Relationships among integration of Primitive reflexes, Motor competence and Crawling in children

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March 6, 2023

Abstract

The inhibition or integration of primary reflexes is fundamental in the child's development. If this does not occur in an adequate manner, reflexes may remain active and children may develop poor motor competence. Therefore, the aims of the study were to analyze the relationships among the persistence of reflexes, motor competence and crawling pattern in children and to assess gender differences. The Primitive Reflex Assessment protocol, the Movement Assessment Battery for Children and an ad-hoc questionnaire for parents were used. The sample consisted of 233 children from childhood education, and two extreme groups were made (low motor competence and typical development or high motor competence). The results indicated that participants with lower reflex inhibition showed lower motor competence, most of them had not crawled, and boys showed a higher presence of non-inhibited reflexes. It can be concluded that both early detection and motor interventions that favour reflex inhibition are necessary.

Introduction

The inhibition or integration of primary reflexes, understood as the suppression of one function through the development of another (Goddard, 2005), together with the emergence of postural reflexes, which allow for functional and voluntary motor responses (Medina et al., 2015), plays a fundamental role in child development (Damasceno, Delicio & Mazo, 2005). This transition from primary to postural reflex is important as it connects basic postural and motor skills in the early years with the development of later motor skills (Goddard, 2005). In addition, it seems that active primary reflexes may make a child's posture and motor skills look clumsy (Gieysztor, Pecuch, Kowal, Borowicz & Paprocka-Borowicz, 2020).

The most severe consequences of primary reflexes persistence are typically found in children with cerebral palsy, while milder persistence has been observed in children with reading difficulties and motor problems (McPhillips, Hepper & Mulhern, 2000). It has also been shown that the non-integration of primitive reflexes can cause developmental delays, and is associated with a variety of disorders, such as ADHD (Konicarova, Bob & Raboch, 2013), autism, learning difficulties (Bilbilaj, Gjipali & Shkurti, 2017; Hickey & Feldhacker, 2021; Matuszkiewicz & Gałkowski, 2021), dyspraxia (Pecuch et al., 2020), dyslexia, behavioral disorders (Rashikj-Canevska & Mihajlovska, 2019) or sensory processing disorders (Bilbilaj et al., 2017, Pecuch et al., 2020, Rashikj-Canevska & Mihajlovska, 2019).

If primary reflexes inhibition does not occur in a proper and orderly manner, children may develop, in addition to other difficulties, poor Motor Competence (MC) (Gieysztor, Choińska & Paprocka-Borowicz, 2018). Early signs of this may appear as difficulties in running, balance, aiming and catching tasks, poor visual coordination, lack of rhythm or defective spatial orientation (Gieysztor et al., 2018; Pecuch, Kołcz-Trzęsicka, Żurowska & Paprocka-Borowicz, 2018; Pecuch et al., 2020).

The primary reflexes considered in this research are those that are most directly related to the acquisition of coordination, balance and physical-sport skills: the Moro reflex (MR), the tonic labyrinthine reflex (TLR), the asymmetrical tonic neck reflex (ATNR) and the symmetrical tonic neck reflex (STNR).

Failure to inhibit the MR can cause difficulties in balance and coordination, which will become evident during ball games (Goodard, 2014). Furthermore, it can lead to excessive muscle tension (Bennet, 1988, cited in Goodard, 2015) which, if prolonged, would lead to fatigue (Goodard, 2015) and, consequently, poor task performance. Instead, non-inhibition of the TLR can lead to poor posture, weak muscle tone and low competence in activities involving temporal sequences (Kokot, 2006).

In the case of the ATNR, its non-inhibition may influence motor patterns involving the trunk and limbs, which attempt to align with the head (Henderson et al., 1993). This results in homo-lateral movements, instead of the cross-lateral pattern that should occur when walking, running or jumping (Goodard, 2015), which negatively contribute to the development of the crawling cross-lateral pattern (Krog, 2015).

