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The effect of Snoezelen intervention on problem behaviors in children with cerebral palsy: A randomized controlled trial

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ABSTRACT

Aim: To evaluate the effect of Snoezelen intervention on problem behaviors in children with cerebral palsy (CP) and to analyze its correlation with motor function, as measured by the Gross Motor Function Classification System (GMFCS).

Method: This study is registered under the Clinical Research Information Service (CRIS) with the registration number KCT0002794. The unique protocol ID for this trial is SRH2018R-01. A randomized controlled trial with 28 children (aged 2–5 years) with CP was conducted. The experimental group received Snoezelen intervention three times a week for four weeks. Problem behaviors were assessed using the CBCL 1.5–5 and K-PSI, and motor function was assessed using the GMFCS.

Results: The experimental group showed a significant reduction in emotionally reactive behavior ($p = 0.044$). A strong negative correlation (Spearman's $\rho = -0.744$, $p = 0.002$) was found between GMFCS scores and changes in emotionally reactive behavior.

Interpretation: The Snoezelen intervention may reduce emotional reactivity and enhance emotional stability in children with CP, although its effectiveness may vary depending on the level of motor impairment. Further research is needed to confirm these findings.

Implications for Rehabilitation

1. The Snoezelen intervention shows potential in improving emotionally reactive behaviors in children with cerebral palsy, indicating its possible use as a therapeutic tool.
2. A strong negative correlation between GMFCS scores and changes in emotionally reactive behaviors underscores the need for further research on how motor function levels may influence intervention outcomes.

1. Introduction

Cerebral palsy (CP) is a lifelong condition resulting from non-progressive brain damage that occurs before, during, or shortly after birth. It affects approximately 2–3 out of every 1000 live births.[1] CP presents in different ways, affecting motor functions, sensory perception, cognition, communication, behavior, and social interactions.[1] Children with limited gross motor function often exhibit more problem behaviors, leading to difficulties in daily adaptation and higher levels of parental stress.[2,3] These challenges necessitate tailored support and

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treatment strategies specifically designed to address the unique needs of each child with CP.

In order to address the challenges faced by children with CP, various therapeutic approaches have been explored. One such approach is Snoezelen intervention, developed by Dutch therapists Jan Hulsegge and Ad Verheul in the late 1970s. The term Snoezelen originates from the Dutch words "snuffelen" (to explore) and "doezelen" (to relax), emphasizing its dual purpose of sensory stimulation and emotional relaxation. Snoezelen provides a controlled multi-sensory environment designed to promote emotional well-being through sensory stimulation.[4] The intervention typically takes place in a specially designed sensory room equipped with elements such as fiber optic lights, bubble tubes, tactile panels, and soft music. These sensory tools aim to reduce stress, encourage self-regulation, and enhance positive emotional experiences, making it a supportive tool for children with developmental challenges.[4,8,12]

Research shows that Snoezelen has positive effects on the emotional state and social interactions of children with brain damage,[5] and can reduce problem behaviors and improve the quality of life in adults with dementia.[6,7] Additionally, Snoezelen intervention has been shown to enhance emotional stability and reduce problem behaviors in individuals with severe intellectual disabilities.[8] Furthermore, it improves emotional states and attention in children with autism spectrum disorders and influences EEG patterns in brain-injured subjects.[9,10]

Snoezelen intervention has been extensively studied and shown to be effective in reducing problem behaviors and promoting emotional stability, particularly among adults with intellectual disabilities and dementia.[11–13] However, there is a notable gap in the research regarding pediatric populations, especially younger children. Most studies to date have focused on adult populations, highlighting the critical need for research that specifically targets children, including those with cerebral palsy (CP). While some studies have explored the use of Snoezelen intervention in children, particularly those with autism spectrum disorder (ASD) and Rett syndrome, these efforts often involve broad age ranges and lack randomized controlled trials (RCTs).[5,14] Many of these studies are limited to small case series or case studies, which restricts the generalizability of their findings. In contrast, a relatively larger study involving 41 children aged 4–12 years with ASD showed that multisensory environments (MSE) could reduce stereotyped behaviors and promote emotional stability.[15] However, even this study did not include an RCT, and the broad age range presents challenges in applying the results to specific pediatric subgroups. Despite these findings, there remains an urgent gap in research specifically targeting children with CP, particularly in younger children. Therefore, there is an urgent need for more systematic studies to evaluate the effects of Snoezelen intervention in children under 5 years old, particularly those with CP.

