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Original

Effect of a psychoeducational intervention on motor and perceptual-visual development through the inhibition of primitive reflexes in schoolchildren aged 4 to 7 years old☆

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ABSTRACT

The efficacy of the *Assessing Neuromotor Readiness for Learning* (Blythe, 2012) on primitive reflex inhibition is described. The sample consisted of 25 girls and 21 boys aged 4–7 years (M = 4.84, SD = 1.10). For the sake of evaluating the efficacy of the intervention, the Developmental Screening by the Chester Institute of Neurophysiological Psychology, INPP (Blythe, 2012), was used by means of a pretest-posttest design with a control group. The statistical analyses performed were ANCOVA and factorial ANOVA—depending on the fulfilment of the assumptions. The main findings refer to the existence of active primitive reflexes in the sample, and how these primitive reflexes are sensitive to the psychoeducational intervention of reflex inhibition through movement. Besides, the involvement of primitive reflex inhibition in the improvement of motor development—but not in perceptual-visual development—has been proved.

Efecto de una intervención psicoeducativa en el desarrollo motor y perceptivo-visual a través de la inhibición de los reflejos primitivos en escolares de 4 a 7 años

Palabras clave:
Reflejos primitivos
Inhibición
Intervención
Desarrollo motor
Desarrollo perceptivo-visual

RESUMEN

Se presenta la eficacia del programa *Assessing Neuromotor Readiness for Learning* (Blythe, 2012) sobre la inhibición de los reflejos primitivos. La muestra está formada por 25 niñas y 21 niños de 4 a 7 años (M = 4.84, DT = 1.10). Para evaluar la eficacia de la intervención se ha utilizado *el Screening del Desarrollo* del Instituto de Psicología Neurofisiológica de Chester, INPP (Blythe, 2012) a través de un diseño pretest-postest con grupo control. Los análisis estadísticos realizados han sido ANCOVA y ANOVA factorial, en función del cumplimiento de los supuestos. Los principales hallazgos hacen referencia a la existencia de reflejos primitivos activos en la muestra y cómo estos reflejos primitivos son sensibles a la intervención psicoeducativa de inhibición de reflejos mediante el movimiento. Además, se ha puesto de manifiesto la implicación de la inhibición de los reflejos primitivos en la mejora en el desarrollo motor, pero no en el desarrollo perceptivo-visual.

Introduction

Primitive reflexes comprise a group of automatic motor responses directed from the brainstem and regulated by the cerebral cortex (Diamond, 2013; Mosquera & Serrano, 2017). These reflexes are the most basic survival mechanism in the neonate. At the same time, reflexes function as an initial exercise that allows

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for developing later motor skills (Blythe, 2005; Gallahue et al., 2006; García-Alix & Quero, 2012). These early motor responses in the neonate are stimulus-dependent and involuntary. Thus, the baby cannot inhibit them until they develop the first perceptual processes and cortical control allowing them to manage their behaviour and inhibit automatic responses (García Molina et al., 2009; Ivanović et al., 2019). Today, primitive reflexes are considered as complex motor patterns (García-Alix & Quero, 2012).

In neonates, the sensorimotor cortex is the area with the highest metabolic activity. It grows during the second and third month of life towards areas related to vision and hearing, and during the eighth month, towards the frontal cortex (Merlo, 2006). Therefore, during the first year of life, this process takes place at the same time that primitive reflexes are inhibited, and repetitive motor activities are observed in the neonate's behaviour. From the repeated motor sequences, motor learning is subsequently developed. This contributes to the maturation of the infant's basic motor system, improving their motor skills, and to the development and maturation of the more complex functions of the cortical-subcortical circuits involved both in higher perceptual and cognitive processes (Bushnell & Boudreau, 1993; Campos et al., 2012; Diamond, 2000; Merlo, 2006; Murray et al., 2006). The cortical-subcortical circuits are considered a series of hierarchically organised modules, in a way that some difficulty at different levels—cortical and/or subcortical—generates an important variety of complications from a neuropsychological point of view (Heyder et al., 2004).

