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Assessing primitive reflex retention and its effect on motor proficiency in Thai preschoolers

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ABSTRACT

Purpose. This study aims to examine the relationship between the retention of primitive reflexes and motor proficiency in preschool children, with a specific focus on healthy Thai preschoolers. In particular, we investigate key primitive reflexes associated with body positioning, including the Asymmetrical Tonic Neck Reflex (ATNR), Symmetrical Tonic Neck Reflex (STNR), and Tonic Labyrinthine Reflex (TLR), to determine their potential impact on motor proficiency.

Methods. Data were collected from 65 children (26 girls and 39 boys) from Bangkok and the surrounding metropolitan area, with a mean age of 5.64 years (SD = 0.38). Each participant underwent assessments using the Primitive Reflex Test, focusing on the ATNR, STNR, and TLR, as well as the motor proficiency assessed with the Bruininks–Oseretsky Test of Motor Proficiency, second edition, Short Form (BOT-2SF).

Results. Statistical analysis revealed a significant inverse correlation between the retention of three primitive reflexes (ATNR, STNR, TLR) and overall motor proficiency (r = –0.543, p < 0.001), indicating that higher reflex retention is associated with lower motor skills. Among individual reflexes, STNR showed the highest negative correlation (r = –0.498), followed by TLR (r = –0.361) and ATNR (r = –0.316). Fine motor precision was most affected by reflex retention. Persistent reflexes were found in 65% of participants, with those retaining 2–3 reflexes scoring notably lower on BOT-2SF assessments.

Conclusions. This first Thai study on retained primitive reflexes and motor proficiency in preschoolers underscores the need for early assessment and timely interventions such as reflex integration therapy to support development.

Key words: reflex integration, neuromotor development, early childhood, fine motor development, gross motor development

Introduction

Primitive reflexes are automatic behavioural and motor reactions directed from the brainstem and controlled by the cerebral cortex [1, 2] that appear in the final four months of prenatal life and early infancy. It takes up to three years of age for development to be complete, which is subsequently inhibited and integrated [3]. Primitive reflexes are important for development because they enable the baby to move against gravity and gradually prepare them for independently moving through the process of integrating in the early months of life [4], influence the body posture and motility of the full-term baby [5] as well as the movement patterns that form during the foetus' development, and are crucial to the infant's survival [6]. Primitive reflexes are widely utilised as indications of neuromotor maturity or immaturity [7]. Neuromotor maturity refers to a child's cognitive, social, emotional, and physical readiness to begin school, which is directly related to motor development and is an external sign or reflection of functional neuromotor maturation. It is also associated with the operation of the proprioceptive, vestibular, and postural systems [8]. According to Blythe [9],

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when any process within the nervous system functions abnormally, it can lead to a condition termed neuromotor immaturity. This condition is marked by immature motor control patterns and is often accompanied by pathological neurological symptoms as well as functional or developmental irregularities within certain neural systems. Additionally, individuals affected by neuromotor immaturity frequently experience difficulties with balance, coordination, motor skills, and visual perception, among other areas, potentially contributing to behavioural disorders and learning difficulties [10].

Numerous studies indicate that retained primitive reflexes can adversely affect motor skills. The persistence of these reflexes and delayed motor responses are also associated with challenges in learning and participation in daily activities [11–13]. Children exhibit a variety of reflexes, including key primitive positioning reflexes such as the Asymmetric Tonic Neck Reflex (ATNR), Symmetric Tonic Neck Reflex (STNR), and Tonic Labyrinthine Reflex (TLR). When these reflexes persist beyond the typical developmental stages, they can disrupt the balance, posture, coordination, and eye movement control. Such disruptions often lead to difficulties with reading, spelling, and fine motor skills, which in turn can impact a child's ability to write effectively [14–16]. Primitive reflexes, though commonly linked to neuromotor disorders, are also present in typically developing children. Studies have highlighted the prevalence of these reflexes in healthy preschool populations, with findings showing that 48–84% of children retain residual or unintegrated primitive reflexes [14, 17, 18]. The connection between primitive reflexes and motor and cognitive development is well-documented. Addressing persistent primitive reflexes is thus essential in preparing preschoolers for foundational learning activities in school, such as movement for exploration, reading, and writing.