The primary objective of this study is to evaluate the effectiveness of Snoezelen intervention on behavior problems in children with cerebral palsy (CP), as assessed by both the Child Behavior Checklist (CBCL) and the child domain of the Korean-Parenting Stress Index (K-PSI). Specifically, the aims of this study are as follow:

1. To evaluate effectiveness of Snoezelen intervention in reducing behavior problems in children aged 2–5 years with CP.
2. To analyze the relationship between motor function levels, as measured by the Gross Motor Function Classification System (GMFCS), and behavior changes after Snoezelen intervention.

This study aims to provide clinicians with evidence-based guidelines for effectively utilizing Snoezelen intervention in managing the behavioral challenges of children with CP.

2. Methods

2.1. Participants

This study involved children aged 2–5 years with cerebral palsy (CP), admitted to the day hospital ward of Seoul Rehabilitation Hospital. Upon admission, participants' motor function was assessed and documented by their rehabilitation physician using the Gross Motor Function Classification System (GMFCS), a standardized tool designed to objectively classify the severity of motor impairment in children with cerebral palsy. The GMFCS categorizes motor abilities into five levels (Level I to Level V) based on the child's self-initiated movements and functional mobility, with higher levels indicating greater severity of motor impairment.[13,16] In this study, GMFCS was used to classify participants' motor function levels and served as a reference to analyze the effects of the Snoezelen intervention across varying degrees of motor function.

Participants were then randomly assigned to Group A (experimental group) and Group B (control group) using a lottery drawing method to achieve randomization. Participant registration and randomization were conducted by the corresponding author, who is a clinical psychologist. The corresponding author also administered the Snoezelen intervention.

Initially, 15 children were allocated to each group, but one child dropped out from each group, 14 children left in each. One child was excluded due to a misdiagnosis of cerebral palsy (CP), and another withdrew from the study due to discharge after enrollment. The sample size was determined based on a study by Sourander et al.,[17] which used the CBCL 1.5–5 as the primary outcome measure to evaluate the effectiveness of an internet-assisted parent training intervention for 4-year--old children. To ensure sufficient statistical power and minimize the risk of Type I and Type II errors, the required sample size for this study was calculated using a 95 % confidence level ($\alpha = 0.05$), 80 % statistical power ($1\text{-}\beta = 0.80$), and a margin of error derived from previously reported effect sizes. Considering the variance observed in prior studies, with a 15 % dropout rate accounted for, a minimum of 13 participants per group was determined necessary. To further ensure the robustness of the findings, the target enrollment was set at 15 participants per group, totaling 30 participants. However, due to the novelty of our study design and the limited availability of directly comparable data, the exact sample size could not be statistically confirmed with complete certainty

2.2. Study design

This study used a randomized controlled pre-post design, conducted from March 23, 2018, to July 21, 2021. Both Group A (experimental group) and Group B (control group) received conventional treatments including physical therapy and occupational therapy. In addition to these treatments, Group A received 12 Snoezelen intervention sessions, administered three times a week, 30 minutes per session for 4 weeks. The effectiveness of the Snoezelen intervention was assessed by comparing changes in behavior as measured by problem behavior tests administered before and after the intervention.

2.3. Ethical considerations

The Institutional Review Board (IRB) of Seoul Rehabilitation Hospital approved this study (IRB approval number: SRH2018R-01). All participants and their guardians were informed about the study's purpose and procedures, and written informed consent was obtained. Additionally, this study was registered with the Korea Clinical Research Information Service (CRIS) under the registration number KCT0002794, to ensure transparency and adherence to ethical guidelines for clinical research.

2.4. Therapeutic environment

The Snoezelen room is equipped with a variety of sensory tools and devices designed to stimulate different senses. In the Snoezelen intervention, various sensory stimuli-including visual, auditory, tactile, olfactory, and relaxation-were utilized within the Snoezelen room. stimuli of the Snoezelen room were utilized.

