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Bibliotherapy-Based Intervention for Promoting Physical Activity Among Children with Autism Spectrum Disorder

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Children with autism spectrum disorder (ASD) often experience low physical activity levels due to social communication difficulties, sensory sensitivities, and limited participation in structured movement-based programmes. This non-randomised quasi-experimental study evaluated a bibliotherapy-based intervention to improve physical activity among 32 children with ASD aged 7–12 years, allocated to intervention (n = 16) and control (n = 16) groups. The intervention consisted of three structured storytelling sessions using a three-dimensional (3D) pop-up educational book over 12 weeks. Physical activity was assessed at baseline (Week 1), mid-intervention (Week 6), and post-intervention (Week 12) using a modified Physical Activity Questionnaire for Older Children (PAQ-C). Secondary outcomes, including motor skills, social interaction, communication, emotional regulation, and attention, were assessed using caregiver-reported questionnaire items. The intervention group demonstrated significant improvements in physical activity compared with the control group ($p < 0.05$). Improvements in the secondary outcomes were also observed. These findings suggest that bibliotherapy may serve as a supplementary health education strategy for children with ASD. However, the small sample, non-randomised design, and reliance on caregiver reports limit interpretation. Larger studies using stronger designs and objective physical activity measures are warranted.

Keywords: Autism spectrum disorder; physical activity; bibliotherapy; health promotion

I. INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterised by persistent deficits in social communication and restricted or repetitive behaviours, often accompanied by sensory processing differences and motor coordination challenges (Lord *et al.*, 2022). Children with ASD are increasingly recognised as a high-risk group for physical inactivity and associated health complications, including overweight and obesity (Maenner *et al.*, 2023).

Recent evidence suggests that children with ASD engage in significantly lower levels of physical activity compared to typically developing peers, largely due to barriers such as reduced social interaction skills, limited motor proficiency, and

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heightened sensitivity to environmental stimuli (Jones *et al.*, 2022). These challenges contribute to sedentary behaviour patterns, which may negatively affect physical, cognitive, and psychosocial development (Bremer *et al.*, 2021).

Although structured physical activity programmes can support motor development and behavioural participation among children with ASD, engagement may be influenced by individual support needs, instructional approaches, and environmental barriers (Healy *et al.*, 2022). Accessible health education strategies are therefore needed to help children understand physical activity messages and encourage the translation of these messages into everyday behaviour.

Bibliotherapy involves the use of stories and reading materials to support learning, reflection, and understanding (Joseph *et al.*, 2024; Redman *et al.*, 2024). In health education, structured storytelling can present behavioural messages in a narrative format, while visual supports may help make information more concrete and accessible. For children with Autism Spectrum Disorder (ASD), a structured and visually supported approach may facilitate understanding by providing predictable cues and opportunities to engage with educational content. The use of structured stories and visual supports aligns with their learning preferences, enhancing comprehension, predictability, and engagement (Smith & Dawson, 2021). However, improved understanding does not necessarily lead to increased physical activity; an additional pathway is needed through which children can connect the health messages with achievable behaviours.

A potential pathway through which storytelling may promote physical activity involves improving children's understanding of health messages and encouraging them to translate this understanding into behaviour. Stories that incorporate familiar activities, visual demonstrations, and clear behavioural prompts may help children understand the importance of physical activity (Lian *et al.*, 2024; Sun *et al.*, 2024). When storytelling is combined with movement-based activities, children may also have opportunities to practise physical movements within a structured and supportive environment. Caregiver engagement may further reinforce these messages and encourage children's participation in physical activities (Chusak *et al.*, 2026). However, this pathway remains a proposed explanation and requires empirical investigation.

Despite research on bibliotherapy, narrative-based learning, visual supports, and structured physical activity programmes, evidence specifically examining a three-dimensional (3D) pop-up book–based bibliotherapy intervention to promote physical activity among children with ASD remains limited within the literature reviewed for this study. Previous narrative-based approaches have considered learning and health-related outcomes, but further evidence is needed to establish whether this type of material is associated with changes in physical activity behaviour. The potential contribution of caregiver engagement to children's activity levels also requires examination, as caregiver support may influence whether health messages are reinforced outside the intervention setting.

