

# A Comparison of Emotional and Behavioral Outcomes in Group- and Individual-Based Physical Activity Interventions of Youth with Autism Spectrum Disorder

Felix Kong

*Great Neck South High School, 4 Grace Court North, Great Neck, NY 11021, United States*

## ABSTRACT

Youth with Autism Spectrum Disorder (ASD) tend to be more socially avoidant and emotionally dysregulated. Combined with their more sedentary lifestyle, these factors contribute to their higher rates of loneliness and lower quality of life. Physical activity intervention (PAI) is increasingly used to address these deficits. However, research comparing characteristics of PAI, such as group versus individual setting, remains limited. The review investigates and compares the behavioral and emotional outcomes of individual- and group-based PAI for youth with ASD. A systematic review across PubMed and ScienceDirect was used to identify relevant studies. Following PRISMA guidelines, 326 studies were assessed for potential eligibility, and 11 studies written in English from 2005 to 2025 were extracted to be analyzed. Findings show that group- PAI consistently improved pattern-based behaviors, mood stability and reactivity, while individual PAI more consistently improved arousal control behaviors. Group PAI was found to more consistently improve overall behavioral and emotional outcomes than individual PAI does. Furthermore, longer duration and higher complexity were associated with group PAI, which could explain these findings. Future research can investigate the independent influences of these specific PAI characteristics on outcomes to pinpoint how they can be optimized in a PAI setting.

**Keywords:** Autism spectrum disorder; youth; emotional; behavioral; physical activity intervention (PAI); group-PAI; individual-PAI; intervention characteristics

## INTRODUCTION

Autism spectrum disorder (ASD) is a developmental disability characterized by early-appearing social, communication, and sensory-motor deficits. As of 2022, ASD affects 1 of 31 eight-year-olds, and the prevalence of ASD among youth has been increasing (1). According to the DSM-5, the diagnosis of ASD is based on two

factors: persistent deficits in social communication and social interaction in multiple contexts and restrictive or repetitive behaviors, interests, or activities, such as stereotyped or repetitive motor movements. (2). Nurturing youth with ASD also poses challenges for caregivers and teachers, particularly in fostering social, emotional, and behavioral skills (3). Youth with ASD also struggle with loneliness, difficulties in communication, and low social support (4). Additionally, they are prone to academic underperformance and to exhibiting higher levels of emotional and behavioral difficulties in school compared to their typically developing peers (4). These issues are intensified when youth with ASD are placed in inclusive classrooms, where they tend to feel even lonelier (5).

---

**Corresponding author:** Felix Kong, E-mail: Felixkong66@gmail.com.

**Copyright:** © 2026 Felix Kong. This is an open access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

**Accepted** March 27, 2026

<https://doi.org/10.70251/HYJR2348.42266277>

Furthermore, youth with ASD tend to be more sedentary and are 40% more likely to have obesity (6, 7).

Physical activity interventions (PAIs) have proven to be an effective practice for behavioral, social, motor, and emotional deficits that those with ASD have at a low cost. Pan found that youth with ASD who participated in a 10-week swimming intervention significantly improved their physical functioning, social competence, and aggressive behaviors (8). Similarly, Tse found that youth with ASD who participated in 12-week jogging intervention significantly improved their externalizing behavior, total problem scale, and emotional regulation (9). In fact, these studies align with Wu’s synthesis of 28 studies assessing the effects of PAI on youth with ASD, which found that PAI significantly enhances motor function and reduces the overall severity of ASD symptoms compared to those with ASD who do not participate (10). These symptoms include social impairment, repetitive stereotyped behavior, and lack of inhibitory control (10). Beyond PAI, research on peer-mediated interventions indicates improvements in social engagement and social skills for youth with ASD (4).

Although numerous studies have examined the behavioral and emotional effects that PAI has on those with ASD, there are gaps in knowledge comparing group and individual PAI on sociobehavioral and emotional gains. Existing studies assess group and individual PAI separately or compare youth with ASD to neurotypical peers, rather than directly comparing the effects of group and individual PAI. This study implements a systematic review to compare the impact of group and individual PAI

on the behavioral and emotional skills of youth with ASD. Furthermore, this study compares how characteristics of PAI (duration, complexity, and consistency) correlate with whether a study is a group or individual PAI. The goal of this review is to provide guidance on which forms of PAI may yield the greatest benefits to youth with ASD and provide practitioners with insights to support long-term development of youth with ASD. Ultimately, this knowledge may provide more insight for more personalized, effective support for youth with ASD.

Guided by Bandura’s Social Learning Theory, group PAI was expected to yield greater behavioral and emotional gains than individual PAI because of higher social interaction, positive reinforcement, and better sociability among other group participants (11).

## METHODS AND MATERIALS

### Study Design

The systematic review was conducted following PRISMA guidelines (12) to examine and compare the effects of group- and individual-based PAI on the behavioral and emotional outcomes of youth with ASD. A completed PRISMA checklist is not provided as Supplementary Tables. Randomized controlled trials, quasi-experimental designs, pilot designs, and feasibility studies were included in which intervention groups received additional PAI (Table 1). Furthermore, interventions had to be of at least light-to-moderate intensity (e.g., walking, dancing, and vestibular and proprioceptive exercises).