- Visual stimuli: fiber optic cables, fiber optic waterfall, fiber optic picture panels, fiber optic tunnels, bubble tubes, etc.
- Auditory stimuli: music, nature sounds, musical instruments, etc.
- Tactile stimuli: tactile panels, tactile stimulation sets
- Olfactory stimuli: aromatherapy oils
- Relaxation stimuli: massage cushions, water beds, bean bags, leaf-shaped chair

2.5. Procedure

During the Snoezelen sessions, the intervention was guided by the goals as outlined by Verheul and Hulsegge.[4] The sessions were designed to achieve the following four key objectives:

1. To seek sensory stimulation: The purpose was to observe how children responded to these stimuli and to understand which stimuli the children found most comfortable or engaging.

2. To understand the world: Children were encouraged to interact with sensory-rich equipment designed to stimulate their cognitive processes. By successfully manipulating these devices, children were able to build self-confidence and develop a deeper understanding of their surroundings.

3. For relaxation: The environment was adapted to the needs of each child, with modifications such as lowering the lights or playing calming music to create a safe and comfortable space.

4. For enjoyment: The sessions were structured to provide a fun and emotionally rewarding experience. Children engaged in activities of their own choosing, prompting positive social interactions and emotional well-being.

In line with these objectives, the therapist followed specific guidelines to maintain consistency and effectiveness in the intervention. The guidelines, as detailed in "Multi Sensory Environment - A Definition and Guidelines",[18] included maintaining a session duration of 30 minutes, consistent involvement of the same therapist in all sessions, and prioritizing the child's physical comfort and safety. The therapist responded promptly to the children's verbal and non-verbal cues and supported the children's interaction with their environment in a non-directive, child-centered manner.

2.6. Data collection and evaluation tools

1. **Child Behavior Checklist for Ages 1.5–5 (CBCL 1.5–5)**:

The Child Behavior Checklist for Ages 1.5–5 (CBCL 1.5–5)[19] is a parent-reported tool designed to assess behavioral and emotional problems in young children. The checklist includes various subscales that provide a comprehensive assessment of the child's behavior and functioning. The Total Problems subscale aggregates scores from all individual subscales included in the CBCL, which helps in categorizing the child's difficulties.

The Internalizing Problems subscale evaluates behaviors that are directed inward. It includes subscales such as Emotionally Reactive, Anxious/Depressed, and Somatic Complaints, which assess the child's emotional sensitivity, internal stress, and physical discomfort, respectively. In contrast, the Externalizing Problems subscale assesses outward-directed behaviors, including Attention Problems and Aggressive Behavior, which focus on difficulties in concentration and social adaptation challenges.

In addition, specific emotions and behaviors are evaluated through subscales such as Emotionally Reactive, which measures the frequency of anxiety or irritability, and Anxious/Depressed, which assesses levels of emotional instability. The Somatic Complaints subscale evaluates physical discomfort, and the Withdrawn subscale measures tendencies towards social isolation. Attention Problems helps identify issues such as ADHD by assessing distractibility, while Aggressive Behavior focuses on the frequency of interpersonal conflicts. The Sleep Problems subscale assesses sleep patterns and disturbances. Lastly, Other Problems includes various behavioral and emotional problems not covered by the other subscales.

The CBCL 1.5–5 has been widely used in numerous studies, and its subscales generally demonstrate strong internal consistency, with Cronbach's alpha values typically exceeding 0.70. It also shows robust test-retest reliability, confirming its stability over time. Furthermore, its validity has been supported by correlations with other established assessment tools, confirming its usefulness in evaluating behavioral and emotional issues in young children.

2. **Korean Parenting Stress Index (K-PSI)**:

The K-PSI measures the stress experienced by parents, focusing on parent-related and child-related stress factors.[20] In this study, only the

