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ARCHERY AS A DEVELOPMENTAL TOOL FOR CHILDREN WITH SENSORY INTEGRATION DISORDER SYMPTOMS

Izabella-Orsolya KOVÁCS, Kinga KÁLCZA-JÁNOSI

Abstract: Our study aims to investigate archery's effectiveness as an innovative program on sensory experiences, self-regulation, executive functions, and attention, comparing the results of pre-assessments and control groups. Participants were 7-8-year-old Waldorf school Hungarian students with sensory integration disorder symptoms. They were assigned to two groups: the experimental group (N=6; 2 girls, 4 boys) and the waitlist control group (N=6; 2 girls, 4 boys). We used a small sample experimental research design and pre- and post-assessments (1 and 2). The Sensory and Motor Experiences Questionnaire measured the groups, the Executive Skills Questionnaire (ESQ) for Grades 1-3, the Behavior Rating Scale of Young Children's Self-Perceptions (BRSPS), the Tower of Hanoi, and the Toulouse-Pieron test. The outcome of our study revealed significant differences in the experimental group between pre-assessment and post-assessment results in the development of attention and executive functions. However, no significant differences were observed in self-perception changes. Based on these findings, we conclude that archery influences the development of executive functions and attention.

Keywords: sensory integration disorder, self-esteem, executive functions, attention, archery

1. Introduction

The potential benefits of archery in special education have not been explored yet. Preliminary research has focused on the effects of archery in the context of ADHD. However, its impact on children with sensory integration disorder has been less explored. The novelty of this study is that no research has investigated archery in 7–8-year-olds from a sensory integration perspective.

The sensory integration process involves registration, modulation, discrimination, and integration of stimuli, which are essential for attention and executive function. (Jorquera-Cabrera et al., 2017; Mailloux et al., 2018; Romero-Ayuso et al., 2018). This intervention explores archery's effect on attention, executive functions, and self-esteem in children with sensory integration disorder.

2. Theoretical Backround

Sensory integration disorder is a multifactorial and heterogeneous disorder (Gerebenné-Várbíró et al., 2021). It can affect children's individual development, daily life, social interactions, and family dynamics (Osborne, 2023; Miller et al., 2007, 2017). Some of the symptoms are sensory experiences, like hypersensitivities or hyposensitivity in hearing, vision, touch, movement, taste & smell, and self-regulation (Koziol et al., 2011). It occurs when children have inadequate responses to sensory inputs (Aguirre et al., 2025).

Its origins are rooted in neurological factors and the lack of inhibition of primitive reflexes (Stephen Sarlós, 2022). One possible factor is a delayed brain maturation rate (Morita et al., 2016; Romero-Ayuso et al., 2020), atypical functioning of cortical activities- such as unbalanced pain perception and inhibition mechanisms (Bar-Shalita et al., 2008, 2019; Huang et al., 2024) or divergent brain structures (Chen et al., 2023; Huang et al., 2024).

The symptoms could be expressed in cognitive development (Gerebenné-Várbíró et al., 2021), behavioral and emotional issues, social involvement, communication and adaptive responses, attention

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filtering problems (Mirzakhani Araghi et al., 2023; Huang et al., 2024), confused self-esteem (Grist et al., 2023; Jorquera-Cabrera et al., 2017; Paquet et al., 2022), fine- and gross motor skills (Jorquera-Cabrera et al., 2017). Based on research findings, we discovered that levels of sensory processing were a predictor of lower self-esteem (Paquet et al., 2022).

The results of the literature suggest that children tend to spread their attention to irrelevant matters, which may be the result of an underdevelopment or deficit in executive functions (Józsa & Józsa, 2018; Armando et al., 2020; Gerebenné Várbíró et al., 2021). However, attentional control is a moderating factor for information processing that occurs at multisensory integration and cognitive levels (Evans, 2020; Schmitt & Schoen, 2022; Li & Deng, 2022; Józsa & Józsa, 2018).

