Literature Review

https://doi.org/10.1590/2317-6431-2024-2948en

Audiology Communication Research
ISSN 2317-6431

Investigation about proposals for rehabilitation of body balance in autism spectrum disorder: integrative literature review

Investigação sobre as propostas de reabilitação do equilíbrio corporal no transtorno do espectro autista: revisão integrativa de literatura

Nathana da Graça Sartori Rodrigues[1], *Ellen Aguirre de Melo*[2], *Valdete Alves Valentins dos Santos-Filha*[3]

ABSTRACT

Purpose: The present study aimed to review the national and international literature regarding proposals to rehabilitate/train postural balance in subjects with Autism Spectrum Disorder (ASD) and verify the speech therapist's performance in that area. **Research strategy:** searches were carried out in the VHL, MedLine and Scopus databases using the descriptors autism spectrum disorder, postural balance and rehabilitation. **Selection criteria:** articles published in national and international journals in English, Spanish and Portuguese. Studies not addressing the subject, that only dealt with the assessment of postural balance, that reported other syndromes and/or sensory impairments associated with ASD and those unavailable for reading were excluded. The investigators evaluated the samples, objectives, instruments/methods/techniques for assessment and rehabilitation of postural balance, therapeutic guidelines, professionals involved and main results obtained. **Results:** 53 articles were retrieved, 12 being selected for full reading. A variety of rehabilitation/balance training proposals for children and adolescents are identified, based on physical activity approaches and motor exercises. Improvement was observed in all proposed interventions, carried out by Physiotherapists, Occupational Therapists and Physical Educators. **Conclusion:** From the reviewed studies analyzed, it was concluded that, although it is a topic little explored by the scientific community, there is a wide range of feasible proposals for rehabilitation/training of postural balance in subjects with Autism Spectrum Disorder, capable of adaptation and reproduction in Brazilian clinical contexts. Even so, we point out that the research did not include the Speech Therapist in the postural balance assessment process, nor in the rehabilitation/training stage, although their role is necessary for comprehensive care and therapeutic success.

Keywords: Autism spectrum disorder; Postural balance; Rehabilitation; Movement; Review

RESUMO

Objetivos: revisar a literatura nacional e internacional a respeito das propostas para reabilitar/treinar o equilíbrio postural em sujeitos com transtorno do espectro autista e verificar a atuação do fonoaudiólogo na referida área. **Estratégia de pesquisa:** foram realizadas buscas nas bases BVS, MEDLINE e Scopus, utilizando-se os descritores transtorno do espectro autista, equilíbrio postural e reabilitação. **Critérios de seleção:** artigos de periódicos nacionais e internacionais em inglês, espanhol e português. Foram excluídos os trabalhos que não se enquadrassem no tema, versassem apenas sobre avaliação do equilíbrio, mencionassem outras doenças/déficits associados ao transtorno e aqueles não disponíveis para leitura. Analisaram-se as amostras, objetivos, instrumentos/métodos/técnicas de avaliação e de reabilitação do equilíbrio, balizadores terapêuticos, profissionais envolvidos e principais resultados. **Resultados**: foram recuperados 53 artigos e selecionados 12 para leitura integral. Identificou-se importante variedade de propostas de reabilitação/treinamento do equilíbrio para crianças/adolescentes, baseadas em abordagens de atividades físicas e treinos motores. Todas elas propiciaram melhorias e foram conduzidas por fisioterapeutas, terapeutas ocupacionais e educadores físicos. **Conclusão:** Embora seja uma temática pouco explorada pela comunidade científica, existe uma variada gama de propostas exequíveis de reabilitação/treinamento do equilíbrio postural em sujeitos com transtorno do espectro autista, passíveis de adaptações e reprodução nos contextos clínicos brasileiros. As pesquisas não incluíram o fonoaudiólogo no processo de avaliação do equilíbrio postural e, tampouco, na etapa de reabilitação/treinamento, embora a sua atuação seja imprescindível para o cuidado integral e sucesso terapêutico.

Palavras-chave: Transtorno do espectro autista; Equilíbrio postural; Reabilitação; Movimento; Revisão

Study carried out at Universidade Federal de Santa Maria – UFSM – Santa Maria (RS), Brasil.

[1]Programa de Pós-graduação (Doutorado) em Distúrbios da Comunicação Humana, Departamento de Fonoaudiologia, Universidade Federal de Santa Maria – UFSM – Santa Maria (RS), Brasil.

[2]Programa de Pós-graduação (Mestrado) em Distúrbios da Comunicação Humana, Departamento de Fonoaudiologia, Universidade Federal de Santa Maria – UFSM – Santa Maria (RS), Brasil.

[3]Curso de Graduação em Fonoaudiologia e Programa de Pós-graduação em Distúrbios da Comunicação Humana, Departamento de Fonoaudiologia, Universidade Federal de Santa Maria – UFSM – Santa Maria (RS), Brasil.

Conflict of interests: No.

Authors' contribution: NGSR and EAM contributed to the conception and design of the study, data collection, analysis and interpretation, writing and revision of the article in an intellectually important way; VAVSF contributed to all stages of the study and, above all, to the final approval of the version to be published.

Funding: Nothing to declare.

Corresponding author: Nathana da Graça Sartori Rodrigues. E-mail: natysarttori@gmail.com

Received: June 12, 2024; **Accepted:** February 23, 2025

INTRODUCTION

Autism spectrum disorder (ASD) is a neurodevelopmental disorder whose manifestations are heterogeneous and characterized by persistent deficits in communication and social interaction, as well as restricted and repetitive patterns of behavior, interests or activities[1]. Recently, the *Centers for Disease Control and Prevention* (CDC), through the *Autism and Developmental Disabilities Monitoring Network* (ADDM), estimated the prevalence of ASD in 2020 at approximately one in 36 children at the of age 8[2].

In addition to the common clinical comorbidities of autism, motor development deficits are also reported in this population. They support the diagnostic criteria[3], since they affect different motor domains, including gross and fine motor skills, motor coordination, postural control and balance[4-8].

