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Physical Activity and Not Digital Technology Use Predict Primitive Reflexes in First-Grade Pupils in Croatia

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Abstract

Primitive reflexes are automatic movement patterns that should be integrated in early childhood, and their persistence may be linked to motor and learning difficulties. As children's lifestyles increasingly involve reduced physical activity and greater digital technology (DT) use, it is important to examine potential associations. This study aims to investigate the retention of the three primitive reflexes, namely ATNR, STNR, and TLR, in children aged 6 to 8 years, and to test whether it can be predicted by the time children spend engaging in different types of physical activities and using digital technology. The research was conducted as part of the project DigiLitA – The effect of environment on child development. The participants were 221 children (117 girls) aged 6 to 8 years (M = 7.06, SD = 0.33, Median = 7), first-grade students, along with one of their parents. Children were tested individually for persistence of the three types of primitive reflexes. Their parents provided estimates of the time the child spends in different physical activities and activities using DT. Results show that at least one of the three primitive reflexes that were tested was present in 59.5% of children. The hierarchical regression model shows that gender (entered at the first step) and frequency of the child engaging in activities such as riding a bike, scooter, or skates (entered at the second step) are significant predictors of the persistence of primitive reflexes. Boys and children who engage less frequently in coordination-demanding physical activities are more likely to have retention of primitive reflexes at their age. The model explained 6.2% of the variance. Using DT to play games for fun did not prove to be a significant predictor of primitive reflexes. These findings suggest that engagement in coordination-demanding physical activities, rather than recreational use of digital technology, is modestly associated with persistence of primitive reflexes in early school-age children.

Keywords: primitive reflexes, digital technology use, environmental influence, physical activity

Introduction

Primitive reflexes are automatic, involuntary movements that are present at birth or appear during motor development (commonly during the first year of life) and typically disappear as the nervous system matures and children master specific motor skills. They help infants interact with the world through stereotypical reactions to specific external stimuli (visual, auditory, proprioceptive) or demands (protective behaviour). Still, most of them are expected to fade as the child's brain develops more complex motor and cognitive functions (Zafeiriou, 2024). However, in some school-age children, these reflexes may persist beyond the usual age of integration (replacement by voluntary movements) at around 6–12 months (Capute & Accardo, 1992), and no later than 3.5 years in the case of the tonic labyrinthine reflex (TLR).

Primitive reflexes are foundational to early motor development. Still, if they persist into school age, they can hinder a child's ability to participate fully in physical activities and cause issues with coordination and balance (Gieysztor et al., 2018a; Gieysztor et al., 2022). Additionally, they can be linked to problems with fine motor skills (Alibakhshi et al., 2018; Richards et al., 2022), cognitive skills like focus and attention (Hickey & Feldhacker, 2022), as well as eye movements and visual perception (Bein-Wierzibinski, 2001, as cited in Goddard Blythe, 2012; Gonzales et al., 2013). Listed abilities are compromised in children with Attention Deficit Hyperactivity Disorder (Landgren et al., 1998; Wang et al., 2023) and can be manifested as a child's inability to focus, sit still, and engage in tasks that require fine motor skills, which are often needed in a school environment. These might further lead to learning difficulties due to inefficient mastering of even more complex tasks such as reading, writing, and organizing thoughts.