**Table 1.** Systematic review inclusion and exclusion criteria for Systematic Review of PAI (Physical activity intervention)

Domain	Inclusion criteria	Exclusion criteria
Study design	Studies must contain empirical data and primary or secondary analyses of these data. Randomized controlled trials, quasi-experimental designs, pilot designs, and feasibility studies were included	<ul style="list-style-type: none"> <li>Any format not providing sufficient information to allow for data extraction</li> <li>Reviews</li> </ul>
Participants	Youth with primary diagnosis of ASD under the age of 18 years	<ul style="list-style-type: none"> <li>Studies focused on adults or studies focused on those without ASD</li> <li>Participant does not have a diagnosis of ASD</li> </ul>
Exposures	PAI of mild-high intensity, consisting of any kind of exercise (running, swimming) Needs to specify if it is a group or solo PAI: <ul style="list-style-type: none"> <li>Group: involving intentional social interaction from mentor, interventionists, or other teammates</li> <li>Solo: does not involve intentional social interaction</li> </ul> Needs control group that does not do PAI	<ul style="list-style-type: none"> <li>PAI of low intensity (ie: yoga)</li> <li>Involves multiple forms of intervention along with PA (ie: music therapy)</li> <li>Does not have control group</li> </ul>

**Continued Table 1.** Systematic review inclusion and exclusion criteria for Systematic Review of PAI (Physical activity intervention)

Domain	Inclusion criteria	Exclusion criteria
Outcomes	Assess behavioral and/or emotional wellbeing of participants. <ul style="list-style-type: none"> <li>• Has reliable measures that assess the quality of wellbeing of control and intervention group before and during intervention. Preferred if assesses quality of wellbeing after intervention too, but is optional</li> <li>• Comparable with results from other studies</li> <li>• Can assess other factors, as long as it assesses social or emotional wellbeing</li> </ul>	Does not assess social and/or emotional wellbeing of participants <ul style="list-style-type: none"> <li>• Measures are not comparable with other studies' measures</li> <li>• Measures are not recognizable or reliable</li> <li>• Does not assess before and after intervention</li> <li>• Has missing data</li> </ul>
Timing	Since 2005	Before 2005
Setting	A setting fit for performing physical activity in (school gym, playground, soccer field.)	A setting that is unfit or may hinder the quality of physical activity
Language	English	Language other than English

Studies with participants under 18 years old were included. No restrictions were imposed on genders, races, or demographics. Studies were required to have confirmation of patient ASD diagnosis, through validated assessment tools or medical reports. Studies in which ASD was not the primary diagnosis were excluded. Additionally, mention of PAI format (group or individual setting) was required. Outcomes needed to assess the behavioral and/or emotional well-being outcomes of PAI of participants. Studies that assessed additional outcomes such as motor control and cognition, were included, though such metrics were not recorded or noted. Studies that did not assess either measure were excluded. The use of reliable behavioral and emotional assessment tools for youth with ASD, such as the Go/No-Go Task (GNG; 13), Autism Behavior Checklist (ABC; 14), and Gilliam Autism Rating Scale-Third Edition (GARS-3; 15), was required to measure outcomes of PAI.

**Search Strategy**

A search across PubMed and ScienceDirect was conducted to ensure comprehensiveness and reliability of search results. The search was limited to English-language articles written from 2005 to 2025. Search terms included four primary categories: disorder, intervention, target audience, and outcomes. Search terms were combined using Boolean operators (Table 2).

In the first phase, two researchers removed duplicates and then independently screened the titles of retrieved articles using the Rayyan software (16) to identify potentially relevant studies. In the second phase, they screened the full texts of eligible articles for inclusion

**Table 2.** Search strategy and number of results (hits) for emotional and behavioral outcomes of pai in youth with ASD in PubMed and ScienceDirect since 2005. The table lists the search strings used for both databases, along with the number of hits in both databases.

Search String	HITS PubMed (since 2005)	HITS ScienceDirect (since 2005)
Autism AND “physical activity”	1480	5403
Autism AND “physical activity” AND social	614	4227
Autism AND “physical activity” AND group	590	4962
Autism AND “physical activity” AND “social interaction”	134	1357
Autism AND “physical activity” AND emotional	196	2783
Autism AND “physical activity intervention” AND emotional	111	96
autism AND “physical activity intervention” AND social	385	2783
autism AND social AND emotional AND “physical activity”	112	2542
autism AND social AND emotional AND “physical activity intervention”	61	91

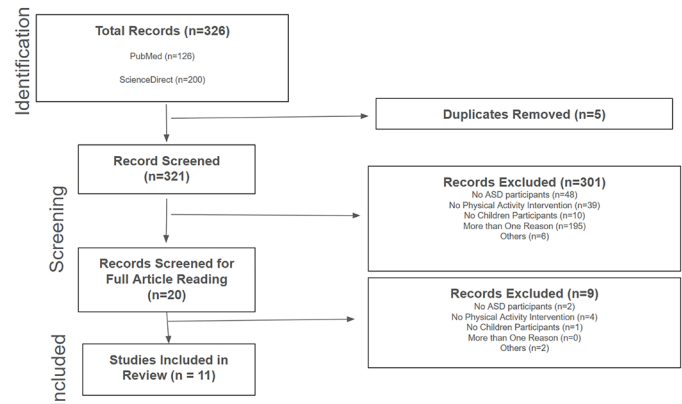
**Continued Table 2.** Search strategy and number of results (hits) for emotional and behavioral outcomes of pai in youth with ASD in PubMed and ScienceDirect since 2005. The table lists the search strings used for both databases, along with the number of hits in both databases.