Finally, if the STNR remains active, as with the MR, it may increase children's difficulties in properly throwing or catching a moving object (Goodard, 2005). Furthermore, this reflex acts as a developmental bridge to the locomotion stage, when children begin to crawl on their hands and knees (Krog, 2015). Although it allows the child to adopt the quadrupedal position, it will prevent progress in this position if it is not properly integrated (Goodard, 2015).

The crawling pattern, another variable considered, favors the integration of the right and left sides of the body, the acquisition of adequate spatial awareness and the development of hand-eye coordination (Hannaford, 2005). Besides, it contributes to the development of motor skills associated with other developmental areas, such as social cognition and language (Leonard & Hill, 2014). It is also important for a child's overall development, and physical, psychological and general well-being (Barnett et al., 2016), although most authors agree that it is not a necessary milestone (Oldak-Kovalsky & Oldak-Skvirsky, 2015).

There is broad evidence that primary reflex activity can exist in the general population (Demiy et al., 2020; Gieysztor, Sadowska & Choińska, 2017; Gieysztor et al., 2018; Gieysztor et al., 2020; Grigg, Fox-Turnbull & Culpan, 2018; Hickey & Feldhacker, 2021; Matuszkiewicz, & Gałkowski,2021; Pecuch et al., 2020; Rashikj-Canevska & Mihajlovska, 2019). Plentiful research has been conducted in children with several difficulties (Bilbilaj et al., 2017; Chinello, Gangi &Valenza, 2018; Konicarova et al., 2013; Mc Phillips & Jordan-Black, 2007; Pecuch et al., 2018, Taylor, Houghton & Chapman, 2004). However, there are few studies assessing the lack of inhibition of these reflexes and their relationship with MC in early childhood (Gieysztor et al., 2018; Pecuch et al., 2018), despite it being a developmental stage in which the first signs of poor reflex inhibition become apparent (Gieysztor et al., 2018).

For these reasons, the aims of the study were to analyze the relationships among the level of inhibition of primary reflexes, MC and the development of the crawling pattern in children, and to assess these relationships according to the participants' gender. These aims were specified in four hypotheses: (1) the non-inhibition of primary reflexes will be higher in those children who show lower MC, (2) the non-inhibition of reflexes will be lower in those children who have developed the crawling pattern, (3) having developed the crawling pattern will be associated with higher MC and, finally, (4) the non-inhibition of primary reflexes will be higher in male participants.

Method

Participants and Inclusion Criteria

The sampling method chosen was the selection of extreme cases, recommended when trying to compare cases or extreme groups (Sampieri, 2018). The initial sample, based on non-probability and convenience sampling (Battaglia, 2008), included 233 children (120 boys and 113 girls) from 10 natural groups of Early Childhood Education (M age = 5.03, SD = 1.21) of eight public schools in a Spanish province.

Once the Movement Assessment Battery for Children was administered, two groups were considered: group

A, 57 children (66.7% boys and 33.3% girls, *M age* = 4.96, *SD* = 0.56) with low MC, i.e., below the 15th percentile, according to the battery classification system (Henderson & Sugden, 1992); and group B, 40 children (51.1% boys and 48.9% girls, *M age* = 5.10, *SD* = 0.52) with typical development or high MC group (TD or HMC), those above the 75th percentile.

Instruments

Assessment of Primary Reflexes. MR, TLR, ATNR and STNR reflexes were selected due to their major influence on motor development (Goddard, 2005; McPhillips & Sheehy, 2004). The assessment protocols described by Goddard (2015) were followed. It was performed using a five-point scale (Table 1). The lower the score obtained, the higher the reflex inhibition.

——————————-Table 1——————————

Every child was individually evaluated according to the protocol of every reflex measured and under a specialist's supervision (Master of Science in Physical Activity and Sport and specialist in Blomberg Rhythmic Movement Training and Primitive Reflexes).