Specifically, alterations in postural balance occur more frequently in people with ASD when compared to the general population[8]. This is a complex task which depends on sensory information from three different systems which act in harmony and integration (somatosensory, vestibular and visual systems). This information is then used by a process *feedback*, allowing corrective muscular responses to be developed to resist gravity[9]. According to the literature, the information from each of the sensory channels is weighted according to its relative reliability after the Sensory Integration (SI) stage[10] – a neurophysiological process in which the central nervous system (CNS) organizes, interprets, processes and modulates the sensory information coming from the three systems, quickly and accurately, which is essential for the postural adjustments to be adopted.

Considering the strong evidence related to SI deficits in autism, it is inferred that the reliability of sensory information from the proprioceptive, vestibular and visual systems, as well as the way in which they are integrated at different levels of central processing, are possibly the key factors in postural balance deficits in ASD[9,10]. However, the specialized literature shows that the assessment and, above all, the rehabilitation of postural balance in autism are topics that have been little explored, given their importance. For this reason, it is believed that research into the nature of deficits in postural balance could provide a new perspective for therapeutic approaches in ASD and, especially, for Speech and Hearing Therapy and the sciences which, in a complementary way, are also dedicated to studying the subject, such as Physical Education, Physiotherapy and Occupational Therapy.

In view of the above, with the aim of deepening knowledge related to postural balance and its alterations in the target population and analyzing the role of the speech therapist in this specific area, this integrative review was proposed in view of the growing incidence of ASD today, in order to encourage future research and contribute to the enrichment of therapeutic interventions, strengthening multiprofessional and interdisciplinary work between related areas, each with its own specificity.

PURPOSE

The aim of this study was to review the national and international literature on proposals for rehabilitating/training postural balance in subjects with autism spectrum disorder (ASD) and to verify the role of speech therapists in this area

RESEARCH STRATEGY

The methodological approach used was an integrative literature review, which allows data from other studies with different approaches and methodological designs (qualitative, quantitative, experimental and non-experimental, among others) to be described and analyzed, making it easier to understand the phenomenon of interest[11].

To prepare the review, the six stages proposed in the literature were followed[12]: guiding question; database searches; collection of study data; critical analysis of the studies included; discussion of the results and final presentation of the synthesis of knowledge.

In the first stage, the following guiding question was formulated: "What are the proposals for rehabilitating/training postural balance that have been used in patients with ASD?".

Next, in the second stage, as proposed by the authors[11], bibliographic searches were carried out in the BVS, MEDLINE/PubMed and Scopus electronic databases, using both Health Sciences Descriptors (DeCS) and Medical Subject Headings terms (MeSh terms). These three literary channels were chosen because they are widely used in the large area of health to which this review relates. The DeCS terms used were: autism spectrum disorder, postural balance and rehabilitation, in English, Spanish and Portuguese. The MeSh terms were *autism spectrum disorder*, *postural balance* and *rehabilitation*. In the VHL and Scopus databases, the and search fields were used respectively*title/abstracttitle/abstract/keyword;* in MEDLINE/PubMed, the was selected*all fields field*. The search strategy included a query in each of the databases mentioned, using the same combinations, so that only the vocabulary (MeSh or DeCS) was different between the databases. It should be noted that no period was set for the search, in order to obtain as many studies as possible that were relevant to the aim of this research and that answered the guiding question, given the authors' prior assumption that there were few studies on the subject in the literature. The searches were carried out between October and December 2023, using the following combinations:

- Searches: "Autism Spectrum Disorder" OR "Trastorno del Espectro Autista"

OR "Autism Spectrum Disorder" AND "Postural Balance" OR "Equilibrio

Postural" OR "Postural Balance" AND Rehabilitation OR Rehabilitación OR

Rehabilitation

It should be noted that the Boolean operator *OR* was used to find documents with any of the terms used as synonyms. In addition, the resource of restricting the results to full texts or was not used, *free full texts* as the authors were able to access some texts via the institutional library, even though these studies were not available to read in full in the electronic databases.

SELECTION CRITERIA

In the second stage of the review[11], the inclusion and exclusion criteria were defined:

- Inclusion criteria: articles published in national and international scientific journals in English, Spanish and Portuguese.
- Exclusion criteria: studies that did not fit the proposed theme and/or did not answer the review's guiding question; that only addressed the assessment of postural balance, without rehabilitation; that mentioned other syndromes (genetic and neurological) and/or sensory deficiencies (e.g. blindness) associated with ASD; those in which the full text was not available to read, even in cases where the authors had access via the institutional library.

After excluding duplicates from the articles retrieved, the papers were subjected to exclusion criteria by reading the titles and abstracts, which resulted in the set of studies that would be used for this review and therefore read in full. Figure 1 shows the flowchart of the sample selection stages, as well as the respective number of articles resulting from each stage.