While several primitive reflexes are examined in middle childhood, the ones that receive the most attention include the asymmetrical tonic neck reflex (ATNR), the symmetrical tonic neck reflex (STNR), and the tonic labyrinthine reflex (TLR). ATNR is present at birth. In addition to assisting in the expulsion of the baby through the birth canal, it is necessary for the development of crossed pattern movements (Goddard Blythe, 2005). ATNR is inhibited by higher cortical centres by around six months of age, and if it persists after this age, it may disrupt motor development, including crawling, crossing the midline, and later hand–eye coordination required for writing. In school-aged children, an active ATNR, particularly when combined with immature head-righting reflexes, can also interfere with the oculomotor control necessary for reading (Goddard Blythe, 2009). STNR typically appears between 5 and 8 months as infants begin moving into a hands-and-knees position and start creeping. This reflex supports the transition from crawling to creeping, but if it persists, it can interfere with coordinating the upper and lower body. Children may then skip creeping, adopt unusual movement patterns, or rely on bottom shuffling. Since creeping fosters balance, coordination, and integration of sensory systems, and supports later skills like posture, eye–hand coordination, and visual tracking, an unintegrated STNR may contribute to challenges in movement and school-related tasks (Gieysztor et al., 2018a; Visser & Franzen, 2010). TLR appears in full-term newborns in two positions: (a) bending the head forward (flexion) increases the tone of other flexors; (b) head bent backwards (extension) increases the tone of other extensors. This is a reflex that controls the position of the head in relation to the body, primarily before the child can sustain an upright position. If the TLR remains active into school age, it may interfere with upright balance, postural stability, and the eye movement control required for reading and writing (Goddard Blythe, 2021).

Various reasons contribute to the retention of primitive reflexes beyond the age of their integration, and among them are serious reasons such as the occurrence of some neurological diseases, trauma, chronic infections, experienced stress, and exposure to toxins. Less dramatic and more frequent reasons are delayed or skipped development of creeping and crawling and a general lack of physical activity. The environment in which a preschool-aged child grows up plays a significant role in their motor development and the integration of primitive reflexes. Physical activity is affected by the persistence of primitive reflexes, which make movement less efficient and more difficult, and might lead to children avoiding physical activity (Gieysztor et al., 2018a; Pecuch et al., 2021). At the same time, physical activity can also be a tool to help integrate those reflexes. Movement-based interventions, especially those that target balance, bilateral coordination, and rhythmic motion, are considered beneficial for reflex integration and overall neurodevelopment (Goddard Blythe et al., 2021; Hirose et al., 2025). Providing real-life opportunities for physical movement from an early age allows children to make the transition from the uncoordinated activity present at birth to coordinated voluntary motor behaviour and helps ensure that reflexes integrate at the appropriate age (Goddard Blythe et al., 2021). On the other hand, a lack of physical activity, often related to prolonged use of digital technology, can hinder development and contribute to the persistence of primitive reflexes.

Chong et al. (2024) found that of the 7017 children aged from 3 to 4 years from 33 countries, only 14.3% met the overall guidelines for physical activity and screen time. The overall guidelines for physical activity were introduced by the World Health Organization (WHO, 2020) and recommend participating in at least 180 minutes of physical activity (at least 60 of which should be of moderate to vigorous intensity). The same source recommends spending no more than 1 hour in sedentary screen time. In a similar study with 4,524 US children aged 8–11 years, Walsh et al. (2018) found that only 18% of children met the physical activity recommendation, while 37% met the screen time recommendation. Korcz et al. (2023) showed that among 8–9-year-olds, 22% met the screen time guidelines, but only 8% met physical activity guidelines. The results of these studies indicate that children generally spend more time than recommended using digital technology and engaging in sedentary behaviour, while simultaneously spending less time than recommended in physical activity. This aligns with the theory of Time Displacement (Putnam, 2000), which suggests that the time spent with digital technology affects the time allocated to other daily activities, and it reduces the time for face-to-face interactions or activities outside the home, such as physical activities. In the literature, studies on the displacement hypothesis in middle childhood provide conflicting findings, with some studies showing evidence of a negative association between screen time and activities such as spending time outside (LeBlanc et al., 2015), while others point out that while total time spent engaged with digital technology increased by 23% since 1997 for children in middle childhood, the co-occurring decline in physical activity cannot be attributed solely to technology time (Goode, 2020).

While there is reason to expect a negative association between physical exercise and retention of primitive reflexes, to the best of our knowledge, no studies have shown the direct link for children in middle childhood. Additionally, no studies have looked into the relationship between physical activity and digital technology use in relation to the retention of primitive reflexes in middle childhood.