Repeated motor sequences and motor learning lead to changes in the synaptic organization of the motor system by increasing the number of representations, engrams, or motor maps corresponding to the movements performed. Therefore, if the movements are not repeated during the first year of life, the synaptic reorganization of the motor map affecting the integration of primitive reflexes does not occur (Kleim et al., 2002). Thus, primitive reflexes remain active and stimulus-dependent without generating postural reflexes and the maturation of more complex perceptual and cognitive processes (Blythe, 2002; Melillo & Leisman 2010; Thelen, 2010). Studies such as that of Bein-Wierzbinski (2001) point out the relationship between primitive reflexes and perceptual processes—after implementing a primitive reflex inhibition program, it shows how the intervention group improves in relation to visuomotor functioning. In the same vein, the presence of primitive reflexes in schoolchildren—and how these reflexes correlate with reduced saccadic accuracy and impaired reading ability—is detected. It also defines the impairment of fine and gross motor development in relation to vision. The presence of primitive reflexes has been related to poor eye movements, poor distance-to-near fixation, difficulty with eye-hand coordination, and visual memory (Berne, 2006). The primitive reflexes that are most affected by visuomotor development are the Moro reflex, the tonic labyrinthine reflex, the spinal Galant reflex, the asymmetrical tonic reflex, and the symmetrical tonic reflex (Berne, 2006). However, the study by Andrich et al. (2018) found no evidence for the spinal Galant reflex and the Moro reflex. Initial studies by Black (1995) and Blythe and Hyland (1998) show that infants with neurodevelopmental difficulties respond to physical exercise programs by improving both their motor and school skills (Allen & Donald, 1995), as well as social competence (Bluechardt et al., 1995). These results have been confirmed in Blythe (2002), Pica (2015), and Summerford (2001).

The current perspective points out that movement is at the base of the brain structure (Diamond, 2000; Piek et al., 2004), which implies that movement allows for restructuring the brain (Bernhardsson & Davidson, 1983), and that the sensorimotor system makes the brain learn to organise itself more efficiently than any other system (Blythe & Hyland, 1998; Kokot, 2003). Consequently, a psychomotor intervention program based on a bottom-up processing approach can maximise the potential outcomes of schoolchildren (Noguera Machacón et al., 2013), both in motor and perceptual development, as well as in learning. Nevertheless, the study of brain structure functioning from a top-down processing approach remains dominant—in fact, most studies focus on understanding executive functions and cognitive processes (Thelen, 2000).

For a movement-focused psychoeducational program to improve school competencies, it must be based on knowledge of the biological basis of learning difficulties and neurodevelopment (Fredericks et al., 2006). Blythe et al. (2009) state that systems affecting the development of motor, vestibular, and postural systems are among the biological bases behind learning. This program should begin with the tactile and vestibular systems, followed by the visual, auditory, and proprioceptive systems. It must also include the relationship between the persistence of uninhibited primitive reflexes and undeveloped postural reflexes (Blythe, 2002). Certain studies point out that primitive reflexes may be active in the individual beyond the expected time (Bilbilaj et al., 2017; Blythe et al., 2009; García-Alix & Quero, 2012; McPhillips & Sheehy, 2004)—in many of these cases, the active presence of reflexes is not interpreted as an indicator of pathology, but it may be at the basis of certain difficulties (García-Alix & Quero, 2012). Specifically, the tonic labyrinthine reflex (TLR), symmetrical tonic neck reflex (STNR), and asymmetrical tonic neck reflex (ATNR) are related to both school and social difficulties (Bilbilaj et al., 2017; Blythe & Hyland, 1998; Blythe et al., 2009; McPhillips & Sheehy, 2004; Piek et al., 2004).

