

# The Efficacy of Yoga Interventions for Children with Autism: A Systematic Review

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## Abstract

The purpose of this study was to produce a systematic review of the efficacy of yoga interventions on behaviors in children with autism. Literature was searched through MEDLINE, Sports Medicine & Education Index, ERIC, Education Research Complete, and PsycInfo. The search criteria included children ages 3-22 diagnosed with autism, a yoga intervention that included physical postures, and at least one adult teaching. An initial total of 280 articles, including 27 duplicates were found. Nine papers met the inclusion criteria. Social and communication behaviors such as initiation, sensory response, and attention were evaluated. In seven of nine studies, positive behavioral results were reported. The results of this systematic review meet Every Student Succeeds Act's Tier 1 of evidence and the National Professional Development Center on Autism Spectrum Disorder's criteria for evidence-based practice, indicating yoga has strong evidence to support its implementation as a behavioral intervention for children with autism.

**Keywords:** Behavioral Intervention; Stress; Asanas; Complementary Alternative Medicine; Adapted Physical Education; Tiers of Evidence

**Abbreviations:** DSM-5: Diagnostic and Statistical Manual of Mental Disorders; ESSA: Every Student Succeeds Act; NPDC: National Professional Development Center for Autism Spectrum Disorder; ASD: Autism Spectrum Disorder; PEDro: Physiotherapy Evidence Database Scale; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RCT: Randomized Control Trial; IAYT: Integrated Application of Yoga Therapy; ABA: Applied Behavioral Analysis; PED: Physiotherapy Evidence Database Scale; PRISMA: Preferred Reporting Items for Systematic Reviews and Meta-Analyses; RCT: Randomized Control Trial; IAYT: Integrated Application of Yoga Therapy; ABA: Applied Behavioral Analysis

## Introduction

Research has shown that children with conduct, intellectual, and developmental disabilities experience higher prevalence of anxiety when compared to children without disabilities [1-3]. For example, anxiety disorders are prevalent in 27% of children without autism and 40% of children with autism<sup>1</sup> [4]. Indeed, children with autism<sup>2</sup> consistently report the highest rates of anxiety and depression amongst young people [5-7]. Children

with autism can be impacted by internalizing disorders such as anxiety in part due to higher stress levels [8]. Common behaviors displayed by individuals with autism (e.g., difficulties in social communication, restricted repetitive behaviors, and sensory features) may be contributing to these disparities in stress levels.

Some children with autism can exhibit aggressive or self-injurious behaviors that stem from comorbidities like anxiety and stress and can be aggravated under stressful conditions [9].

<sup>1</sup>The diagnostic criteria for autism spectrum disorder are outlined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) developed by the American Psychiatric Association (2013). To meet the criteria for the DSM-5 a child must have "persistent deficits" in areas of social emotional reciprocity, social emotional non-verbal communication and development, and maintenance of relationships". While The Individuals with Disabilities Education Improvement Act defines autism as a "developmental disability significantly affecting verbal and nonverbal communication and social interaction, generally evident before age three, that adversely affects a child's educational performance" (U.S.C. §1400, 2004).

<sup>2</sup>The authors recognize the recent debates and varying preferences of "identity first" language (autistic person) to "person- first" (person with autism) language and respect each. For the basis of consistency, this systematic review is written in person first language.

<sup>3</sup>For non-USA readers, Every Student Succeeds Act is the current Federal law that legislates the provision of equal opportunity for all students enrolled in public K-12th grade education institutions (U.S.C. §6301 [2015]).

In addition, some children with autism experience stress and distress from their environment, including sensory (e.g., loud, fast-paced and/or distracting noises) and relationship (e.g., peer victimization, bullying) aspects. School settings are recognized as “large, often complex social and sensory environments, which can be challenging for some young people on the autism spectrum” [6]. However, learning environments, including physical education spaces, may simultaneously be a site where such stressors are amplified and a potential site where students with autism can engage in stress-reduction practices.

Under Every Student Succeeds Act (ESSA)<sup>3</sup>, educational

institutions are required by law to utilize “evidenced-based strategies to improve student achievement, instruction and schools” [10]. Further, the ESSA defines 4 tiers of evidence used to evaluate these strategies (Table 1). To qualify as an evidence-based strategy under ESSA, interventions designed to improve student achievement must be supported by Tier 1-4 evidence [11]. The ESSA levels of evidence are less stringent than the criteria used by the National Professional Development Center on Autism Spectrum Disorder (NPDC) to evaluate the “acceptable level of research” to determine if an intervention produces “positive outcomes of children, youth and/or adults with autism” [12] (Table 2).