Search String	HITS PubMed (since 2005)	HITS ScienceDirect (since 2005)
autism AND “physical activity intervention” AND emotional AND social NOT “systematic review”	57	25
autism AND group AND “physical activity intervention” AND emotional AND social NOT “systematic review”	31	23
autism NOT group AND “physical activity intervention” AND emotion NOT “systematic review”	52	25
“autism spectrum disorder” AND “physical activity intervention” AND emotion NOT “systematic review”	67	9
“autism spectrum disorder” AND (“physical activity” OR “exercise therapy”) AND children AND emotional AND social AND behavioral NOT review	146	180

criteria. Articles that met research criteria were included, and then data were recorded in an Excel sheet to note relevant information and outcomes. The articles that did not fully meet research criteria were excluded. The percentage agreement was calculated to assess consistency. Disagreements among researchers during the screening or data extraction were solved through discussion.

The search retrieved 326 articles (Table 2). 5 duplicates were identified and removed, leaving a remainder of 321 non-duplicate articles for potential eligibility. Following the initial screening, 20 articles met the criteria, while the remaining 301 were excluded

(participants not ASD-focused, n=51; intervention not PAI-focused, n=43; participants were not solely youth under 18 years of age, n=11; other reason, n=8; more than one reason, n=195). Following the full article screening, 11 articles met the criteria, while the remaining 9 were excluded (participants not ASD-focused (n=2); no PAI (n=4); no child participants (n=1); other reason (n=2); more than one reason (n=0; Figure 1).



**Figure 1.** PRISMA flowchart of study selection showing the different phases of the systematic review process: Identification, screening, eligibility, and inclusion. Note: ASD = autism spectrum disorder.

Ultimately, six group and five individual studies were included (Table 3). Although the article criteria included articles after 2005, all the articles were from 2018 or later (Table 3). There were 7 types of PAI used in the 11 articles included in this review: dancing, swimming, jogging, martial arts, proprioceptive/vestibular exercises, cycling, and mini basketball. The majority of studies took place in indoor facilities such as martial arts academies, judo practice facilities, physical activity rooms, gyms, and indoor pools (n=9). Few (n=2) were facilitated in outdoor areas (Table 3). All of these studies included a control group. Some studies’ control groups participated in regular therapy, while others participated in no activity.

**Data Analysis**

Analysis was refined as new data were analyzed using an inductive coding approach (Supplementary Table 1) to allow themes to emerge directly from the included studies rather than being predetermined. Analysis was refined as new patterns emerged until thematic saturation was reached, and were evaluated against existing

evidence to ensure consistency and transparency. In addition to the study’s focus on emotional and behavioral outcomes, studies were read closely and coded manually to capture recurring concepts and trends across group- and individual-based PAI.

Ultimately, five primary themes were identified: emotional, behavioral, duration, complexity, and consistency (refer to codebook appendix material 2). Emotional and behavioral outcomes were assessed to examine and compare the effectiveness of group and individual PAI, and duration, complexity, and consistency were analyzed to understand how they varied in relation to these PAI settings.

**RESULTS AND DISCUSSION**

Most participants were in the age range of 6-13 years. However, one study included participants from 2.3 to 17.3 years of age, which accounts for the wider age range observed in the dataset. There were a total of 524 participants throughout the 11 studies, consisting of 431 males and 93 females. There was a wide range in the length of the total interventions, with studies ranging from 3 days (18) to 48 weeks (23), while PAI session duration varied from 20 minutes (18) to 75 minutes (24). Additionally, both group- (17, 19, 11, 20, 21, 25) and individual-based (18, 22, 23, 9, 24) PAI were represented (Table 3).

The general outcome type of the studies varied from one another, and most consisted of more than one measured outcome type. The vast majority of studies examined behavioral outcomes (3, 8, 17, 18, 19, 20, 21, 22, 23, 24, 25). On the other hand, six studies examined the emotional outcomes (3, 8, 17, 18, 21, 22, 25).

Caputo et al., Ludyga et al., Marzouki, Morales et al., Toscano et al., Tse, and Zhang et al.’s methods of diagnosis were derived from DSM-5 criteria (2, 3, 9, 17, 18, 20, 23, 25); Eri’k et al. from DSM-5 (2, 22) and Childhood Autism Rating Scale (CARS; 26); Phung et al. from Autism Diagnostic Observation Schedule (ADOS-2; 27); and Lindor et al. from unspecified preference with just a report from a medical or health practitioner (21).

**Thematic Analysis**

Emotional and Behavioral Outcomes

PAI produced varied emotional benefits depending on exercise type (Supplementary Table 2 for extracted data on emotional outcomes). Individual PAI, which tended to be more repetitious and less complex, primarily improved emotional regulation. Group PAI, which tended to be more complex and socially engaging, primarily improved emotional reactivity and mood stability.