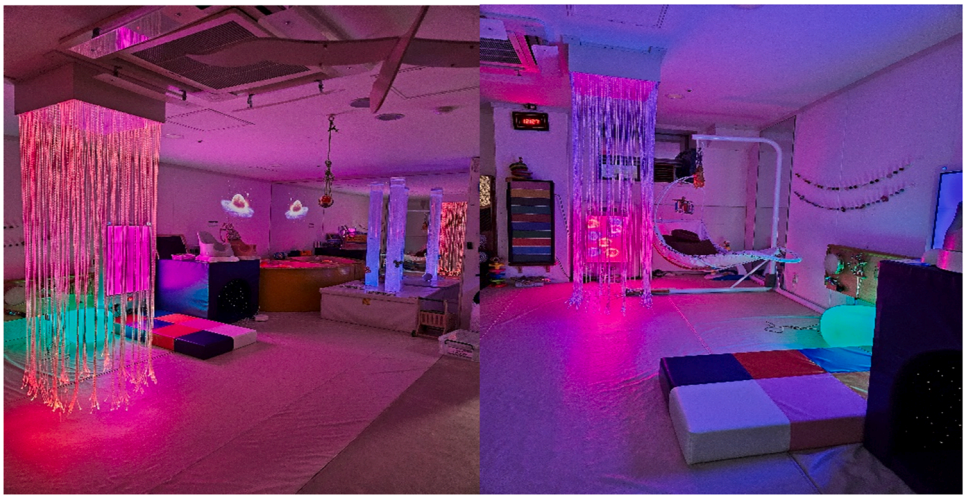

Fig. 1. Snoezelen Room. (a) Overview of the Snoezelen room showing fiber optic waterfall, bubble tubes, and various sensory tools. (b) Additional view of the Snoezelen room with tactile panels, sensory swing, and fiber optic lighting.

scores from the Child Domain were used.

The Child Domain assesses factors such as adaptation, acceptance, demands, mood, distractibility/hyperactivity, and reinforcement.

The K-PSI demonstrates high reliability, with most subscales reporting Cronbach's alpha values above 0.70, indicating consistent measurement. Its test-retest reliability is 0.87. The validity is confirmed through correlation analysis with the K-CBCL and discriminant validity, as shown by score differences between developmentally delayed and typical children.

2.7. Data collection procedures

- Explanation and Consent: Since the participants were too young to obtain direct consent, written consent was obtained after a detailed explanation of the purpose and procedures of the study to their guardians.
- Pre-treatment Assessment: Initial data were collected within seven days prior to the start of the study using CBCL 1.5–5 and K-PSI, along with interviews with guardians.
- Post-treatment Assessment: Follow-up data were collected within seven days after the treatment concluded, again using CBCL 1.5–5 and K-PSI and including guardian interviews.

3. Results

3.1. Baseline characteristics

As shown in Table 1, the experimental group (n = 14) and control group (n = 14) were well-matched across key characteristics such as age, gender, type of CP, involved side, and GMFCS levels, ensuring a balanced comparison. No significant differences were observed in age ($p = 0.511$), gender distribution ($p = 0.686$), type of cerebral palsy (spastic CP: $p = 0.595$), bilateral involvement ($p = 0.838$), and GMFCS levels ($p = 0.925$), indicating comparability between groups for analysis.

Table 1
Implementation of Guidelines during Snoezelen Sessions for Children with CP.

Guideline	Implementation in the Study
Minimum time of 30 minutes	Each session was conducted for a duration of 30 minutes.
Same skilled companion throughout sessions	The same therapist participated in all sessions to maintain consistency.
Meeting participant's physical needs before entering the room	Children's physical condition was checked before entering the room.
Preparing the room based on participant's sensory and motor needs	Various chairs, beanbags, and cushions were provided to ensure the children were safe and comfortable, considering their motor abilities.
Respecting participants' requests and monitoring emotional state	Immediate responses were given to the children's verbal and non-verbal needs. If a child's condition or emotional state appeared poor, they were asked if they wished to leave the session. However, no child left any session prematurely.
Maintaining proximity for safety	The therapist remained within 1 m of the children at all times for safety.
Supporting communication and interaction	The therapist responded promptly to both verbal and non-verbal cues from the children to facilitate effective communication.
Reflecting environmental changes verbally	The therapist verbally acknowledged the environmental changes caused by the children's actions, supporting interaction with the environment.
Maintaining a comfortable environment	The room's temperature and humidity were kept at appropriate levels, and the windows were regularly opened for ventilation.
Collaborating with other therapists	Behavioral characteristics of the children were regularly documented and shared with other therapy providers for collaborative care.
Ensuring equipment accessibility	The environment was arranged so that children could easily access the equipment. In cases where motor limitations made access difficult, the therapist provided close assistance.

3.2. CBCL 1.5–5

The Emotionally Reactive domain showed the most significant improvement in the experimental group, with a reduction of 11.57 points (from 69.93 to 58.36, $p = 0.023$). This change was significantly greater than the control group, which showed minimal change (-0.21 points, $p = 0.779$). This between-group difference was statistically significant ($p = 0.044$).

For Total Problems, Internalizing Problems, and Externalizing Problems, both groups showed reductions in scores, but these changes were not statistically significant either within groups or in the between-group comparison ($p > 0.05$).

