JOURNAL OF SPORTS SCIENCES
https://doi.org/10.1080/02640414.2024.2434800

Routledge
Taylor & Francis Group

SPORTS PERFORMANCE

OPEN ACCESS Check for updates

Active primitive reflexes obstruct tactical and technical skills in football players

Julie Bastiere[a,b], Thibault Lussiana[a,c,d], Aurélien Patoz[d], Cyrille Gindre[a,c,d] and Laurent Mourot[a,e]

[a]Université de Franche-Comté, Besançon, France; [b]ESTAC association, Troyes, France; [c]Research and Development Department, Chavéria, France; [d]Research and Development Department, Aigle, Switzerland; [e]Department of biological science, Faculty of Science, Thompson Rivers University, Kamloops, BC, Canada

ABSTRACT

Primitive reflexes (PRs) are involuntary motor responses present at birth, typically replaced by voluntary motor control during development. If PRs remain active beyond infancy, they can impair motor and cognitive abilities. This study investigated the correlation between active PRs and Tactical (TaS) and Technical Skills (TeS) in professional football matches. Fifty-eight male football players (17.5 ± 1.4 years) from a French academy were assessed for PR activity, categorized into inactive or active PR groups. Assessed PRs included asymmetrical tonic neck reflex (ATNR), symmetrical tonic neck reflex (STNR), tonic labyrinthine reflex (TLR), and Moro reflex (MR). Analysis of twenty matches showed players with active PRs had significantly lower success rates in TaS and TeS, including 15.5% and 31.8% lower pass success in imbalance and finishing zones ($p < 0.01$). Players with active PRs also performed worse in defensive actions and duels ($p < 0.01$). The findings highlight that active PRs hinder football performance, especially in challenging match situations like duels and crowded zones. This suggests the need for training programs to address PR effects and enhance player performance. Further research should refine methods for integrating these RPs.

ARTICLE HISTORY
Received 8 August 2024
Accepted 20 November 2024

KEYWORDS
Performance; Neuroscience; Neurodevelopment; Training

Introduction

Many different skills are needed for football performance (Ali, 2011; Williams & Reilly, 2000). Commonly recognized ones are Tactical Skills (TaS) which are actions in response to dynamic matches situations and Technical Skills (TeS) such as passing, dribbling, shooting, or controlling (Bozkurt & Kucuk, 2018; Gréhaigne & Godbout, 1995; Portillo et al., 2020). To demonstrate these TaS and TeS, players must be able to meet the physical (e.g., strength, speed, and agility) and cognitive (e.g., learning abilities, decision-making, and perception) demands of a football match (Bangsbo et al., 2006; Mohr et al., 2003; Sabarit et al., 2020).

The evaluation of TaS and TeS relies on specific assessments such as spacing between lines or coordination among players for TaS (Low et al., 2020), and dribbling or one-on-one scenarios for TeS (Caetano et al., 2019; Clemente et al., 2016; Duarte et al., 2012) in relation to intrinsic qualities (e.g., physical or cognitive) necessary for high-level practice (Bangsbo et al., 2006). These intrinsic qualities have a direct impact on TaS and TeS and can influence players' performance (Akenhead & Nassis, 2016; Iaia et al., 2009). For example, it has been recognized that cognitive processes can play a crucial role in TeS and TaS development. Indeed, inadequate cognitive training can impair the effectiveness of technical and tactical actions during gameplay (Teodorescu & Gheorghe, 2014).

Primitive reflexes (PRs) are among the factors that could diminish physical and cognitive skills. PRs are present at birth and allow a gradual transition from involuntary motor skills generated by the brainstem to voluntary motor skills from the cerebral nervous system (Illingworth, 1987). Active PRs are progressively integrated during the first years of life concurrently with the enhancement of motor skills (e.g., eye/hand coordination, cross-coordination upper/lower limbs, quadrupedia, and then walking) (Capute et al., 1982; Illingworth, 1987). Despite the general acceptation of an early integration, it has been previously reported that active PRs could still be present in the general population independently of age (Damasceno et al., 2005). The consequences of not integrating PRs are numerous, including declines in various motor, psychological, and cognitive functions (Goddard-Blythe, 2005; McPhillips & Sheehy, 2004; Niklasson & Niklasson, 2022).