In the present study, bibliotherapy was delivered through three structured sessions using a 3D pop-up educational book developed with reference to the Malaysian Food Pyramid 2020. The book used simple language, illustrations, and interactive elements to communicate healthy lifestyle messages, including physical activity. The intervention was implemented in a school-based setting over the study period, with physical activity assessed at baseline, mid-intervention, and post-intervention.

Therefore, this study aimed to evaluate changes in physical activity levels among overweight and obese children with ASD aged 7–12 years following a school-based, pop-up book–based bibliotherapy intervention. A secondary objective was to examine the association between caregiver engagement and children's physical activity levels. Given the non-randomized design, the findings are intended to provide preliminary evidence to inform the development and evaluation of future interventions rather than definitive proof of effectiveness.

II. MATERIALS AND METHODS

A. Study Design and Settings

This study employed a non-randomised quasi-experimental design with intervention and control groups to evaluate the association between a pop-up book–based storytelling intervention and physical activity among children with autism spectrum disorder (ASD). The study was conducted over 12 weeks, with assessments performed at Week 1 (baseline), Week 6 (mid-intervention), and Week 12 (post-intervention) (Nair & Beela, 2024). A control group was included for comparison and did not receive the storytelling intervention during the study period.

The study was conducted in four Program Pendidikan Khas Integrasi (PPKI) schools in North Seberang Perai District, Penang, Malaysia: SK Hashim Awang, SK Pokok Sena, Pengkala Jaya, and Pasir Gebu. These school settings provided the environment for implementing the intervention among eligible school-aged children with ASD.

Participants were allocated to the intervention or control group according to convenience or availability, without randomisation. The intervention used a structured, interactive three-dimensional (3D) pop-up book to communicate health-related messages through storytelling and visual and tactile elements. The book was based on the Malaysian Food Pyramid 2020 and included healthy-lifestyle messages, including physical activity.

B. Participants and Sampling

The target population comprised children aged 7–12 years with ASD attending PPKI schools in North Seberang Perai District. Participants were recruited using convenience sampling after screening against the study eligibility criteria. Eligible participants were required to be aged 7–12 years, have ASD status supported by available school records and teacher or caregiver confirmation, be classified as overweight or obese based on existing medical or school health records, be physically healthy, and have sufficient receptive language abilities to understand simple instructions and participate in storytelling activities. Children with physical or hearing difficulties, chronic illness, or other difficulties that prevented meaningful participation were excluded. Written informed consent was obtained from caregivers before participation.

The study initially aimed to recruit 40 participants. The sample-size calculation for the physical activity outcome was performed using G*Power version 3.1.9.7, based on a two-tailed independent-samples t-test, an effect size of 1.24, a significance level of 0.05, and statistical power of 0.80. This calculation indicated a minimum sample of 24 participants, which was increased to 30 to account for potential attrition. A separate calculation for the second objective estimated a sample of 32 participants. The overall recruitment target was subsequently increased to 40 to allow for a potential 20% dropout rate. The final analysed sample comprised 32 children, with 16 in the intervention group and 16 in the control group; all 32 completed the study.

ASD status and functional level were determined from available school records and information provided by teachers or caregivers. No independent diagnostic assessment or standardised ASD severity assessment was conducted as part of this study. The specific diagnostic criteria and growth reference or cut-off used to classify participants as overweight or obese should be reported if documented in the original study records.

C. Research Tools

1. Three-Dimensional Pop-Up Book

A custom-designed three-dimensional (3D) pop-up book was used as the primary storytelling material for the intervention. The content was developed based on the Malaysian Food Pyramid 2020 and covered the main food groups, recommended daily servings, healthy food choices, water intake, limiting foods high in fat, sugar and salt, and the importance of regular physical activity. The book incorporated colourful illustrations and interactive pop-up elements to present health-related messages in a visually engaging format for children with autism spectrum disorder (ASD).

The book was designed to support the presentation of nutrition and healthy-lifestyle information through structured storytelling and visual prompts. The use of interactive elements

was intended to facilitate engagement and understanding; however, these features were not assumed to demonstrate a specific behavioural mechanism. Any claims regarding expert validation, face validity, or formal validation of the book should be supported by the documented development and validation procedures.