**Table 1:** Tiers of Evidence in the ESSA.

Tier	Level of Evidence	Definition
Tier 1	Strong	Supported by one or more well-designed and well-implemented randomized control experimental studies.
Tier 2	Moderate	Supported by one or more well-designed and well-implemented quasi-experimental studies.
Tier 3	Promising	Supported by one or more well-designed and well-implemented correlational studies (with statistical controls for selection bias).
Tier 4	Demonstrates a rationale	Practices that have a well-defined logic model or theory of action, are supported by research, and have some effort underway by a State Educational Agency, Local Education Agency, or outside research organization to determine their effectiveness.

**Table 2:** The NPDC criteria for evidence-based practice.

An intervention is considered evidence-based if it meets one of the following criteria
Two high-quality experimental or quasi-experimental group design studies conducted by at least two different researchers or research groups
or
Five high-quality single-subject design studies with a total of at least 20 participants and conducted by at least three different investigators or research groups
or
One high-quality randomized or quasi-experimental group design study and at least three high-quality single-subject design studies conducted by at least three different investigators or research groups

With the population of children with autism in the United States rising from 1 in 150 children in 2000 to 1 in 54 children in 2016 [13], the importance of effective interventions supported by the NPDC criteria and ESSA Tier 1-4 evidence is amplified. Geslak and Boudreaux [14] emphasize the importance of using evidence-based practices to teach students with autism in their article Exercise is a Life-Changer for Those with Autism. The most common approaches provided to children with autism are behavior interventions, dietary modifications, medication, or

complementary and alternative medicine [15].

Physical exercise, physical manipulative techniques, and mind-body practices are all examples of complementary and alternative medicines that have shown beneficial results in addressing stress and anxiety in children with autism [16]. Bremer et al. [17]. notes the significance of movement and exercise interventions as “evidence based, effective and sustainable interventions for youth with autism”. Exercise has been a useful intervention to

reduce stress-inducing behaviors of children with autism in the classroom as it can decrease engagement in disruptive, self-harmful behaviors [18]. Exercise that incorporates mindfulness practices has been effective in bringing about affirming behavior change in children with autism [19].

Yoga is a holistic, mind-body practice that uses various techniques such as physical movement, breathwork, and meditation or mindfulness practices [20]. The practice of yoga produces what Benson et al. [21] called The Relaxation Response, causing heart rate, blood pressure, and breathing to slow by activating the parasympathetic nervous system [19]. Research suggests that yoga practice is beneficial in physiological and psychological stress reduction in school aged children [22]. These findings have led nearly 940 schools across the United States to implement yoga programs in their physical education and extra-curricular programming [22]. The impact of yoga on children has been presented in systematic reviews in both clinical [23] and school settings [24].

Birdie et al. [22] performed an evaluation of 34 controlled studies on children without disabilities, which showed preliminary benefits of yoga intervention for the youth population (ages 0-21), however these studies were categorized as low quality for methodology. Serwachi & Cook-Cottone [24] included children with disabilities in their review, including autism, intellectual disabilities, learning disabilities, and emotional disturbance. Out of the 12 studies included in this systematic review, four involved children with disabilities and the articles were deemed to be of low to moderate quality based on the Sackett levels of evidence criteria. Although the yoga interventions with children with disabilities were varied, the overall results were positive and children with autism showed a reduction in stress indicators and heart rate.

Preliminary research on yoga interventions with children with autism reports positive effects [19]. However, prior to this review neither the NPDC criteria [25] for evidence-based practice nor the ESSA tiers of evidence [10,11] have been established supporting yoga as a behavioral intervention for children with autism. Consequently, there is a need for a comprehensive review about the relationship between yoga and the impact it may have on behavior in children with autism, the strength of the evidence and what this means for intervention planning and implementation in

schools. This article reports the findings of a systematic review on the effectiveness of yoga interventions on stress-related behaviors for children with autism.

This work attempts to fill a gap in the literature by assessing studies on the efficacy of yoga interventions for improving behavior outcomes in children with autism. It also evaluates the strength of the evidence in line with the NPDC criteria [25] and ESSA tiers of evidence [10,11]. The significance of this review has the potential to impact those working with children with autism. Firstly, it established that the evidence supporting yoga as an effective behavioral intervention meets ESSA's Tier 1 criteria [10,11] (Table 1). In addition, the quality of research meets the NPDC's criteria [25] for evidence-based practice (Table 2), establishing yoga as an effective behavioral intervention for children with autism.

Additional research is needed to determine whether specific yoga interventions meet the more stringent NPDC criteria [25]. Secondly, the review provides guidance to implement yoga interventions to optimize behavioral outcomes by addressing stress and anxiety in children with autism. Finally, this review could help adapted and general physical education teachers in the development of structural curriculum plans that include yoga and advocating for such programming for administration consideration within their physical education program.