PRs may have a direct impact on a player's ability to effectively respond to the spatio-temporal demands of a match. When PRs remain active, they disrupt voluntary motor coordination and rapid decision-making, both of which are critical in situations where space is limited or time is constrained (Goddard, 1995; McPhillips & Sheehy, 2004). For example, in scenarios where multiple players are concentrated in the same area, a player with active PRs may struggle to anticipate others' movements, quickly adjust their position, or execute technical skills under pressure. Although direct evidence in adult athletes is limited, previous studies have suggested that incomplete integration of PRs impairs motor skills and cognitive processing in young populations (Damasceno et al., 2005; Teodorescu & Gheorghe, 2014). This condition could lead to a decrease in the accuracy and fluidity of technical skills (TeS) such as dribbling,

CONTACT Julie Bastiere j.bastiere@estac.fr Université de Franche-Comté, ESTAC association, 11 rue Marie Curie, Besançon F-25000, France
Supplemental data for this article can be accessed online https://doi.org/10.1080/02640414.2024.2434800

passing, or controlling the ball, as well as tactical skills (TaS) like real-time decision-making, team coordination, or managing duels. However, it is important to note that this interpretation is based on indirect data, and while an association between active PRs and reduced performance under spatio-temporal constraints could be hypothesized, direct evidence remains to be established.

Unfortunately, few studies about PRs in the field of sports performance exist. For instance, previous research focused on 7-year-old children that learnt swimming (Bogdanoviča & Lāriņš, 2020). The results showed that having active PRs increased the time required to assimilate technical gestures and skills quality during swimming. Indeed, children with 8% of active PR achieved a level of swimming proficiency of 77% compared with 33% for children with more than 25% of active PR (Bogdanoviča & Lāriņš, 2020). Although this study described the negative impact of PRs during training on performance levels and learning abilities, the links between PRs and motor skills have not been deeply studied, especially among young and adult athletes targeting high-level performance (Bastiere et al., 2024).

Hence, the main objective of this study was to evaluate whether the presence of active PRs could alter football performance. More specifically, we hypothesized that players with active PR would have poorer TaS and TeS skills during matches, especially when players evolve under spatial and temporal constraints, such as a high number of players in the same area, limited time to play, or proximity to an opponent (duels).

Methodology

To conduct this study, the gameplay of players during championship matches over an entire football season was analysed. The players were divided into two groups based on the presence of PRs (see PR evaluation section). The success rates of various selected skills during the matches were compared between the two groups. Additionally, skills were categorized according to playing positions to maintain the integrity of the game's dynamics for certain skills. For example, central defenders were excluded from the analysis of passes in the finishing zone, and attackers were excluded from passes in the attraction zone (see match data section).

Participants

All players from the academy ($n = 58$) of a French professional club who met the inclusion/exclusion criteria were included in this research. Eligible players required over five years of training in a sports club before joining the academy and had to be injury-free for at least one month prior to the PR evaluation. Each player participated in 3 to 9 matches (270 to 810 minutes) for the evaluation of the success rates of TaS and TeS. Participant characteristics are detailed by global score (see PR evaluation section) and position in Table 1. In addition to the anthropometric data (age, height, and weight), we performed a series of athletic tests to assess the physical capabilities of the players, including measures such as speed, endurance, and lower limb power (counter movement jump and drop jump). However, since the results of these tests did not reveal significant differences between groups, they are not presented for sake of clarity.

All participants provided informed consent prior to their inclusion in the study. Each individual's data was handled and stored in accordance with the principles of confidentiality and privacy. The study was conducted in accordance with the guidelines of the Declaration of Helsinki.

Details of the distribution of participants by the activity of each PR are available in Annexe A (Table A).

Match data

Twenty matches were studied during the regular season, focusing on three teams from the academy at both the U17 and U19 national levels, and the fifth national division. The distribution of matches was as follows: seven matches for the U17 team, seven for the U19 team, and six for the fifth national division team. All matches were played at home. These matches were filmed and subsequently analysed by three video analysts from the training centre who randomly assessed the three teams in a blinded manner, i.e., without knowledge of the results from PR tests conducted throughout the season. Skills observed were categorized into TaS and TeS.