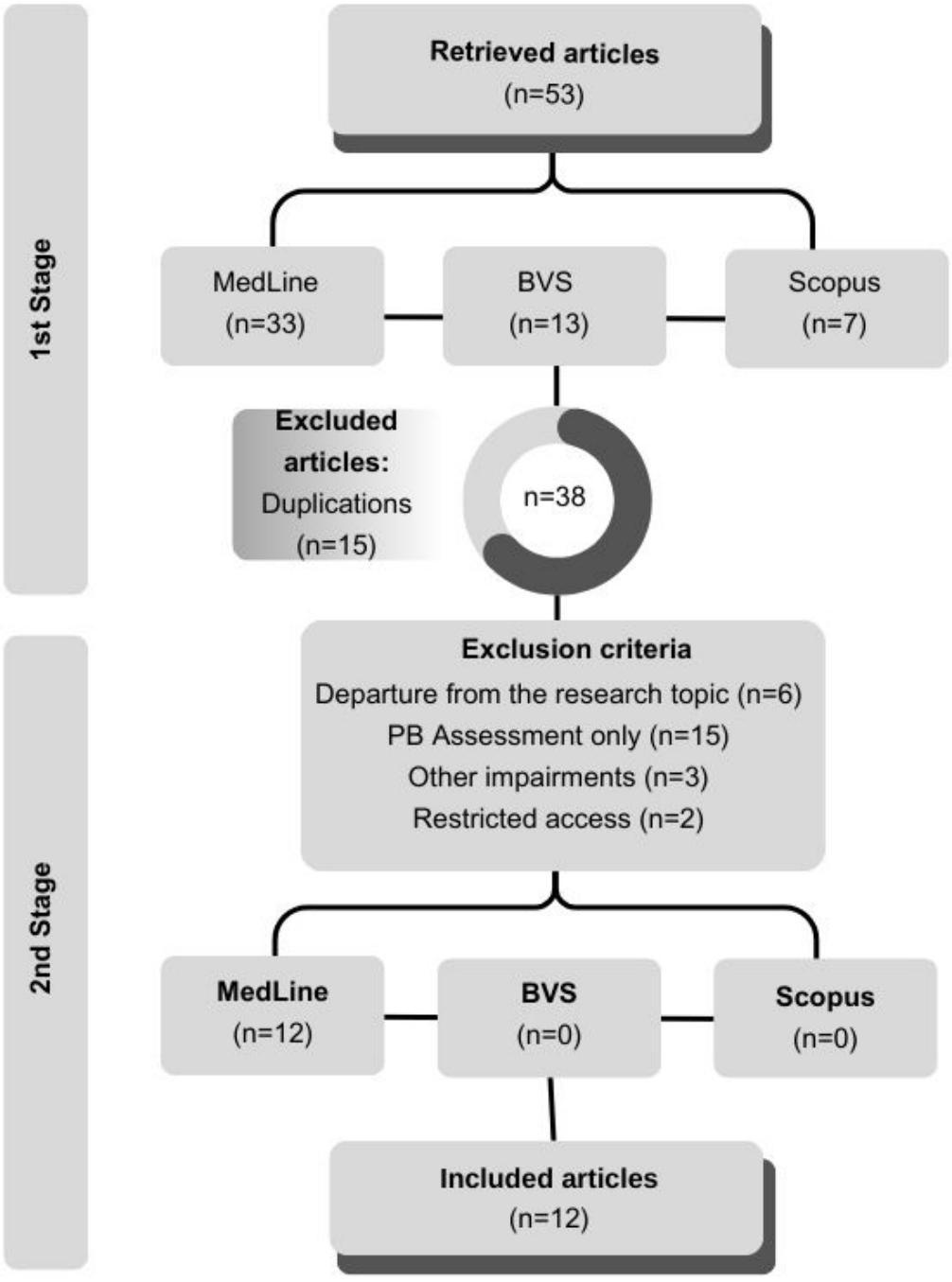

Figure 1. Flowchart of the review sample selection stages and respective number of studies
Subtitle: n = number of articles

DATA ANALYSIS

Setting up the third stage of the integrative review proposed by the authors[11] - collecting and analyzing data from the selected studies - a structured form was used to record the following items: objectives of the studies; characterization of the sample (sample size, age of participants - age range/average age); postural balance assessment instrument(s)/method/technique used; name of the balance rehabilitation/training strategy/technique and description of its application; therapeutic guidelines (number of sessions and duration; periodicity; total treatment time); professional(s) involved and, finally, the main results obtained from the application of the proposed strategies/techniques. When describing the professional involved, the authors have preserved the original terms cited in the articles.

These data were extracted, recorded, presented and critically discussed, concluding the next three stages of the integrative review, which correspond to the critical analysis of the included studies, discussion of their results and, finally, the presentation of the synthesis of knowledge.

RESULTS

Applying the search criteria, 53 articles were retrieved. After eliminating duplicates and complying with the exclusion criteria, 12 articles were selected for full reading and represented the final sample of this review (Figure 1). It should be noted that all the studies included were retrieved from the MEDLINE electronic database.

Chart 1 describes the sample, showing the general characterization of the articles selected according to title, author(s), journal/year of publication and country where the studies were carried out.

The detailed presentation of the studies, according to objectives, sample characterization, instrument/method/technique for assessing postural balance, name of the rehabilitation strategy/technique and description of its application, treatment guidelines, professional(s) involved and main results is shown in Chart 2.

With regard to sample characterization, there was a predominance of studies with relatively small sample sizes, ranging from 2 to 16 subjects with ASD. As for the age range of the subjects studied, the results indicated that 8 (66.7%)[5,7,8,12-14,17,18] investigated only children and 4 (33.3%)[4,6,15,16] investigated children and adolescents.

With regard to the instruments/methods/techniques to assess postural balance, a variety of different tools were identified, of which 6 (50%)[5,6,13,15-17] used simple, low-tech tools (scales and physical tests), 5 (41.7%)[4,7,8,12,18] studies preferred complex, more technologically dense tools (video systems and different force and/or pressure and posturographic platforms), while 1 (8.3%)[14] of the articles used a combination of both.