**Method**

**Inclusion/Exclusion Criteria**

The criteria of this literature search reflected the objectives of the study and availability of findings. The inclusion and exclusion criteria are provided in (Table 3). The inclusion of diagnosis for children with autism was included based on the individual study definition. The ages of participants in each study included were 3-22, given that the students were enrolled in school. Continuation school for students with disabilities is common practice in the United States up until the age of 22. Two reviewers (AH and ZHL) independently assessed the eligibility criteria with subsequent consensus by discussion. To include studies in this systematic review, each study should meet the following inclusion criteria. This review analyzed public research and thus International Review Board approval was not needed.

**Table 3:** Inclusion and Exclusion Search Criteria.

Inclusion Criteria	Exclusion Criteria
· Children between ages of 3-17	· Studies involving adults (18 years and older) or persons aged between 17-22 with a diagnosis of autism not enrolled in school
· Diagnosis of autism	· Language besides English
· Persons aged between 17-22 with a diagnosis of autism enrolled in school	· Articles published prior to Jan. 1 2000
· Intervention Studies that were yoga-based with physical yoga posture (asana) practice	· No yoga intervention

· Intervention included at least 1 trained adult leading based upon the studies' definition of trained adult.	· Not peer reviewed/not reputable
	· No experimental study design (e.g. review, case study, observational study)

**Searching**

The literature was surveyed in July 2021 from five databases: PubMed (Medline), Sports Medicine & Education Index, ERIC (Education Resources Information Center), Education Research Complete and PsycINFO. The databases were chosen to include the multiple fields involved in this research such as kinesiology, physiology, psychology, and education. The search conducted

was a manual search with the publication range of 2000 through 2021. The key terms used for this search were categorized into the population studied, interventions performed, and outcomes achieved (Table 4). The main categories of the search included children, autism, yoga interventions, and stress-related behaviors. All search term categories were connected with "AND". The truncated versions of the terms were also included, for example child\*, relax\*, disrupt\*, etc.

**Table 4:** Key Search Terms

Search Terms	
Children	(Connected with "OR") "child," "adolescence," "young," "youth," "students," or "kids."
ASD	(Connected with "OR") with "ASD," "Autism Spectrum Disorder."
Yoga	(Connected with "OR") "Yoga," "Vinyasa," "Hatha," "flow," "Ashtanga," "Iyengar," and "power yoga."
Outcomes	(Connected with "OR") "stress," "anxiety," "heart rate," "quality of life," "relax," "self-management," "aggress," "violent," "restrictive repetitive behaviors," "biting," "bite," "pull," "pulling," "hit," "hitting," "vocal," "sensory-seeking," and "disrupt".

**Assessment of Study Quality**

Three frameworks were used to assess the quality of the studies. First, the research community standard, the Physiotherapy Evidence Database (PEDro) scale was utilized [26]. This scale was chosen over the Cochrane and Jadad scales because the inclusion of blindness in trials is impractical when assessing behavioral interventions. Secondly, the legislative standard (the ESSA's Tiers of Evidence) was applied (Table 1) [10,11]. To qualify as an evidence-based strategy under ESSA, interventions designed to improve student achievement must be supported by Tier 1-4 evidence [10,11]. Finally, the professional standard, (the NPDC criteria for establishing evidence-based practice) was applied (Table 2) [25]. The NPDC is a national organization in the USA responsible for the development of professional resources for paraprofessionals who work with individuals with autism.

**Data Evaluation**

Data were extracted and organized using Microsoft Excel. The findings were analyzed by descriptive analysis. Aggregation