Overall, group PAI saw more consistent improvements in emotional outcomes, specifically in response and mood. Morales et al. saw fewer temper tantrums, extreme

*Table 3. Study Characteristics of Year of Publication, PAI Setting, PAI Type, Gender and Format*

Date of Publication	Reference Number	Setting	Physical Activity Type	Sex	Emotional Assessment	Behavioral Assessment
August 30 2024	18	Indoor	Cycling	29 male, 1 female	yes	yes
25 June 2019	19	Indoor	Mixed Martial Arts	28 male, 6 female	no	yes
12 August 2021	3	Indoor	Judo	7 male, 4 female	yes	yes
21 January 2025	20	Indoor	Mini Basketball	28 male, 0 female	no	yes
November 2023	21	Indoor	Dance	13 male, 14 female	no	yes
1 May 2025	22	Indoor	Vestibular and Proprioceptive Exercise	17 male, 5 female	yes	yes
Dec 22 2022	23	Both	Jogging	196 male, 33 female	no	yes
01 November 2020	9	Both	Jogging	23 male, 4 female	yes	yes
2024 Feb	24	Indoor	Cycling	52 males, 12 girl	no	yes
2022 Apr 25	25	Indoor	Aquatic Games and Swimming	21 males, 7 girls	yes	yes
8 January 2018	17	Outdoor	Swimming	17 males, 9 females	yes	yes

reactions, negativity on the Gilliam Autism Rating Scale, Third Edition (GARS-3; 15), while Tse saw less impulsiveness, emotional flatness, clinginess with adults on the Emotional Regulation Checklist (ERC; 9). These exercise settings generally had higher levels of social interaction and collaboration, such as judo oppositional games and partner judo technique practice (3), and the aquatic practice involved activities and games, such as noodle kicking and hula-hoop swimming, designed for cooperation and teamwork (17). Individual PAI still saw improvements, mainly in emotional regulation, though noticeably less consistently. They tended to be more structured and strictly aerobic-based exercises that provided less freedom for communication and collaboration.

Across studies, PAI improved behavioral well-being at a more consistent rate than emotional well-being in both group and individual PAI studies (Supplementary Table 2 for extracted data on behavioral outcomes). Still, group PAI saw more consistent improvements in behavioral regulations than individual PAI. Group PAI improvements were mainly associated with improvements in rigid, pattern-based behaviors like repetitive behaviors (judo, 3; basketball, 20; aquatic therapy, 17) and restrictive behaviors (judo, 3). These effects may have result from stronger behavioral activation elicited from the sequencing, imitation, and motor planning, reflected by the judo oppositional games and partner judo technique practice (3); the peer coordination training, catching, and relay racing in a basketball PAI (20); and aquatic activities and games, such as noodle kicking (17). In contrast, individual PAI targeted arousal control, reflected in self-regulation (24), reactivity (23), and hyperactivity (22), though these gains were less consistent. These effects corresponded with the cognitively simpler, repetitive nature of individual PAI.

These findings suggest that group PAI may hold promise in fostering positive outward emotional responses and pattern-based behaviors through shared activities that promote social interaction and connectedness through more opportunities to socially acquire desirable emotional responses. In contrast, individual PAI may target emotional regulation improvements and arousal control behaviors by reducing overstimulation and allowing predictable, structured activity. The differences in the reliability of behavioral and emotional improvements may be explained by the social learning theory. Pro-social traits from group PAI may influence and encourage participants to strive for improvements in behavior and emotional regulation and

control. Similarly, the lack of group- and people-oriented emotional and behavioral outcomes from individual PAI may be explained by the absence of social learning, as there was no collaboration or communication from other participants to incentivize such improvements.

Ultimately, group and individual PAI targeted different aspects of emotional and behavioral well-being. Furthermore, though they are distinct, they appeared to be similarly affected by the level of complexity and social invitingness of a PAI setting, as group PAI tended to improve overall emotional and behavioral outcomes on a more consistent basis than individual PAI because of its more complex and social setting.

### Duration

Longer-duration PAI produced more stable improvements in behavioral outcomes. Specifically, 4 of the 5 studies with high duration in both session length and time saw improvements in behavioral outcomes (17, 19, 20, 23). Similarly, the only study with high duration in session length and time that assessed emotional well-being saw improvements in emotional response (17), which is insufficient to demonstrate consistent emotional improvements resulting from PAI with high duration. This trend of behavioral improvement aligns with the more consistent behavioral improvements of group PAI over individual PAI, as a significantly higher percentage of high-duration PAI were of higher-duration interventions in session length and time (4/6; 17, 19, 20, 21) than individual PAI (1/5; 23).

Overall, these findings suggest a strong association between behavioral improvement and PAI duration, likely due to sustained routines and reinforcement of socially desirable behaviors. The higher duration of group PAI could explain its more consistent behavioral outcomes, instead of the more collaborative nature of group PAI. However, the effects of duration on emotional well-being are not clearly explained, given the small sample size of high-duration studies that analyzed emotional outcomes.

### Complexity

Group PAI tended to be higher in complexity than individual PAI. For instance, Morales et al. involved practice involving judo oppositional games involving body contact, where participants worked in pairs to build each other's touch tolerance. Caputo et al. involved various aquatic activities (e.g., noodle kicking and hula-hoop swimming) to foster group integration, cooperation, and social interaction while also building up participants' swimming skills and comfort. Additionally, Lindor et

al. involved group dance practice and performance, where participants synchronized their movements and positioning. Overall, all group PAIs were complex (6/6; 3, 17, 19, 20, 21, 25). Individual PAI tended to be lower in complexity than group PAI. These included cycling (18), basketball skills (20), jogging (9), and a variety of basic vestibular/proprioceptive, strength, or balance training (22; 23). Overall,  $\frac{1}{5}$  of individual PAI studies were complex in their PAI (24), and the other  $\frac{4}{5}$  studies were basic (9, 18, 22, 23, 24).

