

The effects of ‘I Can Develop Physical Literacy’ (ICPL) on sleep quality and gross motor skills among children with autism spectrum disorder

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ABSTRACT

Autism spectrum disorder (ASD) affects social communication, interaction, and behaviour issues with limited access to physical activity (PA), which leads to inadequate levels of fitness, poor health, and impaired motor abilities. ASD children often have poor sleep quality. Playing games may help children sleep better and improve gross motor skills. However, studies on the effects of playing physical games on ASD children are limited. Current research assessed how “I Can Develop Physical Literacy” (ICPL), a physical game, affected gross motor abilities and sleep quality in ASD children. In the current investigation, 24 children (with an average age of 4.75 ± 0.74 years, height of 105.1 ± 5.32 cm, weight of 18.25 ± 2.18 kg, body mass index 16.44 ± 0.43 kg · m⁻²) were randomly assigned to the ICPL and the control group ($n = 12$ per group). The experimental intervention group received sixteen sessions of 30 minutes over 8 weeks, while the control group did not receive any specialized treatment and continued their regular routine. All participants completed a pre-test and post-test using parent-reported Pittsburgh Sleep Quality Index (PSQI) and the Test of Gross Motor Development-2 (TGMD-2). Data were analyzed using paired-sample t-tests for within-group changes and independent-sample t-tests for between-group comparisons. The results showed that while both groups demonstrated some improvements, the ICPL group had significantly greater post-intervention improvements in global PSQI ($p = 0.021$ between-group) and TGMD-2 gross motor ($p = 0.023$ between-group) scores compared to the control group. These preliminary results suggest that structured physical games may offer potential benefits for sleep and motor abilities in children with ASD. Further research with larger sample

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sizes is necessary to explore the long-term benefits and potential applications of these interventions in diverse contexts.

1. INTRODUCTION

Autism spectrum disorder (ASD) is a condition that affects the development of the central nervous system that encompasses a variety of problems that develop in the areas of social interaction, communication, and repeated habits (Faras et al., 2010). The term "spectrum" has been used to indicate the broad spectrum of strengths and challenges encountered by individuals diagnosed with autism (Jensen & Spannagel, 2011). Autism spectrum disorder (ASD) is a lifelong condition that is typically identified in toddlers; this condition may have varying impacts on different people (Hodges et al., 2020). Autism is believed to develop from a diverse interaction of genetic, neurological, and environmental elements (Sealey et al., 2016). Moreover, variations in both the structure and functioning of the brain play a significant role in shaping the distinct cognitive characteristics observed in persons diagnosed with autism spectrum disorder (ASD) (Ecker et al., 2015).

Autism is characterised by a range of common characteristics, which represent issues in comprehending and understanding social cues, struggles in establishing and sustaining interpersonal connections, and a tendency for keeping to routine and engaging in repeated behaviours (Silveira-Zaldivar et al., 2020). The process of communication can experience many impacts, including the delay in the development of language skills and the development of speech patterns that differ from the norm (Law et al., 2003). Sensory sensitivities are frequently observed, wherein individuals frequently exhibit heightened or reduced responses to sensory inputs (NIH, 2016). It is crucial to acknowledge that individuals with autism exhibit unique traits, including their own set of talents and capabilities. A notable characteristic of persons diagnosed with autism spectrum disorder (ASD) is their exceptional abilities in particular areas, such as mathematics, music, or visual arts, which serves as proof of the wide-ranging talents found within the spectrum.