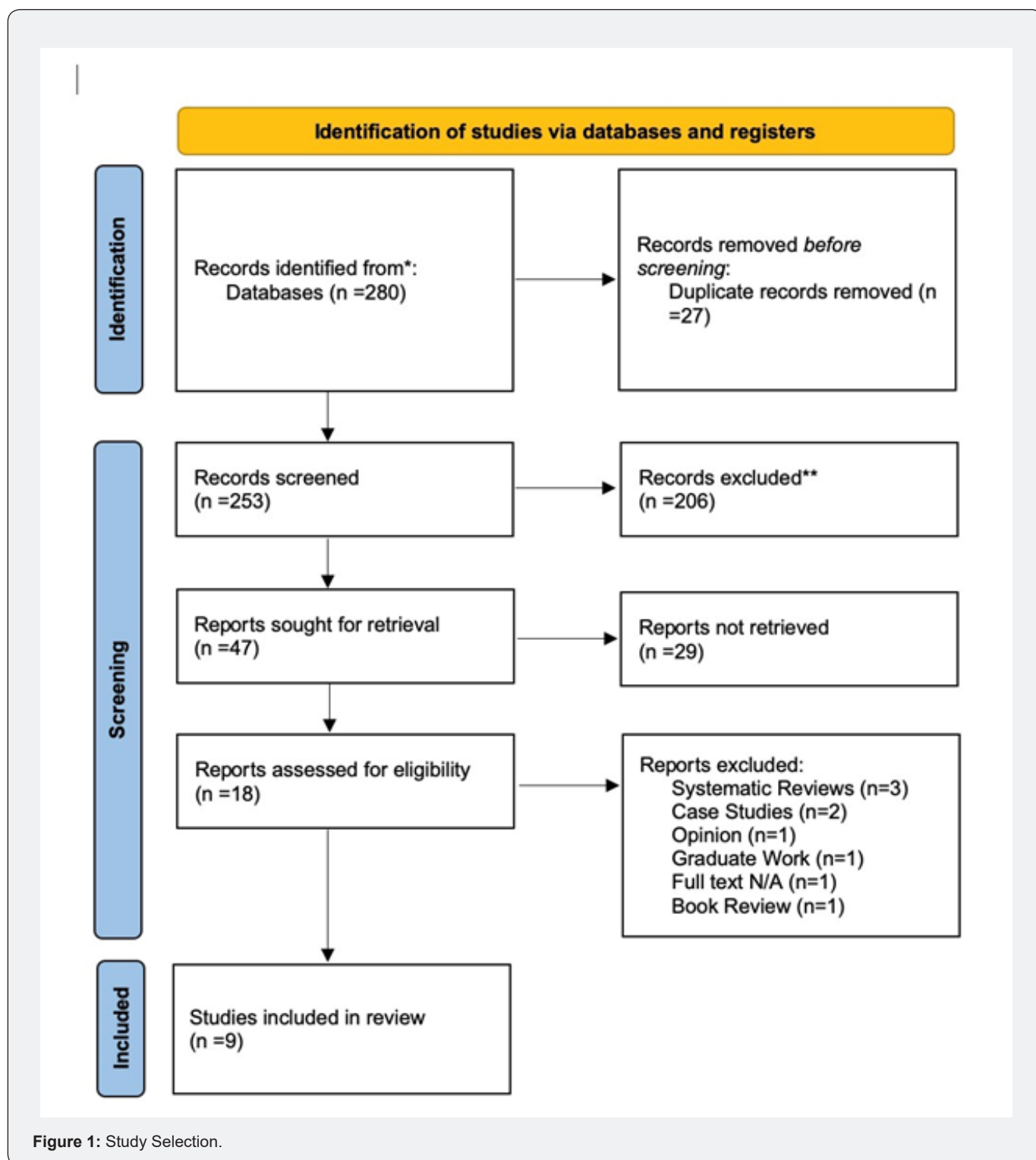
of data was based upon the following: geographical location, population age (breakdown), diagnosis of autism (functioning level if provided), nature of intervention (frequency/duration/type of yoga, setting), and significant outcomes.

**Results**

The results are presented following the PRISMA reporting guidelines [27].

**Study Selection**

The results are displayed in Figure 1. A total of 280 articles, with 27 duplicates, were retrieved. Of these, 206 articles were excluded based on titles not representing this specific topic and an additional 29 excluded based on abstract information. The remaining (n=18) studies were reviewed by full text and nine were excluded leaving a total of nine for the review. In accordance with systematic review best practice, a random 30% sample of the studies were reviewed by a secondary reviewer (ZHL) to ensure reliable screening. Agreement between the reviewers was 100%.



### Study Description

Study characteristics are presented in Table 5. Nine studies from four countries, India, Iran, Australia, and USA, met the criteria for eligibility. Five studies utilized non-Randomized Controlled Trial (RCT) designs [28-32] and four utilized RCT design [33-36].

All studies included some form of yoga in their intervention and all included school age children with autism as their population. Only three of the nine studies took place on elementary school campuses. Two of these schools (in India) were specialized for students with disabilities [28-31]. Koenig et al. [33] was the only

study located in a public-school setting (USA). Home practice was encouraged in many of the studies.

A variety of behaviors were analyzed. There were significant changes in communication and social behaviors presented in seven out of nine studies. Mood has a significant link to behavior and thus it is important to mention here that increased positive

mood was reported in multiple studies [30,31]. Significant results were apparent in response to sensory stimulus, imitation skills, and eye contact [28-34]. A characteristic of many children with autism involves sensory features “such as hypo responsiveness (under-reactivity to environmental stimuli), hyperresponsiveness (over reactivity to stimuli), or sensory seeking (craving/fascination with sensory stimuli)” [37].