Executive functions rely on the best and harmonious functioning of the nervous system (Józsa & Józsa, 2018) and consist of three core components: working memory, inhibition, and cognitive flexibility, but there also are many complex components, like task prioritization, planning, time management, organization, goal-directed behavior, and metacognition (Miller & Wallis et al., 2009). Working memory plays a role in the maintenance and processing of information (Baddeley, 1986; Józsa & Józsa, 2018; Crasta et al., 2020; Gerebenné-Várbíró et al., 2021; Miller et al., 2017; Moritaet al., 2016). Furthermore, inhibition has a role in the regulation of sensory processing (Armando et al., 2020; Fernández-Pires et al., 2020; Gerebenné-Várbíró et al., 2021; Miller et al., 2017). Cognitive flexibility enables adaptive and goal-directed behavior regulation (Diamond, 2013; Józsa et al., 2018).

Therefore, we can conclude that the typical development of executive functions is a protective factor in the activation of different neurodevelopmental disorders, children's behavioral, social-emotional skills, and development (Józsa & Józsa, 2018; Zelazo & Carlson, 2020; Huang et al., 2024).

Physical activities stimulate neurotransmitter production, enhancing executive function processing capabilities. The primary motor cortex reaches its peak development around ages 7-8 (Gerebenné Várbíró et al., 2021). Also, the cortex manages the intersensory integration of gross- and fine-motor coordination (Miller et al., 2017).

Archery is a cognitive function-based sport and a recreational activity (Kim et al., 2019) that supports sensorimotor function by improving attention and fine motor skills (Wu et al., 2021; Stephens-Sarlós, 2022).

Focusing on archery, Donelly et al. (2016) and Van der Niet et al. (2014) support the positive effects on executive function outcomes in adult and young adult populations as well as in children aged 9-13. However, there is a lack of research targeting 7–8-year-olds.

Ustun & Tasgin (2020) confirm the beneficial impacts of archery on attention in 9–13-year-olds. Studies have shown that archery can cause significant improvements in self-esteem (Liu, 2022; Pomatahu & Pauweni, 2023). Only Pomatahu & Pauweni (2023) have found the role of archery in emotional regulation, concentration, and patience. Although archery relies on fine motor skills (Tinazci, 2011), only one study has supported the connection between archery, executive function, and fine motor skills (Oberer et al., 2018).

A meta-analysis by Mirzakhani Araghi et al. (2023) suggested that it would be useful to investigate the relationship between visual and auditory sensitivity, sociability, and recreational activities.

3. Research methodology

3.1. Objectives

The main aim of the study is to discover how archery influences attention, executive function, and self-esteem. On a theoretical level, this study complements the literature by analyzing its developmental impact on 7-8-year-old children with sensory integration disorder symptoms. The methodological goal of the research is to implement an experimental study as a new developmental program, which integrates the development of attention, executive functions, and self-esteem, with archery in the context of sensory integration symptoms. This combination has not been explored in similar research. Additionally, various measurement tools (self-report questionnaires, parent and teacher questionnaires, paper-pencil

tests, and experimental tasks) are applied to obtain a detailed profile of children's progress. On the practical level, this study introduces archery as an innovative developmental tool to support children's skill growth, improving participants' progress along the cognitive skills compared to the pre-test period.

3.2. Hypotheses

H1: There is a relationship between sensory experiences (auditory, visual, olfactory, tactile, and kinesthetic modalities), attention, executive functions, and self-esteem in 7-8-year-old children based on the findings of Crasta et al. (2020), Grist et al. (2023), and Paquet et al. (2022)

H2: Archery impacts the experimental group's self-esteem in their performance. This hypothesis was concluded from the research of Liu, (2022); Mirzakhani Araghi et al., (2023); Oberer et al., (2018); Pomatahu & Pauweni, (2023); Ustun & Tasgin, (2020).

H3: There can be expected differences in the experimental group's pretest and post-test results (Time 1) as well as between the pretest and follow-up measurement (Time 2) from the aspect of executive functions and attention. We formulated our hypotheses based on the research of Liu, (2022); Ustun & Tasgin, (2020).

3.3. Participants

The study included 7-8-year-old native Hungarian-speaking children at the Waldorf School in Cluj-Napoca. The primary selection criteria were the symptoms associated with sensory integration disorder. A total of N=12 children participated in the study. They were split with equal gender and age distribution of the children, see Table 1.

Table 1. *Descriptive Statistics of Participants' Demographic Data*

	Experimental (n=6)	**Control (n=6)**
Age		
	7.33 ± .51	7.33 ± .51
Gender (n, %)		
Female	2 (33.3%)	2 (33.3%)
Male	4 (66.7%)	4 (66.7%)

Note: N=12 (n=6 per group); Mean(M) ± Standard deviation (SD) of participants' age presented.