Movement Assessment Battery for Children (Mabc-2, Henderson & Sugden, 1992) adapted to Spanish by Ruiz & Graupera-Sanz (Ruiz & Graupera-Sanz, 2012). It is a standardized, individually-administered test to assess children with motor difficulties. It is designed for children aged four to 16, divided into three age ranges (3–6; 7–10; 11–16 years). The battery consists of eight subtests divided into three dimensions: manual dexterity, aiming and catching, and balance. It provides a classification system based on the scores obtained in every dimension and the age range. Children scoring below the 5th percentile meet diagnostic criterion A for Developmental Coordination Disorder (American Psychiatric Association, 2013). Children between the 5th and 15th percentiles (63–69 points) are at risk of having movement problems, while children above the 15th percentile ($>$ 69 points) do not present movement problems.

Ad-hoc parent questionnaire consisted in a dichotomous question to ask parents whether their children had developed the crawling pattern (1) or not (0).

Data Analysis

The data analysis was carried out with IBM-SPSS version 24 statistical package. Since the variables did not follow a normal distribution, non-parametric tests were used.

Descriptive statistics and differences between groups in the reflexes variables were calculated and represented through box plots. The same was also calculated for MC and the crawling pattern. Secondly, Spearman correlation coefficients were obtained between every reflex score and the dimensions and the overall score of the Mabc-2 for both groups. Finally, Mann-Whitney U test was conducted to determine the differences between groups regarding reflex inhibition, MC and crawling pattern, as well as to assess potential gender differences. The effect size was calculated through r-statistic, using the formula $r = Z/[?]N(N =$ number of measurements) and it was interpreted according to the next scale (Coolican, 2009) small (0–0.10), medium (0.10–0.30) or large (0.30–0.50).

Results

Primary Reflexes

Table 2 shows the descriptive statistics of the scores obtained by groups in the reflexes assessment, and illustrates the differences between both groups.

———————————Table 2———————————

Significant differences ($p < 0.01$) were found between group in the percentage of reflex inhibition, with large effect size in TLR and STNR reflexes and medium effect size in MR and ATNR [35].

Regarding the reflexes measured (Figure 1), it can be observed that the values were asymmetrically distributed in group A. Thus, the median coincided with the upper limit of quartile (Q) 1 in the case of MR and ATNR, and with the lower limit of Q3 in TLR and STNR. Furthermore, most of the scores took values 1 or 2. By contrast, in group B, the scores for all reflexes were similar, except for TLR, since they took values 0 or 1.

—————————————Figure 1—————————————-

Motor Competence

Table 2 also contains the descriptive statistics of the scores obtained by both groups in the Mabc-2 battery, and the differences between them.

Statistical correlations were calculated in every group (Table 3) to determine the association of primary reflexes scores with Total MC and with the Macb-2 dimensions.

———————————-Table 3——————————-

In group A, negative and statistically significant correlations were found between the overall score of the Macb-2 battery and the reflexes ATNR and MR. In addition, significant correlations were obtained between MR and STNR reflexes and manual dexterity.

In group B, negative and statistically significant correlations were found between the overall score of the Macb-2 battery and all the reflexes assessed. These results seem to indicate inverse association between variables. Only ATNR reflex showed a positive association with aiming and catching ($r = 0.36$), which should not be disregarded.

Crawling Pattern

The Table 4 shows the scores obtained for every reflex measured, differentiating between those participants who had crawled and those who had not.

—————————————Table 4————————————

Significant differences were found in all the reflexes, with small effect sizes between children who had developed the crawling pattern and those who had not.

Besides, Mann-Whitney U test was conducted to analyze the differences in the Mabc-2 battery scores between children who had developed the crawling pattern and those who had not (Table 4). Statistically significant differences were found, with medium effect sizes, in all dimensions and in the overall score of the Mabc-2 between children who had developed the crawling pattern and those who had not.

Finally, in group A, 91.1% of children had not developed the crawling pattern, while in group B only 37.5% had not crawled. When comparing between groups, significant differences were obtained in this variable ($U = 334.000$, $p < .001$).

