive information M(sd)	Training information	Study purposes	Measures administered	Study results
8	Howells et al., 2020 [73•]	Journal of Autism and Developmental Disorders	Australia	$N = 40$ (males = 37); Age range = 5–12 years; $M(sd) = 8.31 (2.01)$ years	One day per week for an average of 12 sessions (60 to 90 min/session)	Social skills Other outcomes: behavioural problems	Pre-test: FSIQ; SRS-2; CBCL; VABS-3; DSM-oriented scales [82] Post-test: CBCL; VABS-3; DSM-oriented scales [82]	Social skills: Albeit the time effect was not significant, the experimental group scores at the post-test were higher than the pre-test Other outcomes: the experimental group showed low emotional/behavioural symptoms, low anxiety problems than in the control group
				Experimental group $N = 19$ (males = 17); $M(sd) = 7.98 (1.71)$ years Control group $N = 21$ (males = 20); $M(sd) = 8.62 (2.26)$ years				
9	Lopez et al., 2017 [61•]	Journal of Education and Training Studies	Spain	$N = 5$ (gender distribution ns); Age range = 6–12 years; $M(sd) = ns$ (ns)	Two weekly sessions of training for 3 months (1 h/session)	Motor and social skills	Learning Standard	Motor skills: global improvement Social skills: global improvement
10	Shanok et al., 2019 [80•]	Journal of Autism and Developmental Disorders	USA	$N = 46$ (males = 37); Age range = 6–24 years; $M(sd) = 11.46 (6.21)$ years	6-week, 12 golf-training sessions (45 min/session)	Motor and social skills	Pre-test: questionnaire developed for the study purposes on social and motor skills Post-test: questionnaire developed for the study purposes on social and motor skills	Motor skills: global improvement Social skills: improvement in receptive and expressive, communication, and self-regulatory skills
11	Miltenberg & Charlop, 2014 [43•]	Journal of Autism and Developmental Disorders	USA	$N = 3$ (males = 2); Age range = 6–9 years; $M(sd) = ns$ (ns)	16 weeks of sport training	Social skills	Pre-test: VABS-II Pre-, post-test, and follow-up were evaluated by observational procedure of behaviors developed for the study purposes	Social skills: improvement in play abilities and language skills

Handball

Table 1 (continued)

Sport targeted in the study	Author(s), year	Journal	Country where the study has been conducted	Sample descriptive information M(sd)	Training information	Study purposes	Measures administered	Study results
<i>Horseback riding</i>								
12	Peters et al., 2022 [75•]	Frontiers in Pediatrics	USA	Experimental group N = 45 (males = 37); Age range = 6–16 years; M(sd) = 10.1 (2.8) years Control group N = 44 (males = 40); Age range = 6–16 years; M(sd) = 10.4 (3.0) years	One weekly small group training session for 10 weeks (1 h/session)	Social skills	Pre-test: SRS; SALT; ABC-C Post-test: SRS; SALT; ABC-C Note: The ABC-C was also completed weekly by the caregiver during the 10 weeks of intervention	Social skills: improvement of self-regulation behaviours and language Other outcomes: self-regulation mediated the therapeutic horseback riding's effect on social skills No significant effect on language skills were found
13	Harris & Williams, 2017 [8•]	International Journal of Environmental Research and Public Health	UK	N = 24 (males = 21); Age range = 6–9 years; M(sd) = 7.5 (10.57) years Experimental group N = 10 (males = 9); M(sd) = 8.2 (10.56) years Control group N = 14 (males = 12); M(sd) = 7 (3.95) years	7 weeks of training sessions (45 min/session)	Social skills	Pre-test: CARS-2; ABC-C Training: MOP1 (experimental group only) Post-test: CARS-2; ABC-C	Social skills: development of a positive engagement Other outcomes: decrease of autistic symptoms and hyperactivity
14	Anderson & Meints, 2016 [68•]	Journal of Autism and Developmental Disorders	UK	N = 15 (males = 11); Age range = 5–16 years; M(sd) = 10 (3.8) years	6 weeks of training sessions consisting of:—an initial assessment day;—5 weeks of a training program (3 h/sessions)	Social skills	Pre-test: AQ-Child; AQ-Adolescents; The empathising quotient/systemising quotient; VABS Post-test: AQ-Child; AQ-Adolescents; The empathising quotient/systemising quotient; VABS	Social skills: increased adaptive behaviours and empathic abilities