TaS were categorized based on passes made in different areas of the field and movements during defensive transitions (Caicedo-Parada et al., 2020; Héros, 2022). All passes made during the matches were recorded and categorized as successful or unsuccessful. Maintaining possession of the ball was considered a success, while losing possession was considered a failure. The zones where the passes were made were the attraction zone (AZ), in front of the opposing midfielders; imbalance zone (IZ), between the opposing midfielders and defenders; and finishing zone (FZ), behind the opposing defensive line. The success of defensive actions was defined as "recovering the ball or closing a passing lane, thereby preventing the progression of the ball". Failure was defined as "not intercepting the ball or not closing a passing lane, thereby facilitating the progression of the ball".

Table 1. Distribution of general characteristics of participants by global score and by position.

Positions	Group	N	Age (y)	Height (cm)	Mass (kg)
All	Active PR	17	17.7 ± 1.5	178.8 ± 6.9	70.2 ± 7.3
	Inactive PR	42	17.6 ± 1.4	177.8 ± 6.0	68.8 ± 6.4
Defensive and offensive midfielders. and full and centre back	Active PR	13	17.5 ± 1.3	178.5 ± 6.4	68.7 ± 6.2
	Inactive PR	29	17.8 ± 1.5	178.3 ± 6.7	69.5 ± 6.8
Defensive and offensive midfielders. full back. winger. and forward	Active PR	32	17.9 ± 1.6	176.8 ± 7.1	69.0 ± 8.0
	Inactive PR	37	17.6 ± 1.5	176.6 ± 5.4	67.5 ± 5.5

No significant difference was reported between groups.

TeS included overground duels and aerial duels, recorded by their successes and failures. Success was defined as keeping or regaining possession, while failure was defined as losing possession or failing to regain it. Fouls whistled by the referee were also recorded (Kraynik et al., 2019).

The skills recorded varied by player position. For all positions, the recorded skills included fouls, overground duels, and aerial duels. For defensive and offensive midfielders, as well as full backs and centre backs, the recorded skills also included defensive actions and passes in the attraction zone. For defensive and offensive midfielders, full backs, wingers, and forwards, the recorded skills included passes in the imbalance zone and passes in the finishing zone. This categorization ensures the analysis respects the different roles and responsibilities associated with each position on the field.

Experimental procedure

Primitive reflex evaluation

The evaluation of PRs took place during the football pre-season in July 2022, following the mid-season break in June. PRs were assessed using the methodology established by the Institute of Neurophysiological Psychology (INPP). Four specific PRs were selected for this study due to their demonstrated relationship with decreases in motor tasks when not integrated (E. Z. Gieysztor et al., 2017; Goddard Blythe, 2015).

- The asymmetrical tonic neck reflex (ATNR) was assessed while standing, feet together, arms forward at shoulder height, eyes closed, wrists flexed, and hands relaxed. The test consisted of a rotation of the head on both sides induced by the practitioner (left side: ATNR L and right side: ATNR R). The movement is continuous with a pause for 5-10 s at the end of each rotation or neutral position. Before starting, the practitioner informed the participant that they must keep their arms forward without moving. The involuntary movement is observed in the function of movement of the hand or arm on the side to which the head was turned, such as a lowering or deviation of the arms.
- The tonic labyrinthine reflex (TLR) was tested in a standing position, feet together and eyes closed. The test was performed following two manipulations. The first consisted of an extension of the head (TLR EXT) and the second in a flexion (TLR FLX) of the head. The movement is continuous with a pause for 5 s at each end of the movement (i.e., head extension and head flexion). The involuntary movement is evaluated based on loss or alternation of balance, such as swaying or falling backward or forward during the test.
- The symmetrical tonic neck reflex (STNR) was tested in a quadruped position (hands below shoulders and knees below hips). The instruction for the participant is to hold the quadruped position during the movement of the head during flexion (SNTR FLX) or extension (STNR EXT). The movement is continuous with a pause for 5 s at each end of the movement (i.e., head extension and head flexion). The involuntary movement is rated in the function of the tremors in one or both arms or hip movements, bending of the arms due to flexion of the head, or arching of the back.
- The Moro reflex (MR) is tested standing, feet joined, arms forward at shoulder height, eyes closed, wrists flexed, hands relaxed, and the head back. After clearly explaining the test and asking if the participant was ready, the subject was asked to drop into the hands of the practitioner by a back rocker. The involuntary movement is observed based on the abduction of the arms or any signs of distress or imbalance during the test.