Most existing studies have primarily focused on the associations between preserved primitive reflexes and learning challenges, such as difficulties in reading, telling time, and maintaining attention, particularly in elementary school children and those with special needs, including ADHD [19, 20], ASD [21, 22], and cerebral palsy [23]. The exploration of this phenomenon in healthy preschoolers remains limited. Consequently, our study aims to fill this gap by examining the relationship between the persistence of primitive reflexes and motor proficiency in healthy Thai preschoolers. In our investigation, we specifically focus on key primitive reflexes related to positioning, including the ATNR, STNR, and TLR. We hypothesise that higher levels of primitive reflex retention will be inversely correlated with motor proficiency, suggesting that increased retention of these reflexes may lead to poorer motor skills.

Material and methods

Participants

This study recruited 65 preschool children, aged 5 to 6 years, from Bangkok and its surrounding metropolitan area using a random selection process. Sample size estimation was conducted using G*Power 3.1, with a correlation coefficient (*r*) of –0.34, derived from previous literature. Specifically, Gieysztor et al. [14] reported a significant inverse correlation between primitive reflex scores and motor skills ($p < 0.05$; $r = -0.34$), which informed the sample size calculation. All children voluntarily participated in the study. Inclusion criteria required that participants had the ability to comprehend the language and had no diagnosed neurological conditions, such as cerebral palsy, or sensory impairments, including vision or hearing deficits. Prior to participation, written informed consent was obtained from the children's parents or legal guardians. The sample included 26 girls and 39 boys, with a mean age of 5.64 years ($SD = 0.38$). The participants were assessed using the Primitive Reflex Test, which evaluated three specific reflexes: the ATNR, STNR, and TLR. Additionally, the Bruininks–Oseretsky Test of Motor Proficiency, second edition, Short Form (BOT-2SF) [24] was administered to measure the overall motor skills.

Primitive reflex test

The examiner evaluated the level of retention of primitive reflexes with the primitive reflex test, which consisted of three test positions: the ATNR test (Schilder test), the STNR test (Bender Purdue test), and the TLR test (erect test), which is an observational test (clinical observation), which is the standard for testing the retention of the primitive reflexes. The tester observes and evaluates the results according to the scoring criteria referring to the study of Pecuch et al. [18]. The total score (maximum of 24 points) for the reflex test was transformed to the level of reflex activity on a scale from 0 to 4 (reflex score 0–1 = 1 no reflex activity, 2–8 = 2 low reflex activity, 9–14 = 3 medium reflex activity, 15–21 = 4 high reflex activity, and 21–24 = maximum activity). Higher scores indicate poorer reflex integration [25].

Schilder test for ATNR

The child should stand with the feet together, arms straight out at shoulder height, and wrists relaxed.

Scoring:

0 – no response, indicating straight arms out in front.

1 – Move the arms up to 20° to the same side as the head or drop them slightly.

2 – Arms can move up to 45° as the head turns, or the arms may drop.

3 – Arm movement > 45° to the side or down, swaying, or loss of equilibrium due to head rotation [4, 26].

Bender–Purdue reflex test for STNR

The child should assume a quadruped position. Instruct them to kneel in a four-point position with the hands and knees.

Scoring: During the extension phase, the primary emphasis was on increased upper-limb extensor tone and lower-limb flexion, such as an inclination to sit on the heels. A favourable score was given during the flexion phase if there was enhanced flexor tone in the arms and extensor tone in the lower part of the body.

0 – no reaction.

1 – Tremor in one or both arms or a slight movement of the hip.

2 – Elbow and/or hip bend, or back arch.

3 – Clear bending of the arms as a result of head flexion.