The complexity of PAI could help explain the more consistent emotional and behavioral improvements of group PAI. Complex PAI tended to prompt more social learning, coordination, and mutual feedback than with individual PAI. This trend is reflected by the vast majority of complex PAI, such as by Morales et al., Caputo et al., and Lindor et al. (3, 17, 21). However, basic PAI was often repetitive and monotonous. All basic PAI were structured around instinctual motor actions such as jogging (9) or the isolated movements in proprioceptive/vestibular exercises (22). Therefore, basic designs may provide fewer opportunities for targeting behavioral and emotional deficits characteristic of individuals with ASD.

Overall, complexity appeared to favor group PAI for behavioral and emotional outcomes, as evidenced by the consistently greater improvements reported across complex group PAI compared to their basic, individually delivered ones. These results suggest that the sociobehavioral and emotional demands necessary for developing these improvements are more abundant in complex PAI, giving group PAI a significantly stronger foundation for generating both behavioral and emotional improvements.

### Consistency

Across studies, greater consistency was associated with more sustained behavioral and emotional benefits. For example, Morales et al. found improved repetitive behaviors and emotional responses (3); Phung et al. found better problem behavior management (19); and Tse found improved external behavior composition, total problem scale, and emotional regulation (9).

However, inconsistent PAIs produced more variable outcomes. For example, Ludyga et al. found worsened emotional judgement and no changes in behavioral face fixation; Lindor et al. found no significant changes in repetitive and restrictive behaviors; and Caputo et al. saw improved emotional response and behavioral adaptation to change and activity level. Additionally, though Morales et al.'s judo PAI saw behavioral and emotional

improvements through a consistent PAI design, there was a dip in behavioral and emotional outcomes below baseline level after a 10-week COVID-19 lockdown that halted PAI. While this study was not labeled as inconsistent, the decline demonstrates that disruptions can cause gains to regress, though the unique impacts of pandemic-related isolation complicate this interpretation (21).

The level of consistency didn't have a strong correlation based on group or individual study.  $\frac{4}{5}$  individual studies were high consistency, and  $\frac{1}{5}$  (20%; 18) were low consistency, while 4/6 group studies were high consistency (3, 20, 19, 25) and 2/6 of group studies were low consistency (33.3%; 17; 21). This suggests that more reliable behavioral and emotional benefits of group PAI over the individual PAI were not likely attributable to a higher consistency. While consistency may support the growth of PAI outcomes, it does not appear to be influenced by PAI type.

### Summary, Strengths and Limitations

Ultimately, group PAI is associated with improvements in pattern-based behaviors, mood stability, and emotion reactivity, while individual PAI is associated with improvements in arousal-control behavioral regulation and emotional regulation. As with behavioral and emotional outcomes, group PAI saw more consistent gains than did individual PAI. These more consistent behavioral and emotional improvements of group PAI may be attributable to the social demands, shared goals, and more socialization present in group PAI, though these results remain inconclusive. Group PAI often demands participants continually coordinate actions, adjust to the needs of peers, and engage in socially cooperative routines, which further reinforce behavioral and emotional improvements.

These trends may also be explained by the higher complexity and duration that support the more consistent emotional and behavioral effects yielded by group PAI over individual PAI, as these domains were more prevalent in the group PAI studies than the individual PAI studies. However, these differences were not attributable to consistency, as there were no major differences in the level of consistency in group and individual PAI-based studies.

One strength of the study was the level of detail in the coding. Through examining duration, complexity, and consistency across group and individual PAI, possible influences of the behavioral and emotional outcomes beyond the nature of group and individual

PAI alone were identified. For the evaluation of the duration and consistency domains, two components were assessed. Duration was measured through the length of PAI sessions in weeks and minutes per PAI session. Consistency was assessed through the changes in frequency of PAI sessions and weeks of PAI up to two weeks. This coding approach invites more precision and depth to descriptions, analysis, and interpretations, which is particularly important in PAI research, where study characteristics (e.g., duration, complexity, and consistency) vary widely. Therefore, standardizing and examining these features alongside comparisons of group and individual PAI helps create a clearer basis for comparison across a diverse set of PAI routines.

However, the higher average duration and complexity observed in group PAI may serve as a confounding variable and a limitation of the study. Because the duration and average complexity of a group are higher than in individual PAI, the extent to which the PAI format affects the behavioral and emotional gains of youth with autism is inconclusive. Instead, emotional and behavioral gains may be primarily influenced by duration and complexity, which leaves this relationship difficult to isolate and attribute specific outcomes to the PAI type. Furthermore, only 11 studies were included for analysis, all of which relied on qualitative analysis rather than quantitative measures. The limited sample size and lack of quantitative measures reduce the reliability of the study's findings. These studies were also from published literature, which risks introducing publication bias. Additionally, throughout studies, traits such as PAI type, the capabilities of participants, and the type of guidance instructors increased the heterogeneity, perhaps independently influencing each study's results and comparability across all studies.

Ultimately, PAI has increasingly been used as a supplement and replacement for the traditionally more costly social skills training to improve symptoms and practice behavioral and emotional skills (31). Still, information on PAI remains limited, particularly regarding the specific characteristics of PAI needed to achieve the best outcomes, due to a lack of unbiased, high-quality research and standardized findings (29, 30).

These findings provide a detailed overview of numerous PAI-based studies, helping to clarify their behavioral and emotional effects. Furthermore, the effectiveness of group and individual PAI on outcomes was compared, which no previous study has done before. This comparison helps narrow what constitutes an optimally effective PAI for youth with autism.

Furthermore, these results may guide future research to explore how the duration and complexity of PAI affect such outcomes, given their strong correlation with group PAI. Ultimately, the results may provide a clearer understanding of the variables that affect behavioral and emotional gains in youth with autism, although the specific influence and severity of each remain uncertain.