Chart 1. General characterization of the articles included in the review*

Title	Author(s)	Journal/year	Country
"Effect of hippotherapy on motor control, adaptive behaviors, and participation in children with Autism Spectrum Disorder: a pilot study"	Ajzenman et al.[12]	American Journal of Occupational Therapy/2013	United States of America
"A therapeutic skating intervention for children with Autism Spectrum Disorder"	Casey et al.[13]	Pediatric Physical Therapy/2015	Canada
"Using Posturography to examine the immediate effects of vestibular therapy for children with Autism Spectrum Disorders: a feasibility study"	Reinert et al.[14]	Physical and Occupational Therapy in Pediatrics/2015	United States of America
"The effect of SPARK on social and motor skills of children with Autism"	Najafabadi et al.[5]	Pediatrics & Neonatology/2018	Iran
"Effect of Motorized Elephant-Assisted Therapy Program on balance control of children with Autism Spectrum Disorder"	Nuntanee and Daranee[15]	Occupational Therapy International/2019	Thailand
"Short rehabilitation training program may improve postural control in children with Autism Spectrum Disorders: preliminary evidences"	Caldani et al.[7]	Scientific Reports/2020	France
"Combined Transcranial Direct Current Stimulation and Selective Motor Training enhances balance in children with Autism Spectrum Disorder"	Mahmoodifar and Sotoodeh[16]	Perceptual and Motor Skills/2020	Iran
"The effects of Aquatic versus Kata techniques training on static and dynamic balance in children with Autism Spectrum Disorder"	Ansari et al.[6]	Journal of Autism and Developmental Disorders/2021	Iran
"Physical activity design for balance rehabilitation in children with Autism Spectrum Disorder"	Roșca et al.[4]	Children (Basel)/2022	Romania
"Transcranial Direct Current Stimulation to facilitate neurofunctional rehabilitation in children with Autism Spectrum Disorder: a protocol for a randomized, sham-controlled, double-blind clinical trial"	Araujo et al.[17]	Frontiers in Neurology/2023	Brazil
"Intervention based on psychomotor rehabilitation in children with Autism Spectrum Disorder ASD: effect on postural control and sensory integration"	Ben Hassen et al.[18]	Children (Basel)/2023	Tunisia
"Balance rehabilitation for postural control in children with Autism Spectrum Disorder: a two-case report study"	Jabouille et al.[8]	Physiotherapy Theory and Practice/2023	France

*Articles organized in chronological order of publication and in alphabetical order of authorship, keeping the respective reference numbers

Chart 2. Detailed description of the studies according to objectives, sample characterization, instrument(s)/method/technique for assessing postural balance, name of rehabilitation strategy/technique and description of application, treatment guidelines, professional(s) involved and main results

Reference*	Objective(s)	Sample: size, age group	I/M/T evaluation and re-evaluation EP	E/T training/rehabilitation and description of application	Beacons: No. of sessions, time, periodicity, total duration	Professional	Main results
Ajzenman et al.[12]	To determine whether equine therapy (horseback riding) increased the functionality and participation of children with ASD.	6 children, from 5 to 12 years old	- Eight-camera video motion capture system (*Cortex® software*) - 50 cm x 50 cm three-dimensional force platform	Animal Assisted Intervention (Equine Therapy): Progression strategy based on five domains (motor control, communication, cognition, social skills and interactive play), ranging from participation in basic to advanced activities. Positions on the horse: sitting forward (mounted), prone, supine, mounted backwards, sitting sideways, kneeling, quadrupedal and standing. The participant had to follow complex instructions through changes of position, obstacle courses and tasks/games (e.g. starting from the activity of simply holding the ball to playing a basic game of catch with the therapist and progressing to playing ball with another colleague).	12 sessions 45 min, 1x/week 12 weeks	Occupational Therapist and Occupational Therapy Assistant	Postural sway decreased significantly after the intervention.
Casey et al.[13]	To evaluate the effects of a highly structured therapeutic skating intervention on motor results and functional capacity in two boys with ASD.	2 children, from 7 to 10 years	- Pediatric Balance Scale - Flamingo test (dynamic) - *Floor to Stand* - *Timed Up and Go (TUG)* - Timed Test of Climbing and Descending Steps - *Timed Up and Down Stairs* Test - Six-minute walk test	Therapeutic Skating: Phase I (ice rink - sports complex): warm-up stage with gradual increase in speed; exertion stage with continuous moderate to vigorous physical activity; relaxation. The participants trained separately with skating coaches in a 1:3 ratio. Phase II: took place in the same ice rink, but incorporated into an inclusive community "free skating" environment. The rink included individuals with and without ASD in order to promote social integration. Participants with ASD were encouraged to *skate* and wear full field hockey equipment during the intervention.	Phase I: 30 sessions, 60 min, 3x/week (10 weeks) Phase II: 9 sessions, 60 min, 3x/week (3 weeks) 13 weeks	Physiotherapist and skating coaches	There was an improvement in balance, motor behavior and functional capacity in the post-tests, whose gains remained above pre-test levels in the follow-up stage.
Reinert et al.[14]	To determine the feasibility of posturography for monitoring acute changes in postural control induced by a Sensory Integration therapeutic intervention. The secondary objective was to identify which posturography result parameters, test conditions and data analysis methods could be most useful in identifying post-intervention changes.	10 children, aged 6 to 10 ASD group (n=5) DT Group (n=5)	- Posturographic platform (BP505, *Bertec®* Corp.) - Functional Range Test - Bilateral Coordination subtest of the Test *Bruininks-Oseretsky* of Motor Proficiency (BOTMP-2)	Sensory Integration Therapy - Vestibular Balance: TEA: single protocol - on the vestibular swing, each subject had to participate in a throwing game, engage in make-believe games, reach and place puzzle pieces on the floor and interact socially, while the researcher controlled the movement of the swing (initially in a simple way, progressing to being rotated). DT: were not trained.	1 session (single), 10 min, 1 day	Occupational Therapist	All the participants showed a reduction in the average speed of sway in the eyes-open condition on the flat surface after the intervention. Posturography can be useful for assessing physiological responses to the Sensory Integration intervention with vestibular balance.

*Articles organized in chronological order of publication and in alphabetical order of authorship, keeping the respective reference numbers; **Completion of the study is scheduled for March 2024

Subtitle: I/M/T = instrument/method/technique; PE = postural balance; E/T = strategy/technique; ASD = Autism spectrum disorder; cm = centimeters; min = minutes; n = number; TD = typical development; G1 = group 1; G2 = group 2; m = meters; tDCS = transcranial direct current stimulation; CE = body balance; mA = milliamps; s = seconds; mm/s = millimeters per second; ENT = Otorhinolaryngology; ex. = example; OA = eyes open; OF = eyes closed ; SPARK = *Simons Powering Autism Research for Knowledge*

Chart 2. Continued...