4 – Bending the arms to the floor in reaction to head flexion or returning the bottom to the ankles as an effect of head extension.

Erect test for TLR

The child should stand straight, feet together, arms at their sides, eyes open, and looking straight ahead (remembering that the tester must stay behind or next to the child at all times during the test, as head movement can cause the child to lose their balance).

Scoring:

0 – indicates no response.

1 – A slight shift in balance and tone of muscles due to a change in head positioning.

2 – Impaired balance during the test, as well as changes in muscle tone.

3 – Near loss of balance, muscular tone changes, and/or confusion as a result of the test method.

4 – Loss of balance and/or a significant increase in muscle tone in an attempt to maintain balance. This could be accompanied by dizziness or disorientation.

Motor proficiency test

The BOT-2SF was utilised to assess the children's motor proficiency. The BOT-2 is a widely recognised, standardised, norm-referenced tool designed to evaluate fine and gross motor skills in individuals aged 4 to 21 years. It includes eight subtests that measure Fine Motor Precision, Fine Motor Integration, Manual Dexterity, Bilateral Coordination, Balance, Running Speed and Agility, Upper-Limb Coordination, and Strength [24]. The BOT-2SF comprises 14 tasks, such as drawing lines through crooked paths, folding paper, copying shapes (square and star), transferring pennies, ball-handling (dropping, catching, and dribbling), jumping in place with synchronised movements, tapping feet and fingers, walking forwards along a line, performing a one-legged stationary hop, balancing on one leg on a beam with the eyes open, knee push-ups, and sit-ups. The test takes approximately 25–30 min to administer. Scores can be reported as total point scores, standard scores, percentile ranks, or descriptive categories. For this study, the total BOT-2SF point score was used. Evidence supports the BOT-2SF's reliability and validity, as demonstrated by recent studies [27, 28]. The scoring system is different for each item, with the total score ranging from 0 to 88 points. The raw results can be transformed into normal numerical scores. Every child receives a sum of raw scores, resulting in a total motor composite, converted into a points score and then to a standard score and percentile (specific age group and gender) using a guide table. A higher score indicates improved motor abilities [29, 30], and can be categorised into 5 levels (well below average, below average, average, above average, and significantly above average).

Statistical analyses

Statistical analysis was performed using SPSS version 18. Descriptive statistics were used to summarise key demographic and clinical information, including gender, age, and perinatal status. The Shapiro–Wilk test was applied to evaluate the data distribution. In cases where the data followed a normal distribution, Pearson's correlation was used to examine the relationship between primitive reflexes and motor proficiency. If the data were non-normally distributed, Spearman's rank correlation was applied instead. The magnitude of the correlation was classified per the following thresholds; r = 0.1–0.29 small, 0.3–0.49 moderate, 0.5–0.69 large, 0.7–0.89 very large, 0.9–0.99 nearly perfect, 1 perfect [31]. A significance level of $p < 0.05$ was set for all statistical tests.

Results

Reflex activity level among preschool participants

Table 1 presents the distribution of primitive reflex scores, with the ATNR assessed on a 4-point scale (0–3) and the STNR and TLR on a 5-point scale (0–4). For the ATNR, over half of the participants showed mild reflex persistence (score 1) on both the right and left sides of the body, while fewer exhibited moderate-to-strong persistence (scores 2–3). STNR flexion was mostly absent, with 70.8% scoring 0, whereas STNR extension showed greater persistence, with 44.6% scoring 1 and 40% scoring 2 or 3. Similarly, TLR flexion was predominantly absent (69.2% scoring 0), while TLR extension exhibited greater variability, with 33.8% scoring 1 and 38.4% scoring 2 or 3. Overall, mild reflex persistence was the most common, and extreme reflex persistence (score 4) was absent, reflecting a range of motor control development within the sample.