Other behavioral domains, including Anxious/Depressed, Somatic Complaints, Withdrawn, Sleep Problems, Attention Problems, Aggressive Behavior, and Other Problems, showed minimal changes in both groups with no statistically significant differences ($p > 0.05$).

3.3. K-PSI

In the Child Domain of the Parenting Stress Index, the experimental group showed a slight improvement, while the control group slightly worsened. However, this difference was not statistically significant ($p = 0.482$).

3.4. Correlation between GMFCS and changes in emotionally reactive scale

A significant negative correlation ($\rho = -0.744$, $p = 0.002$) was found between GMFCS and changes in the emotionally reactive scale, as measured by Spearman's rank correlation coefficient. This indicates that higher GMFCS scores, which reflect lower motor function, are associated with less improvement in the emotionally reactive scale.

To further analyze the relationship between GMFCS levels and changes in the emotionally reactive scale, a linear regression analysis was performed. The regression model yielded an R^2 value of 0.4993, indicating that approximately 49.93 % of the variance in CBCL score changes can be explained by GMFCS levels. While this suggests a moderate linear relationship between GMFCS and CBCL scores, it also

Table 2
Baseline Characteristics of the Study Participants.

Characteristic	Experimental Group (n = 14)	Control Group (n = 14)	p-value
Age, M (SD)	3.19 (0.88)	2.87 (0.88)	0.511
Gender, n			0.686
Male	9	10	
Female	5	4	
Type, n (%)			0.595
Spastic	12 (86)	13 (93)	
Other	2 (14)	1 (7)	
Involved side, n (%)			0.838
Unilateral	3 (21)	4 (29)	
Bilateral	11 (79)	10 (71)	
GMFCS level, n (%)			0.925
I	2 (14)	2 (14)	
II	2 (14)	4 (29)	
III	3 (21)	0	
IV	3 (21)	4 (29)	
V	4 (29)	4 (29)	

p-values were calculated using a Mann-Whitney *U* test, Pearson's chi-square test. GMFCS, Gross Motor Function Classification System.

Table 3
Outcome measures at baseline and post-intervention.

	Group	Baseline Mean (SD)	Post-Intervention Mean (SD)	Mean Change (SD)	Within-Group P-value	Between-Group P-value
CBCL 1.5–5						
Total Problems	Exp	74.64 (24.41)	68.36 (24.32)	6.29 (15.21)	0.196	0.635
	Ctrl	76.21 (26.68)	73.50 (27.88)	2.71 (11.06)	0.347	
Internalizing Problems	Exp	73.14 (25.05)	69.14 (20.54)	4.00 (15.66)	0.382	0.910
	Ctrl	77.14 (27.93)	75.07 (26.64)	2.07 (8.13)	0.307	
Externalizing Problems	Exp	70.79 (26.17)	61.43 (29.55)	9.36 (21.58)	0.142	0.178
	Ctrl	64.79 (32.27)	65.64 (33.41)	−0.86 (12.42)	0.972	
Emotionally Reactive	Exp	69.93 (24.04)	58.36 (28.03)	11.57 (16.17)	0.023[a]	0.044[a]
	Ctrl	72.43 (30.33)	72.64 (27.13)	−0.21 (10.98)	0.779	
Anxious/Depressed	Exp	69.29 (21.99)	63.93 (24.99)	5.36 (22.34)	0.328	0.571
	Ctrl	70.21 (33.25)	58.21 (31.45)	12.00 (21.94)	0.060	
Somatic Complaints	Exp	64.79 (27.07)	64.36 (23.52)	0.43 (25.52)	0.965	0.571
	Ctrl	70.43 (29.87)	66.21 (31.99)	4.21 (16.19)	0.206	
Withdrawn	Exp	70.93 (23.36)	72.93 (23.07)	−2.00 (27.94)	0.969	0.910
	Ctrl	86.71 (11.27)	84.00 (10.29)	2.71 (11.57)	0.423	
Sleep Problems	Exp	71.21 (24.32)	64.57 (26.05)	6.64 (18.37)	0.272	0.769
	Ctrl	65.86 (28.91)	55.57 (35.32)	10.29 (33.14)	0.476	
Attention Problems	Exp	83.86 (21.48)	75.71 (24.79)	8.14 (19.97)	0.154	0.227
	Ctrl	85.57 (13.05)	82.36 (17.96)	3.21 (8.81)	0.261	
Aggressive Behavior	Exp	62.57 (28.04)	55.14 (29.71)	7.43 (25.62)	0.345	0.210
	Ctrl	57.29 (35.32)	60.21 (35.95)	−2.93 (15.16)	0.754	
Other Problems	Exp	75.93 (26.52)	70.79 (28.98)	5.14 (14.42)	0.169	0.874
	Ctrl	81.93 (18.62)	78.29 (22.41)	3.64 (15.30)	0.456	
K-PSI						
Child Domain	Exp	77.93(23.41)	75.14 (27.31)	2.79 (21.34)	0.701	0.482
	Ctrl	80.50(21.31)	84.36 (15.63)	−3.86 (14.50)	0.575	