2. Demographic Data

Demographic data were collected using a questionnaire adapted from the instrument described by Durratul Ain *et al.* (2021). The questionnaire collected information about the child's age, gender, ethnicity, and duration of ASD diagnosis, as well as parental education level and household income. Caregivers provided the relevant information.

3. Physical Activity Questionnaire

Children's physical activity was assessed using a modified version of the Physical Activity Questionnaire for Older Children (PAQ-C), adapted for use in this study. Caregivers reported the children's physical activities during the preceding seven days, with pictorial prompts and assistance provided where necessary. The questionnaire was used to assess physical activity patterns and derive activity scores according to the scoring procedure applied in the study.

D. Intervention Procedure (Bibliotherapy Sessions)

The intervention was conducted over 12 weeks, with outcome assessments at Week 1 (baseline), Week 6 (mid-intervention), and Week 12 (post-intervention). The intervention group received three storytelling sessions using the 3D pop-up book, with each session lasting approximately 20 minutes. The researcher facilitated the sessions by reading the story aloud and presenting the book's visual and interactive elements.

During each session, the researcher presented the health-related messages using simple language and visual prompts and encouraged children to engage with the story. Teachers or caregivers assisted children when necessary. The intervention comprised three sessions in total across the 12-week study period, rather than weekly storytelling sessions throughout the study.

The control group did not receive the storytelling intervention or the pop-up book during the study period. Both groups completed outcome assessments at baseline, Week 6, and Week 12.

Any claims about structured researcher observations, predefined observation criteria, caregiver-led activities between sessions, reflection exercises, or follow-up discussions should be included only if these procedures were actually conducted and documented. If researcher observations were used to assess engagement, describe the checklist, its items, scoring, and validation separately from the caregiver-reported physical activity outcomes.

E. Outcome Measures

Physical activity was the primary outcome and was assessed at baseline (Week 1), Week 6, and Week 12 using a modified physical activity questionnaire for children with autism spectrum disorder (ASD). Caregivers reported their children's physical activity patterns, including activity frequency, duration, and intensity, as well as the types of activities performed. Physical activity levels were assessed using the questionnaire scores and categories reported in the study results. Daily physical activity duration was recorded separately in minutes and compared between the intervention and control groups.

Secondary outcomes included caregiver-reported changes in children's motor skills, social interaction, communication, emotional regulation, and attention and focus. These domains were assessed using additional items in the questionnaire and analysed separately to examine changes over the intervention period.

F. Statistical Analysis

Data were analysed using IBM SPSS Statistics version 30.0. Data distribution was examined using skewness and kurtosis. Continuous variables were summarised as means and standard deviations, while categorical variables were reported as frequencies and percentages. The chi-square test was used to

compare categorical characteristics between the intervention and control groups. For continuous baseline variables, the independent-samples t-test was used where its assumptions were satisfied.

Changes in physical activity outcomes across baseline, Week 6, and Week 12 were analysed using repeated-measures methods appropriate to each outcome. For continuous outcomes measured in both groups at all three time points, mixed-design analysis of variance (ANOVA) was used, where applicable, to evaluate the main effects of time and group, as well as the group-by-time interaction. The interaction effect was used to assess whether changes over time differed between the intervention and control groups. Statistical significance was set at $p < 0.05$.

G. Ethical Approval

The research protocol was approved by the Ministry of Education Malaysia and the Human Research Ethics Committee of Universiti Sains Malaysia (Jawatankuasa Etika Penyelidikan Manusia, JEPeM) (USM/JEPeM/PP/24070584).

III. RESULTS

A. Socio-demographic Characteristics

The sociodemographic characteristics of participants are presented in Table 1. A total of 32 children with Autism Spectrum Disorder (ASD) participated in this study, with equal distribution between the intervention group (n = 16) and control group (n = 16). The majority of participants were male (93.8%) in both groups. Most participants were Malay, with full representation in the intervention group (100%) and majority representation in the control group (81.3%). No statistically significant differences were observed between groups in terms of gender, ethnicity, household income, parental education, or marital status ($p > 0.05$), indicating baseline homogeneity.