The psychoeducational purpose of this study has been the integration of primitive reflexes in the development of a sample of schoolchildren—that is, to help develop more mature response patterns involving the emergence of postural reflexes by repeating a series of routines. This repetition favours the maturation process of the brain structure, which in turn leads to anatomical and genetic changes, together with the capacity to generate functions through learning (Olivé, 2001). In relation to this, the school program *Assessing Neuromotor Readiness for Learning* (Blythe, 2012) is presented. It consists of a battery of tests, together with an ordered sequence of movements that combine executions which are typical of motor developmental milestones with movements aimed at inhibiting reflexes. This program has studies that endorse both the evaluation and the results of its implementation in different educational centres such as Mellor school, Prince Albert school, Swanwick school, NEELB school in the UK (Blythe, 2005) prior to its official publication (Blythe, 2012), the Care and Educational Complex in Krakow, Poland (Grzywniak, 2016), different public and non-public schools in Vlora, Albania (Bilbilaj et al., 2017), and a group of schools in Lower Silesia, Poland (Gieysztor et al., 2018). Implementing the psychoeducational program has led to improvements in motor areas such as balance and movement coordination (Blythe, 2005; Gieysztor et al., 2018), in academic performance through improved reading and learning skills (Bilbilaj et al., 2017; Blythe, 2005; Chinello et al., 2018; Matuszkiewicz & Gałkowski, 2021), and in behavioural difficulties (Bilbilaj et al., 2017; Grzywniak, 2017).

Combining exercises specific to motor developmental milestones with movements aimed at inhibiting reflexes is what differentiates the *Assessing Neuromotor Readiness for Learning* (Blythe, 2012) from other movement programs, such as *Blomberg Rhythmic Movement Training* (Blomberg, 2014), which assesses only movements aimed at primitive reflex inhibition, or Padovan (1997), based on movements from motor developmental milestones, and for which there is still not much scientific evidence published (da Silva Neto et al., 2016). The systematic search of databases (PsycInfo, Proquest, Scopus, Web of Science, PubMed and ScienceDirect) on primitive reflexes intervention programs ("primitive reflexes" and "intervention") in schoolchildren across full-text and peer-reviewed studies—excluding those that examined neurodiverse conditions—has yielded few studies at the international level (Callcott, 2012; Gieysztor et al., 2018; Goddard Blythe et al., 2022; Kalemba et al., 2023) and none at the national level. Therefore, this study aims to pioneer the exploration of how an intervention affects primitive reflex inhibition in a national sample, and to be one of the few studies at international level using such a young sample.

The objective of this research is to evaluate the impact of the school intervention program *Assessing Neuromotor Readiness for Learning* (Blythe, 2012) in the development of a group of schoolchildren. To this end, the following objectives were established: (1) to estimate the presence of the symmetrical tonic reflex (STR), asymmetrical tonic neck reflex (ATNR), and tonic labyrinthine reflex (TLR) in the study sample; (2) to analyse the differences in primitive reflexes between the intervention group and the control group after the intervention; (3) to estimate the impact on the neuromotor test scores after the intervention; and (4) to estimate how the visual perception test results are affected after the intervention. The research hypotheses are as follows: (1) the initial evaluation of all schoolchildren will show an evident presence of primitive reflexes; (2) the intervention group will show a statistically significant decrease in the presence of primitive reflexes with respect to the control group; (3) the intervention group will show a statistically significant improvement in the neuromotor test scores; and (4) the intervention group will show a statistically significant improvement in the visual perception test results.

Method

Participants

The research began with 53 schoolchildren—of these, only 51 finished. To set up the initial sample, all schoolchildren had the opportunity to be part of the program. The total sample consisted of 51 schoolchildren aged 4–7 years (27 girls and 24 boys) (M = 4.84, SD = 1.10) from the Maria Montessori International Centre in Malaga. The control group consisted of 25 schoolchildren (12 girls and 13 boys) (M = 5.03, SD = 1.11), and the intervention group consisted of 26 schoolchildren (15 girls and 11 boys) (M = 4.66, SD = 1.08). The assignment of the students to the groups was random—the even numbers from the official school list were assigned to the intervention group, and the odd numbers to the control group. The participants did not exhibit any associated pathologies. The sample presents a medium-high sociocultural level and comes from a mainly urban residential area.