This study aims to investigate the retention of the three primitive reflexes, namely ATNR, STNR, and TLR, in children aged 6 to 8 years, and to test whether the retention of primitive reflexes can be predicted based on the time children spend engaging in different types of physical activities and using digital technology.

Methods

Sample

The participants were 221 children (117 girls) aged 6 to 8 years (M = 7.06, SD = 0.33), first-grade students, along with one of their parents. Children were tested individually for the persistence of the three types of primitive reflexes. Their parents provided estimates of the time the child spends in different physical activities and using DT.

Procedure

The data used in this paper were collected in Croatia during the first wave of a longitudinal study conducted within the framework of a larger research project DigiLitA – The effect of environment on child development: The association of digital technology use, home literacy environment and physical activity with the well-being of children in early school years, funded by the European Union programme NextGeneration EU (project number 01/02-73/23-2519-5).

Ethical approval was obtained from the Ethics Committee of the Ivo Pilar Institute of Social Sciences, along with permission to conduct the study in elementary schools from the Ministry of Science, Education, and Youth. Ten elementary schools in Osijek and the surrounding area were invited to participate, and eight agreed to join the study. Schools were selected based on having larger student populations and at least one staff member with an M.A. in psychology, as only these schools administer specific school readiness assessments.

Following approval from each school principal, the study was introduced to parents of first-grade students during the initial parent–teacher meeting. Parents in attendance received an envelope containing a short project description, a written consent form, and questionnaires. They were also given an additional envelope, with instructions to complete the questionnaire, sign the consent form if they agreed to participate, and return both – the consent form separate from the questionnaire, which was sealed in the envelope.

Children whose parents provided consent were individually assessed during regular school hours. The retention of primitive reflexes was assessed by trained members of the research team, all psychologists, who completed a short training in the identification of primitive reflexes based on videos and manuals provided by international colleagues. These materials are not publicly available but are authorized for internal professional use. Each session lasted approximately 30 minutes and was conducted in the morning. In total, 358 children and their parents were approached, of whom 221 consented to participate (61%). To acknowledge their contribution, each participating child and parent received a gift certificate for a visit to the local zoo.

Measures

Primitive Reflexes

Children were tested for the presence of three different primitive reflexes using the INPP Developmental Screening Test and School Intervention Programme (Goddard Blythe, 2012). The ATNR was assessed using the quadrupod Ayers test for the ATNR; the STNR was assessed using the quadrupod test for the STNR; and the TLR was assessed using the erect test for the TLR (Goddard Blythe, 2012). Children were tested individually in a relaxed setting, and the testing procedure was presented as a short and fun exercise. The researcher would show the children how to take a specific position and then encourage the children to take the same position. There were two positions – one on a soft mat, where children would be down in a 'table' position, on their knees and hands, and one in an erect position, with the arms relaxed down on the side of the body. At each position, the child was asked to move their head slowly and gently up, looking at the ceiling, or down, looking at their toes, or on the left or right side, without moving other parts of the body. At each position and with each movement, the researcher would monitor changes in balance or muscle tone and rate the child from 0 (no abnormality detected) to 4 (reflex retained, i.e., present to 100%). The reflex reactions were always observed in other body areas. For each test, there were two conditions (either left-right head rotation or head flexion and extension), so each test was given two scores. The three scores for each of the two conditions for the three primitive reflexes tests were combined into one, with a greater result showing a greater degree of retention of primitive reflexes. The entire testing procedure lasted up to 5 minutes. The researchers who assessed the degree of retention of primitive reflexes received a short training in the assessment process through video and print materials and a short practical training with volunteers recruited from personal contacts.

The Time a Child Spends Engaging in Different Physical Activities

Parents were asked to estimate how often during a typical week their child plays with other children outside (on the street, a playground, or a sports field), goes for a walk, or rides a bicycle, scooter, or skates. The answers were given on a scale from 0 ("Never") to 7 (7 times a week).

The Time a Child Spends Using DT

Parents were asked to estimate how often their child uses all digital technology devices for fun, using a 5-point scale, from 1 ("Never") to 5 ("Very often").