Table 1 (continued)

Sport targeted in the study	Author(s), year	Journal	Country where the study has been conducted	Sample descriptive information M(sd)	Training information	Study purposes	Measures administered	Study results
15	Borgi et al., 2016 [71•]	Journal of Autism and Developmental Disorders	Italy	N = 28 (males = 28); Age range = 6–12 years; M(sd) = 8.6 (1.7) years Experimental group N = 15 (males = 15); M(sd) = ns Control group N = 13 (males = 15); M(sd) = ns	One weekly training session for 6 months with a total number of 25 sessions (60–70 min/ session)	Social skills Other outcomes: adaptive behaviours and executive functions	Pre-test: VABS; TOL Post-test: VABS; TOL	Motor skills: milder improvement in motor skills Social skills: improvement in social functioning Other outcomes: improvement in executive functions
16	Gabriels et al., 2015 [57•]	Journal of the American Academy of Child and Adolescent Psychiatry	USA	N = 116 (males = 101); Age range = 6–16 years Experimental group N = 58 (males = 49); M(sd) = 10.5 (3.2) years Control group N = 58 (males = 52); M(sd) = 10.0 (2.7) years	10 weeks of training sessions (45 min/ session)	Social skills Other outcomes: self-regulation and adaptive behaviours	Pre-test: PPVT-4; SALT; BOT-2 (Short Form); SIPT; VABS-II; ABC-C; SRS Post-test: PPVT-4; SALT; BOT-2 (Short Form); SIPT; VABS-II; ABC-C; SRS	Social skills: improvement in social and communication skills Other outcomes: decrease in irritability and hyperactivity behaviours
17	Holm et al., 2014 [42•]	Journal of Autism and Developmental Disorders	USA	N = 3 (all males); Age range = 6–8 years; M(sd) = ns	1, 3, and 5 times/ week for 12 weeks	Motor and social skills	Pre-test: ABC-C; SRS; SP-CQ Training: ABC-C; SRS; SP-CQ Post-test: ABC-C; SRS; SP-CQ	Motor skills: global motor improvement Social skills: increased verbalization and joint attention abilities
18	Lanning et al., 2014 [60•]	Journal of Autism and Developmental Disorders	USA	N = 25 (males = 21); Age range = 5–14 years Experimental group N = 13 (males = 9); M(sd) = 7.5 (3.2) years Control group N = 12 (males = 12); M(sd) = 9.8 (3.2) years	12 weeks of training sessions (1 h/ session)	Motor and social skills Other outcomes: quality of life and psychophysical skills	Pre-test: PedsQL; CHQ After 3 weeks of sports training: PedsQL; CHQ After 6 weeks of sports training: PedsQL; CHQ After 9 weeks of sports training: PedsQL; CHQ Post-test: PedsQL; CHQ	Motor skills: improvement in physical functioning Social skills: improvement in social and school activities functioning Other outcomes: improvement of well-being and behavioural features

Table 1 (continued)

Sport targeted in the study	Author(s), year	Journal	Country where the study has been conducted	Sample descriptive information M(sd)	Training information	Study purposes	Measures administered	Study results
19	Jenkins, DiGiennaro Reed, 2013 [59•]	Research in Autism Spectrum Disorder	USA	N = 7 (males = 6); Age range = 6–14 years; M(sd) = 9.5 years	One weekly training session for 9 weeks (1 h/ session)	Motor and social skills	Pre-test: CBCL; TRF (CBCL teacher rating form) Post-test: CBCL; TRF (CBCL teacher rating form)	Motor skills: improvement in postural control Social skills: no significant improvement in behavioural problems
20	Gabriels et al., 2012 [58•]	Research in Autism Spectrum Disorders	USA	N = 42 (males = 36); Age range = 6–16 years; M(sd) = 8.7 (ns) years Experimental group N = 26 (males = 21); M(sd) = ns (ns) Control group N = 16 (males = 15); M(sd) = ns (ns)	One session of training for 10 weeks (1 h/ session)	Motor and social skills	Pre-test: ABC-C; VABS-II; BOT-2; SIPT Post-test: ABC-C; VABS-II; BOT-2; SIPT	Motor skills: global motor improvement Social skills: improvement in adaptive behaviours and expressive language
<i>Martial Arts</i>								
21	Rivera et al., 2020 [63•]	Child Psychiatry & Human Development	USA	N = 33 (males = 22); Age range = 8–17 years; M(sd) = 12.67 (2.99) years	One weekly training for 8 weeks (45 min/ session)	Social skills	Pre-test: socio-demographic information; Patient Weighing Scale; ABC Post-test: ABC; Parent Interviews	Social skills: improvement in social skills and self-esteem
22	Bahrami et al., 2016 [69•]	Journal of Autism and Developmental Disorders	Iran	N = 30 (males = 26); Age range = 5–16 years; M(sd) = 9.13 (3.27) years Experimental group N = 15 (males = 13); M(sd) = 9.20 (3.32) years Control group N = 15 (males = 13); M(sd) = 9.06 (3.33) years	Four weekly training sessions for 14 weeks (the initial duration of each exercise session was 30 min, which was progressively increased to approximately 90 min for a session)	Social skills	Pre-test: GARS-2 (communication subscale) Post-test: GARS-2 (communication subscale) Follow-up (after 1 month): GARS-2 (communication subscale)	Social skills: improvement in communication skills