**Table 5:** Study Characteristics.

Authors	Study Design	Setting & Participants	Type of Yoga	Frequency	Aim	Intervention Duration	Change in autistic behaviors
Deorari & Bhardwaj – [29]	Non-RCT: Single Group pre-post design	5-16 yr. olds with autism from Abhiprerna Foundation, Haridwar, India (n= 30)	Hatha Yoga with Chanting	60min/day	Determine the effect of yogic intervention on children with autism	3 Months	+
Koenig et al. [33]	RCT: Pretest-posttest	Elementary students with autism from a large urban public school in New York, USA (IG n=24, CG n=22)	Get ready to learn Program	15-20min/day	Examine effect of Get Ready to Learn Yoga program on adaptive & maladaptive behaviors in children with autism	16 Weeks	+
Litchke et al. [30]	Non-RCT: Single Group pre-post design: Exploratory	813 yr. old, male autism Summer camp attendees in Mumbai, India (n= 5)	Teen Yoga Warriors program (multimodal mandala yoga)	60min bi-weekly	Examine effects of specifically designed multimodal Mandala yoga program on social and emotional skills of youth with autism	4 weeks	+
Narasingharao et al. [31]	Non-RCT: Group pre-post design: Exploratory	5-16 yr. olds with autism from Academy for Severe Handicap and Autism in Bengaluru, India (IG n=32, CG n=29)	Integrated Application of Yoga Therapy (IAYT)	75min/day	Determine the efficacy of structured yoga intervention for sleep, gastro issues and behavioral issues in children with autism	90 Days	+
Radhakrishna et al. [28]	Non-RCT: Single Group pre-post design: Exploratory	8-14 yr. olds with autism from SGS Vagdevi Elementary School (2000-2007) in Bangalore, India (n=6)	IAYT	60min/day	To determine the effects of IAYT on children with autism	2 Academic Years	+
Rosenblatt et al. [32]	Non-RCT: Pre-post treatment	3-16 yr. olds with autism referred for outpatient care in a medical school teaching hospital in USA (n=24)	Not specified (dance included)	45min (8sessions)	Develop and assess the therapeutic effect of a novel movement-based CAM approach for children with autism	8 Weeks	+



Sotoodeh et al. [34]	RCT	7-15 yr. olds from an Autism school in Thran, Iran (IG n= 15, CG n=14)	Yoga for Children with ASD (book guide)	30min/day	Examine the effect of Yoga Training Program on severity of autism in Children	8 Weeks	+
Tanksale et al. [27]	Pilot RCT	8-12 yr. olds with autism, Queensland, Australia (IG n=31, CG n=30)	Hatha Yoga with props, visuals and narrative explanations	60min/week	Evaluate the effectiveness of Incredible Explorers Yoga program for children with autism	6 Weeks	/
Vidyashree et al. [36]	RCT	8-14 yr. olds with autism from Swabhimaan Trust, Palavakkam, Chennai, India (IG n=25, CG n=25)	Hatha Yoga (Strengthening, calming and chanting)	40min/day	Investigate the effect of yoga on short term heart rate variability in children with autism	3 Months	/

IG= Intervention Group

CG= Control Group

“+”= Favorable change in autistic behaviors

“-” = Negative change in autistic behaviors

“/” = No change in autistic behaviors

Hyper- or hypo reactivity means children on the spectrum have high intensity or focus on sensory input or output [38]. Examples, reported by parents, of how this feature presents itself in children with autism include over preoccupation with sounds or lack of acknowledging noises [39]. Loud noises and bright lights are other commonly reported sensory stressors. As many sensory features are uncontrollable in everyday life it is helpful for children with autism learn how to cope with their emotional responses to these stressors (primarily stress & anxiety) and behaviors to improve quality of life. Children with autism have difficulty with social emotional interactions, non-verbal communication and retaining relationships [9]. These children display social behaviors such as failure to initiate, respond to or participate in quality conversations.

Emotional interactions, such as sharing emotion, interests or affect is reduced [38]. Furthermore, nonverbal communication cues such as eye contact and body language may not be recognized by children with autism. A complete lack of nonverbal communication is also common [9]. Due to difficulties understanding cues and atypical reactions children with autism may find it difficult to build and retain friendships and relationships. Numerous yoga interventions target these social behaviors, anticipating an outcome that will positively influence quality of life [40]. Initiating interactions and response to initiation was a frequent behavior change seen in participants within the yoga intervention [30,35]. An increase in attention span and the use of executive functions was reported across multiple studies [30,31,35].