Each PR was assessed on a subjective scale ranging from 0 to 4, in increments of 1, based on observed involuntary movements following specific tasks or stimulations. A rating of 0 indicated inactive PR activity (i.e., no involuntary response to stimuli during the test), while a rating of 4 indicated maximal PR activity (i.e., significant involuntary movements in response to stimuli during the test). The PRs were evaluated only once by the same examiner, an expert in this field. The details of the PR activity scoring scale are available in supplementary material (Scoring Sheet – Primitive Reflexes Scales).

The overall level of PRs activation was evaluated by calculating a global score (GS), which corresponds to the sum of the individual test scores (Pecuch et al., 2021). The GS allows for the assessment of PR activation strength across five categories: <10% (null), ≥10% and <25% (low), ≥25% and <50% (medium), ≤50% and <75% (high), and ≥75% (maximal) (Blythe, 2005; Goddard Blythe, 2015). Participants were systematically categorized into two groups based on their scores: the inactive PR group, when the GS was null or when individual PR test yielded a score of 0, and the active PR group, when the GS was "low" or higher, or when individual PR test yielded a score greater than 0. The results are presented according to this classification, reflecting both the total activity of PRs and the activity of individual PRs (Table 2).

Statistical analysis

All analyses were conducted using Python (v3.8.16, retrieved from http://www.python.org). Descriptive statistics are given as mean ± standard deviation. The success rates were calculated based on raw data collected during

Table 2. Classification of group by primitive reflex (PR) activity and global score (GS).

Group	PR activity score	Sum of PR activities	GS	PR activity (%)
Inactive PR	0	0-2	No-activity	≤7 (no abnormal activity)
Active PR	1	3-7	Low	8 - 25%
	2	8-13	Medium	25 - 50%
	3	14-20	High	50 - 75%
	4	21-28	Maximal	75 - 100%

matches, by determining the ratio of successes to attempts for each skill and each player. These rates were then averaged according to the groups with either inactive or active PRs. To standardize the data, they were normalized to 100 minutes of playing time before calculating the success rate for each skill for each player. Cohen's d was calculated for key comparisons to provide a better understanding of the magnitude of differences between the groups (e.g., active vs. inactive PRs). Pearson's correlation coefficient was initially calculated to explore potential relationships between age and performance metrics across different player positions. Given the lack of significant age-related correlations and the homogeneous age distribution across samples, independent t-tests were used for group comparisons. Data normality was assessed using Shapiro–Wilk tests. Mann–Whitney U tests were applied when normality was not verified, while t-tests were used otherwise (assuming equal variance). We ensured that each metric was measured independently and reported only once per subject, avoiding any reuse of the same metric in different tests. This approach helps to prevent inflating the risk of Type I errors. The level of significance was set at $p \leq 0.05$.

Results

The success rates for both TaS and TeS in the active and inactive PR groups are presented in two parts: 1) the success rates (TaS and TeS) based on the overall activity of players and 2) the success rates based on the activity of each PR.

Success rate and global PR activity

Tactical Skills

The pass success rate within or from the AZ did not differ significantly between the two groups. However, the active PR group had a significantly lower pass success rate, 15.5% lower in the IZ and 31.8% lower in the FZ ($p \leq 0.01$, d = 0.87 for IZ, d = 1.22 for FZ), compared to the inactive PR group (Figure 1).

For defensive actions (Figure 2), similar trends were observed, with the active PR group having a 20.7% significantly lower average success rate ($p = 0.01$, d = 0.94) compared to the inactive PR group.

Technical Skills

The results showed that the average success rates of TeS are significantly lower in the active PR group. Specifically, overground duels have a 34.2% ($p = 0.001$, d = 1.73) lower success rate, and aerial duels have a 26.0% ($p = 0.01$, d = 0.90) lower success rate on average (Figure 3).

Similarly, the number of fouls during matches was higher by an average of 0.4 ($p = 0.02$, d = −0.58) fouls per 100 minutes of playing time for the active PR group (Figure 4).

Success rate and each PR activity

Tactical Skills

The success rates of all analysed TaS are presented in Table 3 based on the activity score of each tested PR.

The tactical zones of the field showed lower success rates when PRs are active. In the IZ and FZ zones, the average success rate is significantly lower for the group with an active ATNR R, with a reduction of nearly 15% in the IZ ($p = 0.003$, d = −1.09) and up to 34.8% in the FZ ($p < 0.001$, d = −1.48) compared to the group with an inactive PR. Specifically, in these two zones (IZ and FZ), three out of the seven tested PRs show lower success rates when they are active: ATNR R for both zones, MR for the FZ ($p < 0.01$, d = −0.64), and STNR (in both positions) for the IZ (EXT : $p < 0.05$, d = −0.90; FLX : $p < 0.05$, d = −0.61). Conversely, the AZ zone did not appear to be a zone where active PR group lower the success rate of passes. Only STNR EXT showed a higher success rate, with an increase of 3.7% for the active PR group.