Reference*	Objective(s)	Sample: size, age group	I/M/T evaluation and re-evaluation EP	E/T training/rehabilitation and description of application	Beacons: No. of sessions, time, periodicity, total duration	Professional	Main results
Najafabadi et al.[5]	To evaluate the effectiveness of a selected group of exercises known as Sports, Play and Active Recreation for Kids (SPARK) on the motor and behavioral skills of children with ASD.	28 children, aged 5 to 12 Treatment Group (n=12) Control Group (n=14)	- *Bruininks-Oseretsky* Test of Motor Proficiency (BOTMP-2)	SPARK program: Treatment: session divided into 3 parts - 10 min warm-up; 20 min activities according to treatment objectives (stability and movement); 10 min cool-down. Fitness activities - aerobic dance, running games and skipping rope. Physical fitness activities - sports such as soccer, basketball, games *frisbee* and *kickball*. Control: only performed routine tasks.	36 sessions, 40 min, 3x/week 12 weeks	Physical Educator and Psychologist supervision	The SPARK program significantly improved static and dynamic balance, bilateral coordination and social interaction.
Nuntanee and Daranee[15]	To create a motorized elephant-assisted therapy program and examine its effect on improving balance control in individuals with ASD.	20 subjects, aged 8 to 19 Experimental Group (n=10) Control Group (n=10)	- *Swaymeter* Test (Physiological Profile Assessment subtest) - *Bruininks-Oseretsky* Test of Motor Proficiency (BOTMP-2)	Motorized elephant-assisted therapy: Experimental: 2 motorized elephants were used in 4 activities: 10 min introduction; 20 min washing and drying the elephant with a towel; 20 min riding and controlling the elephant to the correct direction after a command; 30 min playing a game with colleagues; 10 min closing and putting away materials. Control: no intervention.	8 sessions, 90 min, 2x/ week 4 weeks	Occupational Therapist	The pre-test control and experimental groups did not differ in balance control, but in the post-test, the postural sway of the experimental group was significantly different from that of the control group in the eyes-open and eyes-closed conditions.
Caldani et al.[7]	To explore the effect of a short postural rehabilitation training program on postural abilities in children with ASD.	20 children, average age 11 years and 7 months G1 (n=10) G2 (n=10)	- Postural stability (Equilibre Multitest System, *Framiral®)*	Rehabilitation training protocol for postural control: G1, "Buoy" exercise: the participant had to stand on the platform *Framiral* and look at a screen (340 cm × 170 cm) 2.5 m away, on which a buoy (130 cm × 130 cm) in the sea was projected. Body movements were expressed by a green dot on the buoy and the objective was to move your body at specific points on the buoy while avoiding swimming in the sea. Crowd" exercise: consisted of passers-by walking down the street towards the participant with an average speed varying from 0.5mm/s to 1.5mm/s. The participant had to move their body to avoid hitting the passers-by. G2: were not trained.	1 session (single), 6 min, 1 day	Medical (ENT)	In the first recording, postural instability was similar in the two groups of children with ASD despite the viewing conditions. In the second recording, immediately after training, there was an improvement in postural control related to a mixed effect of the training/rehabilitation, but also of the test-retest.
Mahmoodifar and Sotoodeh[16]	To investigate the effects of anodic tDCS combined with selective motor training on the balance of children with ASD.	18 subjects, aged 6 to 14 Experimental Group (n=9) Control Group (n=9)	- Movement Assessment Battery for Children-2 (MABC-2): EC subscale (1 static and 2 dynamic tests)	TDCS combined with motor training: Experimental: anodic CBT (1.5 mA over the left primary motor cortex) combined with motor training (jumping; jumping on a hula hoop; walking on a 5 cm × 2 m board on tiptoe; walking with one foot in front of the other). Control: 20 s simulated tDCS at the beginning of each session, providing 1.5 mA of stimulation, but immediately interrupted.	10 sessions, 20 min Not available	Trained therapist (Physical Education Department)	Both anodic CBT combined with motor training and simulated CBT combined with motor training had significant impacts on balance. However, participants who received real eCBT and motor training performed significantly better than those who received simulated eCBT and motor training.

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Chart 2. Continued...

Reference*	Objective(s)	Sample: size, age group	I/M/T evaluation and re-evaluation EP	E/T training/rehabilitation and description of application	Beacons: No. of sessions, time, periodicity, total duration	Professional	Main results
Ansari et al.[6]	To compare the effect of a land exercise program and swimming on balance skills in children with autism.	30 subjects, aged 8 to 14 2 Experiment Groups (n=10 each) 1 Control Group (n=10)	- *Stork* test (static) - Heel-to-toe walking test (dynamic)	Aquatic exercises and techniques:*kata* Water exercises group: 5 min warm-up (walking, running, jumping jacks, arm/leg movements); 15 min orientation training (sagittal, transverse and longitudinal rotation); 20 min basic swimming (breathing, floating and stroke skills); 15 min free swimming (group activities and playing with toys); 5 min cool-down. Techniques Group*Kata:* blocking, punching, hurricanrana and kicking movements with explosive speed against an imaginary opponent. Control Group: no intervention	20 sessions, 60 min 2x/week: 30 min (up to 2nd week); 45 min (3rd to 4th week); and 60 min (5th to 10th week) 10 weeks	Swimming coaches; *Kata* coaches; chief researcher	Both interventions had a significant effect on balance skills ($p < 0.001$). Interestingly, a greater improvement in balance performance was found in the technique group*Kata* .
Roșca et al.[4]	To analyze the evolution of postural stability after physiotherapeutic exercises based on balance training in subjects with ASD.	28 subjects, aged 8 to 14	- *RSscan* pressure and force platform	Physical activity protocol: List of 6 exercises: breathing and stabilization; walking on a narrow gym bench (4x); standing on one leg - 10 s each (6x); standing on one leg, with the other leg in front, to the side and behind without touching the ground (6x); jumping from one leg to the other while using circles on the ground to mark (4x); walking on a balance board (with/without support).	72 sessions, 30 min, 3x/week 24 weeks	Physiotherapist	The application of the program based on physical exercises led to a significant improvement in the balance parameters of the participants, under complex evaluation conditions.
Araujo et al.[17]**	Determine whether anodic tDCS on the primary motor cortex and cerebellum can improve the effects of gait training and postural control on motor skills, mobility, functionality balance, cortical excitability, cognitive aspects and behavioral aspects in children with ASD.	30 children, aged 3 to 8 Experimental Group 1 (n=not available) Experimental Group 2 (n=not available) Control (n=not available)	- Movement Assessment Battery for Children-2 (MABC-2) - Pediatric Balance Scale - *Timed Up and Go (TUG)*	TDCS combined with neurofunctional motor training: Experimental group 1: anodic tDCS (1 mA, 20 min) on the primary motor cortex combined with neurofunctional motor training. Experimental group 2: anodic tDCS (1 mA, 20 min) on the cerebellar region combined with neurofunctional motor training. Control group: simulated tDCS (gradual intensity of 1 mA during the initial 30s) combined with neurofunctional motor training. Neurofunctional motor training: immediately at the start of CBTCT with gait and postural control training (10 min each). Gait: the child should walk on the treadmill, with the maximum training speed being that at which they can maintain adequate foot support at initial contact and throughout the support phase of the gait cycle - gradual increase in the initial 2 min and gradual reduction in the final 2 min. Postural control: a circuit of 4 individually selected exercises, based on the MABC-2 (balance and aim subscale) and the child's performance, which will be performed for 40 seconds with a 20-s rest interval (e.g. balancing on one foot; walking on tiptoe). A total of 2 complete circuits with a 2-minute rest between circuits.	10 sessions, 20 minutes, 5x/week 2 weeks	Physiotherapist	The authors believe that the three intervention groups will show improvements in motor skills, mobility and functional balance. The effect size is expected to be greater in the experimental groups compared to the control group. It is also believed that the effects obtained in the experimental groups will be maintained in the follow-up assessments four and eight weeks after the end of the interventions.