Table 1. Distribution of primitive reflex scores across different reflex types (*n* = 65)

Reflex	Scale [*n* (%)]				
	0	1	2	3	4
ATNR R	8 (12.3)	34 (52.3)	13 (20.0)	10 (15.4)	n/a
ATNR L	5 (7.7)	35 (53.8)	18 (27.7)	7 (10.8)	
STNR FLX	46 (70.8)	16 (24.6)	3 (4.6)	0	0
STNR EX	10 (15.4)	29 (44.6)	24 (36.9)	2 (3.1)	0
TLR FLX	45 (69.2)	12 (18.5)	4 (6.2)	4 (6.2)	0
TLR EX	18 (27.7)	22 (33.8)	16 (24.6)	9 (13.8)	0

0, 1, 2, 3, 4 – level of reflex activity
ATNR R/L – asymmetrical tonic neck reflex right/left
STNR FLX/EX – symmetrical tonic neck reflex flex/extend
TLR FLX/EX – tonic labyrinthine reflex flex/extend
n/a – not applicable to this reflex type

Motor proficiency assessment: variability across BOT-2SF subtests

The results from the BOT-2SF subtests (Table 2) show varied levels of motor proficiency among participants. The distribution of scores was as follows: 3% were categorised as well below average, 25.8% as below average, 68.2% as average, and 3% as above average. Specific areas of performance revealed high average proficiency with moderate variability in fine motor skills (precision, integration), balance, and bilateral coordination. Manual dexterity showed mid-range performance with low variability, while running speed, upper limb coordination, and strength displayed lower scores and higher variability.

Table 2. Descriptive statistics of BOT-2SF subtest scores

BOT-2SF test/subtest	Min–Max	Mean	*SD*
Fine motor precision	0–14	6.42	3.08
Fine motor integration	0–10	6.71	2.70
Manual dexterity	0–6	3.54	1.29
Bilateral coordination	0–7	5.26	2.09
Balance	3–8	6.14	1.45
Running speed and agility	0–9	4.55	3.09
Upper limb coordination	0–9	2.63	2.55
Strength	0–10	2.92	2.51
BOT-2SF total score	6–63	38.03	11.62
BOT-2SF classification	well below average [*n*, (%)]	2 (3)	
	below average [*n*, (%)]	17 (25.8)	
	average [*n*, (%)]	44 (68.2)	
	above average [*n*, (%)]	2 (3)	

Impact of retained primitive reflexes on motor proficiency: correlational analysis

The results (Table 3) indicate significant relationships between the primitive reflex scores (ATNR, STNR, TLR, and reflex test) and various subtests of the BOT-2SF. The STNR showed the most consistent negative correlations across subtests, with significant associations in Fine Motor Precision ($p < 0.001$), Bilateral Coordination ($p < 0.05$), Balance ($p < 0.01$), Upper Limb Coordination ($p < 0.001$), and Strength ($p < 0.01$), as well as with the BOT-2SF Total Score ($p < 0.001$) and BOT-2SF Standard Score ($p < 0.001$), indicating a moderate correlation. The Total Reflex test demonstrated a strong correlation with the BOT-2SF total score ($p < 0.001$) and moderate negative correlations with Fine Motor Precision ($p < 0.001$), Bilateral Coordination ($p < 0.01$), and Strength ($p < 0.001$), as well as the BOT-2SF standard score ($p < 0.001$). The ATNR and TLR demonstrated fewer but significant correlations, notably with Fine Motor Precision, Bilateral Coordination, and Upper Limb Coordination, highlighting the impact of retained reflexes on motor proficiency. These findings suggest that greater reflex retention is associated with lower motor performance across multiple domains.