3.4. Instruments

4.4.1. Demographic Data. We edited the Demographic Data Questionnaire. The questions addressed potential disabilities and other factors, as well as gender, age, hands and foot dominance, presence of glasses, participation in other sports activities, illnesses, family conflicts, other interventions, and a diagnosis.

4.4.2. Sensory and motor experiences questionnaire. This test compares the mean scores with normative values. Higher scores show greater difficulties. Scoring was conducted using a comparative analysis of a Hungarian population reference table. The average score was calculated from the sum of the sensory modality subscales, considering reverse-coded items (Hearing 1, Hearing 4, Hearing 7, Hearing 11, Hearing 19, Vision 7, Movement 4, Movement 5, Taste and Smell 6, Taste and Smell 9, Taste and Smell 11, Taste and Smell 13, Self-Regulation and Social Relationships 10, Self-Regulation and Social Relationships 22). Results were compared to the normative sample average. The reliability of the questionnaire is shown in Table 3.

4.4.3. Executive Skills Questionnaire for children (ESQ). This questionnaire measures executive skills, see Table 2. It is constructed for children in grades 1-3. A higher score means the absence of executive function deficits. The reliability of the questionnaire is shown in Table 3.

Table 2. *ESQ Scoring*

Subscales	Items
Response Inhibition	1-3
Working memory	4-6
Emotional control	7-9
Sustained attention	10-12
Planning/Prioritization	12-15
Goal-directed behavior	16-18
Cognitive flexibility	19-21
Metacognition	22-24

Note: Higher scores show better executive performance. Scores are summed across items.

4.4.4. The Behavioral Rating Scale of Presented Self-Esteem for Young Children. The Behavioral Rating Scale of Presented Self-Esteem for Young Children is a newly developed teacher-rating tool for rating measures for children's self-esteem. Item scores are summed, with higher scores reflecting higher self-esteem. The reliability of the questionnaire is shown in Table 3.

4.4.5. Toulouse-Piéron Concentration Test. The Toulouse-Piéron Concentration Test is a paper-and-pencil, time-limited test. Participants have 4minutes to complete the test before putting down their pencils. Attention is analyzed both quantitatively and qualitatively. The right side of the test sheet has three columns: C (Correct responses), G (Incorrect responses), and O (Omissions). The total score for each column is calculated separately. Scores are compared to Romanian standard values. Quantitative score (Tc): The sum of correctly marked symbols. Qualitative score: Calculated using the formula: $Tc-Tg/Tc+To\times1000$ where Tg is incorrect responses, To is omissions, and Tc is correct responses. The reliability of the questionnaire is shown in Table 3.

4.4.6. Tower of Hanoi. The test requires participants to move disks to reconstruct the tower on the opposite peg while following a predefined sequence. This tool assesses problem-solving ability, planning skills, organizational skills, decision-making, and adherence to rule-based constraints. Performance is measured using a time-based method. The goal is to complete the task with the fewest possible moves while adhering to the following rules: A larger disk cannot be placed on a smaller one, only one disk can be moved at a time, and the participant can only hold one disk at a time.

4.4.7. Visual Analog Scale (VAS) to quantify children's subjective performance evaluation. The Visual Analog Scale is designed as a horizontal line with emoji indicators, representing a range of performance ratings. The endpoints are extreme values: 0 ("I performed poorly") and 10 ("I performed excellently"). Children are instructed to point to the emoji that best reflects their self-perceived performance.

Table 3. *Summary of Measurement Tools*

Instrument	Author/Year	Subscales	Reliability(α)
Sensory and Motor Experiences Questionnaire	(Domonkos et al., 2019)	Hearing, Vision, Touch, Movement, Taste & Smell, Self-Regulation	.76 .85 .82 .83 .86 .92
ESQ	(Nasir et al., 2021)	Response Inhibition, Working Memory, Sustained Attention, Task Prioritization, Planning, Time Management, Organization,	- - - 0.72 0.95 0.94 -

		Goal-Directed Behavior, Cognitive Flexibility, Metacognition Total	0.69 - - .90
The Behavioral Rating Scale of Presented Self-Esteem for Young Children	(Haliwanger & Harter, 2019)	Self-esteem (Confidence, Curiosity, Initiative, Exploration, Independence)	.95 -
Toulouse Pieron test	(Toulouse & Pieron, 1904)	(Selective & Sustained Attention, Processing Speed, Inhibition)	0.92
Tower of Hanoi	(Simon, 1975)	(Planning, Organization, Inhibition, Cognitive Flexibility, Abstract Thinking)	-
Visual Analog Scale	(Islaeli et al., 2023)	(self-evaluation)	-

Note: This table shows measurement subscales and their consistency.