Instruments

The Chester Institute of Neurophysiological Psychology—INPP—*Developmental Screening* (Blythe, 2012) was used for the initial and final assessments. The screening consists of a battery of tests assessing balance, proprioceptive skills, primitive reflexes, and visuomotor functioning through physical procedures that evoke movement (Bilbilaj et al., 2017; Blythe, 2005; Blythe, 2012; Grzywniak, 2016). The tests appearing in the screening are:

Primitive reflex test (Blythe, 2012): *asymmetrical tonic neck reflex right* (ATNR right) and *left* (ATNR left); *symmetrical tonic neck reflex in flexion* (STNR flex) and *in extension* (STNR ext); *tonic labyrinthine reflex in flexion* (TLR flex), and *in extension position* (TLR ext).

Neuromotor tests (Blythe, 2012): *Romberg test with eyes open* (RombergEyeOp) and *Romberg test with eyes closed* (RombergEyeClo), *one leg stand* with the *right leg* (OLSRight) and with the *left leg* (OLSLeft); *crawling on hands and knees* (Crawling); *Crossing the Midline Test 1* (Midline I) and *2* (Midline II) of Ayres (1972); *Finger and thumb opposition test with* both the *right hand* (FingerThumbRight) and the *left hand* (FingerThumbLeft).

Tests for visual perception, visual-motor and spatial integration (Blythe, 2012): Tansley's Standard Figures test and drawings based on the Bender Visual-Motor Gestalt Test (Bender, 1976). It evaluates visual perception—understood as the ability to correctly interpret what is seen—, visuomotor integration—understood as the ability to coordinate motor movement according to the visual stimulus—, and observable spatial difficulties in the size, orientation, and design of figures and shapes (*Circle, Cross, Square, X, Triangle, UnionJack*).

Each of the tests is scored from 0 to 4. 0 is used when no abnormality is detected, 1 if it shows a 25% level of dysfunction—it is considered a low level (low)—, 2 if it shows 50% dysfunction (medium), 3 shows 75% dysfunction (high), and 4 shows 100% dysfunction (very high).

Procedure

The participants in this research are schoolchildren from the Maria Montessori International Centre in Malaga, an educational centre fundamentally based on supporting and respecting children in their development process until they become adults. It considers education as a natural process that the individual carries out spontaneously, and learning is based on the experience provided by contact with the environment. The choice of the centre is made in the interest of its management team to prevent developmental difficulties that could affect school learning. The study design considered the standards of the Ethical Committee for Experimentation of the University of Malaga (CEUMA in Spanish), in accordance with the Declaration of Helsinki. In addition, the ethical acceptance of the centre's management is requested, as well as all the relevant permits for the research. The first stage consists in collecting data prior to the intervention, which is based upon the assessment of balance, proprioceptive skills, primitive reflexes, and visuomotor functioning. The assessment is performed by a guide in cooperation with one of the authors of the work trained in INPP, which is carried out individually in a room set up for this purpose. Data collection takes place at the beginning of the 2017 school year, after the first month of adaptation and throughout October. The second stage consists in implementing the movement program *Assessing Neuromotor Readiness for Learning* (Blythe, 2012) in the intervention group, while the control group continues its training according to the curriculum designed by the centre. The movement program takes place Monday through Friday for 10–15 minutes each day in the assigned movement classroom. The intervention lasts 7 months—from November to May. The third stage consists in collecting data after the intervention, which is carried out under the same conditions as the initial evaluation and takes place in June.

Data analysis

First, a descriptive analysis of the test scores was performed. Subsequently, based on a longitudinal design of pretest-posttest measures with a control group, ANCOVA and Factorial ANOVA tests were used, depending on the fulfilment of the assumptions, the factor being the group variable with two levels (control and intervention). The dependent variables (DV) were the scores of the primitive reflexes, neuromotor, and visual perception variables in the posttest, whereas the covariates were the scores of these same variables in the pretest. The IBM SPSS v. 25 statistical software was used for data analysis. For the calculation of the effect size, omega squared (ω^2) was used. Values between 0.01 and 0.06 indicate a small effect size, whereas values between 0.06 and 0.14 indicate a medium effect size, and those greater than 0.14, a large effect size (Field, 2013). To estimate the degree of reliability of the instruments used, McDonald's ω coefficient was used—it makes the calcula-