Gender Differences

Mann-Whitney U test was used to assess the existence of gender differences in reflex inhibition. When comparing this variable in the full sample, significant differences ($p < 0.05$) between boys and girls were only found in the percentage of MR reflex inhibition, with medium effect size ($R = 0.2$), boys scoring higher than girls. When gender was examined within groups, significant differences ($p < 0.1$) between boys and girls were also found in the percentage of MR reflex inhibition in group A (Table 5), with medium effect size ($R = 0.2$).

———————————————-Table 5——————————————-

Mann-Whitney U test was performed to compare boys and girls regarding motor competence. In the full sample, significant gender differences ($p < 0.01$) were found in all the instrument dimensions. More specifically, in group A the data yielded gender differences in aiming and catching, with a significance value of $p = 0.043$ (Table 5).

Finally, gender differences were observed in the crawling pattern development. Only 19% of boys had developed the crawling pattern, compared to 42.2% of girls. Mann-Whitney U test revealed significant differences ($p < 0.05$) with small effect size ($R = 0.2$). Within-group differences by gender were also analyzed, but no significant results were obtained.

Discussion

The aims of this study were to analyze the relationships among the level of inhibition of primary reflexes, MC and the development of the crawling pattern in children aged 5 to 6, and to assess the differences based on the participants' gender, which were specified in four hypotheses.

Regarding the first hypothesis, the results showed that the non-inhibition of primary reflexes was higher in those children with lower MC, as they obtained higher scores in the test applied (Goddard, 2015). Significant differences between children with and without developmental impairments were found (Matuszkiewicz & Gałkowski, 2021), with large effect size for TLR and STNR, in line with other studies where these reflexes were found to be the least integrated ones in infants (Hickey & Feldhacker, 2021; Madejewska, Choińska, Gieysztor & Trafalska, 2016].

Differences were also observed, with medium effect size, in MR and ATNR, suggesting that the participants' low MC might have its origin in the lack of reflex inhibition, which may also affect other domains, as these problems rarely occur in isolation (Matuszkiewicz & Gałkowski, 2021; McPhillips & Sheehy, 2004).

Regarding correlations between MC scores and reflex inhibition in group A, the Macb-2 total score showed negative and statistically correlations with ATNR, one of the most frequent reflexes in preschool children (Gieysztor et al., 2017), and MR. The latter may be justified by its relationship with balance and coordination (Goddard, 2014), which are the most common motor problems in children with psychomotor disorders (Pecuch et al., 2018) and are also skills that allow children to effectively participate in Physical Education (PE) lessons (Dalziell, Booth, Boyle & Mutrie, 2019)

Likewise, in group A, manual dexterity presented significant correlations with MR and STNR, which could be justified considering the relationship between MR and coordination and balance already mentioned, and the transfer of these skills to ball games and sports (Goodard, 2005). These data suggest that children with movement difficulties show greater presence of these reflexes (Pecuch et al., 2020), which seems to affect their general coordination as well as their performance in tasks involving hand-eye coordination.

Regarding group B, negative and significant associations were found between all dimensions and the overall Macb-2 score and all reflexes assessed. These results suggest that the lower the reflex evidence, the higher MC (Gieysztor et al., 2017; Gieysztor et al., 2018; Goodard, 2005; Goodard, 2015).

However, the positive relationship between aiming and catching and ATNR in children without motor difficulties should not be disregarded ($r = 0.\ 36$, $p < 001$). It disagrees with other study (McPhillips & Sheehy, 2004), where authors stated that children with persistent ATNR were at risk of motor difficulties, as poor inhibition of this pattern may be the cause of fine and gross motor control problems, and could disrupt the emergence of motor skills such as rolling, crawling, creeping, and catching or kicking a ball (McPhillips & Sheehy, 2004). Therefore, the first research hypothesis is accepted, but further studies are needed to assess the relationship between ATNR and throwing and catching skills.

When assessing the second study hypothesis (reflex non-inhibition will be lower in children who have developed the crawling pattern), significant differences were found, with small effect size, in the percentage of reflex inhibition between children who had developed the crawling pattern and those who had not. Therefore, the hypothesis is accepted. Furthermore, these results point to the fact that active primary reflexes may have influence on the development of the crawling pattern in children, due to their negative contribution to the development of the cross-lateral pattern (Krog, 2015).