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Reference*	Objective(s)	Sample: size, age group	I/M/T evaluation and re-evaluation EP	E/T training/rehabilitation and description of application	Beacons: No. of sessions, time, periodicity, total duration	Professional	Main results
Ben Hassen et al.[18]	To investigate the effectiveness of psychomotor training on postural control in children with ASD.	30 children, average age 8 years and 6 months Experimental group (n=16) Control group (n= 14)	- Stabilometric platform (*Posture Win*, *Techno* Concept®)	Psychomotor training: The program consisted of 4 stages: 5 min warm-up, 15 min of activity on the trampoline followed by 20 min of psychomotor exercises in the form of a circuit, and finally 5 min of warm-down and stretching. Balance activities, cognitive stimulation games, fine and gross motor exercises and jumping and sensory integration activities (e.g. transferring bottles of different colors from side A to side B while following an obstacle course, moving up and down when necessary).	18 sessions, 45 min, 2x week 9 weeks	Not available	Psychomotor training significantly improved postural control in the orthostatic position in different conditions when compared to the control group, in all the parameters assessed.
Jabouille et al.[8]	To investigate the effect of balance rehabilitation on postural control in conditions of low and increased cognitive load in two children with ASD.	2 children (10 years and 5 months old; 7 years and 3 months old)	- Posturographic platform: Single task: OA/OF; Double task: recognition of Emotions (images representing a neutral condition, sadness, anger, happiness and fear)	Own protocol: Balance exercises, jumping and stabilization situations, associated with cognitive-motor tasks *(Wii® Balance Board)*: First 30 min: 4 dual-task exercises; final 10 min: balance exercises on *Wii®* (average of 3 different games per session).	8 sessions, 40 min, 2x/ week 4 weeks	Physiotherapist	The program resulted in a 30% to 96% improvement in postural control parameters in the single-task condition for both participants. In the dual-task condition, participant 1 progressed in all conditions, while participant 2 progressed in 3 of the 5 conditions.

*Articles organized in chronological order of publication and in alphabetical order of authorship, keeping the respective reference numbers; **Completion of the study is scheduled for March 2024

Subtitle: I/M/T = instrument/method/technique; PE = postural balance; E/T = strategy/technique; ASD = Autism spectrum disorder; cm = centimeters; min = minutes; n = number; TD = typical development; G1 = group 1; G2 = group 2; m = meters; tDCS = transcranial direct current stimulation; CE = body balance; mA = milliamps; s = seconds; mm/s = millimeters per second; ENT = Otorhinolaryngology; ex. = example; OA = eyes open; OF = eyes closed ; SPARK = *Simons Powering Autism Research for Knowledge*

With regard to postural balance rehabilitation/training strategies/techniques, 6 (50%)[4,5,8,16-18] studies were based on programs consisting of traditional fitness/conditioning activities and motor training; in 2[16,17], physical/motor training was combined with transcranial direct current electrostimulation (tDCS) and in another[8] study, motor training was complemented by a "gamification" strategy (Nintendo Wii®). Another study (8.3%)[7] exclusively supported the "gamification" of therapy through *software* with interactive virtual reality games, using the platform*Framiral*®. . Two (16.7%) studies invested in the training of instrumental/functional tasks of daily living, through Animal Assisted Therapy (AAT) (Equine Therapy)[12] and the use of a motorized elephant prototype[15]. Another 2 (16.7%)[6,13] studies proposed sports approaches for training postural balance. Finally, 1 (8.3%)[14] study used the Sensory Integration (SI) strategy with vestibular balance.

As for the therapeutic markers, the number of sessions varied between the studies, from a single session to 72 sessions. It was also found that the frequency of sessions varied, with 2 and 3 weekly sessions being prevalent, identified in 4 (33.4%)[6,8,15,18] and 3 (25%)[4,5,13] studies, respectively. In addition, 2 (16.7%)[7,14] studies designed a single (daily) intervention session, 1 (8.3%)[12] study proposed a weekly session, 1 (8.3%)[17] study planned 5 weekly sessions, while 1 (8.3%)[16] did not specify the information. As for the duration of the session, it ranged from 6 to 90 minutes, with the average time being 38.8 minutes; it should be noted here that 3 (25%)[6,13,15] of the studies mentioned proposed sessions lasting 60 minutes or more. Regarding the total duration of the training/rehabilitation program, the results indicated that 9 (75%)[4-6,8,12,13,15,17,18] studies organized therapeutic programs in weeks, with an average of 10 weeks. In addition, 2 (16.7%)[7,14] indicated a single (daily) session, while another (8.3%)[16] study did not detail the total duration of the program.