Impact of retained primitive reflexes on BOT-2SF standard scores

Table 4 displays the BOT-2SF standard scores categorised by the number of retained primitive reflexes

Table 3. Correlation coefficients between primitive reflex scores and BOT-2SF subtest performance

BOT-2SF test/subtest	ATNR		STNR		TLR		Total primitive reflex	
	r	*p*-value	*r*	*p*-value	*r*	*p*-value	*r*	*p*-value
Fine motor precision	–0.269*	0.030	–0.467**	0.000	–0.297*	0.016	–0.461**	0.000
Fine motor integration	–0.077	0.544	–0.118	0.348	–0.087	0.492	–0.100	0.427
Manual dexterity	–0.009	0.941	–0.128	0.308	–0.046	0.715	–0.082	0.515
Bilateral coordination	–0.233	0.062	–0.305*	0.014	–0.281*	0.023	–0.384**	0.002
Balance	–0.063	0.616	–0.375**	0.002	–0.124	0.324	–0.247*	0.048
Running speed and agility	–0.371**	0.002	–0.209	0.094	–0.203	0.104	–0.356**	0.004
Upper limb coordination	–0.214	0.086	–0.427**	0.000	–0.273*	0.028	–0.441**	0.000
Strength	–0.170	0.176	–0.363**	0.003	–0.302*	0.015	–0.440**	0.000
BOT-2SF total score	–0.316*	0.010	–0.498**	0.000	–0.361**	0.003	–0.543**	0.000
BOT-2SF standard score	–0.206	0.100	–0.484**	0.000	–0.248*	0.047	–0.433**	0.000

ATNR – asymmetrical tonic neck reflex, STNR– symmetrical tonic neck reflex, TLR – tonic labyrinthine reflex
* significant at the 0.05 level, ** significant at the 0.01 level

Table 4. ANOVA and post hoc results: BOT-2SF standard scores

Source	Sum of squares	*df*	Mean square	*F*	*p*-value
Between groups	849.01	2	424.50	7.55	0.001
Within groups	3485.85	62	56.22		

Post hoc tests

(I) Number of retained primitive reflexes (mean ± *SD*)	(J) Number of retained primitive reflexes (mean ± *SD*)	Mean difference (I–J)	*SE*	*p*-value
no reflex retain (48.48 ± 7.70)	2–3 reflex retain (38.38 ± 5.77)	10.094*	2.602	0.000
1 reflex retained (44.41 ± 7.98)	2–3 reflexes retained (38.38 ± 5.77)	6.029*	2.503	0.033

SE – standard error
Dunnett *t*-tests treat one group as a control and compare all other groups against it.
* The mean difference is significant at the 0.05 level.

(ATNR, STNR, or TLR). Specifically, 35.38% of participants exhibited no retained reflexes, 44.62% exhibited one retained reflex, and 20% exhibited retention of 2–3 reflexes. Post hoc comparisons revealed that participants with no retained reflexes had significantly higher scores than those with 2–3 retained reflexes ($p < 0.001$), and those with one retained reflex also had significantly higher scores than those with 2–3 retained reflexes ($p < 0.05$). These results suggest that retaining more primitive reflexes is associated with lower BOT-2SF standard scores.

Discussion

Our study examines key primitive reflexes related to body positioning – specifically, the ATNR, STNR, and TLR – and their retention in preschool children. We explore the relationship between the persistence of these reflexes and motor proficiency. These primitive reflexes are fundamental to early childhood postural development, serving as the foundation for balance, coordination, and muscle tone. Their proper integration is essential for the development of efficient motor function and movement control, enabling children to engage in more advanced motor activities as they grow. The ATNR, for example, helps infants develop head and neck control, while the STNR and TLR are involved in establishing the foundation for upright posture, crawling, and overall body coordination [25]. Currently, only a few studies have investigated primitive reflex retention in healthy preschoolers [13,14]. Most previous studies have focused on school-aged children and children with special needs, such as ADHD [19, 20], ASD [21, 22], and cerebral palsy [23], to demonstrate the association between preserved primitive reflexes and problems with reading, learning, telling time, and retaining attention. The level of non-integrated reflexes in this group is high compared to healthy children. The participants in our study were healthy Thai preschool children with no reported special needs, and they were assessed for the presence of the ATNR, STNR, and TLR. Our study is the first to report retained primitive reflexes in Thailand. Notably, 65% of the children exhibited persistent primitive reflexes, with 44.62% retaining one reflex and 20% retaining 2–3 reflexes. In contrast, 35.38% of the participants demonstrated no retained reflexes. A similar prevalence of retained primitive reflexes was found in previous research by Gieysztor et al. [14], where over 60% of preschool children in Poland exhibited at least one retained primitive reflex, with 25% of them showing reflexes at levels 3 and 4, indicating that most of the examined preschool children had non-integrated reflexes.