5. Procedure

Data collection was conducted following the identification and contact with first-grade teachers. Parents gave their consent by completing a written agreement. Before the pre-assessment, parents completed the Demographic Questionnaire and the Sensory and Motor Experiences Questionnaire using a paper-and-pencil method. Based on these assessments, children who showed 1-2 standard deviations (SD) in at least one subscale from the normative values were selected.

We conducted the study in three phases: pre-assessment, post-assessment, and follow-up. In all three phases, we used the Toulouse-Piéron Test and the Tower of Hanoi task. The intervention lasted for four weeks. Participants attended sessions twice a week, plus one more session, each lasting 45 minutes. Each session began with a warm-up activity. Materials were collected in the final five minutes, and the children evaluated their performance using a Visual Analog Scale.

The post-assessment and follow-up assessments mirrored the pre-assessment procedures, including the administration of the Toulouse-Piéron Test and the Tower of Hanoi task.

5. 1. Arrow Program

In our Arrow program, each training session began with a warm-up round. Each child had to demonstrate a warm-up exercise, under our supervision, which the others then imitated. For the remaining 35 minutes of the intervention, the children practiced archery with a bow and arrow for kids. During archery, each child was assigned a specific task. The first child shot the arrows, the second signaled when the first could shoot, the third one kept score, the fourth held the arrows, the fifth retrieved the arrows, and the sixth was the "silence king/queen", ensuring a quiet environment and fair task execution. At the end of the intervention, we packed up, and the children evaluated their performance using the Visual Analog Scale.

5. 2. Research Design

This study used a small-scale experimental design. Experimental research eases the evaluation of innovative methodologies, including interventions using archery. Unlike other research designs, a small-scale experimental design enables the development of a more comprehensive participant profile while tracking progress compared to pre-assessment. This allows monitoring of development for both individual and group levels. Furthermore, unlike single-subject designs, the inclusion of a control group decreases confounding variables.

This study used cluster sampling. Children were included if they showed at least one symptom of sensory integration disorder, while those without symptoms were excluded. The study used a presence vs. absence variation. It included pre-assessment, post-assessment, and follow-up measurements to

evaluate both the short-term and long-term effects of archery training. Additionally, the study aimed to differentiate between the impact of the intervention and the natural developmental trajectory of the children, comparing results with the waiting-list control group.

5.3. Data Analysis

Data from questionnaires and other assessment tools were processed using IBM SPSS 25 statistical software. In cases where normal distribution was not met, non-parametric tests were applied. Correlations were analyzed using Spearman's rank correlation test, and within-group comparisons were conducted using the Wilcoxon signed rank test.

6. Results

H1: There is a relationship between sensory experiences (auditory, visual, olfactory, tactile, and kinesthetic modalities), attention, executive functions, and self-esteem in 7-8-year-old children.

The results of the Spearman correlation analysis showed a significant correlation between different sensory modalities, executive functions, attention, and self-esteem (see Table 4).

Table 4. *Spearman correlation between sensory modalities, executive functions, attention, and self-esteem*

	1	2	3	4	5	6	7	8	9	10	11
1. Auditory	-										
2. Visual	.614*	-									
3. Tactile	.646*	.740**	-								
4. Kinesthetic	.682*	.449	.502	-							
5. Gustatory and olfactory	.837**	.557	.654*	.731**	-						
6. Self-regulation	.660*	.549	.481	.668*	.716**	-					
7. Working memory	-.420	.015	-.171	-.280	-.607*	-.343	-				
8. Cognitive flexibility	-.185	-.417	-.656*	-.101	-.449	-.355	.201	-			
9. Metacognition	-.772**	-.487	-.510	-.294	-.706*	-.523	.646*	.370	-		
10. Self-esteem	-.694*	-.676*	-.593*	-.362	-.752**	-.668*	.270	.605*	.600*	-	
11.Pieron_concentration	-.788**	-.774**	-.739**	-.730**	-.705*	-.717**	.378	.250	.576*	.536	-

Note: *p < .05, **p < .01. Spearman correlations were used for all subscales. Further analysis was conducted only on subscales that showed stronger and more relevant associations in the context of the study.