When considering the main professionals involved in the research, physiotherapists stood out (33.3%)[4,8,13,17], followed by occupational therapists (25%)[12,14,15] and physical educators (25%)[5,6,16]. One (8.3%) study was conducted by a medical professional (ENT)[7] and another (8.3%)[18] did not mention the category.

Based on the analysis of the data presented by the studies in this review, it was found that 100% of the postural balance rehabilitation/training proposals resulted in an improvement in the postural balance parameters previously assessed, after comparing the scores from the initial baseline assessment and the scores from the reassessment with the same instruments previously used.

DISCUSSION

This integrative review article provided contact with and analysis of studies that applied different therapeutic approaches to rehabilitating/training the postural balance of subjects with ASD, which contributes to broad knowledge of the subject. It is essential to point out that, even though there has been recent interest in the subject (Chart 1), a small number of references were retrieved, demonstrating that the topic is incipient in the specialized literature, as well as instigating further studies.

With regard to the nationality of these publications, there was a predominance of international scientific productions carried out in Iran, the United States of America and France, in line with the findings of a study[19], which identified a recurrence of research also carried out in Iran. As pointed out in the aforementioned study, the research carried out in Brazil shows that the target audience most studied is adults and the elderly, which strengthens the existing consensus that body balance dysfunctions are more common in this age group. This reinforces the importance of encouraging research that explores the subject with children.

With regard to the objectives of the articles reviewed, it was noted that, although they were diverse, they focused on investigating the effectiveness of different therapeutic approaches on controlling body balance in children with autism. By adopting these objectives, these studies reinforce the need to produce theoretical support that can guide and enrich the clinical practice of professionals dedicated to the habilitation and rehabilitation of autistic individuals.

As for the characterization of the studies' samples, it was observed that they were restricted in their entirety, as they consisted of experimental groups with a small number of participants (a maximum of 16 subjects diagnosed with ASD). Considering that the authors were not concerned with generalizing results or making population estimates, a certain characteristic can be justified. Furthermore, the context confirms the need to explore the subject in order to conduct future research with substantially representative samples.

In general, there was no specificity in the classification of age groups, however, the prevalent age group was 6 to 14 years, confirming previous studies that investigated vestibular rehabilitation and balance training in children and adolescents[20-22]. The preference for the school age group, observed in most of the articles, reinforces the argument in the specialized literature that the proprioceptive system develops between 3 and 4 years of age, while the maturation of the visual and vestibular systems extends to around 15 years of age - specifically between 7 and 15 years of age[23] -, which possibly makes it possible to diagnose postural balance alterations more accurately.

As far as instruments/methods/techniques for assessing body balance are concerned, there was a considerable diversity of options, ranging from scales and quick-to-perform tests[5,6,13,15-17] to digital platforms and systems[4,7,8,12,18], with clinical protocols combined or isolated. It is interesting to note that these instruments are regularly used by professionals working in the fields of Physical Education, Physiotherapy and Occupational Therapy. Therefore, it cannot be denied that this panorama is possibly linked to the specific objectives of these productions, which investigated different parameters related to children's postural balance. Added to this is the fact that the application of another tool requires the fulfillment of tasks, and it is essential that the researcher considers, in addition to physical capabilities, the cognitive development levels of each subject to be assessed, in order to ensure reliability in obtaining the results. However, despite this variability, when considering the particularities of speech therapy in the area of Otoneurology and Balance, this review found that only two[8,14] of the studies retrieved used posturography as an assessment tool. This agrees with the argument in the literature that, despite being considered a valuable and complementary tool in the assessment of postural balance, which allows individual analysis of proprioceptive, vestibular and visual information, their central interaction and the body's motor responses in different sensory conditions for the maintenance of balance, methodological and, above all, analysis differences appear as challenges to maximizing its clinical usefulness[14].

With regard to proposals for balance training/rehabilitation, the focus of this study, numerous therapeutic strategies were found, some of which are easily adaptable and feasible in current clinical contexts. This finding seems to reinforce the considerations of a previous study that research into the efficacy of alternative approaches to treating the clinical symptoms of autism has increasingly been prioritized, following the rapid increase in its prevalence in the population[24].

Analyzing in detail the therapeutic proposals presented in the current review, the majority of those that planned programs focused on physical activities and motor training stood out[4,5,8,16-18], which is in line with the systematic review and recent, which proves the positive relationship of physical activity in enhancing motor skills, executive functions and communication, as well as reducing deficits in social interaction and stereotyped behaviors in subjects with ASDmeta-analysis[25].

Research into the pathophysiology of autism has shown altered patterns of brain growth, as well as the organization of neural architecture and its connectivity, already described in regions such as the amygdala, frontal cortex, cerebellum and corpus callosum[26,27]. In this sense, it is justifiable to invest in therapies that provide characteristic gains, such as the transcranial direct current electrostimulation (tDCS) technique. It is a non-invasive, safe and easy-to-apply neuroregulatory resource that can alter cortical excitability and induce functional reorganization of the brain, albeit for a short period of time, justifying its efficiency in the management of specific autism symptoms[28]. In the present review, two[16,17] articles analyzed the effects of this technique combined with physical/motor training on the postural control of autistic subjects, agreeing with previous studies which also obtained promising results in cognition, social and behavioral skills using the same resource[26,27].

One noteworthy aspect identified in this review was the "gamification" of some postural balance training proposals - this involves the use of systematic games order to encourage adherence and apprehension by the target audience[28]. However, it's interesting to note that one of the studies[7] used the resource exclusively, in intensive training, using a *software program* containing two types of exercises that challenged the participant to remain stable in a standing posture in the face of conflicting situations. In another study[8], the resource *Nintendo Wii*® was proposed in combination with a previous protocol of balance, jumping and stabilization exercises associated with cognitive tasks, as traditional training, with a longer duration. This shows that there is no rigid standard when it comes to designing programs to train postural balance, as long as they use approaches with proven efficacy and in accordance with properly defined therapeutic objectives. Although the implementation of this resource may not seem feasible, especially in public clinical environments, it reflects innovation in the field of health care and encourages the qualification of human resources.