This study assessed motor proficiency in children using the BOT-2SF, with a mean score of 38.0 (*SD* = 11.6). The distribution of performance levels showed that 3% of children scored well below average, 25.8% fell below average, 68.2% performed within the average range, and 3% scored above average. The study also examined the relationship between primitive reflex retention and motor proficiency in healthy Thai preschoolers. Correlation analyses revealed significant negative associations between primitive reflex retention and various motor proficiency subtests. Among the assessed reflexes, the STNR showed the most consistent negative correlations across multiple motor domains, including fine motor precision, bilateral coordination, balance, upper limb coordination, and strength. Additionally, the total primitive reflex retention score demonstrated moderate negative associations with fine motor precision, bilateral coordination, strength, and overall motor proficiency (BOT-2SF total score). While the ATNR and TLR displayed fewer significant correlations, they still negatively impacted key motor skills. Notably, fine motor precision and upper limb coordination appeared particularly vulnerable to retained reflexes, with the STNR showing the most substantial negative impact. Furthermore, children with higher reflex retention scores exhibited lower BOT-2SF total and standard scores, reinforcing the inverse relationship between primitive reflex retention and motor proficiency. These findings suggest that greater retention of primitive reflexes, especially the STNR, is linked to poorer motor function across multiple domains. This highlights the importance of early screening and intervention to mitigate the effects of retained primitive reflexes and support optimal motor skill development in preschool-aged children.

Further analysis of the impact of retained primitive reflexes on BOT-2SF standard scores revealed that participants with no retained reflexes had significantly higher scores than those with 2–3 retained reflexes. Additionally, children with one retained reflex also scored higher than those with 2–3 retained reflexes. These findings suggest that a higher number of retained primitive reflexes is associated with lower motor proficiency, as children with greater reflex activity demonstrated lower motor skills. This is consistent with studies by Gieysztor et al. [14] and Pecuch et al. [25], which found similar inverse correlations between reflex scores and motor proficiency. Our study, the first to assess the relationship between primitive reflexes and motor proficiency using the BOT-2, supports the notion that retained reflexes hinder motor development. Blythe [8] stated that the BOT-2 is a highly accurate measure of motor skills, further validating the significance of our findings. This finding demonstrates that the retention of primitive reflexes inhibits children's motor development, leading to severe struggles. Our study, the first to use the BOT-2 to explore this link, supports the idea that retained primitive reflexes hinder motor development. Additionally, previous research indicates that delayed motor responses and retained reflexes can negatively affect learning and daily activities, with the impact intensifying as children grow older [11–13]. Although some studies suggest that primitive reflexes may disappear with age, our findings highlight the importance of early assessment and intervention to prevent delays in skill development.

Conclusions

Our study is the first in Thailand to examine the impact of retained primitive reflexes on motor proficiency in Thai preschoolers and to apply the BOT-2 in this research area. This study reveals a significant inverse relationship between retained primitive reflexes and motor proficiency in preschoolers, underscoring the importance of early detection and intervention. Based on our findings, we advocate for early assessment programs to detect retained reflexes. Timely interventions, such as reflex integration therapy, can reduce potential impacts on academic and daily functioning. Collaboration among schools, paediatricians, and healthcare professionals is vital to raise awareness and provide timely support, particularly for at-risk children.

The current study has several limitations. First, the sample size is relatively small and homogenous, and therefore may not fully represent the broader Thai preschool population. Additionally, the cross-sectional design prevents the establishment of causal relationships between retained reflexes and motor proficiency. The use of specific assessment tools, such as the BOT-2SF, may not capture all aspects of motor proficiency or reflex persistence. Finally, environmental and contextual factors, such as socio-economic status and physical activity levels, were not controlled, which could have influenced the results.