Table 1
Mean scores obtained in the different tests before the intervention

Test	Group	*M*	*SD*
Reflexes	Control group	15.52	4.11
	Intervention group	17.73	4.75
Neuromotor	Control group	21.04	5.34
	Intervention group	22.62	4.92
Visual	Control group	5.56	2.74
	Intervention group	6.23	3.54
Total	Control group	42.12	2.74
	Intervention group	46.58	3.54

Table 2
ANCOVA results showing *F-statistic* values, statistical significance (*p*) and effect size (ω^2), and confidence interval (95% CI)

Test	*F*	*p*	ω^2	95% CI
Reflexes	23.35	.000**	.276	0.12–0.49
Neuromotor	10.09	.003**	.157	0.02–0.35
Visual	2.86	.098		
Total	23.62	.000**	.275	0.12–0.49

*$p < .05$.
** $p < .01$.

tions more stable, reflects the true level of reliability, and does not depend on the number of test items.

Results

Table 1 shows the means of each of the tests evaluated in both groups before the intervention. Primitive reflexes are present both in the control group and in the intervention group. The data obtained indicate that there are no schoolchildren with low levels of primitive reflexes. Of the schoolchildren, 41.18% present a medium level, and 58.82% present a high level.

The internal consistency of the tests used was checked—it showed a high reliability using McDonald's ω: 0.96 for the total test, 0.85 for the reflex test, 0.82 for the neuromotor test, and 0.72 for the visual test. To evaluate the efficacy of the program in relation to the different study variables, a ANCOVA test was applied (Table 2), showing a statistically significant effect of the psychoeducational intervention on reflex tests, neuromotor tests, and total score, but not on visual tests.

To calculate the effect size, the omega-squared coefficient (ω^2) was used, which is appropriate for small samples as it provides an unbiased measure. The results show a large effect size in both primitive reflexes and neuromotor tests, as well as in the total test score, showing a decrease in their levels in the intervention group. Table 3 shows the descriptive statistics of the variables analysed after the intervention, where the differences in scores between the control group and the intervention group can be seen.

Figure 1 shows the results obtained in the pre-test and post-test in both groups, where lower levels of reflexes and neuromotor difficulties can be seen after the intervention.

In order to have a much more detailed description of the differences spotted after the intervention, an analysis was performed for each of the tests (see Table 4) by means of an ANCOVA or a factorial ANOVA blocking the pre-test variable when it was not possible to meet the homogeneity of slopes assumption.

The results show a statistically significant improvement in most of the neuromotor and reflex tests in the intervention group, compared to the control group, whereas there are no differences between the two groups in the perceptual-visual tests.

Discussion

The main findings of this study refer to the presence of the symmetrical tonic, asymmetrical tonic, and tonic labyrinthine reflexes in the study sample—thus corroborating the first hypothesis—, and the existence of these primitive reflexes in a sample of schoolchildren, as reported by authors such as Blythe (2012), Gieysztor et al. (2018), Goddard Blythe et al. (2022), and Pecuch et al. (2020) in their studies. All schoolchildren present active primitive reflexes, mainly at a moderate level (medium-high). This indicates that levels of primitive reflexes are usually high in children under 7, with low levels of reflexes not frequently found at these ages (Blythe & McGlown, 1979), and that these have not been automatically and naturally inhibited. However, the prevalence of uninhibited primitive reflexes in children varies from study to study. Goddard Blythe et al. (2022) state that 60% of 4–5 year old schoolchildren present uninhibited reflexes to a medium-high degree, but more importantly, only 2.5% show no signs of reflex retention. Gieysztor et al. (2018) point out that the reflex with the highest prevalence in infant sample is ATNR (right) and ATNR (left)—with approximately 80% presence in the sample—and that STNR in extension is present in approximately 70% of the sample. However, STNR in flexion is present in approximately 20%. Hickey and Feldhacker (2022) state that 100% of 4- to 6 year old schoolchildren tested have at least one retained reflex. The data obtained in this study indicate that the presence of uninhibited reflexes is generalised in children, showing that primitive reflexes are not fully inhibited during the first year-and-a-half of life. These results suggest that the evolutionary process of inhibition differs from its historical consideration. From a medical point of view, the presence of primitive reflexes is viewed as an indicative of some type of pathology (Blythe & McGlown, 1979). However, current studies postulate that primitive reflexes may remain active without implying the existence of any pathology (Gieysztor et al., 2018; Goddard Blythe et al., 2022), although developmental difficulties may arise (Goddard Blythe et al., 2022). The fact that reflexes are active in neurotypical population may be because during the first year of life, key developmental movements have not been frequently repeated—therefore, the synaptic reorganization of the motor map necessary for integration has not occurred (Kleim et al., 2002). Stress during pregnancy or maternal illness, as well as chronic stress, illness, trauma, or injury to the infant, may also cause reflexes not to be inhibited (Chandradasa & Rathnayake, 2020). Due to some of these reasons, the reflex remains active and is expressed in the presence of a stimulus that elicits it