Values are the mean change (SD) in scores between baseline and post-intervention for each group. [a]P-value < 0.05 indicates a statistically significant difference in the mean change in scores within a group or between groups. The within-group comparisons were performed using the Wilcoxon signed-rank test, and the between-group comparisons were performed using the Mann-Whitney *U* test. CBCL 1.5–5, Child Behavior Checklist for Ages 1.5–5; K-PSI, Korean-Parenting Stress Index

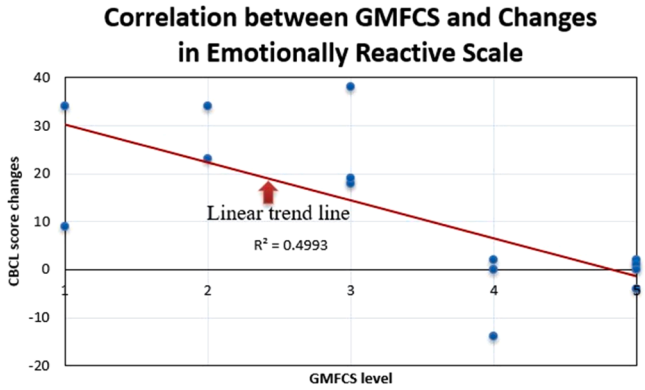

Fig. 2. Correlation between GMFCS and Changes in Emotionally Reactive Scale.

highlights that 50.07 % of the variability in emotional reactivity remains unexplained by motor function alone, suggesting the potential influence of other factors.

4. Discussion

This study aimed to evaluate the effectiveness of Snoezelen intervention in reducing behavior problems in children aged 2–5 years with cerebral palsy (CP) and to analyze the relationship between motor function levels, as measured by the Gross Motor Function Classification System (GMFCS), and behavior changes following the intervention. The results provide valuable insights into the behavioral and emotional outcomes of Snoezelen intervention, though the effects varied across different domains. Snoezelen intervention showed several important trends in improving behavior, particularly in reducing emotional reactivity. A significant improvement was observed in the Emotionally Reactive scale in the experimental group, with a mean reduction of 11.57 points ($p = 0.023$), and a statistically significant between group difference ($p = 0.044$).

This suggests that Snoezelen intervention is particularly effective in helping children with CP manage emotional dysregulation, especially in those with heightened emotional responses, as supported by previous research.[5]

The sensory rich Snoezelen environment provides a calming, emotionally stabilizing space, particularly for children with cerebral palsy (CP) who face frustration due to physical limitations.[21] In this study, sessions were carefully structured with consistent lengths and the same therapist to ensure comfort and safety, focusing on sensory stimulation and relaxation. Features like soft mats, waterbeds, and swings offered physical comfort, allowing children to engage with sensory stimuli in a secure, stress-free way, contributing to emotional stability and easing the challenges associated with CP.

The significant reduction in emotionally reactive behaviors highlights the effectiveness of Snoezelen intervention in helping children with CP manage emotional dysregulation. The multisensory environment promotes relaxation and emotional engagement, which in turn helps to reduce emotional outbursts, anxiety, and agitation. These findings align with previous research showing that Snoezelen intervention can effectively decrease maladaptive behaviors and enhance emotional well-being, particularly in children with developmental disabilities and those recovering from severe brain injuries.[5,12]

However, Snoezelen intervention's impact on other emotional domains, such as Internalizing Problems and Somatic Complaints, was less pronounced. In these areas, the experimental group showed only minor improvements, suggesting that while Snoezelen can help with emotional reactivity and externalized behaviors, it may be less effective for internalized issues like anxiety or somatic symptoms. This may indicate the need for complementary therapies to address more complex internalized psychological problems.