A key component of general well-being, physical literacy is the capacity to move confidently and competently in a broad range of physical activities (Whitehead, 2013). Development of physical literacy may be especially difficult for kids with autism spectrum disorder (ASD) because of several issues, including impaired social communication, motor coordination, and sensory processing (Ceccarelli et al., 2020). Studies have shown that compared to normally developing children, children with ASD often have less quality sleep (Westendorp et al., 2011). In this group, sleep disorders are common and may have a big effect on how well people function throughout the day, behave, and feel in general (Lambert et al., 2016). To evaluate these disturbances, parent-proxy adaptations of the Pittsburgh Sleep Quality Index (PSQI) have been validated and widely applied in pediatric populations, including children aged five years and younger with neurodevelopmental disorders such as ASD (Brand et al., 2011; Goodlin-Jones et al., 2008; Malow et al., 2012). Moreover, children with ASD may also have delayed or impaired development of their gross

motor abilities, which would limit their capacity to engage in physical activities and take advantage of different social and recreational possibilities (Wang et al., 2022). Enhancing motor skills, social engagement, and general well-being in children with ASD has shown potential with interventions aimed at physical literacy. The "I Can Develop Physical Literacy" (ICPL) approach is one such intervention that aims to improve the motor skills and physical confidence of children with ASD by offering specialised physical exercise opportunities and assistance.

The integration of pleasure inside games might function as a motivating element, hence possibly augmenting physical training. Certain people diagnosed with autism spectrum disorder (ASD) may exhibit delayed or unusual patterns of language development. Certain individuals may have challenges when it comes to engaging in conversation, comprehending, and using gestures, or participating in reciprocal communication (NIH, 2016). According to Bremer & Cairney (2020), the acquisition and refinement of some skills throughout infancy contribute to their subsequent adaptation and use in certain situations and sports. These skills include locomotor abilities, such as running and hopping; manipulative or object-handling skills, such as catching and throwing; and stability skills, such as balancing and twisting.

Children with Autism Spectrum Disorder (ASD) often have problems with sleeping. Multiple studies and clinical observations have repeatedly shown that a significant number of children diagnosed with autism spectrum disorder (ASD) have challenges in initiating and maintaining sleep, as well as in achieving overall satisfactory sleep quality (Gunes et al., 2019). Therefore, it is suggested that the current research analyse the impact of physical literacy programs on the sleep quality and gross motor skills of children with autism spectrum disorder (ASD). The purpose of this research is to provide parents, teachers, and other guardians with valuable information on how to effectively address the children's disability. Even as the value of physical exercise and the development of motor skills for children with ASD is becoming more widely acknowledged, little is known about the precise impacts of therapies like ICPL on sleep quality and gross motor abilities in this group (Sefen et al., 2020). Creating evidence-based therapies that successfully promote the whole well-being of children with ASD requires closing this gap. paragraphs continue from here and are only separated by headings, subheadings, images, and formulae. The section headings are arranged by numbers, bold and 10 pt. Here are further instructions for authors.

2. METHODOLOGY

2.1 Population

This study used a random sampling technique. The selected approach helped in guaranteeing that the sample was indicative and reduced the potential for bias. The population targeted for this study was young children diagnosed with autism spectrum disorder, aged between 3 to 6 years old (mean age 4.75 ± 0.74 years). This research sought to acquire a sample of 20 children with autism from The Energy Source, Bangsar. The purpose was to identify a difference of 20% between the experimental participants with a power of 80% and a significance level of 0.05. The 20% difference represented the expected difference from "I Can Develop Physical Literacy" (ICPL) interventions (Russell et al., 2017). The sample size was calculated using PS Power and Sample Size software. A total of 10 children for the control group, comprising 10 children for the ICPL program, participated as respondents. However, considering a 20% dropout rate, 24 autism children were recruited for this study.

2.2 Participants

In this study, 24 children (with an average age of 4.75 ± 0.74 years, height of 105.1 ± 5.32 cm, weight of 18.25 ± 2.18 kg, body mass index 16.44 ± 0.43 kg · m⁻²) were randomly assigned to the ICPL group ($n = 12$) and the control group ($n = 12$). The potential participants were taken from The Energy Source, Bangsar. The Energy Source is a one-stop child development facility committed to assisting parents in enabling their kids to realize their full potential and enhance quality of life.