In this sense, and as mentioned above, the STNR acts as a bridge to the next stage of creeping and crawling development (Krog, 2015). The results obtained in this research are consistent with this statement, since the scores observed for this reflex were significantly higher among those children who had not developed the crawling pattern. This can be explained by the fact that the STNR allows children to adopt a quadruped position, and it will prevent progression or movement in this position if it remains active (Goodard, 2005).

As for the third hypothesis (having developed the crawling pattern will be associated with greater MC), significant differences were found in the global score and all dimensions of the Mabc-2 between children who had crawled and those who had not. These differences may reveal the importance of the acquisition of the crawling pattern in the development of more complex skills, as the integration of the right and left sides of the body is essential to achieve adequate spatial awareness and to properly develop hand-eye coordination (Hannaford, 2005). Failure to acquire this pattern can affect performance in simple tasks such as throwing a ball or batting (Henderson, French & McCarty, 1993) and, consequently, lead to low satisfaction when performing sport activities and low participation in PE lessons (Gieysztor et al., 2018; Goddard, 2015). This issue is important as children who feel safe while participating in PE are more likely to be intrinsically motivated to continue participating (Rudd et al., 2020).

In the group comparison, 91.1% of group A participants versus 37.5% of group B had not crawled, resulting in significant differences between groups ($U = 334.000$, $p = .00$). This allows us to accept the third hypothesis, as well to consider the importance that the acquisition of this pattern may have in the development of other later skills (Kubicec, Jovanovic & Schwarzer, 2020).

As a secondary goal, we aimed to assess the differences based on the participants' gender. In this regard, it was hypothesized (4) that reflex inhibition would be lower in male participants. Boys scored higher than their female counterparts in all the reflexes assessed, showing lower reflex inhibition. Nevertheless, only significant differences were observed in the MR, with $p < 0.05$ in the whole sample and $p < 0.01$ in group A (Table 9). Thus, the hypothesis is partially accepted.

These results are in keeping with previous research that proved that boys presented higher incidence of active reflexes, both in a healthy population (Gieysztor et al., 2018; Hickey & Feldhacker, 2021; Madejewska et al., 2016; Matuszkiewicz & Gałkowski, 2021; Rashikj-Canevska & Mihajlovska, 2019) and in children with some kind of difficulty (Mc Phillips & Jordan-Black, 2007; McPhillips & Sheehy, 2004).

The gender differences show that gender can play an important role in children with motor difficulties. Thus, girls showed higher integration of some reflexes and higher motor development than their peers (Gieysztor et al., 2018), and a higher percentage of them had developed the crawling pattern compared to boys.

Conclusion

The results of this research suggest that the lack of primitive reflex inhibition in children may be related to low MC and the failure to develop the crawling pattern. Although it seems logical to think that the lack of inhibition may have a neurological origin, there are studies that indicate that it may be a consequence of a lack of time devoted to free movements. Thus, not only early detection is necessary, but also the implementation of physical activity programs that stimulate the inhibition of primary reflexes since, whatever the origin of the problem is, all children could benefit from this type of program.

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Table 1

Neurological Test Scoring

Score	Description
0	No anomaly. No evidence of a fully-developed primary reflex has been found
1	There is evidence of primary reflexes up to 25%
2	Residual presence of primary reflexes up to 50%
3	Primary reflexes virtually retained up to 75%
4	Primary reflexes retained, 100% present, total absence of postural reflexes

Table 2

Descriptive statistics and differences in reflex inhibition and Mabc-2 scores between groups