One of the key findings from this study was the negative correlation ($\rho = -0.744$, $p = 0.002$) between GMFCS levels and changes in the Emotionally Reactive scale. This suggests that children with higher

GMFCS levels, which indicate more severe motor impairments, showed less improvement in emotional reactivity after Snoezelen intervention. A linear regression analysis further confirmed this relationship, yielding an R^2 value of 0.4993, indicating that approximately 49.93 % of the variance in emotional reactivity can be explained by GMFCS levels. However, the linear regression model only partially explains these changes, suggesting the possibility of non-linear influences or other external factors impacting the relationship between motor function and emotional reactivity. The remaining 50.07 % of variability could be due to other factors, such as engagement with the sensory stimuli or external environmental influences not captured in the current study. This correlation emphasizes the importance of considering motor function when implementing Snoezelen intervention. Children with severe motor impairments may struggle to fully engage with the sensory stimuli, reducing the intervention's effectiveness in helping them regulate their emotions.

However, several limitations of this study must be acknowledged. One significant limitation is that while all participants received conventional treatments, these treatments were not standardized or controlled across the study. This variability could have influenced the outcomes, making it challenging to attribute the observed behavioral changes solely to the Snoezelen intervention. The reliance on parent -reported measures, which can introduce subjective bias, is another limitation. Additionally, the study was conducted at a single institution with a small sample size, which may limit the generalizability of the findings. Finally, the study only evaluated the short-term effects of the Snoezelen intervention, so the long-term impact remains unknown. The data for this study were collected over a three-year period from 2018 to 2021. Although some time has passed since data collection, it is important to emphasize that the core principles and implementation of Snoezelen intervention have remained consistent. Consequently, the findings of this study continue to be relevant and applicable to current practices.

In conclusion, this study provides preliminary evidence that Snoezelen intervention, when implemented according to specific therapeutic guidelines, can effectively reduce emotionally reactive behaviors in children with cerebral palsy. The multisensory environment helps create a calming, engaging space that promotes emotional regulation, though its effects on other behavioral issues, such as aggression or internalized problems, may be more limited. The significant correlation between GMFCS levels and emotional reactivity highlights the role of motor function in intervention outcomes, suggesting that children with severe motor impairments may experience reduced benefits from the intervention. This finding emphasizes the need for personalized strategies that consider individual motor function levels to maximize therapeutic effects. Future studies should continue to explore the long-term effects of Snoezelen intervention and investigate tailored approaches to enhance its benefits across diverse populations, ultimately improving the quality of life for children with cerebral palsy and other developmental disabilities.

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Author Statement

All authors have contributed significantly to the conception, design, data collection, analysis, and manuscript preparation. Each author has reviewed and approved the final version of the manuscript and agrees to be accountable for all aspects of the work. There are no conflicts of interest to declare.

CRediT authorship contribution statement

Kim Jeong-Soo: Writing – review & editing, Formal analysis. **Hwang Yun-Tae:** Investigation, Data curation. **Lee Ji-Young:** Investigation, Data curation. **Lee Jee-Sun:** Writing – review & editing, Resources. **Yi Sook-Hee:** Methodology, Formal analysis, Conceptualization. **Kim Mina:** Writing – original draft, Investigation, Data curation, Conceptualization.

Declaration of Generative AI and AI-assisted technologies in the writing process

None.

Declaration of Competing Interest

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ctim.2025.103139.