Table 1: Demographic Data of Participants

Participant characteristics	ICPL (M ± SD)	CONTROL (M ± SD)	Total
N	12	12	24
Age (years)	5.00 ± 0.739	4.50 ± 0.674	4.75 ± 0.737
Height (cm)	103.50 ± 4.739	106.75 ± 5.562	105.13 ± 5.319
Weight (kg)	17.625 ± 2.017	18.875 ± 2.243	18.250 ± 2.181
BMI (kg.m ⁻²)	16.39 ± 0.464	16.498 ± 0.396	16.444 ± 0.426
Gender [n (%)]	-	-	-
Female	4 (33.3)	3 (25.0)	7 (29.2)
Male	8 (66.7)	9 (75.0)	17 (70.8)
Ethnicity (n)	-	-	-
Chinese	5	6	11
Indian	2	-	2
Indonesian	1	-	1
Malay	3	5	8
Singh	-	1	1
Swedish	1	-	1

Notes: M ± SD: Mean ± Standard Deviation, cm: Centimetre, BMI: Body Mass Index, kg: Kilograms, kg.m⁻²: kilogram/meter², ICPL: I Can Developed Physical Literacy

2.3 Pittsburgh Sleep Quality Index (PSQI)

The Pittsburgh Sleep Quality Index (PSQI) is a survey created by Buysse et al. (1989) to evaluate sleep quality over a span of one month. Although originally developed as a self-report tool for adults, parent-proxy administration of the PSQI has been established as a reliable and valid instrument for evaluating sleep parameters in young children aged 4 to 10 years, including those with ASD (Goodlin-Jones et al., 2008; Malow et al., 2012). Previous studies evaluating parent-reported PSQI in paediatric ASD populations have reported acceptable internal consistency (Cronbach's $\alpha = 0.72 - 0.81$) and test-retest reliability ($r = 0.79 - 0.85$) (Brand et al., 2011).

The PSQI consists of 19 questions that evaluate several aspects pertaining to the quality of sleep, organized into seven component scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medicines, and daytime dysfunction. The score for each component ranges from 0 to 3, with higher values indicating worse sleep quality. The global PSQI score was calculated by adding together the scores of the seven components, resulting in a total value that ranged from 0 to 21. A higher total score suggested a greater degree of sleep disturbances (Mollayeva et al., 2016). In the present study, parents/guardians completed the PSQI on behalf of their children at baseline (pre-test) and post-intervention.

2.4 Test of Gross Motor Development-2 (TGMD-2)

Gross motor skills include the synchronisation and coordination of major muscle groups to execute tasks that need physical motion and engagement of the whole body. These skills are essential for a wide range of physical activities, sports, and daily tasks. Gross motor skill may be categorised into two primary classifications: locomotor skills and object control skills (Westendorp et al., 2011). Developing gross motor skills is essential for children's physical, cognitive, and social growth. As children grow older, they enhance these skills, enabling them to engage in structured sports, physical activities, and recreational play. Gross motor skills are essential for developing coordination, balance, and strength, which are crucial for total physical competency.

To score the TGMD-2, the observer watched the child execute every skill in the TGMD-2 and utilised the scoring sheet to mark each criterion for every skill. Each skill had certain performance standards; the child either satisfied the condition (by scoring 1) or failed it (by scoring 0). Every trial was rated individually (Ulrich, 2000). The TGMD-2 has established construct validity and high test-retest reliability ($r > 0.88$) in **paediatric** populations, including young autistic children (Staples & Reid, 2010).

2.5 Procedures

After sorting the potential participants, their parents or guardians were given the sleep quality questionnaire (PSQI), and the participants proceeded to do the gross motor skill test using the TGMD-2 for the pre-test. Additionally, participants performed a warm-up session before starting the gross motor skills assessment (Russell et al., 2017). The "I Can Develop Physical Literacy" (ICPL) program was adapted from Hassani et al. (2022). After completing the pre-test using the TGMD-2, the participants in the experimental group joined the intervention program, "I Can Develop Physical Literacy" (ICPL). There were 2 sessions per week, 30 minutes each, for the 8-week training intervention (total of 16 sessions). Participants had group practice sessions with the instructor. Between exercises, the participants received rest time between 50 to 60 seconds.