Table 1 (continued)

Sport targeted in the study	Author(s), year	Journal	Country where the study has been conducted	Sample descriptive information M(sd)	Training information	Study purposes	Measures administered	Study results
Swimming								
23	Marzouki et al., 2022 [74•]	Biology	Tunisia	N = 28 (males = 21); Age range = 6–7 years Experimental group I N = 10 (males = 7); M(sd) = 6.3 (0.5) Experimental group II N = 10 (males = 8); M(sd) = 6.4 (0.5) Control group N = 8 (males = 6); M(sd) = 6.3 (0.5)	Two weekly training sessions for 8 weeks (50 min/session)	Motor and social skills	Pre-test: TGMD-2; subscale of the GARS-2; ERC Post-test: TGMD-2; the stereotypy subscale of the GARS-2; ERC	Motor skills: improvement in gross motor skills and stereotypes behaviour in experimental groups I and II Social skills: small change effect on emotional functioning in three groups was found
24	Battaglia et al., 2019 [70•]	Journal of Functional Morphology and Kinesiology	Italy	N = 3 (males = 2); Age range = 11–15 years; M(sd) = ns (ns)	Two training sessions for 12 weeks (45–50 min/session)	Motor and social skills	Pre-test: C.F.V; VABS; Seca Electronic Scale; TGMD; observation schedule for social behaviours [83] Post-test: Seca Electronic Scale; TGMD; observation schedule for social behaviours [83]	Motor Skills: improvement in locomotor skills and motor control Social skills: improvement in social behaviours
25	Battaglia et al., 2019b [78•]	Life Span and Disability	Italy	N = 1 individual with autism (male); Age = 4.2 years old	Two training sessions for 12 weeks (45–50 min/session)	Motor and social skills	Pre-test: C.F.V; PEP-3; TGMD; observation schedule for social behaviours [83]; VABS Post-test: TGMD; observation schedule for social behaviours [83]	Motor skills: locomotor and object control skills after the CI-MAT program Social skills: improvements in his social behaviours (sensitivity to other's presence and eye contact)

Table 1 (continued)

Sport targeted in the study	Author(s), year	Journal	Country where the study has been conducted	Sample descriptive information M(sd)	Training information	Study purposes	Measures administered	Study results
26	Zanobini & Solari, 2019 [65•]	Journal of Autism and Developmental Disorders	Italy	N = 25 (males = 19) Age range: 3–8 years Experimental group N = 13 (males = 10); M(sd) = 6.82 (1.51) years Control group N = 12 (males = 9); M(sd) = 6.50 (1.84) years	Once every 2 weeks from January to May 2017 (12 sessions half an hour long each); follow-up session after 6 months of interruption of training	Motor and social skills	The evaluation involved only the experimental group Pre-test: The Autism Behavior Checklist [84]; SRS; HAAR Post-test: The Autism Behavior Checklist; SRS; HAAR Follow-up: The Autism Behavior Checklist; SRS; HAAR	Motor skills: improvement in aquatic skills Social skills: improvement in relational skills
27	Caputo et al., 2018 [41•]	Journal of Autism and Developmental Disorders	Italy	N = 26 (males = 17); Age range = 6–12 years Experimental group N = 13 (males = 11); M(sd) = 8.3 (2.3) years Control group N = 13 (males = 6); M(sd) = 7.7 (2) years	10 weeks of training program for a total of 96 sessions (45 min for a session) Phase I: once a week, one-to-one expert-to-child Phase II: once a week, one-to-one expert-to-child Phase III: twice a week in a small group	Motor and social skills	The evaluation involved only the experimental group Pre-test: CARS; VABS; HAAR Post-test: CARS; VABS; HAAR	Motor skills: improvement in aquatic skills Social skills: improvement in the emotional response and adaptation to change