As briefly mentioned, complementary and integrative interventions have been repeatedly implemented in the health care of autistic individuals. One of the most effective types studied in the last decade is Equine-Assisted Intervention (EIA) or Equine Therapy, in which a trained therapist and a therapeutic animal mediate recreational activities, especially in neurobehavioral domains[29]. Only one study retrieved in the present review[12] reported on the strategy, indicating significant effects on reducing postural oscillation, a fact which reinforces the postulate in the scientific world that equine therapy brings vehemently recognized benefits in cases of autism, especially for sensory and motor functions, executive and cognitive functions, social functioning, language skills and behavioral regulation[29-31].

No less important, the application of sports approaches by two of the articles analyzed in this review[6,13] confirms previous research that has reaffirmed the infinite benefits generated by the practice of sports, specifically swimming and martial arts in this population. The authors detected clear progress in postural control and static and dynamic balance, speed and overall motor coordination, as well as a reduction in sensory deficits, dyspraxia and motor stereotypes[32,33].

With prevalence estimates of around 90% to 95% of cases, difficulties in processing sensory information in autism stem from the central nervous system's impaired regulation of arousal, which results in extreme sensitivity (hyperreactivity) or insensitivity (hyporesponsiveness) to environmental stimuli. This condition is capable of exacerbating motor impairments and represents significant challenges for the functionality and independence of individuals with ASD and their families in activities of daily living[34]. From this perspective, the Ayres® Sensory Integration (SAI) therapeutic approach, which is the domain of Occupational Therapy, is one of the most recommended and requested by parents of autistic patients in the United States of America[35]. In the present study, the positive results obtained with the Sensory Integration (SI) strategy, using vestibular balance[14] agree with the statements of the aforementioned authors, given its positive impact on the treatment of sensory processing dysfunctions[34,35] that can affect vestibular function.

In light of the above, it is understood that the training strategies explored by the studies in this integrative review are in line with the literature consulted, as they have valued alternative and integrative medicine approaches, proving the effectiveness of these treatment modalities, which are complementary to traditional methods of therapeutic care[24,33] for the management of postural balance deficits in ASD. They also reinforce the dynamism and particularities of professional practice in autism.

Although no specific studies involving speech therapists were identified in this review, it is essential to mention that, according to the Speech Therapy Council System, which published the Guidance on the Role of Speech Therapists in Body Balance Assessment and Rehabilitation, it is understood that the role of these professionals is extremely important for the therapeutic success of body balance dysfunctions, considering that it is also one of the areas of expertise of this science[36]. This guide proposes that the treatment time for postural balance disorders should be customized according to the clinical picture, existing comorbidities, the patient's age and the period in which the intervention began, as well as including tasks aimed at somatosensory, vestibular and stimulationvisual. The analysis of the studies in Chart 2 shows agreement with the recommended approach. Still on this topic, the current research is in line with a study[19], in which the authors analyzed proposals for children's body balance training, the total duration of which showed significant variability, with an average duration of eight weeks. Returning to the tripod of the vestibular system, it is said that postural balance is the product of a complex set of structures and neural pathways from three sensory systems (vestibular, proprioceptive and visual) work in an integrated manner with each other and the central nervous system (CNS)[8-10]. For this reason, it is

justifiable for the three systems to be considered in cases where rehabilitation/training is indicated.

In this study, although the proposals were varied, it was observed that the researchers did not distinguish in detail which body systems were being trained through the activities and exercises included in their therapeutic programs. One possible justification is that the published studies were restricted to research environments and, for this reason, only one or other pillar of postural balance was explored, precisely in an attempt to understand its impact on the others. It should also be noted that the studies were conducted predominantly by physiotherapists and occupational therapists. Therefore, the specific approaches to the treatment of alterations in body balance differ from what is common in the practice of speech therapists, which does not negate the interdisciplinary nature of the knowledge and the joint work of these professionals.

Due to the complexity and multideterminants that influence the development of people with ASD, it is essential that the intervention plan includes common and integrated objectives and goals between the health professionals who work with these people, in order to achieve better results, which implies the need for interprofessional collaboration[37]. However, in this literature review, only one article[13] included a multi-professional team, with a physiotherapist and a skating coach. In one study[5] conducted by a physical educator under the supervision of a psychologist, it was not possible to say whether the two professionals actually worked collaboratively in the therapeutic processes. It can be inferred that the configuration of the teams was most likely due to the objectives of the studies, especially considering the areas of knowledge that have historically been dedicated to the study of movement, such as Physiotherapy, Physical Education and Occupational Therapy.

Finally, no was identified speech therapist in the studies reviewed. Nor was this professional recognized as a qualified member to conduct the training/rehabilitation of postural balance dysfunctions in subjects with autism. It can thus be seen that the field is still fragmented among health professionals. Thus, future studies are needed to disseminate and broaden the scope of speech therapy in cases of ASD, which is currently centered on the areas of oral language and social communication[38], as well as reinforcing the importance of multidisciplinary teamwork for the successful prognosis of progression in cases of autism.

It is therefore suggested that further research be carried out with the target audience and the inclusion of the speech therapist as an essential member to assess and rehabilitate/train balance, in order to enrich therapeutic programs in ASD, enhancing the skills and abilities of individuals.

CONCLUSION

Although it is a subject that has been little explored by the scientific community, there is a wide range of feasible proposals for the rehabilitation/training of postural balance in subjects with autism spectrum disorder, which can be adapted and reproduced in Brazilian clinical contexts. The studies did not include the speech therapist in the postural balance assessment process, nor in the rehabilitation/training stage, although their work is essential for comprehensive care and therapeutic success.

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