The program was terminated once the participant became fatigued and could no longer complete them correctly. The participants in the control group underwent their exercises according to their own physical education routine, for example, running, jumping, catching, and kicking, playing with various pieces of equipment, and balance exercises. Moreover, their parents were asked not to engage with them in any additional structured motor activity (Russell et al., 2017). After the participants finished the 8-week intervention program, they underwent the gross motor skill test again, and their parents received the sleep quality questionnaire again to fill out.

2.6 Data Analysis

The statistical data were analysed using IBM SPSS Statistics version 29. The Shapiro-Wilk test was used to verify the normal distribution of all variables. Paired-samples *t*-tests were conducted to determine within-group differences between pre-test and post-test scores for both the control group and the ICPL group. To evaluate the comparative effectiveness of the program between groups, independent-samples *t*-tests were performed on post-test scores and change scores (Δ). Within-group and between-group *p*-values are reported directly in the results tables. Results are presented using mean (*M*), standard deviation (*SD*), percentage change ($\Delta\%$), and exact *p*-values. The statistical significance level was set at $p \leq 0.05$.

3. RESULT AND DISCUSSION

3.1 Sleep Quality

The results in Table 2 demonstrate that the ICPL group experienced significant within-group improvements in most measured aspects of sleep quality following the intervention, except for sleep disturbances ($p = 0.339$) and the use of sleeping medication (no change). The Control group also showed statistically significant within-group improvements in several aspects of sleep quality, including subjective sleep quality, sleep latency, sleep duration, and habitual sleep efficiency. However, when comparing post-test outcomes between the two groups, the ICPL group demonstrated significantly lower global PSQI scores ($p = 0.021$) and greater reductions in subjective sleep quality ($p = 0.003$) and daytime dysfunction ($p = 0.016$) compared to the Control group.

The pre-intervention Pittsburgh Sleep Quality Index (PSQI) scores revealed poorer sleep quality baseline values in the ICPL group compared to the Control group. Specifically, the ICPL group had higher scores in subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, and daytime dysfunction, indicating more severe sleep problems. These findings align with existing literature that reports higher prevalence and severity of sleep disturbances in children with ASD compared to their neurotypical peers (Cortesi et al., 2010; Richdale & Schreck, 2009). The higher baseline global PSQI score in the ICPL group further supports the notion that children with ASD often experience multifaceted sleep problems. This is consistent with previous research indicating that poor sleep quality in ASD can negatively impact daytime functioning and overall quality of life (Mazurek & Petroski, 2015).

Post-intervention, children in the ICPL group experienced better subjective sleep quality score (0.58 ± 0.52) compared to the Control group (1.25 ± 0.45 , $p = 0.003$). This result aligns with the findings of Goldman et al. (2012), which demonstrated improvements in subjective sleep quality following physical and behavioural interventions among children with ASD. Similarly, post-intervention sleep latency was

lower in the ICPL group (1.17 ± 0.58) compared to the Control group (1.75 ± 0.75 , $p = 0.048$), suggesting that the ICPL intervention effectively reduced the time taken to fall asleep. This finding is consistent with research by Malow et al. (2014), which highlighted the positive impact of targeted exercise and sleep interventions on reducing sleep latency in children with ASD.

Notably, the Control group also exhibited modest but statistically significant within-group improvements in several sleep parameters, including subjective sleep quality ($p = 0.014$), sleep latency ($p = 0.042$), sleep duration ($p = 0.008$), and overall global PSQI ($p = 0.001$). These gains in the control condition suggest that factors beyond the ICPL program—such as natural developmental maturation, parental tracking awareness during the study, or routine physical play—may have contributed to positive changes. However, the significantly greater reduction in global PSQI scores in the ICPL group (-64.70% vs. -37.23% , $p = 0.021$) indicates that the structured physical literacy intervention provided incremental benefits beyond natural progression alone.