Table 1 (continued)

Sport targeted in the study	Author(s), year	Journal	Country where the study has been conducted	Sample descriptive information M(sd)	Training information	Study purposes	Measures administered	Study results
28	Alaniz et al., 2017 [66•]	Journal of Autism and Developmental Disorders	USA	N = 7 (males = 6); Age range = 3–7 years; M(sd) = 6.09 (.24) years	One weekly training session for 24 weeks (1 h/ session)	Motor and social skills	Structural features: Clinician-Rated Severity of Autism Spectrum and Social Communication Disorders (1) Pre-test: Aquatic Skills Checklist (developed by researchers); SSIS Post-test after 8 h of training: Aquatic Skills Checklist (developed by researchers; SSIS Follow up after 16 h of training: Aquatic Skills Checklist (developed by researchers Follow up after 24 h of training: Aquatic Skills Checklist (developed by researchers	Motor skills: improvement in aquatic skills Social skills: no significant improvement
29	Ennis, 2011 [56•]	The Journal of Aquatic Physical Therapy	USA	N = 6 (gender distribution ns); Age range = 3–9 years; M(sd) = ns (ns)	10 weeks of training sessions (1 h/ session)	Motor and social skills	Pre-test: WOTA; Peds-QL Post-test: WOTA; Peds-QL	Motor skills: improvement in aquatic skills Social skills: fair/poor development and improvement in communication skills

Table 1 (continued)

Sport targeted in the study	Author(s), year	Journal	Country where the study has been conducted	Sample descriptive information M(sd)	Training information	Study purposes	Measures administered	Study results
30	Pan, 2010 [62•]	Autism	China	N = 16 (males = 16); Age range = 6–9 years Experimental group N = 8 (males = 8); M(sd) = 7.27 (1.25) years Control group N = 8 (males = 8); M(sd) = 7.20 (.89) years	Two weekly training sessions (90 min/ session) for 21 weeks consisting of: - 10 weeks of training; - 10 control weeks; - 1 week of transition	Motor and social skills Other outcomes: non-social behaviours	Pre-test: HAAR; SSBS-2 Post-test: HAAR; SSBS-2 Follow-up: HAAR; SSBS-2	Motor skills: improvement in aquatic skills Social skills: no significant improvement in social skills Other outcomes: decrease of anti-social behaviour

ns not specified

Aberrant Behavior Checklist [ABC; ABC-C [85]]; Autism-Spectrum Quotient for Adolescents [AQ-Adolescents; [86]]; Autism-Spectrum Quotient for Children [AQ-Child; [87]]; Bruininks-Oseretsky Test of Motor Proficiency [BOT-2; [88]]; Child Behavior Checklist [CBCL; [89]]; Child Behavior Checklist – Teacher Reported Form [TRF; [89]]; Child Eating Behavior Questionnaire [CEBQ[90]]; Child Health Questionnaire [CHQ; [91]]; Childhood Autism Rating Scale [CARS; CARS-2; [92, 93]]; Childhood Executive Functioning Inventor [CHEXI; [94]]; Children’s Sleep Habits Questionnaire [CSHQ[95]]; Correspondences and Functions Evaluation Test [C.F.V; [96]]; Emotion Regulation Checklist [ERC; [97]]; Full-Scale Intelligence Quotient [FSIQ; [98]]; Gilliam Autism Rating Scale – Second Edition [GARS-2; [99]]; Humphries’Assessment of Aquatic Readiness [HAAR; [100]]; Gross Motor Development Test [TGM; [101]]; Measurement of Pet Intervention Checklist [MOPi; [102]]; Movement Assessment Battery for Children, Second Edition [MABC-2; [103]]; Peabody Picture Vocabulary Test, Fourth Edition [PPVT – 4; [104]]; Pediatrics Quality of Life Measurement Model [Peds-QL; [105]]; Repetitive Behavior Scale-Revised [RBS – R; [106]]; School Social Behavior Scales [SSBS-2; [107]]; Sensory Integration and Praxis Test [SIPT; [108]]; Sensory Profile Caregiver Questionnaire [SP-CQ; [109]]; Social Interaction Skills Questionnaire [CHIS; reference not available]; Social Skills Improvement Scale [SSIS; [110]]; Social Responsiveness Scale [SRS; SRS-2; [111, 112]]; Systematic Analysis of Language Transcripts [SALT; [113]]; Teacher Observation Scale [TOS; reference not available]; Test of Gross Motor Development [TGMD; TGMD-2; [101, 114]]; Tower of London [TOL; [115]]; Vineland Adaptive Behavior Scales [VABS; VABS-II; [116–118]]; Water Orientation Test of Alyn [WOTA; [119]]