### Quality Assessment

Three frameworks were used to evaluate the quality of the studies, the PEDro scale [26], the ESSA's Tiers of Evidence [10,11] and the NPDC's criteria for evidence-based practice [25]. The quality of studies, based on the PEDro scale [26] are presented in (Table 6). The results are as follows; three studies were of poor quality [28,29,32] one was deemed fair [30], four were considered good [31,33,35,36] and one excellent [34]. Five studies lacked an active control group for comparison of results [28-30,32,35]. Blinding was present only in the study conducted by Sotoodeh et al. [34]. This lack of control groups and blinding can cause author and evaluator bias in the outcomes reported. No articles were excluded based on methodological quality as the bar is different for ESSA compared to systematic reviews, even the low-quality studies still meet tier 1-3 levels of evidence in ESSA.

Given the study design characteristics of the nine studies included in this systematic review, the quality of evidence supporting yoga as an effective behavioral intervention for children with autism meets the criteria of the ESSA's Tier 1 [10,11] (supported by one or more well-designed and well-implemented randomized control experimental studies). In addition, with four well-designed and well-implemented randomized control experimental studies conducted by four different research groups, the quality of evidence meets the NPDC criteria [25] to establish yoga as an evidence-based practice that produces positive outcomes for children with autism. However, additional research is needed to verify the evidence-base for specific yogic interventions and this population.

**Table 6:** Quality Assessment: PEDro Scale.

	Vidyashree, 2019	Deorari 2014	Sotoodeh, 2017	Litchke, 2018	Narasingharao, 2017	Koenig, 2012	Tanksale, 2021	Radhakrishna, 2010	Rosenblatt, 2011
Eligibility criteria specified	✓	✓	✓	✓	✓	✓	✓	✓	✓
Subjects were randomly allocated to groups	✓		✓			✓	✓		
Allocation was concealed	✓		✓						
The groups were similar at baseline regarding the most important prognostic indicators	✓		✓		✓	✓	✓		
There was blinding of all subjects			✓						
There was blinding of all therapists who administered therapy									
There was blinding of all assessors who measured at least one key outcome			✓						
Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups	✓	✓	✓	✓	✓	✓	✓	✓	✓
All subjects for whom outcome measures were available received the treatment control condition as allocated or, where this was not the case data for at least one key outcome was analyzed by «intention to treat.»		✓	✓	✓					
The results of between-group statistical comparisons are reported for at least one key outcome	✓		✓		✓	✓	✓		
The study provides both point measures and measures of variability for at least one key outcome	✓		✓	✓	✓	✓	✓	✓	✓
Total (out of 11)	7	3	9	4	5	6	6	3	3



### Discussion

The purpose of this review was to determine the efficacy of yoga interventions on behaviors in children with autism within the school setting. Based upon the preliminary findings there may be various benefits to children with autism participating in yogic interventions to impact stress and anxiety related behavioral changes. Positive results of behavior change in children with autism were seen in seven out of nine studies identified. Sotoodeh et al. [34] found significant improvements in the experimental group, compared to the control group, in sociability, sensory awareness, and physical behaviors using The Autism Treatment Evaluation Checklist [41].

Likewise, Litchke et al [30] found a significant difference in pre-post scores in social communication skills such as response to initiation, initiating interactions, affective understanding and perspective taking, as measured by the Treatment and Research Institute for Autism Spectrum Disorder Social Skills Assessment [42]. The overall test results in this study indicate an increase in social skills and a “positive mood state post yoga” [42]. The fifteen item Childhood Autism Rating Scale [43] which includes categories such as: emotional response; adaptation to change; visual response; listening response; taste, smell, and touch response; fear/nervousness; and verbal/ non-verbal communications was used by Deorari & Bhardwaj [29] to determine behavior change.

The overall test results of the experimental group showed a 7.54% decrease in symptoms while the control group showed a 0.79% increase. Based on a parental behavior questionnaire, Narasingharao et al. [31] found significant positive changes in social skills in the experimental group after the yoga intervention with no significant changes in the control group. Categories such as imitation, emotion regulation, and initiation were assessed in this study. The Aberrant Behavior Checklist [44] was used by Koenig et al. [33] to assess the efficacy of the Get Ready to Learn Yoga Program. In the overall scores of the checklist, observation of the experiment group showed significant differences when compared to the control group.

The mean change from pre to post test showed that participants in the experiment group had less maladaptive behaviors than the control group. Both parents and teachers' ratings reflected improved behaviors in and out of the classroom setting for the group participating in the yoga intervention. The repetition of yoga intervention, specifically Integrated Application of Yoga Therapy (IAYT), may help the arousal levels in children with autism and produce a calming affect [28]. Communication skills, such as maintaining eye contact and an increase in sitting tolerance occurred in the intervention group participating in IAYT. Parents reported participants social interactions with their peers and family improved because of the intervention.