Defensive actions showed lower success rates in players from the active PR group for all tested PRs (i.e., in at least one of the tested PR positions). The success rates were significantly reduced, with average decreases of up to 25.5% ($p = 0.004$, d = −1.41) for TLR EXT, 17.1% f ($p = 0.001$, d = 0.72) or ATNR R, 14.8% ($p = 0.004$, d = −0.64) for MR, and 8.4% ($p = 0.02$, d = −0.35) for STNR EXT.

Technical Skills

The success rates of all analysed TaS are presented in Table 3 based on the activity score of each tested PR.

Overground duels showed similar results. The success rate was significantly lower for each tested PR (i.e., in at least one of the tested PR positions; $p < 0.05$) except for the TLR (EXT and

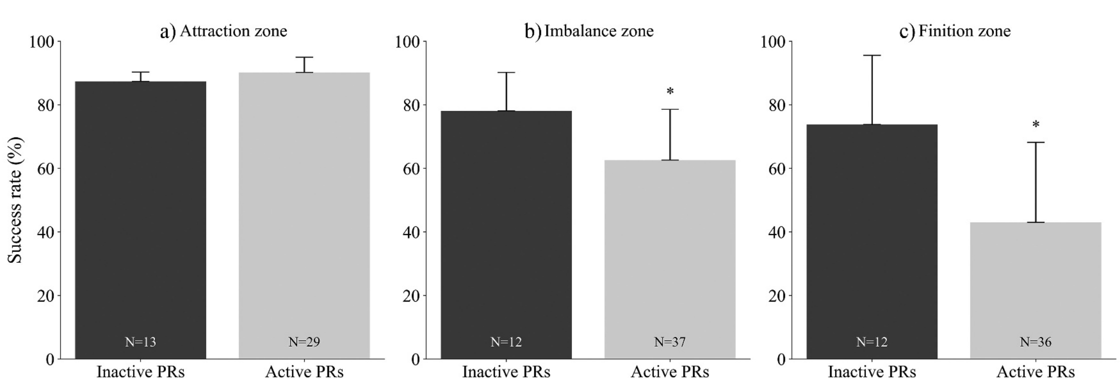

Figure 1. Comparative analysis of tactical skill success rates between active and inactive PR groups in passing across the (a) attraction zone, (b) imbalance zone, and (c) finishing zone as defined by the opponent's defensive block. * significant difference between inactive and active PR groups ($p \leq 0.05$).

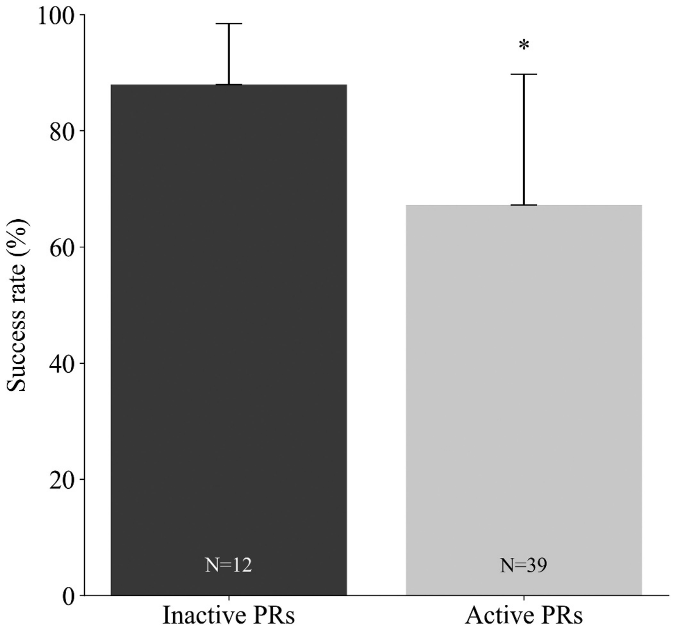

Figure 2. Comparative analysis of tactical skill success rates between active and inactive PR groups in defensive actions. * significant difference between inactive and active PR groups ($p \leq 0.05$).