In sum, Table 1 reports: the authors and the publication year, the peer-reviewed journal where the study was published, the country where the study has been conducted, the sample descriptive information (i.e., sample size, gender distribution, participants' mean age, standard deviation, and age range), the training duration, the study purposes, the measure(s) administered, and the main study findings.

Countries where the Studies were Carried Out, the Type of Sports, and the Participants

The majority of the studies ($n = 24$) were carried out in countries of the Global North.

Eight studies were detected from the reviewed studies. Three of them were team sports (i.e., basketball, football, and handball) and the remaining ones were individual sports (i.e., athletics, golf, horseback riding, martial arts, and swimming). Among the latter, swimming [41•, 56•, 62•, 65•, 66•, 70•, 74•, 78•] and horseback riding [8•, 42•, 57•, 58•, 59•, 60•, 68•, 71•, 75•] were the most popular sports considered by the literature. Few studies evaluated the effectiveness of athletics [79•], basketball [64•, 67•, 76•, 77•], football [55•, 61•, 72•, 73•], golf [80•], handball [43•], and martial arts [63•, 69•] on motor and social skills.

Concerning the participants' characteristics, as reported by all authors of the reviewed studies, the involved autistic children and adolescents had previously received a diagnostic evaluation by the healthcare service.

Regarding the sample characteristics, we resumed information on the size, gender distribution, and age. The sample size varied from 2 to 33 participants in the majority of the studies, whereas the other ones involved a medium-large sample size. For instance, three studies [57•, 58•, 75•] on horseback riding involved 42, 45, and 116 children respectively. Two studies on football [72•, 73•] recruited 35 and 40 children respectively and only one study on athletics [79•] enrolled 46 participants. Only one case report [78•] was included in the narrative review. A consideration of the sample concerned its composition. Specifically, as seen in Table 1, 13 studies [42•, 43•, 55•, 56•, 59•, 61•, 63•, 66•, 67•, 68•, 70•, 79•, 80•] evaluated the effectiveness of sports training only on the experimental group. Sixty-six studies [8•, 41•, 57•, 58•, 60•, 62•, 64•, 65•, 69•, 71•, 72•, 73•, 74•, 75•, 76•, 77•] compared the group who trained in sports to the group who did not. With regards to the gender distribution, in line with the gender ratio of autism (4:1), in all studies, the autistic group consisted of males predominantly. Only two studies [56•, 61•] did not report the information. When the participants' age range was considered, findings reported that it varied consistently among reviewed studies. To be accurate, three studies [64•, 77•, 78•] enrolled only pre-schoolers (age < 5 years) and 11 studies [8•, 41•, 42•, 43•, 55•, 61•, 62•, 67•, 68•, 71•, 74•] involved schoolers (age range 6–13 years). Again, 4 studies [56•, 65•, 66•, 76•] recruited both pre-schoolers and schoolers (age range 3–9 years). Participants

aged 5–17 years were enrolled in 12 studies [57•, 58•, 59•, 60•, 63•, 69•, 70•, 72•, 73•, 75•, 79•, 80•] and only one study [80•] recruited participants aged 6–24 years.

Training Information and Studies' Purposes

Each sports training programme lasted from 7 to 24 weeks. The majority of the studies opted for a training period of 12 weeks. Each training session lasted 45 to 90 min and the weekly training varied from 1 to 5 days.