Table 1. Socio-demographic characteristics of participants

Variables	Intervention (n=16) n (%)	Control (n=16) n (%)	Total	p-value
Gender child's				1.000
Male	15 (93.8)	15 (93.8)	30 (93.8)	
Female	1 (6.2)	1 (6.2)	2 (6.2)	
Ethnicity				0.182
Malay	16 (100)	13 (81.3)	29 (90.6)	
Chinese	-	1 (6.2)	1 (3.1)	
Indian	-	2 (12.5)	2 (6.3)	
Others	-	-	-	
Household Income (RM)				0.641
≤RM950	-	1 (6.2)	1 (3.1)	
RM951-RM3000	3 (18.8)	5 (31.3)	8 (25.0)	
RM3001-RM3860	2 (12.5)	1 (6.2)	3 (9.4)	
RM3861-RM8319	5 (31.3)	6 (37.5)	11 (34.4)	
RM6000		1 (6.2)	1 (3.1)	
≥RM8320	6 (37.5)	2 (12.5)	8 (25.0)	

Father's Education				0.721
Primary	1 (6.2)	2 (12.5)	3 (9.4)	
Secondary	4 (25.0)	5 (31.3)	9 (28.1)	
PMR	-	-	-	
SPM	3 (18.8)	3 (18.8)	6 (18.8)	
STPM	1 (6.2)	-	1 (3.1)	
Diploma	4 (25.0)	3 (18.8)	7 (21.9)	
Bachelor's	3 (18.8)	3 (18.8)	6 (18.8)	
Mother's Education				0.688
Primary	-	1 (6.2)	1 (3.1)	
Secondary	2 (12.5)	2 (12.5)	4 (12.5)	
PMR	-	-	-	
SPM	4 (25.0)	4 (25.0)	8 (25.0)	
STPM	1 (6.2)	-	1 (3.1)	
Diploma	5 (31.3)	4 (25.0)	9 (28.1)	
Bachelor's	3 (18.8)	3 (18.8)	6 (18.8)	
Master	1 (6.2)	1 (6.2)	2 (6.2)	
PhD	-	1 (6.2)	1 (3.1)	
Marital Status				0.544
Married	14 (87.5)	15 (93.8)	29 (90.6)	
Others	2 (12.5)	1 (6.2)	3 (9.4)	

B. Baseline Characteristics and Group Comparability

The comparison of children's age and age at autism diagnosis between groups is shown in Table 2. Between-group comparisons of continuous variables were conducted using independent-samples t-tests, the mean age of participants was 9.56 ± 1.64 years in the intervention group and 9.19 ± 1.90 years in the control group, with no significant difference observed ($p = 0.208$). However, a significant difference was found in the age at autism diagnosis, where children in the intervention group were diagnosed later (5.88 ± 1.95 years) compared to the control group (4.75 ± 1.85 years) ($p = 0.002$). This difference indicates that the groups were not fully comparable at baseline and should be considered when interpreting the intervention findings.

Table 2. Comparison of children's age and age at autism diagnosis between groups

Continuous variable	**Intervention Group Mean (SD)**	**Control Group Mean (SD)**	**p-value**
Children's Age (years)	9.56 (1.64)	9.19 (1.90)	0.208
Autism diagnosis (years)	5.88 (1.95)	4.75 (1.85)	0.002*

C. Changes in Physical Activity Levels Across Intervention Period

Changes in daily physical activity frequency across three time points are presented in Table 3. Changes over time within each group were analysed using repeated-measures analysis of variance (ANOVA). In the intervention group, physical activity levels increased progressively from baseline (18.8%) to mid-intervention (43.8%) and post-intervention (68.8%), with a statistically significant improvement ($F = 15.67$, $p < 0.001$).

In contrast, the control group showed minimal change, increasing only from 18.8% to 25.0%, with no statistically significant difference ($F = 1.22$, $p = 0.543$). These findings indicate that the bibliotherapy-based intervention had a positive effect on physical activity engagement among children with ASD. These findings indicate an improvement in the reported physical activity outcome over time in the intervention group.