The study by Rosenblatt et al. [32] showed that a yoga

intervention for children with autism may be most effective for the population of latency age (ages 5-12). Significant changes in the atypical scores on the Behavioral Assessment System for Children [45] were found across all participants with the most significant in the latency aged group. Rosenblatt et al. [32], suggest “during this developmental period (children with autism) may have greater receptivity to the programs' unique emphasis on movement and sound”. The intervention aspects consistent in all studies were movement (asanas) and mindfulness or meditation, such as breathwork or chanting.

The combination of these aspects has proven to produce the relaxation response in children without autism as well as children with autism [32]. The current research on yoga with children with disabilities has shown to have physiological benefits and can reduce stress and anxiety through reducing sympathetic nervous system activity in the body [46]. Vidyashree et al. [36] and Rosenblatt et al. [32] reported findings on heart rate variability and respiratory rate (respectively) give insight into the physical impacts of yoga interventions on children with autism. Vidyashree et al. [36] study on heart rate variability found that a yoga intervention for children with autism is successful in bringing about an increase in the parasympathetic nervous system, which can improve psychological balance.

The increase in parasympathetic properties in the body after yoga intervention illustrates the biological evidence of relaxation in children with autism and an inference can be made between this calm physiological state and improvement in problematic behaviors caused by yoga. However, this study by Vidyashree et al. [36] focused on the heart rate variability change in children with autism and therefore is an indicator of behavior but not an exact measure. There were no direct positive behavior changes reported in this study. This article was deemed qualified for inclusion based on meeting the inclusion criteria and gives a unique insight into the physiological aspect of these interventions. There was success in bringing about parasympathetic nervous system dominance in the participants but because of the lack of behavioral data the positive results could not be aligned with the other studies.

Tanksale et al. [35] was the other study that did not report findings on behavior change. There were however parent reports in improvements in executive control following the intervention, as seen by the confidence interval (-4.17; 95%) of between group scores at post treatment and a 6-week follow-up. This suggests significance with small to medium effect size, however when combined with the secondary outcomes (i.e., goal attainment, sleep, anxiety & emotional awareness) the results of this study were mixed. The only significance between the groups for anxiety (self-reported and parent reported) was for performance anxiety. This study was of good quality based on the PEDro scale but lacked an active control group and showed mixed results in behavior change.

Seven of nine studies evaluated reported positive changes in one or more behavior variables, suggesting yoga as a potential complementary intervention for children with autism. There are numerous, reputable, evidence-based practices for children with autism that can be tailored to a child's specific needs and goals [47]. The most widely used interventions are based on Applied Behavior Analysis (ABA), which focuses on the antecedents and consequences of behavior. ABA can be an effective strategy in affecting adaptive behaviors in children with autism [48], however, there arguments regarding this intervention as unethical within the autistic community [49].

The use of this therapy is most effective when it is intensive (25-40 hours a week) and long term (1-3 years). Examples of interventions that use ABA principles are Discrete Trial Training and Pivotal Response Training. Discrete Trial Training consists of elements of one skill separated into multiple parts and students are rewarded with positive reinforcement incrementally, for each part [50]. Conversely, Pivotal Response Training is play-based and targets 'pivotal' areas of a child's development (e.g., motivation, self-management), rather than a specific behavior [51]. There has been much recent controversy over the use of ABA interventions for students with autism. Activists and autism- rights groups have expressed concern over the historical implementation of ABA, namely in the Young Autism Project by Ivar Lovaas.

The use of shock as a form of punishment, the rigid "one size fits all protocol" and the time commitment of the intervention are of concern to current groups who prefer more human, individual treatments [52]. Furthermore, activist groups claim that stifling autistic people from such stereotypical behaviors like self-regulation is a form of abuse, since these behaviors have been proven to reduce anxiety and stress in people with autism [53]. Unfortunately, research on various interventions has often neglected the impact that stress and anxiety have on the autistic child and their behaviors [54]. As such, research suggests ABA interventions may be insufficient at addressing the stress and anxiety felt by students with autism and may even increase stress and anxiety [49].

The costliness of ABA intervention for families and school districts alike can be a critical barrier to students receiving beneficial services [55]. As a result, alternative interventions to address behaviors are being sought by education professionals and families. Complementary and alternative medicines such as modification in diet, physical manipulative techniques, and mind-body practices have shown positive results in addressing stress and anxiety in children with autism [16]. Yoga, a mind-body practice, offers a cost-effective alternative to resource-intensive interventions, such as Discrete Trial Training, while addressing the stress and anxiety of children with autism and may aid in behavior and coping strategies.