Regarding the studies' purposes, we included in the review only studies investigating the effectiveness of sports training in improving both motor and social skills simultaneously in autistic children and adolescents. Nevertheless, the reviewing process emphasised that the additional goal of some studies was to promote other individuals' outcomes. For instance, repetitive behaviours or stereotypes [41•, 59•, 63•, 64•, 65•], executive functions [58•, 64•, 71•, 76•], sleep–wake- and eating-related routines [77•], and quality of life [79•] were the pivotal considered.

Studies' Designs and Measures Administered

As can be seen in Table 1, all studies included in the current narrative review applied a longitudinal design. To be specific, 23 studies [8•, 41•, 42•, 55•, 56•, 57•, 58•, 59•, 60•, 63•, 64•, 68•, 70•, 71•, 72•, 73•, 74•, 75•, 76•, 77•, 78•, 79•, 80•] applied a pre-post-test (ABA) design and 5 studies [43•, 62•, 65•, 66•, 69•] included a follow-up step (ABAA). Two studies [61•, 67•] evaluated the effectiveness of sports training by analysing the children's performance across time, albeit they did not specify the time between the data collection.

Regarding the structure of the sports training activities, in the majority of the studies [43•, 57•, 58•, 59•, 60•, 61•, 65•, 66•, 68•, 71•, 74•, 75•, 79•] they were performed in small groups (e.g., 3–8 members). The study by Shanok and colleagues [80•] placed participants in sub-groups that ranged from 5 to 15 individuals. In three studies [41•, 69•, 70•] the training was structured gradually. In other words, firstly participants performed sports activities in a one-to-one (operator-autistic child) relationship and afterward in a one-to-small group relationship. The study by Alp and Akin [67•] enrolled two individuals, therefore the training activities were performed in a one-to-two relationship. Three studies [57•, 78•, 120] planned one-to-one (operator-autistic child) activities and 9 studies [8•, 55•, 56•, 63•, 64•, 72•, 73•, 76•, 77•] did not report this information in the paper. A pivotal consideration regards the presence of professionals trainer for the specific sport who supervised the sports activities.

Because all studies aimed to evaluate the effectiveness of sports training programmes, specific measurements before (pre-test) and afterward (post-test) the sports training activities were applied. Regarding the assessment of motor skills, each study administered standardised tools according to the

targeted sport (see Table 1 for details). To evaluate social skills, the most applied tool was the Vineland Adaptive Behaviour Scales [VABS; [116–118]]. In two studies, authors administered measures developed for the study purpose for assessing both social ([43•, 80•] and motor skills [80•].

When the study measured the improvement on other outcomes because of the sports training specific tools were administered. For instance, autistic symptomatology was evaluated by using the Childhood Autism Rating Scale [CARS; [92, 93]] and the Gilliam Autism Rating Scale-Second Edition [GARS-2; [99]]. Repetitive behaviours, hyperactivity, and aggressive behaviours were measured using the Social Responsiveness Scale [SRS-2; [111, 112]], the Repetitive Behaviour Scale-Revised [RBS-R; [106]], the Aberrant Behaviour Checklist-Community Edition [ABC-C; [85]], and the School Social Behaviour Scales [SSBS-2; [107]]. Whereas cognitive functioning was evaluated by using the Tower of London [TOL; [115]] and the Childhood Executive Functioning Inventory [CHEXI; [94]]. Only one study [76•] examined any neurological change (e.g., executive functions) via an fMRI scan.

Studies' Findings

Overall, all reviewed studies reported an improvement in participants' motor and social skills. Additional improvements in social interaction, ability to play in groups, and social behaviours (e.g., sharing, cooperation, participation, gaze engagement) because of the sports training were found.

Concerning participants' motor skills, except for one study [71•] which revealed weaker improvement, the majority of the studies reported a better performance in speed-agility performances and increased muscle strength [77•], aiming and catching [72•], locomotors skills and motor control [70•], aquatic skills [41•, 62•, 65•, 66•], coordination and movements orientation, global motor [42•, 58•, 60•, 61•, 72•, 79•, 80•], postural control [59•] and gross motor [74•].