Results

In Table 1, descriptive statistics for the study variables are presented. According to parental reports, children engage in different physical activities such as playing outside, walking, or riding a bicycle/scooter/skates approximately four times per week. Furthermore, most parents reported that their children sometimes play digital games for fun. The presence of primitive reflexes was also analysed, and a mean score of 1.79 and a median value of 1 (range 0–7; MAD = 1), suggest a minimal presence of primitive reflexes in first-grade children. In fact, 40.5% of children had no retention of primitive reflexes.

As for individual reflexes that were examined, no child was assessed to have fully retained any of the reflexes. The maximal value given for a specific reflex was 3, which is described as "Reflex present to 75% (virtually retained)", and this value was assessed only for two reflexes, both for the same child. Depending on the primitive reflex, the percentage of children who had any level of retention at this age ranged from 19.2% for the STNR, for the flexion position (when the child looks down), to 31.2% for the TLR, for the extension position (when the child looks upwards).

Table 1.

Descriptive Statistics for the Study Variables

	N	M	SD	Min–max	Skew	Kurtosis
Physical activity-playing	218	4.30	1.93	0–7	-0.12	-1.01
Physical activity-walking	217	3.82	2.01	0–7	0.09	-1.02
Physical activity-bike/scooter/skates	216	3.93	1.97	0–7	0.05	-0.93
DT-games for fun	219	3.09	0.97	1–5	-0.22	-0.22
Primitive reflexes	215	1.79	2.04	0–11	1.16	1.17
Age	221	7.06	0.33	6.33–8	0.31	-0.39

The correlation analysis (Table 2) revealed several significant relationships among the key variables included in the regression model. The presence of primitive reflexes was negatively correlated with the frequency of riding a bicycle, scooter, or skates during the week ($r = -.223$, $p < .01$), which means that children who engaged more frequently in these physical activities showed a lower presence of primitive reflexes compared to those who engaged less. A significant negative correlation was also found between the presence of primitive reflexes and walking ($r = -.161$, $p < .05$). Regarding gender differences, girls showed a lower presence of primitive reflexes compared to boys ($r = -.177$, $p < .01$). There was a significant positive correlation between all three measures of physical activity. Additionally, playing digital games for fun was negatively correlated with both playing outside ($r = -.146$, $p < .05$) and walking ($r = -.148$, $p < .05$).

Table 2.

Correlations for the Study Variables

	Physical activity – playing outside	Physical activity – walking	Physical activity – bike/scooter/skates	DT-playing games for fun	Retention of primitive reflexes	Age	Gender

Physical activity – playing outside	1	.538**	.534**	-.146*	-.055	.024	-.008
Physical activity – walking		1	.508***	-.148*	-.161*	.163*	.134*
Physical activity – bike/scooter/skates			1	.011	-.223**	.011	-.007
DT – playing games for fun				1	.003	-.048	-.181**
Retention of primitive reflexes					1	-.011	-.177**
Age						1	-.146*
Gender∞							1

Note. *p < .05, ** p < .01, ***p < .001, ∞ Gender was coded as 0 for boys and 1 for girls.

A two-step hierarchical multiple regression was conducted to explore the impact of different physical activities and playing digital games for fun on the presence of primitive reflexes in first-grade children. The regression coefficients are presented in Table 3. In Step 1, only age and gender were included as predictor variables. Results showed that age and gender alone did not significantly contribute to explaining the presence of primitive reflexes, $F(2, 206) = 2.979$, $p = .053$. In Step 2, physical activity variables (playing, walking, and riding a bicycle, scooter, or skates) and playing digital games for fun were added. The model significantly predicted the presence of primitive reflexes, $F(6, 202) = 3.292$, $p < .01$, and explained 6.2% of the variance. Furthermore, the results indicated that the only significant predictors were the extent to which children engaged in activities such as riding a bicycle, scooter, or skates ($\beta = -.271$, $p = .001$) and gender ($\beta = -.152$, $p < .05$). Overall, the findings suggest that engaging in physical activities requiring motor coordination, such as riding a bicycle, scooter, or skates, and gender differences may play a meaningful role in explaining the presence of primitive reflexes. However, these variables explained only a small portion of the variance, which implies that further research is needed to identify additional contributing factors.