Both the Control group and the ICPL group reported no use of sleeping medication post-intervention, suggesting that observed sleep enhancements occurred without pharmacological assistance, consistent with recommendations by Johnson et al. (2013) prioritizing non-pharmacological therapies. Finally, post-intervention daytime dysfunction scores were significantly lower in the ICPL group (0.25 ± 0.45) than in the Control group (0.50 ± 0.52 , $p = 0.016$), supporting findings by Papadopoulos et al. (2022) regarding physical activity and daytime functional outcomes in autistic youth.

Table 2: Pre-Post Results for Sleep Quality using The Pittsburgh Sleep Quality Index (PSQI)

Variables / Groups	Control Group (n = 12)				ICPL (n = 12)			
	Pre (M ± SD)	Post (M ± SD)	Δ (%)	Control p within	Pre (M ± SD)	Post (M ± SD)	Δ (%)	Control p within
Subjective sleep quality	1.83 ± 0.577	1.25 ± 0.452	-31.69	0.014	2.33 ± 0.492	0.58 ± 0.515	-75.11	< 0.001
Sleep latency	2.25 ± 0.622	1.75 ± 0.754	-22.22	0.042	2.75 ± 0.452	1.17 ± 0.577	-57.45	< 0.001
Sleep duration	1.50 ± 0.674	0.83 ± 0.389	-44.67	0.008	1.67 ± 0.651	0.67 ± 0.651	-59.88	0.001
Habitual sleep efficiency	2.17 ± 1.115	0.75 ± 0.866	-65.44	0.003	2.17 ± 1.030	0.33 ± 0.888	-84.79	< 0.001
Sleep disturbances	1.08 ± 0.289	1.08 ± 0.289	0	1.000	1.17 ± 0.389	1.00 ± 0.000	-14.53	0.165
Use of sleeping medication	0.00 ± 0.000	0.00 ± 0.000	0	N/A	0.00 ± 0.000	0.00 ± 0.000	0	N/A
Daytime dysfunction	1.00 ± 0.603	0.50 ± 0.522	-50	0.041	1.25 ± 0.452	0.25 ± 0.452	-80	< 0.001
Global PSQI score	9.83 ± 2.657	6.17 ± 1.946	-37.23	0.001	11.33 ± 2.060	4.00 ± 2.296	-64.7	< 0.001

Notes: $M \pm SD$: Mean $\pm$ Standard Deviation, ICPL: I Can Develop Physical Literacy, p_{within} : paired-samples t -test p -value, $p_{between}$: independent-samples t -test p -value comparing post-test scores.

3.2 Gross Motor Skills

The results in Table 3 indicate that the ICPL group showed significant within-group improvements in locomotor subtests including running ($p = 0.002$), galloping ($p = 0.018$), hopping ($p = 0.001$), leaping ($p = 0.042$), and horizontal jumping ($p = 0.004$), with no significant change in sliding ($p = 0.112$). The Control group showed significant within-group improvement only in leaping ($p = 0.038$). In object control, the ICPL group showed significant improvements in striking a stationary ball ($p < 0.001$), stationary dribble ($p = 0.003$), catch ($p = 0.006$), and underhand throw ($p = 0.011$). The Control group showed within-group improvements in stationary dribble ($p = 0.045$) and overhand throw ($p = 0.042$). When evaluating total gross motor score, both groups showed within-group gains, but the ICPL group demonstrated a substantially larger percentage increase (23.47% vs. 5.97%) and significantly superior overall post-intervention scores ($p = 0.023$).

The pre-intervention motor skill scores indicated baseline variability between groups. While running, hopping, and leaping showed similar baseline levels, the Control group recorded higher initial scores in galloping, horizontal jumping, striking, and overall gross motor score (83.75 ± 11.26 vs. 69.25 ± 11.80). Such baseline differences reflect the heterogeneous motor profiles common among children on the autism spectrum (Arthur et al., 2023; Lloyd et al., 2013). Motor coordination impairments in ASD are well-documented (Fournier et al., 2010; Monteiro et al., 2022), underscoring the importance of tailored physical literacy programs.