## **CONCLUSION**

Through a systematic review of 11 articles, the study examined the effects of group and individual PAI on the behavioral and emotional outcomes of youth with autism. The findings reveal that group PAI was associated with improvements in pattern-based behaviors, mood stability, and reactivity, while individual PAI was associated with improvements in arousal control behaviors and internal emotional regulation. Overall, the behavioral and emotional gains in group PAI were more consistent than those in individual PAI. Furthermore, group PAI saw a consistently higher duration and complexity than individual PAI, which could also help explain the more consistent gains in group PAI. Ultimately, these findings suggest that group PAI shows potential for improving behavioral and emotional outcomes in youth with autism, although the evidence remains inconclusive. These findings can guide future research by narrowing the scope of the characteristics of PAI not exclusively through PAI design, but also through duration and complexity.

Future research should investigate the individual influences of the behavioral and emotional outcomes of specific PAI characteristics to pinpoint which can be optimized for maximum gains. These characteristics may perhaps be tested through head-to-head trials that manipulate intervention format (group and individual), duration, and complexity separately to determine the extent to which each of these factors affects outcomes.

## **ACKNOWLEDGEMENTS**

Words cannot express my gratitude towards my research mentor Professor Meelan Thondoo for her thorough guidance and helpful feedback throughout the entire researching process.

## **CONFLICT OF INTEREST**

The author declares that there are no conflicts of interest related to this work.

## REFERENCES

1. Shaw KA, Maenner MJ, Bakian AV, Bilder DA, et al. Early Identification of Autism Spectrum Disorder Among Children Aged 4 Years — Autism and Developmental Disabilities Monitoring Network, 11 Sites, United States, 2018. *MMWR Surveillance Summaries*. 2021; 70 (10): 1–14. U.S. Department of Health and Human Services, CDC. <https://doi.org/10.15585/mmwr.ss7010a1>
2. Grzadzinski R, Huerta M, Lord C. DSM-5 and autism spectrum disorders (ASDs): an opportunity for identifying ASD subtypes. *Mol Autism*. 2013 May 15; 4 (1): 12. doi: 10.1186/2040-2392-4-12. PMID: 23675638; PMCID: PMC3671160.
3. Morales J, Fukuda DH, Garcia V, Pierantozzi E, et al. Behavioural Improvements in Children with Autism Spectrum Disorder after Participation in an Adapted Judo Programme Followed by Deleterious Effects during the COVID-19 Lockdown. *Int J Environ Res Public Health*. 2021 Aug 12; 18 (16): 8515. doi: 10.3390/ijerph18168515. PMID: 34444263; PMCID: PMC8394929. 3
4. Kasari C, Rotheram-Fuller E, Locke J, Gulsrud A. Making the connection: randomized controlled trial of social skills at school for children with autism spectrum disorders. *J Child Psychol Psychiatry*. 2012 Apr; 53 (4): 431-9. doi: 10.1111/j.1469-7610.2011.02493.x. Epub 2011 Nov 26. PMID: 22118062; PMCID: PMC3238795.
5. Chamberlain B, Kasari C, Rotheram-Fuller E. Involvement or isolation? The social networks of children with autism in regular classrooms. *J Autism Dev Disord*. 2007 Feb; 37 (2): 230-42. doi: 10.1007/s10803-006-0164-4. PMID: 16855874. 5
6. Healy S, Haegele JA, Grenier M, Garcia JM. Physical Activity, Screen-Time Behavior, and Obesity Among 13-Year Olds in Ireland with and without Autism Spectrum Disorder. *J Autism Dev Disord*. 2017 Jan; 47 (1): 49-57. doi: 10.1007/s10803-016-2920-4. PMID: 27671801. 6
7. Curtin C, Anderson SE, Must A, Bandini L. The prevalence of obesity in children with autism: a secondary data analysis using nationally representative data from the National Survey of Children's Health. *BMC Pediatr*. 2010 Feb 23; 10: 11. doi: 10.1186/1471-2431-10-11. PMID: 20178579; PMCID: PMC2843677.
8. Pan CY. Effects of Water Exercise Swimming Program on Aquatic Skills and Social Behaviors in Children with Autism Spectrum Disorders. *Autism*. 2010 Jan; 14 (1): 9-28. doi: 10.1177/1362361309339496. PMID: 20124502.
9. Tse, Andy CY. Brief report: impact of a physical exercise intervention on emotion regulation and behavioral functioning in children with autism spectrum disorder. *Journal of autism and developmental disorders*. 2020; 50: 4191-4198. <https://doi.org/10.1007/s10803-020-04418-2>
10. Wu Yifan, et al. The effect of physical exercise therapy on autism spectrum disorder: a systematic review and meta-analysis. *Psychiatry Research*. 2024; 339: 116074. <https://doi.org/10.1016/j.psychres.2024.116074>
11. Nabavi, Razieh Tadayon, and Mohammad Sadegh Bijandi. Bandura's Social Learning Theory & Social Cognitive Learning Theory. 2012, ResearchGate, [www.researchgate.net/publication/267750204\\_Bandura%27s\\_Social\\_Learning\\_Theory\\_Social\\_Cognitive\\_Learning\\_Theory](http://www.researchgate.net/publication/267750204_Bandura%27s_Social_Learning_Theory_Social_Cognitive_Learning_Theory). (accessed on 2026-03-12).
12. Liberati A, Altman DG, Tetzlaff J, Mulrow C, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Med*. 2009 Jul 21; 6 (7): e1000100. doi: 10.1371/journal.pmed.1000100. Epub 2009 Jul 21. PMID: 19621070; PMCID: PMC2707010.
13. Gomez P, Ratcliff R, Perea M. A model of the go/no-go task. *J Exp Psychol Gen*. 2007 Aug; 136 (3): 389-413. doi: 10.1037/0096-3445.136.3.389. PMID: 17696690; PMCID: PMC2701630.
14. Cassidy A. Autism Behavior Checklist. In: Volkmar, F.R. (eds) *Encyclopedia of Autism Spectrum Disorders*. Springer, New York, NY. 2013. [https://doi.org/10.1007/978-1-4419-1698-3\\_1367](https://doi.org/10.1007/978-1-4419-1698-3_1367)
15. Karren BC. A Test Review: Gilliam, J. E. (2014). Gilliam Autism Rating Scale—Third Edition (GARS-3). *Journal of Psychoeducational Assessment*. 2016; 35 (3): 342-346. <https://doi.org/10.1177/0734282916635465>
16. Ouzzani Mourad, et al. Rayyan—A Web and Mobile App for Systematic Reviews. *Systematic Reviews*. 2016; 5 (210): 2016. <https://doi.org/10.1186/s13643-016-0384-4>
17. Caputo G, Ippolito G, Mazzotta M, Sentenza L, Muzio MR, Salzano S, Conson M. Effectiveness of a Multisystem Aquatic Therapy for Children with Autism Spectrum Disorders. *J Autism Dev Disord*. 2018 Jun; 48 (6): 1945-1956. doi: 10.1007/s10803-017-3456-y. PMID: 29313176.
18. Ludyga S, Bruggisser F, Leuenberger R, Ishihara T, et al. Acute effects of exercise on gaze fixation and affective response inhibition in children with autism spectrum disorder: A randomized cross-over study. *Autism Res*. 2024 Sep; 17 (9): 1934-1943. doi: 10.1002/aur.3224. Epub 2024 Aug 30. PMID: 39212128.
19. Phung JN, Goldberg WA. Promoting Executive Functioning in Children with Autism Spectrum Disorder Through Mixed Martial Arts Training. *J*