Table 3
Descriptive statistics: means (*M*), standard deviations (*SD*), and adjusted means ($M_{adjusted}$) of the variables analysed

Test	Group	*M*	*DT*	$M_{adjusted}$
Reflexes	Control group	11.41	6.68	12.62
	Intervention group	5.43	6.04	4.27
Neuromotor	Control group	13.45	9.75	13.89
	Intervention group	7.30	4.64	6.88
Visual	Control group	2.90	1.65	3.03
	Intervention group	2.30	2.03	2.18
Total	Control group	27.77	15.39	30.11
	Intervention group	15.08	10.29	12.84

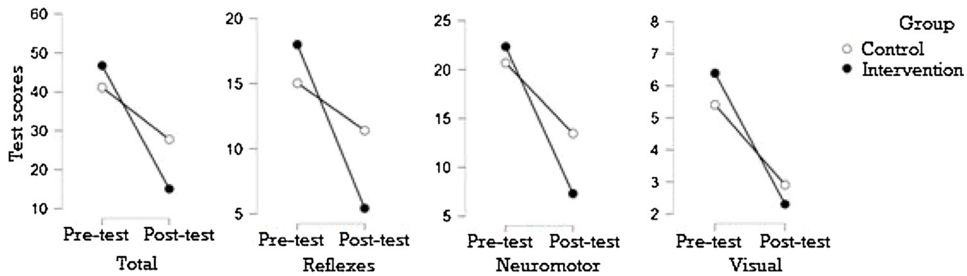

Figure 1. Line graphs with the means obtained in the two groups before and after the intervention.

Table 4
ANCOVA or factorial ANOVA results showing *F-statistic* value, statistical significance (p), effect size (ω^2), and confidence interval (95% CI)

Test	Test	F	p	ω^2	95% CI
	ATNR right	12.31	.001**	.20	0.04–0.38
	ATNR left	11.91	.001**	.19	0.03–0.37
	STNR flex	9.09	.004**	.14	0.02–0.33
Reflexes	STNR ext	9.48	.004**	.13	0.02–0.34
	TLR flex	3.67	.062		
	TLR ext	6.59	.014*	.09	0.00–0.29
	RombergEyeOp	11.03	.002**	.13	0.03–0.36
	RombergEyeClo	0.31	.579		
	OLSRight	7.57	.009**	.12	0.01–0.31
	OLSLeft	6.60	.014	.10	0.00–0.29
Neuromotor	Crawling	10.48	.002**	.17	0.03–0.35
	Midline I	4.72	.035*	.07	0.00–0.25
	Midline II	12.83	.001**	.19	0.04–0.39
	FingerThumbRight	1.07	.306		
	FingerThumbLeft	.13	.714		
	Circle	3.83	.057		
	Cross	0.03	.859		
	Square	.06	.809		
Visual	X	1.02	.322		
	Triangle	.01	.903		
	UnionJack	.03	.865		

* $p < .05$.
** $p < .01$.