Regarding the participants' social skills, except for the study by Marzouki and colleagues [74•] that reported few improvements, all reviewed studies reported an enhancement in participants' performance in this domain. For greater clarity of the results, we clustered the improvements in social skills by the DSM-5 diagnostic criteria. With a focus on the social interaction domain, studies showed an improvement in communication skills [42•, 43•, 57•, 64•, 69•, 75•, 76•, 77•, 79•, 80•], increasing adaptive behaviours and empathic abilities [68•], joint attention abilities [42•], and expressive language [58•, 80•]. With regards to verbal communicative behaviours, the reviewed studies reported better participants' performance in non-verbal communication [78•] and in emotional response [41•, 57•, 73•, 75•, 80•]. Finally, regarding the ability to develop, maintain, and understand social relationships, the studies showed an enhancement of participants' adaptive behaviours [41•, 58•].

Discussion

The purpose of the present systematic narrative review was to provide an up-to-date overview of the studies evaluating the effectiveness of sports training programmes in enhancing motor and social skills in autistic children and adolescents. The overall aim of the present section was to highlight the strengths and weaknesses of these studies to suggest recommendations for future research.

In this section, the main findings emerging from the critical analysis were argued more in-depth. The electronic search extracted 30 studies published in the last 13 years (2010–2022), and more than half of them were published in the last 6 years (2017–2022). This suggests that the topic is an emerging field of interest for autism-related research.

The first consideration was around the types of sports which have been applied to the autistic population. Albeit a team sport may be more worthwhile in promoting social skills, results outlined that individual sports were more trained than team ones. This may be due to the troubles related to the management of autistic individuals in a group setting. For instance, individual unpredictable behaviours and functioning (e.g., presence and/or severity of a cognitive disability, presence or lack of language skills) along with difficulties regarding their engagement in social activities [121], could be the autistic traits better handled when a one-to-one or one-to-two relationship occurs.

Three key reflections concerned the participants' characteristics (i.e., gender and age, and the sample size). Firstly, male autistic individuals were involved in studies more than females and the gender ratio (4:1) of the disorder [1] could be the explanation. Nevertheless, although autistic females appear more socially [122, 123] and communicative [124] competent than males by camouflaging their autistic traits [124–126], they may have severe difficulties in maintaining long-term friendships and social interactions with peers [123]. Hence, to overcome these difficulties, sports activities performed in teams could be pivotal to fostering their social and communicative skills by learning adequate strategies for social interactions (e.g., back and forward communication).

The second key reflection regards the participants' age, our review highlighted that few studies involved preschoolers. As early intervention plays a crucial role in improving autistic symptomatology [127, 128], the need for sports training programmes suitable for younger children under 6 years is advisable. A supplementary reflection that may be problematic concerned the wide age range of participants (i.e., from as young as 3–6 through to older adolescence or young adulthood) in some of the reviewed studies. Although recruiting autistic individuals within a small age range may be challenging, even more so when early childhood is considered, results of studies evaluating the effectiveness of sports training on participants across a wide age range may be interpreted cautiously. That is why these findings may be affected by the bias related to the heterogeneity of the sample which affected their generalizability.

The third key consideration regarding the participants was the sample size. Except for the study by Gabriels and colleagues [57•], the reviewed studies have fewer than 50 participants, with a number having fewer than 10. Only one case report [78•] was found by the search strategy. The small sample size of these studies reflects the two sides of the same argument. On one side, the main criticisms of these studies were the low generalisability, reliability, and replicability of results. Nevertheless, performing sports training with a large group of autistic individuals may be troublesome in practice. That is why the professionals involved in the training should take into account simultaneously the functioning, the individual traits, and the co-occurring symptoms (e.g., ADHD) of each participant. These diversities may be better managed in a small group. On the other side, performing sports activities in a small group and/or on a single case may allow for investigating more in-depth the individuals' autistic traits. This may provide pivotal knowledge and inform clinical settings.