- Autism Dev Disord.* 2019 Sep; 49 (9): 3669-3684. doi: 10.1007/s10803-019-04072-3. PMID: 31240587.
20. Zhang W, Cai K, Xiong X, Zhu L, et al. Alterations of Triple Network Dynamic Connectivity and Repetitive Behaviors After Mini-Basketball Training Program in Children with Autism Spectrum Disorder. *Sci Rep.* 2025 Jan 21; 15 (1): 2629. doi: 10.1038/s41598-025-87248-5. PMID: 39838077; PMCID: PMC11751186.
  21. Lindor Ebony, et al. The Feasibility and Acceptability of AllPlay Dance for Autistic Children: A Pilot Randomised Controlled Trial. *Research in Autism Spectrum Disorders.* 2023; 109: 102271, <https://doi.org/10.1016/j.rasd.2023.102271>
  22. Eri'k E, Safran EE & Şevgin Ö. Effectiveness of vestibular and proprioceptive exercises in reducing hyperactivity in children with autism spectrum disorder: A randomized controlled trial. *Research in Autism.* 2025; 123: Article 202543. <https://doi.org/10.1016/j.reia.2025.202543>
  23. Toscano CVA, Ferreira JP, Quinaud RT, Silva KMN, Carvalho HM, Gaspar JM. Exercise Improves the Social and Behavioral Skills of Children and Adolescent with Autism Spectrum Disorders. *Front Psychiatry.* 2022 Dec 22; 13: 1027799. doi: 10.3389/fpsy.2022.1027799. PMID: 36620673; PMCID: PMC9813515.
  24. Tse AC, Liu VH, Lee PH, Anderson DI, Lakes KD. The relationships among executive functions, self-regulation, and physical exercise in children with autism spectrum disorder. *Autism.* 2024 Feb; 28 (2): 327-341. doi: 10.1177/13623613231168944. Epub 2023 May 10. PMID: 37161786.
  25. Marzouki H, Soussi B, Selmi O, Hajji Y, et al. Effects of Aquatic Training in Children with Autism Spectrum Disorder. *Biology (Basel).* 2022 Apr 25; 11 (5): 657. doi: 10.3390/biology11050657. PMID: 35625385; PMCID: PMC9138228.
  26. Chlebowski C, Green JA, Barton ML, Fein D. Using the childhood autism rating scale to diagnose autism spectrum disorders. *J Autism Dev Disord.* 2010 Jul; 40 (7): 787-99. doi: 10.1007/s10803-009-0926-x. PMID: 20054630; PMCID: PMC3612531.
  27. Akshoomoff N, Corsello C, Schmidt H. The Role of the Autism Diagnostic Observation Schedule in the Assessment of Autism Spectrum Disorders in School and Community Settings. *Calif School Psychol.* 2006; 11: 7-19. doi: 10.1007/BF03341111. PMID: 17502922; PMCID: PMC1868476.
  28. Wang S, Chen D, Yang Y, Zhu L, Xiong X, Chen A. Effectiveness of physical activity interventions for core symptoms of autism spectrum disorder: A systematic review and meta-analysis. *Autism Res.* 2023 Sep; 16 (9): 1811-1824. doi: 10.1002/aur.3004. Epub 2023 Aug 4. PMID: 37539450
  29. Wang Y, Qian G, Mao S, Zhang S. The impact of physical exercise interventions on social, behavioral, and motor skills in children with autism: a systematic review and meta-analysis of randomized controlled trials. *Front Pediatr.* 2025 Feb 27; 13: 1475019. doi: 10.3389/fped.2025.1475019. PMID: 40083436; PMCID: PMC11903732.
  30. Carcelén-Fraile MDC, Hita-Contreras F, Mesas-Aróstegui MA, Aibar-Almazán A. Effects of Physical Activity on Executive Function and Emotional Regulation in Children and Adolescents with Neurodevelopmental Disorders: A Systematic Review and Meta-Analysis. *Healthcare (Basel).* 2025 Sep 24; 13 (19): 2415. doi: 10.3390/healthcare13192415. PMID: 41095504; PMCID: PMC12524881.
  31. Chasson GS, Harris GE & Neely WJ. Cost comparison of early intensive behavioral intervention and special education for children with autism. *Journal of Child and Family Studies.* 2007; 16 (3): 401-413. <https://doi.org/10.1007/s10826-006-9094-1>