	Group A (n = 57)	Group B (n = 45)				
	M(SD)	*M(SD)*	*U*	*p*	*Z*	*R*
Reflexes						
MR	1.16 (0.62)	0.60 (0.58)	720.0	<.001	-4.23	0.40
TLR	1.67 (0.79)	0.96 (0.71)	657.0	<.001	4.59	0.50
ATNR	1.42 (0.82)	0.84 (0.99)	773.0	<.001	3.63	0.36
STNR	1.65 (0.92)	0.78 (0.82)	623.0	<.001	4.68	0.46
Mabc-2 Dimensions						
Aiming and catching	16.51 (4.08)	23.24 (3.82)	245.00	<.001	-6.61	0.65
Manual dexterity	16.23 (5.47)	25.96 (3.23)	171.00	<.001	-7.69	0.76
Balance	19.81 (4.81)	31.44 (4.91)	130.500	<.001	-7.78	0.77
Total score	52.54 (8.46)	82.40 (4.32)	5.500	<.001	-8.21	0.81

M = Mean; SD = Standard deviation

Table 3

Correlations between reflexes scores and motor competence variables in groups

Reflexes	*Total score*	*Manual dexterity*	*Aiming and catching*	*Balance*
Group A	**Group A**	**Group A**	**Group A**	**Group A**
MR	-0.32*	-0.39**	-0.08	-0.13
TLR	0.05	0.15	0.13	0.07
ATNR	-0.29*	-0.12	0.10	0.23
STNR	0.25	-0.27*	-0.06	-0.14
Group B	**Group B**	**Group B**	**Group B**	**Group B**
MR	-0.53*	-0.09	-0.13	-2.81
TLR	-0.37**	0.19	-0.03	0.03
ATNR	-0.19*	0.09	0.36*	0.27
STNR	-0.52**	-0.54**	-0.13	-0.01

**p < 0.05; **p < 0.01*

Table 4

Differences in reflex scores and Mabc-2 dimensions based on the participants' crawling pattern development

	Crawling (n = 32)	Not Crawling (n = 47)				
	M (SD)	*M (SD)*	*U*	*p*	*Z*	*R*
Reflexes						
MR	0.64 (0.60)	1.19 (0.64)	390.0	.007	-2.47	0.25
TLR	1.18 (0.77)	1.51 (0.83)	380.0	.009	-2.60	0.26
ATNR	0.93 (.90)	1.26 (0.831)	420.0	.045	-2.01	0.20
STNR	1.04 (0.84)	1.68 (1.045)	365.0	.008	-2.65	0.26
Mabc-2 Dimensions						
Aiming and catching	21.75 (4.81)	17.49 (5.99)	213.00	<.001	-4.315	0.50
Balance	27.89 (7.30)	21.77 (6.01)	269.50	<.001	-3.651	0.42
Manual dexterity	23.39 (6.56)	17.28 (6.44)	283.00	<.001	-3.496	0.40
Total score	76.25 (14.58)	58.62 (15.38)	227.00	<.001	-4.146	0.47

M = Mean; SD = Standard deviation

Table 5

Scores obtained for the different reflexes and Mabc-2 dimensions by gender. Group A

	Boys (n = 38)	Girls (n = 19)				
	M (SD)	*M (SD)*	*U*	*p*	*Z*	*R*
Reflexes						
MR	1.26 (0.60)	0.95 (0.621)	268.500	0.043	-1.791	0.2
TLR	1.68 (0.77)	1.63 (0.83)	346.500	0.790	-0.266	0.04
ATNR	1.47 (0.76)	1.32 (0.95)	328.500	0.552	-0.595	0.08
STNR	1.68 (0.96)	1.58 (0.838)	357.000	0.943	-0.072	0.01
Mabc-2 Dimensions						
Aiming and catching	1.26 (0.60)	0.95 (0.621)	268.500	0.043	-1.791	0.2
Balance	1.68 (0.77)	1.63 (0.83)	346.500	0.790	-0.266	0.04
Manual dexterity	1.47 (0.76)	1.32 (0.95)	328.500	0.552	-0.595	0.08
Total score	1.68 (0.96)	1.58 (0.838)	357.000	0.943	-0.072	0.01

M = Mean; SD = Standard deviation

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`Figure 1.docx` available at https://authorea.com/users/592893/articles/628189-relationships-among-integration-of-primitive-reflexes-motor-competence-and-crawling-in-children