The Spearman correlation showed a strong and significant positive correlation between auditor and gustatory-olfactory (rs = .837, p < .01), as well as between auditory and tactile (rs = .646, p < .05), between auditory and kinesthetic (rs = .682, p < .05), between auditory and self-regulation (rs = .660, p < .05), and auditory and visual (rs = .614, p < .05).

Additionally, significant positive correlations were found between visual and tactile (rs = .740, p < .01), gustatory-olfactory and kinesthetic (rs = .731, p < .01), and gustatory-olfactory and self-regulation (rs = .716, p < .01). A significant positive correlation was observed between gustatory-olfactory, and tactile (rs = .654, p < .05), and between kinesthetic and auditory (rs = .682, p < .05). Furthermore, kinesthetic, and self-regulation (rs = .668, p < .05) showed positive correlation.

On the other hand, strong and significant negative correlations were found between auditory and metacognition (rs = -.772, p < .01), auditory and concentration (rs = -.788, p < .01), visual perception and concentration (rs = -.774, p < .01), tactile and concentration (rs = -.739, p < .01), kinesthetic and concentration (rs = -.730, p < .01), self-regulation and concentration (rs = -.717, p < .01), and gustatory-olfactory and self-esteem (rs = -.752, p < .01).

Significant negative correlations were found between self-regulation and self-esteem (rs = -.668, p < .05), auditory and self-esteem (rs = -.694, p < .05), tactile and self-esteem (rs = -.593, p < .05), visual and self-esteem (rs = -.676, p < .05), gustatory- olfactory and working memory (rs = -.607, p < .05), gustatory- olfactory perception and metacognition (rs = -.706, p < .05), gustatory-olfactory and concentration (rs = -.705, p < .05), and tactile and cognitive flexibility (rs = -.656, p < .05).

Finally, significant correlations were observed between metacognition and concentration (rs = .576, p < .05), metacognition and working memory (rs = .646, p < .05), self-esteem and cognitive flexibility (rs = .605, p < .05), as well as self-esteem and metacognition (rs = .600, p < .05).

H2: Archery has an impact on the experimental group's self-evaluation of their performance.

Based on the results, the median score shows increased self-esteem from the pre-test (Mdn = 8.50) to the post-test (Mdn = 10.00). The Wilcoxon signed-rank test (Z = -1.856, p = .068) reveals that four children improved their performance scores in the posttest, see Table 5.

Table 5. *Self-evaluation based on performance*

		N	Mean ranks	Sum of ranks	Z	p	Mdn
post-performance -pre-performance	Negative ranks Positive ranks Equal	0[a] 4[b] 2[c]	.00 2.50	.00 10.00	-1.856[cc]	.068	10.0000 8.50000

Note: a. post-performance < pre-performance, b. post-performance > pre-performance, c. post-performance = pre-performance, cc. based on positive ranks.

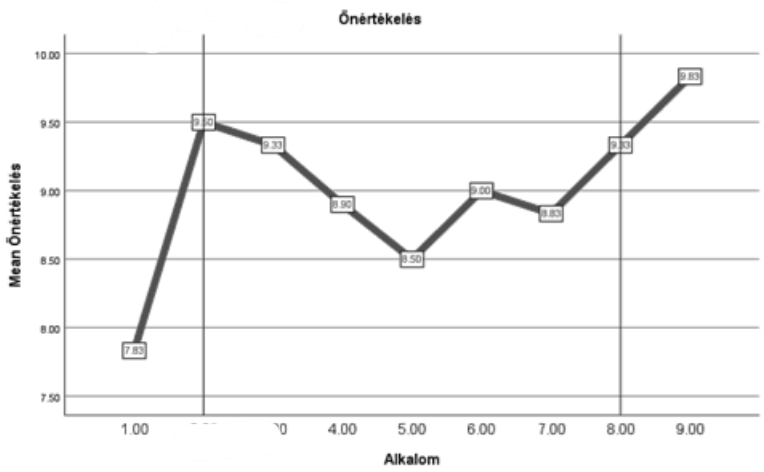

Figure 1. *Children's self-esteem is based on the Visual analog scale.*

As Figure 1. shows, there was a steady increase in children's self-esteem compared to the first session. Visual analysis illustrates the positive tendency in children's archery performance by their evaluation (see Figure 1). The mean score increased from 7.83 to 9.83.