Table 3.

Results of the Hierarchical Regression Analysis Predicting Primitive Reflex Persistence from Physical Activity and Recreational Digital Game Use

95% CI

Predictor	B	β	t	p	Low	Up	Adj. R^2	ΔAdj. R^2	P
Step 1							.019	.019	.053
Age	-.324	-.055	-.796	.427	-1.128	.479			
Gender	-.644	-.165	-2.389	.018	-1.176	-0.113			
Step 2							.062	.043	.004
Age	-.250	-.042	-.612	.541	-1.055	.555			
Gender∞	*-.594*	*-.152*	*-2.158*	*.032*	-1.136	-.051			
PA – playing	.139	.138	1.585	.114	-.034	.312			
PA – walking	-.043	-.045	-.515	.607	-.209	.122			
PA – bike, skates	*-.271*	*-.274*	*-3.263*	*.001*	-.434	-.107			
DT – games for fun	.039	.020	.282	.778	-.235	.313			

Note. Adj. R^2 = Adjusted R^2, CI = Confidence Interval, ∞ Gender was coded as 0 for boys and 1 for girls.

Discussion

This study examined the retention of three primitive reflexes, namely the asymmetrical tonic neck reflex (ATNR), the symmetrical tonic neck reflex (STNR), and the tonic labyrinthine reflex (TLR) in children aged 6–8 years, and explored whether the persistence of these reflexes is associated with levels of different types of physical activity and digital technology use. While previous research has linked retained primitive reflexes to challenges in motor coordination, balance, and learning (Gieysztor et al., 2018a; Richards et al., 2022), little was known about how everyday activity patterns might contribute to their persistence.

The results showed that at least one of the primitive reflexes that were tested was present in around 60% of children aged 6 to 8, which means that around 40% of children have no retention of primitive reflexes at the start of primary school. Findings from previous studies are difficult to compare because they depend on the reflexes that the children are tested for and the exact age of the children in the study. Most studies included children who are slightly younger than children in our sample, because children in Croatia start school somewhat later than in other European countries. For example, Pecuch et al. (2021) tested 112 Polish children aged 4 to 6 and found that 7.1% of them had no retention of primitive reflexes, which is a far lower percentage than the one found in our study. However, similar to our study, Pecuch et al. (2021) found that one of the most frequently occurring reflexes was the TLR in extension position, while the least frequent one was the STNR, for the flexion position, which is in accordance with our findings. Gieysztor et al. (2018a) showed that 11% of 35 preschool children aged 4 to 6 have no retained primitive reflexes, with the STNR, for the flexion position again being the one that was least frequently occurring. Finally, Goddard Blythe et al. (2021) showed that around 85% of 120 British preschool children aged 4 to 5 had a retained ATNR or STNR of 50% or more. In conclusion, previous studies point to a larger percentage of children showing signs of primitive reflex retention, but they include younger participants and often smaller samples. A plausible explanation might be that children continue to integrate primitive reflexes with age and that in older children, the percentage of retention is lower, both in terms of prevalence and severity. However, there is no critical age at which primitive reflexes are generally integrated, since studies showed the existence of the ATNR and STNR in adult subjects as well (Bruijn et al., 2013). The pattern of the lowest and highest rates of individual primitive reflex retention is similar in previous studies to the results from our study, which might imply a similar pattern of specific reflexes retention.