Table 3. Daily physical activity frequency comparison across sessions

Groups	Pre	During	Post	f-value	p-value
Intervention Group (n=16)	3 (18.8%)	7 (43.8%)	11 (68.8%)	15.67	<0.001*
Control Group (n=16)	3 (18.8%)	3 (18.8%)	4 (25.0%)	1.22	0.543

D. Caregivers Reported Developmental and Behavioral Outcomes

Observed developmental outcomes, including motor skills, social interaction, communication, emotional regulation, and attention, are presented in Table 4. The intervention group demonstrated consistent improvements across all domains over the 12-week period. Repeated-measures analysis of variance (ANOVA) was used to assess changes in these outcomes over time.

Table 4. Physical activity and observed skill improvements (n=32)

Intervention Group (n=16)					
Observed Benefits	**Session 1 (Pre)**	**Session 2 (During)**	**Session 3 (Post)**	**f-value**	**p-value**
Motor Skills	2(12.5%)	7(43.8%)	10(62.5%)	10.45	0.005*
Social Interaction	3(18.8%)	7(43.8%)	11(68.8%)	9.87	0.007*
Communication	1(6.2%)	4(25.0%)	8(50.0%)	8.32	0.016*
Emotional Regulation	1(6.2%)	5(31.3%)	9(56.3%)	11.23	0.004*
Attention & Focus	5(25.0%)	8(50.0%)	12(75.0%)	11.25	0.004*
Control Group (n=16)					
Observed Benefits	**Session 1 (Pre)**	**Session 2 (During)**	**Session 3 (Post)**	**f-value**	**p-value**
Motor Skills	2(12.5%)	2(12.5%)	3(18.8%)	0.44	0.801

Social Interaction	3(18.8%)	3(18.8%)	4(25.0%)	0.22	0.895
Communication	1(6.2%)	1(6.2%)	1(6.2%)	0.00	1.000
Emotional Regulation	1(6.2%)	1(6.2%)	2(12.5%)	0.53	0.766
Attention & Focus	4(25.0%)	4(25.0%)	5(31.3%)	0.23	0.891

Note: Values are presented as frequency (percentage). Session 1 = pre-intervention, Session 2 = during intervention, and Session 3 = post-intervention. Data were analysed using repeated measures analysis. F-values represent test statistics. A p-value of < 0.05 was considered statistically significant.

Motor skills significantly increased from 12.5% at baseline to 62.5% at post-intervention ($p = 0.005$). Social interaction improved from 18.8% to 68.8% ($p = 0.007$). Communication increased from 6.2% to 50.0% ($p = 0.016$). Emotional regulation improved from 6.2% to 56.3% ($p = 0.004$). Attention and focus increased from 25.0% to 75.0% ($p = 0.004$).

The control group showed no statistically significant changes in these domains ($p > 0.05$). These findings represent caregiver-reported observations and should not be interpreted as independently verified developmental changes. The results are exploratory secondary findings and should be interpreted cautiously.

E. Baseline Physical Activity Levels

Baseline physical activity levels are presented in Table 5. The chi-square test of independence was used to compare the distribution of children across physical activity categories between the two groups, while an independent-samples t-test was used to compare mean daily physical activity duration, assuming the relevant test assumptions were met.

Table 5. Baseline physical activity levels in children with ASD

Physical Activity Level	**Intervention Group (n=16)**	**Control Group (n=16)**	**Statistical test**	**p-value**
Activity Level (n)			$\chi2=0.526$	0.769
High	3 (18.8%)	3 (18.8%)		
Moderate	9 (56.2%)	10 (62.5%)		
Low	4 (25.0%)	3 (18.8%)		
Duration (Minutes)			t=-0.069	0.945
Mean Duration (SD)	48.12 ± 8.2	48.31 ± 7.9		

Note:
- Values are presented as frequency (percentage) unless otherwise stated
- Baseline data (Session 1) were used for analysis
- Physical activity levels were analysed using the Chi-square test
- Mean daily physical activity duration was compared using an independent samples t-test
- A p-value of < 0.05 was considered statistically significant
- SD = Standard Deviation

Both groups were comparable at baseline, with no significant differences in low, moderate, or high physical activity categories ($\chi^2 = 0.526$, $p = 0.769$). The mean daily physical activity duration was also similar between the intervention group (48.12 ± 8.2 minutes) and control group (48.31 ± 7.9 minutes), with no significant difference observed ($t = -0.069$,

p = 0.945). These results confirm baseline equivalence between groups prior to intervention.