H3: There can be expected differences in the experimental group's pretest and post-test results (Time 1) as well as between the pretest and follow-up measurement (Time 2) from the aspect of executive functions and attention.

We examined the preliminary assumption test before conducting the Wilcoxon signed-rank test. As Table 6., only the Pieron concentration test indicated development in the control group in the control group.

Table 6. *Pre-, post- and follow-up measures within the experimental group on executive functions and attention*

Test	Group	Direction of Change	N	Mean ranks	Sum of ranks	Z	p	Mdn
Hanoi_post-test-Hanoi_pre-test	Experimental	Negative Ranks Positive Ranks	6[b] 0[c]	3.50 .00	21.00 .00	-2.201[cc]	.028	80.9750-191.3600
	Control	Negative Ranks Positive Ranks Equal	5[b] 1[c] 0[d]	3.20 5.00	16.00 5.00	-1.153[cc]	.249	60.0400-90.1450
Hanoi_follow up-Hanoi_pre-test	Experimental	Negative Ranks Positive Ranks	6[e] 0[f]	3.50 .00	21.00 .00	-2.201[cc]	.028	59.8250-191.3600
Pieron_conc_post-test-Pieron_conc_pre-test	Experimental	Negative Ranks Positive Ranks	1[g] 5[h]	1.00 4.00	1.00 20.00	-1.992[dd]	.046	70.0000-27.5000
	Control	Negative Ranks Positive Ranks Equal	0[e] 5[f] 1[g]	.00 3.00	.00 15.00	-2.023[dd]	.043	80.0000-49.5000
Pieron_conc_follow up-Pieron_conc_pre-test	Experimental	Negative Ranks Positive Ranks	1[h] 5[i]	2.00 3.80	2.00 19.00	-1.782[dd]	.075	67.000-27.5000
	Control	Negative Ranks Positive Ranks Equal	0[h] 5[i] 1[j]	.00 3.00	.00 15.00	-2.023[dd]	.043	55.0000-80.0000
Pieron_ritm_post-test-Pieron_ritm_pre-test	Experimental	Negative Ranks Positive Ranks	0[k] 6[l]	.00 3.50	.00 21.00	-2.207[dd]	.027	84.5000-27.5000
	Control	Negative Ranks Positive Ranks Equal	1[k] 4[l] 1[m]	3.00 3.00	3.00 12.00	-1.214[dd]	.225	73.5000-55.0000
Pieron_ritm_follow up-Pieron_ritm_pre-test	Experimental	Negative Ranks Positive Ranks	0[n] 6[o]	.00 3.50	.00 21.000	-2.201[dd]	.028	96.5000-27.5000

Note: b. Hanoi_post-test <Hanoi_pre-test, c. Hanoi_followup > Hanoi_pre-test d. Hanoi_post-test = Hanoi_pre-test, e. followup <Hanoi_pre-test f. Hanoi_followup > Hanoi_pre-test, g. Pieron_konc_percentile_calitativ_post-test <Pieron_conc_calitativ, h. Pieron_conc_percentile_calitativ_post-test > Pieron_conc_calitativ, i. Pieron_conc_percentile_calitativ_post-test = Pieron_conc_calitativ, j. Peron_conc_calitativ_followup <Pieron_conc_. calitativ, k. Peron_conc_calitativ_followup > Pieron_conc_. calitativ, l. Pieron_ritm_percentile_cantitativ_post-test <Pieron_ritm_percentile_cantitativ, m. Pieron_ritm_percentile_cantitativ_post-test > Pieron_ritm_percentile_cantitativ, n. Pieron_ritm_percentile_cantitativ_post-test = Pieron_ritm_percentile_cantitativ o. Pieron_cantitativ_followup > Pieron_ritm_percentile_. Cantitativ
cc. Based on positive ranks; dd. Based on negative ranks.

As Table 6. demonstrates, based on the Wilkoxon signed-rank test, there is a significant improvement in the control group after the archery intervention.