FLX). When the ATNR R was active, the success rate was, on average, 34.2% ($p < 0.001$, d = −1.85) lower for the active group, 24.5% ($p < 0.001$, d = −1.13) lower for the MR, and 16.7% ($p = 0.005$, d = −0.71) lower for the STNR EXT.

Aerial duels showed significantly lower success rates in the active PR group for 6 out of the 7 tested ($p < 0.05$). The success rate of aerial duels was on average 34.4% lower when the STNR EXT was active, and approximately 20% lower when the MR, TLR FLX, and STNR FLX were active.

The number of fouls during matches was significantly higher in the active PR group only when 2 of the 7 are active. The MR, when active, showed an average increase of 0.6 ($p < 0.001$, d = 1.11) fouls, and the ATNR R showed an average increase of 0.4 ($p < 0.001$, d = 0.84) fouls per 100 minutes of total playing time.

Discussion

The results of this study validate our hypothesis that active PRs can significantly impair the TaS and TeS of young football players. Specifically, we hypothesized that players with active PRs would exhibit poorer TaS and TeS during matches, particularly under spatial and temporal constraints, such as a high density of players in the same area, limited time for decision-making, or close proximity to an opponent during duels. The Cohen's d values observed in this study ranged from moderate to large, indicating that the differences between the active and inactive PR groups are not only statistically significant but also meaningful in practical terms. For example, the large effect sizes (e.g., d = 1.73 for overground duels) suggest a considerable impact of active PRs on performance.

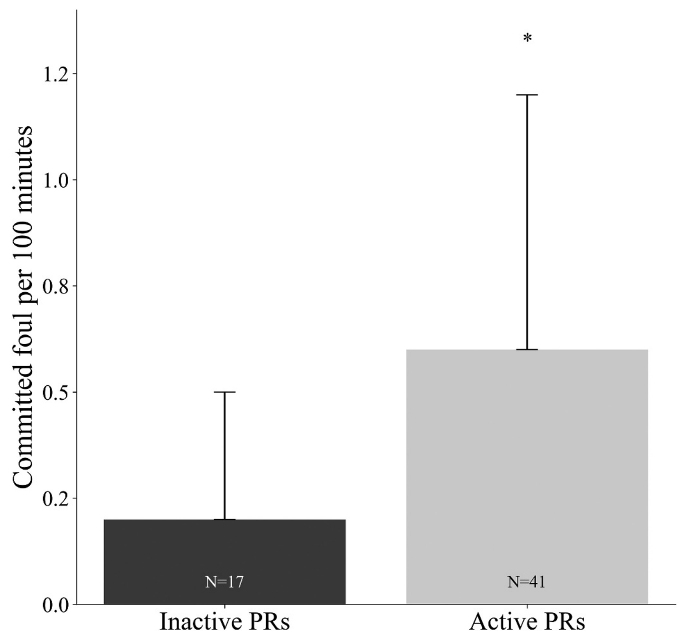

Figure 4. Comparative analysis of technical skill success rates between active and inactive PR groups in fouls. * significant difference between inactive PR and active PR groups ($p \leq 0.05$).

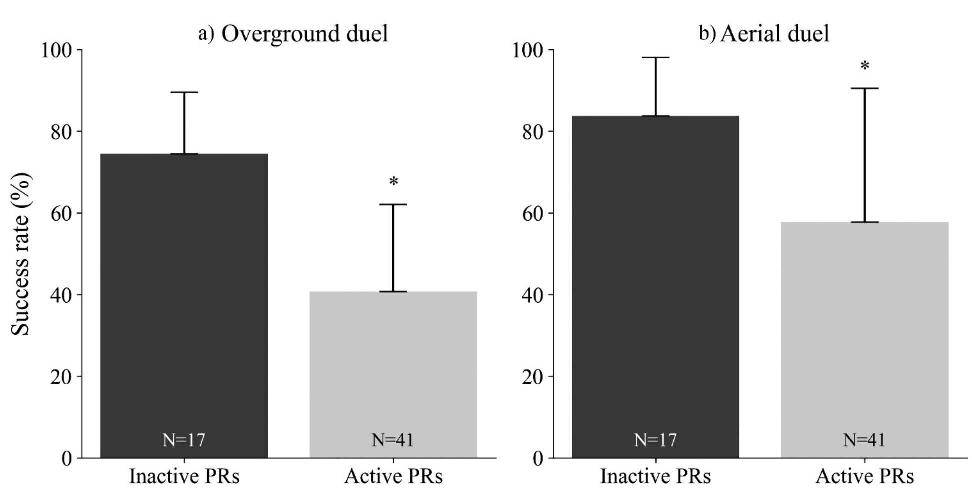

Figure 3. Comparative analysis of technical skill success rates between active and inactive PR groups in (a) overground duel and (b) aerial duel. * significant difference between inactive PR and active PR groups ($p \leq 0.05$).