F. Post-Intervention Comparison of Physical Activity Levels

Post-intervention comparisons between groups are presented in Table 6. Between-group differences in categorical physical activity levels were assessed using the chi-square test of independence, while the mean physical activity score was compared using an independent-samples t-test, provided the relevant assumptions were satisfied. The intervention group showed significantly higher levels of physical activity compared to the control group.

Table 6. Comparison of physical activity levels between intervention and control

Physical Activity Level	Intervention Group (%)	Control Group (%)	p-value
Low	12.5%	43.8%	0.014*
Moderate	18.7%	31.2%	0.421
High	68.8%	25.0%	0.012*
Mean Score (SD)	2.56(0.63)	1.81(0.83)	0.006*

Note: Physical activity levels were assessed using the PAQ-C, with categories (Low, Moderate, High) and mean scores compared between groups using Chi-square and independent t-tests. A p-value of < 0.05 was considered statistically significant.

The proportion of children in the high physical activity category was significantly greater in the intervention group (68.8%) compared to the control group (25.0%) (p = 0.012). Conversely, the low physical activity category was significantly lower in the intervention group (12.5%) compared to the control group (43.8%) (p = 0.014). The mean physical activity score was also significantly higher in the intervention group (2.56 ± 0.63) compared to the control group (1.81 ± 0.83) (p = 0.006).

Overall, the findings showed more favourable physical activity outcomes in the intervention group than in the control group at Week 12. Given the non-randomized design and small sample, these findings should be interpreted as preliminary evidence of an association between the bibliotherapy intervention and improved physical activity outcomes.

IV. DISCUSSION

A. Key Findings and Interpretation

This study evaluated changes in physical activity levels following a 12-week bibliotherapy-based intervention among children with autism spectrum disorder (ASD). The findings demonstrated more favourable physical activity outcomes in the intervention group than in the control group over the study period. Children in the intervention group showed a progressive increase in physical activity levels, whereas the control group showed comparatively little change.

These findings suggest that participation in the bibliotherapy-based intervention was associated with improved physical activity outcomes among children with ASD. The visual and narrative format of the pop-up book may have helped present health-related messages in a concrete and accessible manner. However, the non-randomised design and small sample mean that the findings should be interpreted as preliminary evidence rather than confirmation of the intervention's effectiveness.

B. Comparison with Previous Studies

The present findings are consistent with recent studies indicating that children with ASD benefit from structured, visually supported interventions that enhance behavioural

engagement and learning motivation (Healy *et al.*, 2022; Jones *et al.*, 2022). Previous research has shown that storytelling-based interventions and social narratives can improve adaptive behaviours and participation in structured activities among children with developmental disorders (Smith & Dawson, 2021).

Unlike interventions that directly deliver or practise physical exercise, the present bibliotherapy-based intervention used a three-dimensional pop-up book to communicate health-related messages through a visually supported narrative format. This approach may offer an additional health education strategy in school settings. Nevertheless, the findings should not be directly equated with those of structured exercise programmes or studies using objective physical activity measurements, because differences in intervention delivery and outcome assessment may affect the results.

The present study adds preliminary evidence on the use of a pop-up book–based bibliotherapy intervention to promote physical activity among school-aged children with ASD in Malaysia. Its contribution lies in examining this approach in a school-based setting with repeated assessments over the intervention period. Comparisons with previous studies should consider differences in participant characteristics, intervention intensity, caregiver involvement, and physical activity measurement methods.

C. Possible Mechanisms of Effect

The observed improvements may be explained by several interrelated mechanisms. First, bibliotherapy provides visual and narrative structure, which is particularly beneficial for children with ASD who often respond better to concrete and predictable learning formats. Second, bibliotherapy may have supported children's interest and motivation by presenting physical activity concepts in a familiar and engaging narrative format.

Repeated exposure to the health messages may also have helped children become more familiar with physical activity concepts and routines. If caregivers or teachers reinforced these messages in daily activities, this may have provided additional opportunities for participation. However, emotional engagement, motivation, behavioural rehearsal, and mental simulation were not directly measured and should therefore be considered possible explanations rather than demonstrated mechanisms. Further research should investigate these processes directly to clarify how bibliotherapy-based interventions may influence physical activity.