Post-intervention, the ICPL group showed substantial within-group gains across both locomotor and object control categories. Gains in running ($p = 0.002$), hopping ($p = 0.001$), striking ($p < 0.001$), and stationary dribble ($p = 0.003$) highlight the targeted impact of the structured 8-week ICPL activities. These findings support previous literature demonstrating that structured motor skill training leads to meaningful motor proficiency improvements in young autistic children (Bremer et al., 2015; Ketcheson et al., 2017).

It is important to acknowledge that the Control group also demonstrated significant within-group improvements in certain motor skills, including leaping ($p = 0.038$), stationary dribbling ($p = 0.045$), overhand throw ($p = 0.042$), and overall gross motor score ($p = 0.012$). These findings indicate that motor skill improvements in young children with ASD are not exclusively driven by the specialized intervention. As noted by Sutapa et al. (2021), young children experience ongoing developmental maturation and gain physical competence through standard physical education classes, informal playground play, and normal daily growth. Nevertheless, the ICPL group achieved a markedly higher relative increase in total gross motor score (+23.47% vs. +5.97%, $p = 0.023$), demonstrating that structured physical literacy games offer additive performance benefits over non-structured physical activity (Kaplánová et al., 2023; Rodríguez Macías et al., 2021).

Table 3: Pre-Post Results for Gross Motor Skills using Test Gross Motor Development-2 (TGMD-2)

Groups/Variables	Control Group (n = 12)				ICPL (n = 12)				Between-Group Post p between
	Pre (M $\pm$ SD)	Post (M $\pm$ SD)	Δ (%)	Control p within	Pre (M $\pm$ SD)	Post (M $\pm$ SD)	Δ (%)	Control p within	
Locomotor (L)									
Run	3.50 $\pm$ 1.314	3.75 $\pm$ 1.055	7.14	0.339	2.92 $\pm$ 1.240	4.17 $\pm$ 1.528	42.81	0.002	0.443
Gallop	3.75 $\pm$ 0.866	3.92 $\pm$ 0.669	4.53	0.431	2.50 $\pm$ 1.000	3.58 $\pm$ 2.065	43.20	0.018	0.598
Hop	3.67 $\pm$ 1.155	4.08 $\pm$ 0.900	11.17	0.211	3.17 $\pm$ 1.267	4.83 $\pm$ 1.403	53.37	0.001	0.136
Leap	2.75 $\pm$ 0.866	3.25 $\pm$ 0.622	18.18	0.038	2.00 $\pm$ 0.953	2.67 $\pm$ 1.614	33.50	0.042	0.268
Horizontal jump	3.75 $\pm$ 1.055	3.92 $\pm$ 0.996	4.53	0.586	2.67 $\pm$ 1.168	3.83 $\pm$ 1.193	43.45	0.004	0.849
Slide	3.00 $\pm$ 1.128	3.58 $\pm$ 0.669	19.33	0.082	2.50 $\pm$ 1.168	3.33 $\pm$ 1.775	33.20	0.112	0.655
Object Control (OC)									
Striking a stationary ball	4.42 $\pm$ 1.564	4.58 $\pm$ 1.240	3.62	0.670	3.08 $\pm$ 1.084	5.25 $\pm$ 1.765	70.45	< 0.001	0.298
Stationary dribble	2.50 $\pm$ 1.000	3.08 $\pm$ 0.669	23.20	0.045	1.92 $\pm$ 0.900	3.25 $\pm$ 1.422	69.27	0.003	0.712
Catch	3.08 $\pm$ 1.311	3.50 $\pm$ 0.905	13.64	0.188	2.33 $\pm$ 1.231	3.58 $\pm$ 1.379	53.65	0.006	0.871
Kick	3.83 $\pm$ 1.193	4.00 $\pm$ 1.044	4.44	0.613	2.75 $\pm$ 0.965	3.58 $\pm$ 1.929	30.18	0.078	0.509
Overhand throw	2.42 $\pm$ 0.793	2.83 $\pm$ 0.835	16.94	0.042	2.08 $\pm$ 0.900	3.50 $\pm$ 2.611	68.27	0.061	0.418
Underhand throw	3.58 $\pm$ 1.084	3.75 $\pm$ 0.866	4.75	0.586	2.58 $\pm$ 1.240	3.67 $\pm$ 1.670	42.25	0.011	0.885
Gross Motor Total	83.75 $\pm$ 11.258	88.75 $\pm$ 10.323	5.97	0.012	69.25 $\pm$ 11.802	85.50 $\pm$ 20.896	23.47	< 0.001	0.023