Ethical approval

The research related to human use complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Research Ethics Committee of Mahidol University, Thailand (approval No.: MU-CIRB 2024/055.1203).

Informed consent

Informed consent was obtained from all individuals included in this study.

Conflict of interest

The authors state no conflict of interest.

Disclosure statement

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References

[1] Diamond A. Executive functions. Ann Rev Psychol. 2013;64:135–68; doi: 10.1146/annurev-psych-113011-143750.
[2] Capute AJ, Accardo PJ, Vining EP, Rubenstein JE, Ronald Walcher J, Harryman S, Ross A. Primitive reflex profile. A pilot study. Phys Ther. 1978;58(9):1061–5; doi: 10.1093/ptj/58.9.1061.
[3] Schott JM, Rossor MN. The grasp and other primitive reflexes. J Neurol Neurosurg Psychiatry. 2003;74(5):558–60; doi: 10.1136/jnnp.74.5.558.
[4] Goddard S. Reflexes, Learning and Behavior. A Window into the Child's Mind. A Non-Invasive Approach to Solving Learning and Behavior Problems. Eugene: Fern Ridge Press; 2002.
[5] van Kranen-Mastenbroek VH, Folmer KB, Caberg HB, Kingma H, Blanco CE, Troost J, Hasaart TH, Vles JS . The influence of head position and head position change on spontaneous body posture and motility in full-term AGA and SGA newborn infants. Brain Dev. 1997;19(2):104–10; doi: 10.1016/s0387-7604(96)00484-6.
[6] McPhillips M, Hepper PG, Mulhern G. Effects of replicating primary-reflex movements on specific reading difficulties in children: a randomised, double-blind, controlled trial. Lancet. 2000;355(9203):537–41; doi: 10.1016/s0140-6736(99)02179-0.
[7] Zafeiriou DI. Primitive reflexes and postural reactions in the neurodevelopmental examination. Pediatr Neurol. 2004;31(1):1–8; doi: 10.1016/j.pediatrneurol.2004.01.012.
[8] Blythe SG. Assessing Neuromotor Readiness for Learning. The INPP Developmental Screening Test and School Intervention Programme. John Wiley and Sons; 2012.
[9] Blythe SG. Neuromotor Immaturity in Children and Adults. The INPP Screening Test for Clinicians and Health Practitioners. John Wiley and Sons; 2015.
[10] Blythe SG, Beuret LJ, Blythe P. Attention, Balance, and Coordination. The A.B.C. of Learning Success. Wiley-Blackwell; 2009.
[11] Canevska OR, Mihajlovska M. Persistence of primitive reflexes and associated problems in children. Ann Fac Philos Skopje. 2019;72(22):513–522; doi: 10.37510/godzbo1972513rc.
[12] Grigg T, Culpan I, Turnbull W. Primitive reflex integration and reading achievement in the classroom. J Neurol Exp Neurosci. 2023;9(1):18–26; doi: 10.17756/jnen.2023-103.
[13] Hickey J, Feldhacker DR. Primitive reflex retention and attention among preschool children. J Occup Ther Sch Early Interv. 2022;15(1):1–13; doi: 10.1080/19411243.2021.1910606.
[14] Gieysztor EZ, Choińska A, Paprocka-Borowicz M. Persistence of primitive reflexes and associated motor problems in healthy preschool children. Arch Med Sci. 2018;14(1):167–73; doi: 10.5114/aoms.2016.60503.
[15] Blythe SG. Neuromotor Immaturity in Children and Adults. The INPP Screening Test for Clinicians and Health Practitioners. John Wiley and Sons; 2014.
[16] Berne SA. The primitive reflexes: considerations in the infant. Optom Vis Dev. 2006;37(3):136–45.
[17] Blythe SG, Duncombe R, Preedy P, Gorely T. Neuromotor readiness for school: the primitive reflex status of young children at the start and end of their first year at school in the United Kingdom. Education 3-13. 2022;50(5):654–67; doi: 10.1080/03004279.2021.1895276.