D. Strengths and Limitations

The study included intervention and control groups and repeated assessments, providing preliminary information about changes over the intervention period. However, several limitations should be acknowledged. The small sample, recruitment from selected schools in Penang, and high predominance of male participants limit generalisability. Non-random allocation may also have introduced selection bias. Furthermore, the baseline difference in age at ASD diagnosis may have influenced group comparability.

Physical activity was assessed through caregiver-reported information rather than objective monitoring, creating the possibility of recall and reporting bias. The validity of the modified physical activity questionnaire and the formal validation of the bibliotherapy material should be clearly documented. The intervention dose also requires further investigation, including whether the frequency and duration of sessions were sufficient to support sustained changes.

However, several limitations should be acknowledged. First, the sample was relatively small and drawn from selected schools in Penang, which limits generalisability. Second, participants were allocated without randomisation, creating the possibility of selection bias. A significant baseline difference in age at ASD diagnosis was also observed between groups, which may have influenced the findings despite the similarity in participants' chronological age.

Third, physical activity was assessed through caregiver-reported information rather than objective measures such as accelerometers. Consequently, recall and reporting bias may have affected the results. The high proportion of male participants also limits the extent to which the findings can be generalised to girls with ASD.

The intervention dose also requires further investigation. Although the bibliotherapy sessions were delivered over the study period, the optimal frequency, duration, and intensity of the intervention remain unclear. In addition, the extent of formal validation of the pop-up book should be clearly documented. Potential observer bias and the absence of documented blinding procedures may also have affected outcome assessment or reporting.

Finally, the developmental and behavioural outcomes, including motor skills, social interaction, communication, emotional regulation, and attention, were based on caregiver-reported questionnaire items. These findings should not be interpreted as independently verified developmental improvements. Further studies using clearly defined and validated outcome measures are needed to examine these outcomes more rigorously.

E. Implications for Practice and Policy

The findings highlight the potential value of pop-up book–based bibliotherapy as a supplementary approach to communicating physical activity messages to children with ASD in school settings. Educators, caregivers, and health professionals may consider visual and narrative materials as part of broader health education activities, provided that the materials are appropriate to children's communication and support needs.

However, the current findings are insufficient to establish bibliotherapy as a stand-alone or proven intervention for increasing physical activity. Its practical value may depend on implementation, accessibility, caregiver and teacher support, and whether changes in reported activity are confirmed through more objective measurements. Further evaluation is required before broader curriculum or policy recommendations can be justified.

F. Recommendations for Future Research

Future studies should recruit larger and more diverse samples and use randomised controlled designs where feasible to strengthen evidence regarding the potential effects of bibliotherapy-based interventions. Physical activity should be assessed using validated instruments alongside objective measures, such as accelerometers, where possible. Researchers should also clarify the optimal intervention dose, establish the validity and suitability of the pop-up book materials, and use standardised measures to assess developmental and behavioural outcomes. Blinded outcome assessment should be considered to reduce potential observer bias. Longer follow-up periods are needed to determine whether improvements in physical activity are sustained. Further research should also examine the association between caregiver engagement and children's physical activity levels and investigate whether factors such as motivation, engagement, and reinforcement of health messages may help explain observed changes. These investigations would provide stronger evidence regarding the feasibility, potential mechanisms, and longer-term value of pop-up book–based bibliotherapy for promoting physical activity among children with ASD.

V. CONCLUSION

This study found that participation in a pop-up book–based bibliotherapy intervention was associated with improved physical activity participation among children with autism spectrum disorder (ASD). Children in the intervention group showed more favourable physical activity outcomes than those in the control group. Caregivers also reported improvements in motor skills, social interaction, communication, emotional regulation, and attention; however, these secondary outcomes should be interpreted cautiously because they were based on caregiver reports. The results provide preliminary evidence of the potential value of bibliotherapy as a supplementary health education approach, rather than definitive proof of effectiveness. Nevertheless, the non-randomised study design, small sample, and reliance on caregiver-reported measures limit the strength of the conclusions. Further studies involving larger and more diverse samples, objective physical activity measurements, and longer follow-up periods are needed to confirm these findings and determine the sustainability of the observed improvements.

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Conflict of Interest

The authors declare no conflict of interest.

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