**Supplementary Table 1. Codebook Definition of Emotional Outcomes, Behavioral Outcomes, Duration, Complexity, and Consistency.**

Code	Emergent Definition (from data)	Examples / Coding Rule	Analytic Purpose
<b>Emotional</b>	Captures how emotional regulation or related outcomes (e.g., mood, lability, self-awareness, negativity) changed as a result of the intervention.	Marked as <i>improved</i> , <i>no change</i> , or <i>worsened</i> and add any quantitative reported subscale results or qualitative descriptions.	To understand how PAIs influence emotional regulation and effective well-being.
<b>Behavioral</b>	Refers to reported changes in adaptive or maladaptive behaviors, such as reductions in repetitive behaviors or improved social interaction.	Marked as <i>improved</i> , <i>no change</i> , or <i>worsened</i> based on study findings describing observable behavioral shifts; and add any quantitative reported subscale results or qualitative descriptions.	To assess the behavioral benefits of PAIs and links to social functioning.
<b>Duration</b>	The total length and intensity of the intervention, derived from reported weeks and total minutes.	Add coding rule: Short intervention: 8 or less weeks PAI Long intervention: 9+ weeks PAI  Short exercise: 20 min or less Moderate exercise: 21-40 min Long exercise: 40+	To explore how intervention length and exposure relate to observed effects.
<b>Complexity</b>	Emerged from descriptions of skill difficulty and level of supervision required.	<i>Basic</i> = simple, independent tasks learned relatively quickly  <i>Complex</i> = difficult skills requiring extensive practice.	To interpret whether the cognitive or physical challenge of the intervention influences engagement or outcomes.
<b>Consistency</b>	The regularity and persistence of PAI practice/games over time, including how often (at least two weeks) and how little break the activity was performed.	<i>low consistency</i> = at least one substantial variability in outcome measures in either regularity or persistence metric  <i>high consistency</i> = infrequent inconsistencies in frequency or duration	To examine whether intervention regularity contributed to sustain emotional and behavioral improvements.

**Supplemental Table 2.** Recorded Code Outcomes and Characteristics of Included Studies.

Ref.	Emotional Outcome	Behavioral Outcome	Duration	Complexity	Consistency
18	Mixed: worsened go-trial accuracy; no change in no-go or reaction time	No clear behavioral improvement	2 sessions; 40 min total	Basic (cycling)	Low (2 sessions, 5-day gap)
19	Not assessed	Improved problem behavior (SSIS scores ↓)	13 weeks; 585 min	Complex (MMA training)	High (2×/week)
3	Improved emotional response (GARS-3); declined post-lockdown	Improved repetitive behavior; declined post-lockdown	8 weeks; 600 min	Complex (judo, partner interaction)	Mixed (intervention high; disrupted by COVID)
20	Not assessed	Reduced RBS-R total score; improvements in restricted/self-injurious behavior	12 weeks; 2400 min	Complex (team basketball)	High (5×/week)
21	Not assessed	Minimal, non-significant improvement	10 weeks; ~8–10 h	Complex (group dance)	Low (irregular sessions)
22	No significant emotional change	Improved hyperactivity/impulsivity; no overall behavioral change	8 weeks; 640 min	Basic (vestibular/proprioceptive)	High (2×/week)
23	Not assessed	Partial improvements (reactivity, stereotypes, sleep); others unchanged	48 weeks; 2880 min	Basic (multi-exercise)	High (2×/week)
9	Improved emotional regulation; no change in negativity/lability	Improved external behavior; no change in internal behavior	12 weeks; 1440 min	Basic (jogging)	High (4×/week)
24	Not assessed	Improved self-regulation (bike training group)	2 weeks; 600 min	Mixed (basic cycling vs complex bike learning)	High (5×/week)
25	No significant emotional effect	Reduced stereotypical behavior (GARS-2)	8 weeks; 800 min	Complex (aquatic training)	High (2×/week)
17	Improved emotional response (CARS)	Improved adaptation to change and activity level	~10 months; 4320 min	Complex (aquatic + social integration)	Low (variable frequency)

Note: PAI = Physical Activity Intervention; GARS = Gilliam Autism Rating Scale; ERC = Emotion Regulation Checklist; CARS = Childhood Autism Rating Scale; RBS-R = Repetitive Behavior Scale-Revised.