(Blythe, 2002). Nonetheless, this expression varies depending on the development and maturation of the CNS. Thus, active primitive reflexes change the form of expression. The reflex will not be observed as in a newborn, but involuntary responses which are triggered by a stimulus will be found. The involuntary nature of the behavioural pattern and the presence of the same expression in different individuals highlights the existence of primitive reflexes. As Blythe (2017) points out, symptoms associated with symmetrical tonic neck reflex retention consist of poor upper and lower body integration, difficulty maintaining posture—especially when standing or sitting—, hypotonia, poor hand-eye coordination, and difficulty to estimate speed and time. Regarding the retention of the asymmetric tonic neck reflex, the difficulties refer to the ability to cross the midline of the body (cross pattern movement, crawling, bilateral integration, and establishment of laterality), as well as to problems in the development of independent eye movement. Finally, retention of the tonic labyrinthine reflex is observed in poor balance, postural difficulties, toe walking, low or high muscle tone, visual-perceptual issues, vertigo, and auditory confusion. These multiple symptoms can be mistaken as normotypic features in infants, but their presence is connected to the manifestation of primitive reflexes and not to other factors, since the different signs are associated in blocks to the presence or absence of reflexes.

In relation to the effectiveness of the treatment, the differences between the intervention group and the control group after intervening through the *Assessing Neuromotor Readiness for Learning* program (Blythe, 2012) have shown that the inhibition of primitive reflexes is greater in the intervention group, thus fulfilling the second hypothesis. Consequently, primitive reflexes are sensitive to the psychoeducational intervention of reflex inhibition. The mere passage of time to which the control group was subjected did not prove to be enough for inhibition to occur naturally—this corroborates data obtained in similar interventions conducted with older children (Demiy et al., 2020; Gieysztor et al., 2018; Hoag, 2015; Ivanović et al., 2019). Therefore, the psychoeducational intervention *Assessing Neuromotor Readiness for Learning* (Blythe, 2012) has been shown to be effective in working the symmetrical tonic, asymmetrical tonic, and tonic labyrinthine reflexes, helping to develop more mature response patterns, and thus integrating primitive reflexes in development, as well as inhibiting their action on motor behaviour. The data obtained after the intervention indicate how repetitive motor behaviour that is performed systematically and reproduces the movements characteristic of developmental milestones has an important impact on development, whether these movements are made during the developmental milestones themselves or produced later intentionally through an intervention.

Different authors have pointed out that the lack of inhibition of primitive reflexes it is a sign of immaturity of subcortical structures (García-Alix & Quero, 2012) and, consequently, the presence of primitive reflexes can predict motor dysfunction (Blythe, 2012; Melillo & Leisman, 2010). In this regard, the data obtained corroborate both the third hypothesis and the aforementioned research. Through this intervention, this study points to the implication of primitive reflex inhibition on motor skills by producing a significant improvement. The intervention group shows improvement in crawling, finger-thumb opposition, and both dynamic and static balance. To make such a significant improvement in the intervention group, an integration of information from the visual, vestibular, and proprioceptive systems had to take place. This is, in itself, a maturation of the CNS which is the result of the repetitive motor behaviour that has been carried out through the intervention program, and that tries to emulate what happens during the first year of developmental life at the motor level. For this reason, this work supports the data describing the impact of the presence of primitive reflexes on the motor development of schoolchildren which advise the convenience of carrying out specific intervention programs with the aim of favouring the inhibition of primitive reflexes and thus unblocking development. Therefore, the results obtained are consistent with the literature (Bilbilaj et al., 2017; Blythe et al., 2009; Kokot, 2003; McPhillips et al., 2000; McPhillips & Sheehy, 2004) where primitive reflexes are supposed to underlie development.

Nonetheless, the fourth hypothesis—that inhibition of primitive reflexes makes a statistically significant improvement in visual perception test scores—could not be corroborated. The literature reports that eye tracking difficulties when crossing the midline are related to the asymmetrical tonic neck reflex; difficulties in near and far focusing are connected to the presence of the symmetrical tonic reflex, and visuomotor dysfunctions, spatial problems, and perceptual difficulties are linked to the tonic labyrinthine reflex (Blythe, 2005; Sarlós, 2021), but this study has not found such results. The results are in line with those presented by Rodríguez Mejía (2019)—this author also found no significant differences in visuoperceptual measures between pre- and post-intervention. These findings raise several questions, the first being whether the decrease in primitive reflexes was sufficient to elicit change in visual perception. The second question concerns the sensitivity of the test to measure the change, whereas the third is related to the time elapsed between the completion of the intervention program and the post-intervention evaluation. Following the hypotheses of Kleim et al. (2002), perhaps the time in which the final evaluation has been programmed may have been too hurried, as it takes practice over time for the change in synaptic organization to occur. This raises the possibility of conducting several post-test evaluations with a defined interval to confirm the evolution of development for several months after the program ends, as well as investigating the other two issues.