References

1. Rosenbaum P, Paneth N, Leviton A, et al. A report: the definition and classification of cerebral palsy April 2006. *Dev Med Child Neurol Suppl.* 2007;109:8–14. https://doi.org/10.1111/j.1469-8749.2007.tb12610.x.
2. Parkes J, White-Koning M, Dickinson HO. Association between gross motor function and problem behaviors in children with cerebral palsy. *Pediatrics.* 2009;124(4):1181–1186. https://doi.org/10.1186/1471-2474-8-50.
3. Beckung E, Hagberg G. Behavioral and emotional problems in children with cerebral palsy and their relation to parental mental health. *Dev Med Child Neurol.* 2002;44(5):309–316. https://doi.org/10.1016/j.ejpn.2015.12.003.
4. Hulsegge J, Verheul A. Snoezelen: Another world. *Rompa.* 1987.
5. Hotz GA, Castelblanco A, Lara IM. Snoezelen: a controlled multi-sensory stimulation therapy for children recovering from severe brain injury. *Brain Inj.* 2006;20(8):879–888. https://doi.org/10.1080/02699050600832635.
6. Maseda A, Sánchez A, Marante MP, et al. Multisensory stimulation on mood, behavior, and biomedical parameters in people with dementia. *Am J Alzheimers Dis Other Demen.* 2014;29(7):637–645. https://doi.org/10.1177/1533317514532823.
7. Cruz J, Marques A, Figueiredo D, et al. Effects of a motor and multisensory-based approach on residents with moderate-to-severe dementia. *Am J Alzheimers Dis Other Demen.* 2011;26(4):282–289. https://doi.org/10.1177/1533317511411177.
8. Hogg J, Cavet J, Lambe L, Smeddle M. The use of Snoezelen as multisensory stimulation with people with intellectual disabilities: a review of the research. *Res Dev Disabil.* 2001;22(5):353–372. https://doi.org/10.1016/s0891-4222(01)00077-4.
9. Kim MK, Park NK. Evaluating the impact of a multisensory environment on target behaviors of children with autism spectrum disorder. *HERD.* 2022;15(2):163–179. https://doi.org/10.1177/19375867211050686.
10. Gómez SR, García JA, Quintana AR. Effects of Snoezelen room activities and physical exercise on EEG patterns in adults with brain injury. *Disabil Rehabil.* 2016;38(23):2315–2323. https://doi.org/10.1016/j.cmpb.2016.08.008.
11. Singh NN, Lancioni GE, Winton ASW, et al. Effects of snoezelen room, activities of daily living skills training, and vocational skills training on aggression and self-injury by adults with mental retardation and mental illness. *Res Dev Disabil.* 2004;25(3):285–293. https://doi.org/10.1016/j.ridd.2003.08.003.
12. Lancioni GE, Cuvo AJ, O'Reilly MF. Snoezelen: an overview of research with people with developmental disabilities and dementia. *Disabil Rehabil.* 2002;24(4):175–184. https://doi.org/10.1080/09638280110074911.
13. Fava L, Strauss K. Multi-sensory rooms: comparing effects of the snoezelen and the stimulus preference environment on the behavior of adults with profound mental retardation. *Res Dev Disabil.* 2010;31(1):160–171. https://doi.org/10.1016/j.ridd.2009.08.006.
14. Lotan M. Management of rett syndrome in the controlled multisensory (snoezelen) environment: a review with three case stories. *The Scientific World JOURNAL.* 2006;6:791–807. https://doi.org/10.1100/tsw.2006.159.
15. Unwin KL, Powell G, Jones CRG. The use of multi-sensory environments with autistic children: exploring the effect of having control of sensory changes. *Autism.* 2022;26(6):1379–1394. https://doi.org/10.1177/13623613211050176.
16. Palisano RJ, Rosenbaum P, Walter S, et al. Development and reliability of a system to classify gross motor function in children with cerebral palsy. *Dev Med Child Neurol.* 1997;39(4):214–223. https://doi.org/10.1111/j.1469-8749.1997.tb07414.x.
17. Sourander A, McGrath PJ, Ristkari T, et al. Internet-assisted parent training intervention for disruptive behavior in 4-year-old children: a randomized clinical trial. *JAMA Psychiatry.* 2016;73(4):378–387. https://doi.org/10.1001/jamapsychiatry.2015.3411.

18. Eijgendaal M., Eijgendaal A., Fornes S., 2010. Multi Sensory Environment (MSE/Snoezelen)–A Definition and Guidelines. ISNA-MSE;. Available from: https://www.isna-mse.org.
19. Achenbach T.M., Rescorla L.A. *Manual for the ASEBA Preschool Forms & Profiles*. Burlington, VT: University of Vermont, Research Center for Children, Youth, & Families; 2000.
20. Abidin RR. *Parenting Stress Index, Third Edition: Professional Manual*. Odessa, FL: Psychological Assessment Resources, Inc; 1995.
21. Medina G, Ostrosky-Solís F. Early intervention: Effects of the multisensory environment room Snoezelen in children with cerebral palsy and at risk of neurological damage. *Adv Psychol Res*. 2007;53:185–196.