### Limitations

There are limitations to this review. The first acknowledges that the voices, opinions, and experiences of children with autism are notably absent from the studies included in this review. Although out of the control of the authors, we recognize that this represents a significant omission in the data and limits the scope of the findings. The second limitation relates to the minimal number of studies available on yogic intervention involving this population. This review was not able to be meta-analyzed due to the heterogeneity of the applicable studies. Since the aspects and type of yoga intervention were varied and are each multifaceted it is hard to determine the most effective intervention strategy when using yoga as an intervention.

The third limitation relates to the search strategy used. A portion of research found on this topic was from India, thus language bias is an important limitation to note. Hindi is recognized as the primary language of India and used by the central government. English is the sole language of the assessors and thus there could present a language and cultural bias. This language limitation could have stunted the size of the initial article search. Older studies before the year 2000 were excluded to ensure the most relevant data was presented, however there could be useful information in those past studies. The definition of yoga was limited to the physical postures (asanas); therefore, some studies related to meditation and mindfulness only were not included in this review. In addition, this literature review examined research on behaviors related to stress and anxiety in children with autism.

The complete benefits of yoga for children with autism, such as physical or academic benefits, were not included in the search terms. The fourth limitation is the lack of comparison between the various settings and their effects on outcomes, in part due to the inability to perform a meta-analysis. Further analysis about the effects of interventions in a school setting would be beneficial. Finally, extraneous variables of parent involvement and teacher competencies were not included in this review. Most studies reviewed did include this data, however it was not the focus of this review. This review provides preliminary evidence that yoga interventions could assist stress and anxiety in children with autism, yet more thorough research is needed to support these findings within a school setting.

### Research Gaps

This review was limited demographically with the majority, five of the 9 studies being conducted in India, yoga's birthplace. More research on these interventions with a diverse population is necessary for conclusive generalizable results. There is a gap in research on these interventions given by adapted physical educators and the effects of their expertise and experience with children with autism and yoga. Further research is needed to

determine if the expertise and experience of the instructors delivering the intervention impacts the outcomes for participants. There were several methodological limitations to the studies reviewed as well. Many studies did not include a control group, five of the nine studies, which could lead to participant biases and the Hawthorne effect [56].

Allocation of control group or intervention group was concealed in only two studies, and only one contained blinding of the assessors. Parent observation and assessment of behavior was a common method used to collect data and could present biases. Only one study included participant self-assessment. It is important that research provides a platform for the voices and opinions of autistic children to be heard and analyzed. The myriad of behavioral tests used in these studies show the need for reliable and universal methods to assess behaviors of children with autism so that scores can become standardized and more appropriately compared. In addition, the functioning level of participants was not disclosed in all studies and therefore a limitation on the equitable comparison of participants exists and impacts the ability to generalize the results and implementation of yoga interventions.

The revisions to the DSM-5 provide severity markers, however there are still discrepancies within research on qualifying autism symptoms. The functioning level of the subjects may impact the outcomes of different types of yoga interventions. Findings about the efficacy of these interventions only encompass a short time frame so there is a need for further research to perform longitudinal studies of behavioral outcomes across time. The high quality of the RCT studies and results of favorable outcomes make this study design the most desirable and reliable for future studies. More studies, akin to Sotoodeh et al.<sup>34</sup> that contain the blinding of evaluators, are needed in this field to improve the reliability of findings. Due to the specificity and access to the population, the number of subjects was relatively small for most studies with the largest being 61 subjects, including the control group. Research with larger, more homogenous study design is suggested to draw a more universal conclusion about effectiveness of yoga interventions.

## Conclusion

Yoga is a noninvasive way for children with autism to manage stress and anxiety as a complement to other behavioral interventions. Further studies may concentrate on one or a few select behaviors related to stress & anxiety in children with autism within a similar severity level to examine the effect of yoga interventions. This focused research could give insight into the specific areas of behavior yoga interventions. Further research should also examine the type of yoga intervention such as physical poses, meditation, or mindfulness impact on children with autism

within a school setting. The results of this systematic review meet Every Student Succeeds Act's Tier 1 of evidence [10,11] and the NPDC's criteria [25] for evidence-based practice, indicating yoga has strong evidence to support its implementation as a behavioral intervention for children with autism.

Therefore, this type of intervention can be used in a school setting through the expertise and collaboration of adapted physical educators, general physical educators, and physical or occupational therapists alike. This systematic review provides the preliminary findings for those wanting to implement yoga as an intervention for children with autism. There are numerous research-based programs (IAYT, Get Ready to Learn Yoga Program, Incredible Explorers Program, Multimodal Mandala Yoga) that were outlined in these studies that could be utilized by adapted physical education teachers, and other professionals, working with children with autism, including families and parents. However, further research is needed to establish whether each specific yogic intervention meets the NPDC criteria [25] for evidence-based practice. These various programs should be researched more thoroughly in the future to determine the most effective type of yoga practice for this population.

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