As we can see, the experimental group solved the Hanoi task in a shorter time during the post-test (Mdn = 80.9750, n = 6) compared to the pre-test (Mdn = 191.3600, n = 6). Furthermore, this value continued to decrease in the follow-up assessment (Mdn = 59.8250, n = 6), Z = -2.201, p = .028. Contrary, no significant decrease was found in the control group between the pre-test (Mdn = 90.1450, n = 6) and the post-test (Mdn = 60.0400, n = 6), Z = -1.153, p = .249.

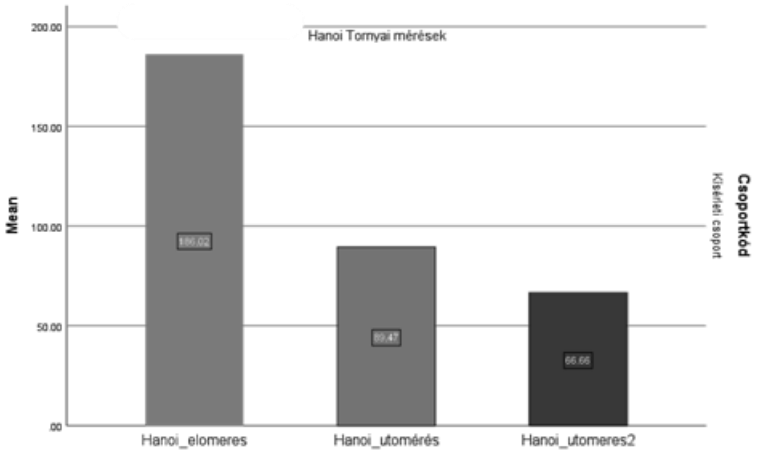

Figure 3. *Hanoi Tower measurements in the experimental group*

Figure 3. shows a significant and continued improvement in executive functions and decreased problem-solving time.

According to the Pieron concentration measurements, in the experimental group, five participants showed significant improvement compared to the pre-test (Mdn = 27.5000, n = 6) and the post-test (Mdn = 70.0000, n = 6), Z = -1.992, p = .046. Archery had a short-term effect on the experimental group, as the follow-up indicates (Mdn = 67.0000, n = 6), Z = 1.782, p = .075. A significant improvement was also observed in the control group between the pre-test (Mdn = 80.0000, n = 6) and the post-test (Mdn = 49.5000, n = 6), Z = -2.023, p = .043., but it was less than in the experimental group.

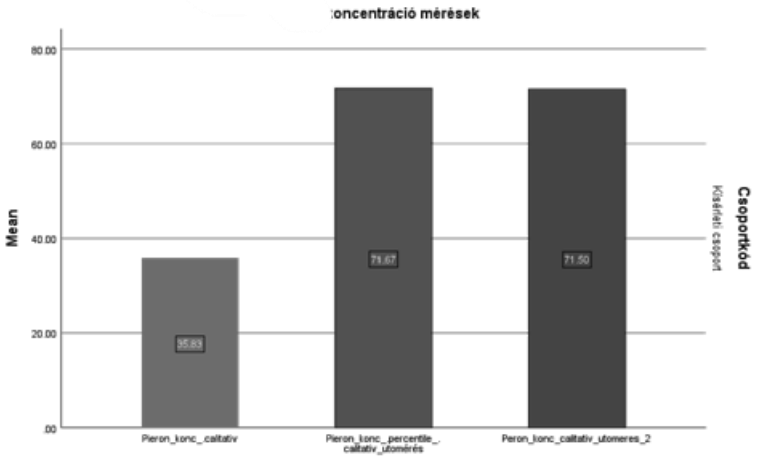

Figure 4. *Pieron concentration measurements in the experimental*

Figure 4. demonstrates the qualitative development of concentration. Pieron test indicates that the experimental group exhibited low concentration levels in the pre-test and showed persistent improvement in the post-test in the long term.

Furthermore, there was observed significant improvement compared to the pre-test median (Mdn = 27.5000) with the post-test median (Mdn = 67.0000), Z = -2.207, p = .027, and with the follow-up median (Mdn = 84.5000), Z = -2.201, p = .028. in the concentration rhythm. In contrast, no significant improvement was found in the control group between the pre-test (Mdn = 55.0000, n = 6) and the post-test (Mdn = 73.5000, n = 6), Z = -1.214, p = .225.