The critical analysis carried out for the present review paves the way for further consideration of the study design applied in the studies. To be accurate, we found that more than half of the reviewed studies compared two groups of autistic individuals, those who trained in sports activities and those who did not. Findings showed that the individuals who taught in sports activities improved their skills supporting the effectiveness of sports training programmes. Nevertheless, because sports activities are designed to improve both motor and social skills, two arguments may be in support of the inclusion of a group of typically developing (TD) individuals. First, methodologically, including a group of TD participants provided more in-depth information around the effectiveness of the sports activities in improving motor and social skills according to typical age-related developing stages. Second, including a group of TD peers could encourage the development, promotion, and strengthening of autistic individuals' social skills, over and above sports training alone. That is, the TD participants could play a dual role: (1) he/she could be the scaffold [129] in the social skills learning process for the autistic peers and (2) he/she could be the social partner toward whom the autistic individual applied the social skills learned in the therapeutic setting promoting their generalisation.

Thus, conceiving inclusive sports training programmes could support overcoming the social stigma related to disabilities and the consequent disability-related social isolation experienced both by the vulnerable population and their families.

In designing the sports training programmes, two pivotal characters should be engaged. On one hand, professionals familiar with working with autistic individuals and knowledgeable in the target sports monitor best and support social and motor skills learning. On the other hand, the autism

community is also important to be involved and consulted to address and guide the development of these programmes and meet the needs of the autistic population.

The duration and frequency of sports training for autistic children to reach better performance should be a further key topic to discuss. The reviewed studies suggested that the sports training should extend from 7 to 24 weeks for 45–90 min per session. Because of few studies we reviewed carried out a follow up evaluation of the motor and social skills improved, the results from those studies performing sports activities for a few weeks could be interpreted as promising, indicating that a brief intervention could be successful.

By way of conclusion, the outcomes reported by the reviewed studies draw attention to the simultaneous enhancement in motor and social skills because of the sports training programmes. These outcomes could be the first step in overcoming the above-mentioned barriers faced by autistic populations. The benefits because of their inclusion in sports activities reflect a virtuous circle. It means that being engaged in sports activities could lead autistic individuals to improve their motor skills which, in turn, could lead them to accomplish their daily tasks. As a consequence, they could perceive themselves as more competent and they could participate more easily and spontaneously in other activities in several environmental settings (i.e., home, school).

Recommendations for Future Research

According to strengths/weaknesses excerpted from studies, several recommendations for future research were provided.

Namely, the effectiveness of individual sports in improving motor and social skills was demonstrated. Therefore, further future studies examining the effectiveness of team sports training programmes are recommended.

A second recommendation arose from several criticisms concerning the sample characteristics. First, findings suggested the need for further studies involving a large number of female individuals to expand knowledge regarding what social and communicative skills are owned by them and inform intervention/training programmes. Additionally, considering the increased rate of late diagnosis in female individuals [130], more studies devoting attention to this population are required. A second issue concerns the participants' age highlighting the need for novel and original studies aimed at detecting what sports are most suitable for childhood and what are the age-appropriate sports activities. A third consideration was around the inclusion of TD individuals in sports training programmes designed for autistic people. Autistic individuals' functioning, as well as TD children's lives, could benefit from inclusive sports training programmes (i.e., programmes involving autistic individuals plus TD children). The

advantages for autistic individuals were previously reported. Regarding TD individuals, playing and cooperating with autistic peers could be a valuable vehicle to become aware of their traits and functioning. This sensitisation, in turn, leads TD individuals to learn appropriate and responsive behaviours to interact with people with disabilities.

A further issue on future research could investigate the effectiveness of short interventions which could inform clinicians and social policy services on which sports training could be performed for a limited period (e.g., summer camps).

In conclusion, the systematic narrative review pointed out the need for future studies devoting attention to the impact of sports training on other crucial individual outcomes including sleep/wake- and eating-related routines and autistic symptomatology (e.g., repetitive behaviours).

Conclusion

The narrative review results should be read in light of the limitations of excluding papers evaluating motor skills exclusively and involving young adults.

Overall, the review highlighted that sports training boosted motor and social skills. This finding paves the way to open a conclusive and critical reflection regarding the social inclusion policies applied to the autistic community. As well as guaranteeing accessibility to specialised psychological therapies, the availability of inclusive sports training programmes considering autistic traits should likewise be ensured. This could allow autistic population individuals to perform sports activities adapted to their functioning, increasing their physical wellness, and their engagement in social interactions. In addition, the application of social inclusion policies could promote a community environment disability-related stigma-free.

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Declarations

Competing Interests The authors report there are no competing interests to declare.

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Authors note: by Buijsman and colleagues [131], throughout the manuscript, we used the identity-first language (i.e., autistic people) terms.