[18] Pecuch A, Gieysztor E, Telenga M, Wolańska E, Kowal M, Paprocka-Borowicz M. Primitive reflex activity in relation to the sensory profile in healthy preschool children. Int J Environ Res Public Health. 2020;17(21):8210; doi: 10.3390/ijerph17218210.
[19] Konicarova J, Bob P. Retained primitive reflexes and ADHD in children. Act Nerv Super. 2012; 54(3–4):135–8.
[20] Melillo R, Leisman G, Mualem R, Ornai A, Carmeli E. Persistent childhood primitive reflex reduction effects on cognitive, sensorimotor, and academic performance in ADHD. Front Public Health. 2020;8:431835; doi: 10.3389/fpubh.2020.431835.
[21] Melillo R, Leisman G, Machado C, Machado-Ferrer Y, Chinchilla-Acosta M, Melillo T, Carmeli E. The relationship between retained primitive reflexes and hemispheric connectivity in autism spectrum disorders. Brain Sci. 2023;13(8):1147; doi: 10.3390/brainsci13081147.
[22] Melillo R, Leisman G, Machado C, Machado-Ferrer Y, Chinchilla-Acosta M, Kamgang S, Melillo R, Leisman G, Machado C, Machado-Ferrer Y, Chinchilla-Acosta M, Melillo T, Carmeli E. Retained primitive reflexes and potential for intervention in autistic spectrum disorders. Front Neurol. 2022; 13:922322; doi: 10.3389/fneur.2022.922322.
[23] Sigafoos J, Roche L, O'Reilly MF, Lancioni GE. Persistence of primitive reflexes in developmental disorders. Curr Dev Disord Rep. 2021;8:98–105; doi: 10.1007/s40474-021-00232-2.
[24] Bruininks R, Bruininks B. Bruininks–Oseretsky Test of Motor Proficiency. 2nd ed. Minneapolis: NCS Pearson; 2005.
[25] Pecuch A, Gieysztor E, Wolańska E, Telenga M, Paprocka-Borowicz M. Primitive reflex activity in relation to motor skills in healthy preschool children. Brain Sci. 2021;11(8):967; doi: 10.3390/brainsci11080967.
[26] Morrison DC, Hinshaw SP, Carte ET. Signs of neurobehavioral dysfunction in a sample of learning disabled children: stability and concurrent validity. Percept Mot Skills. 1985;61(3):863–72; doi: 0.2466/pms.1985.61.3.863.
[27] Yoon D, Choi D, Kim M, Ji S, Joung Y-S, Kim EY. Validity of the BOT-2 short form for Korean school-age children: a preliminary study. Children. 2024; 11(6):724; doi: 10.3390/children11060724.
[28] Köse B, Kara ÖK, Kara K, Karabulut E, Şahin S. Investigating the compatibility, interchangeability, and clinical usability of BOT2-BF and BOT2-SF in primary school-aged children with and without developmental dyslexia. Appl Neuropsychol Child. 2022;11(3):391–9; doi: 10.1080/21622965.2020.1862656.
[29] Cools W, De Martelaer K, Samaey C, Andries C. Movement skill assessment of typically developing preschool children: a review of seven movement skill assessment tools. J Sports Sci Med. 2009;8(2):154–68.
[30] Dana A, Ranjbari S, Chaharbaghi Z, Ghorbani S. Association between physical activity and motor proficiency among primary school children. Int J School Health. 2023;10(3); doi: 10.30476/INTJSH.2023.98237.1295.
[31] Hopkins WG, Marshall SW, Batterham AM, Hanin J. Progressive statistics for studies in sports medicine and exercise science. Med Sci Sports Exerc. 2009;41:3–12; doi: 10.1249/MSS.0b013e31818cb278.

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