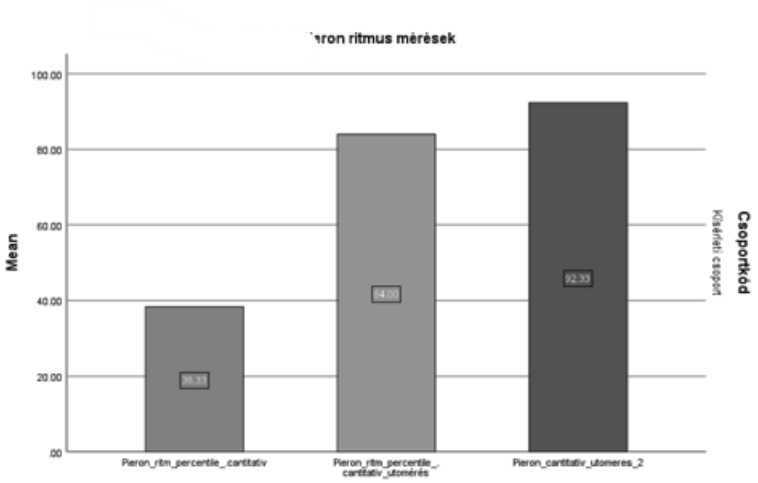

Figure 5. *Pieron rhythm measurements in the experimental group*

As Figure 5. compared to the pre-test, the Pieron psychometric test shows significant improvement in the post-test. Moreover, in this case, the effectiveness of the intervention remained evident even after the two-week intervention-free period.

6. Discussion

As we can see, archery has a positive effect on attention and executive functions, so it can be a developmental activity for children with sensory integration disorder symptoms. Our results proved by H1 that lower working memory, metacognition, and flexibility significantly correlate with sensory experience problems, which is supported by Murer et al, (2021) and Lin (2020). Gordon Oberer et al. (2018) identified a significant correlation between executive function and tactile perception, whereas we found it between flexibility and tactile perception. We demonstrated that attention correlates with sensory experiences supported by Grist et al. (2023). Confirming Paquet et al. (2022), we found a correlation between sensory integration impairment symptoms and self-esteem. From these results, if the nervous system fails to process and integrate sensory information effectively, it impacts response patterns, self-perception, and attention, therefore, our ability to plan, organize, and memorize becomes reduced.

The H2 was evaluated with the Wilcoxon signed-rank test and was not fulfilled. Self-evaluation showed a positive tendency in the post-test, but there was no significant improvement. We hypothesize from our observation that it was influenced by extreme self-esteem during the first and last sessions, the Target panic phenomenon (Prior & Coates, 2020), and the Visual Analog scale subjectivity (Klimek et al., 2017). This reflects that with a prolonged intervention, the program might have resulted in more effective development in the children's self-esteem (see Figure 2) (Liu, 2022).

By the Wilcoxon Signed Rank test, H3 was confirmed. Our findings suggest that archery had long-term effects on executive functions and rhythmic concentration. These results are consistent with the research of Schmidt et al. (2015) and Ustun & Tasgin (2020).

7. Conclusions

In summary, there is proof of an association between archery and SPD symptoms (Aguirre et al., 2025), thus justifying the aim of investigating the effects of archery on attention, self-esteem, and executive functions in children with SPD symptoms. Furthermore, a significant relationship was found with sensory integration disorder symptoms, executive functions, self-esteem, and attention. Although not all hypotheses were confirmed, the children's cognitive skills improved, and they enjoyed the activity, which holds pedagogical significance. Therefore, we achieved our main research objectives.

8. Limitations, Strengths, and Future Directions

The limitation of our research is the sample size, which may limit the generalizability of the results. The vacations between different modules also influenced our research. The strengths were the waiting list control group and that we used several measurement tools, such as paper-pencil questionnaires, Visual Analogue Scale, and psychometric tests so that our results highlighted the applicability of different methods. Regarding future improvements, we recommend that archery interventions be continued for a longer period, with a larger sample size from various schools. Alternatively, it may be more effective in the future to shoot at non-value items rather than a target, reducing the need for target-oriented assessment.

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Authors

Izabella-Orsolya KOVÁCS, Babes-Bolyai University, Faculty of Psychology and Educational Sciences, Applied Psychology Department, Cluj Napoca, Romania. E-mail: k.izabella02@gmail.com

Kinga KÁLCZA-JÁNOSI, Assoc. Prof. Dr., Babes-Bolyai University, Faculty of Psychology and Educational Sciences, Applied Psychology Department, Cluj Napoca, Romania