The results from the regression analysis showed that age and gender alone did not significantly explain reflex retention. However, when physical activity and digital technology use were added to the model, the model became significant, although the explained variance was modest (6.2%). Among the predictors, only participation in activities such as riding a bicycle or a scooter and/or skating and gender significantly contributed to the presence of reflexes. Specifically, children who engaged more frequently in these coordination-demanding activities and girls showed fewer retained reflexes. This finding aligns with the notion that physical activities requiring balance, bilateral coordination, and rhythmic movement support reflex integration (Goddard Blythe et al., 2021; Hirose et al., 2025). This also implies that it is not just physical activity, but a specific type of physical activity that might be important for primitive reflexes and their integration. This is also evident in the finding that, while according to parental reports, children engage in different physical activities, on average, 3 to 4 times a week, children spend significantly more time playing outside than riding a bicycle, scooter, or skates, or going for a walk. So, it is not the most frequent physical activity that is related to primitive reflex retention, but rather one that places specific demands on balance and coordination. The significant gender effect also indicates possible biological or behavioral differences, echoing findings from other developmental studies where boys and girls demonstrated different movement patterns or susceptibilities in motor development (LeBlanc et al., 2015). Results from this study show that, once other variables about different activities children engage in are introduced in the model, female gender is associated with less retention of primitive reflexes. In a previously mentioned study with children from 4 to 6 years, Hickey & Feldhacker (2022) also found that boys demonstrated more reflex retention than girls for 6 of the 7 tested reflexes. Interestingly, digital technology use for fun was not a significant predictor of primitive reflex retention. This may suggest that while sedentary screen-based behaviors are often associated with reduced physical activity levels (Chong et al., 2024; Walsh et al., 2018), their direct impact on reflex retention may be indirect or mediated through reduced opportunities for active play. Despite the significant associations, the explained variance of primitive reflex retention was relatively small, suggesting that reflex persistence is likely influenced by a wider range of factors, including neurodevelopmental, environmental, and possibly genetic contributors not captured in this study. This highlights the need for longitudinal research to better understand causal pathways and to explore whether specific interventions, such as structured movement programs, can accelerate reflex integration. Such programs, implemented before school starts, could significantly impact school success.

This study is not without limitations. The community sample and a cross-sectional design prevent us from making more generalized and causal conclusions. Also, in the current study, no information was provided about the existence of any developmental delays or specific difficulties (neurological disease, trauma, stress) that some of the children in the sample might be facing, and previous studies underline an association between, e.g., ADHD and primitive reflex retention (Wang et al., 2023). Finally, relying on the parental estimates of the time children spend in different activities also introduces a significant risk of recall bias and social desirability bias, which may compromise the accuracy of the reported physical activity and digital technology use (Koning et al., 2018).

Conclusion and Practical Implications

In conclusion, this study provides preliminary evidence that gender and engagement in activities requiring coordination, such as riding a bicycle, scooter, or skates, are associated with the integration of primitive reflexes in first-grade children. Although the effect size was modest, these findings underscore the importance of physical activity in middle childhood and point to the need for further research to identify additional determinants of reflex integration. Persistent reflexes have been associated with motor difficulties (Gieysztor et al., 2022), postural issues such as scoliosis (Gieysztor et al., 2018b), and reading difficulties (Hazzaa et al., 2021; McPhillips et al., 2000), yet in Croatia, as in many other European countries, they are not included in standard developmental assessments. The testing of the three relevant primitive reflexes before starting school is a simple and short procedure, and incorporating reflex evaluation into regular medical examination protocols could complement existing screening methods and help clarify their role as early indicators of neurodevelopmental risk. Furthermore, evidence suggesting that movement-based reflex integration activities can improve academic outcomes underscores the need for a systematic study of the prevalence of primitive reflex retention in school-age children and how physical activity contributes to reflex inhibition (Grigg et al., 2018). Expanding research in this area has the potential to bridge gaps between clinical practice, education, and developmental science, ultimately supporting more effective interventions and healthier developmental trajectories.

The findings have practical implications for educators and parents. Encouraging children to participate in coordination-rich activities like cycling and skating may not only support motor development but also reduce the likelihood of retained primitive reflexes that can interfere with balance, posture, and school-related tasks such as reading and writing (Gonzales et al., 2013). As current evidence suggests many children fail to meet the WHO (2020) guidelines for physical activity, promoting these kinds of engaging, skill-based movements could be particularly beneficial.

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