The results suggest that the intervention is effective in the early ages, and that the motor skills which are at the base of learning benefit the most from such intervention. From this research—and from all the data provided—, the aim is to promote the implementation of this type of psychoeducational motor intervention based upon a bottom-up processing approach at the early childhood and primary school levels, to maximise the learning process. This study argues that inhibiting reflexes—through repetition of specific motor behaviours—produces changes in synaptic organization so that the brain learns to organise itself in a more efficient way. This efficiency is manifested through improvements in neuromotor skills. Following the same line as Blythe et al. (2009), primitive reflexes are presented as the mechanism lying at the biological basis of learning, which affects the development of the motor, vestibular, and postural systems.

Limitations and future research

The main limitation of this study stems from the sample used, since it belongs to a private centre not integrated into the public education network. Therefore, the results may not be transposed to the general population. However, this characteristic gives greater value to the study, as it is an international centre recognised worldwide for an agreed methodology in all its centres (Lillard, 2012; Marshall, 2017). In addition, different studies have demonstrated the influence of the Montessori methodology on aspects such as IQ and social maturity level (Ahmadpour & Mujembari, 2015), executive functions, and creative skills (Denervaud et al., 2019). It also has evidence from neuroscience (L'Ecuyer et al., 2020). For this reason, the Montessori method—characterised by learning centred on the evolutionary development of schoolchildren—has not proven to be sufficient for the inhibition of primitive reflexes requiring a specific intervention to achieve this goal. On the other hand, the total number of participants is very limited. In this sense—and to guarantee the results on the intervention effectiveness—, a decision has been made in relation to the design: to divide the sample into an intervention group and a control group, so that the results of the intervention can be compared with an equivalent group. It should be noted that some of the widely cited studies in this field of research also have small samples (Bein-Wierzbinski, 2001; Bilbilaj et al., 2017; Hickey & Feldhacker, 2022; Kalemba et al., 2023). Finally, although the design of the study has been carried out considering the regulations of the Ethical Committee for Experimentation of the University of Malaga (CEUMA), in accordance with the Declaration of Helsinki, this study was initially designed as an exploratory study, so the actual procedure was not necessary.

The conclusions about the presence of primitive reflexes in infancy suggest the need to consolidate the results obtained by replicating the study in a more representative sample. On the other hand, it may be interesting to determine the impact of primitive reflexes on socio-affective and cognitive development, both through the effect of different interventions and the comparative study of children with reflex inhibition in relation to contextual, family, and cultural variables that may differentially influence development. It is also necessary to clarify how the presence of primitive reflexes exerts an influence on both school performance and learning difficulties. Finally, information provided by neuroimaging and/or electromyogram studies can provide further description of structural changes in CNS maturation.

Conclusion

Currently, there is a great lack of knowledge about reflexes beyond the first year and a half of a baby's life. Many education and psychology professionals are unaware that reflexes are present both in neurotypical children and in those with neurodevelopmental disorders. In this study, primitive reflexes are shown to be a barrier to psychomotor development, as evidenced after completing the intervention. Intervening on primitive reflexes for their inhibition and developmental integration has led schoolchildren to greater competence in the motor, vestibular, and postural systems. Therefore, the results suggest the need to introduce psychoeducational programs in reflex inhibition from a bottom-up perspective—that is, from the biological bases that can affect development. For this purpose, it is necessary to carry out training and dissemination work in the professional field through programs for training in reflex assessment and intervention. Uninhibited reflexes influence psychomotor development, which is involved in school performance, ranging from practical aspects such as postural control, psychomotor skills, and laterality, to more symbolic aspects such as body schema and spatial and temporal structuring. This undoubtedly affect academic development and can be improved by intervening in the inhibition of primitive reflexes through educational programs.

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