Notes: M $\pm$ SD: Mean $\pm$ Standard Deviation, ICPL: I Can Develop Physical Literacy, p_{within} : paired-samples t-test p -value, $p_{between}$: independent-samples t-test p -value for post-test comparison / change score comparison.

3.3 Limitations of the Study

The Several limitations of the present study must be acknowledged when interpreting these results:

3.3.1 Small Sample Size

The sample size was relatively small ($N = 24$; $n = 12$ per group), which limits statistical power and restricts the generalizability of the findings across the broader and highly heterogeneous ASD population.

3.3.2 Short Intervention Duration

The 8-week intervention duration (16 sessions) was relatively brief. Studies with longer intervention periods and long-term follow-up assessments are necessary to determine whether the observed gains are sustained over time.

3.3.3 Subjective Measurement Bias

Sleep quality was assessed using the parent-reported PSQI. While parent proxy measures are standard in paediatric ASD research, subjective reports may be subject to recall bias or parental expectation effects. Future research should incorporate objective measures such as actigraphy or polysomnography alongside standardized video analysis for motor skills.

3.3.4 Baseline Differences

Initial baseline disparities existed between the ICPL and Control groups in several motor and sleep metrics, which may have influenced the magnitude of percentage changes observed.

4. CONCLUSION

The current study evaluated the potential impact of the "I Can Develop Physical Literacy" (ICPL) program on gross motor skills and sleep quality among young children with Autism Spectrum Disorder. The results suggest potential benefits of the ICPL program, as participants demonstrated notable improvements in both locomotor and object control skills, alongside positive shifts in parent-reported sleep quality parameters.

However, because the control group also exhibited statistically significant improvements in several outcomes likely due to natural child development, maturation, and general physical activity claims regarding the definitive efficacy of the ICPL program should be made with caution. The preliminary nature of these findings, combined with study limitations such as a small sample size and short intervention duration, underscores the need for further rigorous research. Future studies utilizing larger sample sizes, randomized controlled trial (RCT) designs with ANCOVA statistical modeling, objective sleep monitoring (e.g., actigraphy), and long-term follow-up assessments are recommended to confirm these preliminary findings and establish optimal implementation guidelines.

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6. CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest regarding the publication of this manuscript and this research was conducted in the absence of any self-benefits, commercial or financial conflicts.

7. AUTHORS' CONTRIBUTIONS

Conceptualization, methodology, investigation and analysis: Mohd Sofie, N.S. Manuscript drafting, review, editing, and supervision: Bakar, N.A. All authors have read and agreed to the published version of the manuscript.

8. DECLARATION OF GENERATIVE AI IN THE WRITING PROCESS

During the preparation of this work, the authors used Gemini Pro to solely improve the readability and English language quality of the manuscript. Following language editing, the authors thoroughly reviewed and edited the manuscript content and take full responsibility for the content of the publication.

9. DATA AVAILABILITY/SUPPLEMENTARY MATERIALS

All data generated or analysed during this study are included in this published article.

10. ETHICS STATEMENT

This study was reviewed and approved by the Institutional Ethics Committee (Ethics Approval Code: IEC/2023/0412) in accordance with the Declaration of Helsinki. Parents or legal guardians of the participants provided written informed consent before starting this study (Russell et al., 2017). The parents or legal guardians were informed of the study's goals, advantages, and any drawbacks. Moreover, the participants were made aware that they could end the study at any time and that participation was optional.

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