Table 3. The success rate of tactical skills (Tas) for each primitive reflex (PR) and both active and inactive PR groups.

TaS	Primitive reflex	Inactive PR group Mean ± SD	Active PR group Mean ± SD	Mean Difference	Cohen's d
Attraction zone (%)	MR	88.9 ± 4.0	90.4 ± 4.5	1,5	0,35
	ATNR L	88.5 ± 4.4	90.0 ± 4.4	1,5	0,34
	ATNR R	87.4 ± 2.9	92.2 ± 4.8	4,8	1,21
	STNREXT	**88.1 ± 4.1**	**91.8 ± 4.2**	3,7	0,89
	STNRFLX	89.0 ± 4.1	89.9 ± 5.1	0,9	0,19
	TLREXT	88.2 ± 3.4	89.4 ± 4.5	1,2	0,30
	TLRFLX	88.1 ± 3.1	90.1 ± 5.0	2	0,48
Imbalance zone (%)	MR	69.0 ± 16.6	61.0 ± 15.3	−8	−0,50
	ATNR L	67.5 ± 17.8	65.7 ± 15.9	−1,8	−0,11
	ATNR R	**78.1 ± 12.1**	**62.6 ± 16.0**	−15,5	−1,09
	STNREXT	**72.4 ± 17.8**	**59.0 ± 11.1**	−13,4	−0,90
	STNRFLX	**70.5 ± 16.6**	**60.8 ± 14.9**	−9,7	−0,61
	TLREXT	75.3 ± 14.3	65.4 ± 16.5	−9,9	−0,64
	TLRFLX	67.7 ± 17.4	65.9 ± 16.4	−1,8	−0,11
Finishing zone (%)	MR	**56.4 ± 29.5**	**40.0 ± 21.2**	−16,4	−0,64
	ATNR L	55.3 ± 30.3	48.3 ± 26.5	−7	−0,25
	ATNR R	**74.8 ± 21.8**	**40.0 ± 25.2**	−34,8	−1,48
	STNREXT	57.7 ± 27.6	42.2 ± 26.4	−15,5	−0,57
	STNRFLX	51.5 ± 29.2	52.2 ± 26.7	0,7	0,03
	TLREXT	**73.0 ± 28.3**	**48.4 ± 27.0**	−24,6	−0,89
	TLRFLX	62.2 ± 30.1	47.1 ± 26.5	−15,1	−0,53
Defensive actions (%)	MR	**75.1 ± 25.3**	**60.3 ± 20.7**	−14,8	−0,64
	ATNR L	72.2 ± 27.3	69.6 ± 23.1	−2,6	−0,10
	ATNR R	**83.1 ± 24.6**	**65.9 ± 23.4**	−17,2	−0,72
	STNREXT	**74.1 ± 27.2**	**65.7 ± 20.2**	−8,4	−0,35
	STNRFLX	73.5 ± 25.6	66.3 ± 23.2	−7,2	−0,29
	TLREXT	**93.9 ± 5.8**	**68.5 ± 24.8**	−25,4	−1,41
	TLRFLX	**86.1 ± 11.5**	**66.5 ± 27.3**	−19,6	−0,94

ATNR = asymmetrical tonic neck reflex; STNR = symmetrical tonic neck reflex; TLR = tonic labyrinthine reflex; L= left; *R* = right; EXT= extension; FLX = flexion; TeS = Technical Skill. * Significant difference between inactive PR and active PR groups ($p \leq 0.05$) are reported in bold.

Our data reveal that each analysed skill was diminished in players with at least one active PR, except for passing in or from the AZ, where players operate without spatial or temporal stress on the field, allowing them to take advantage of larger spaces and distant opponents. Overall, the presence of active PRs leads to a substantial decrease in key performance metrics critical for success in football. This decline in performance underscores the need for targeted interventions to address and mitigate the effects of active PRs, ensuring that players can perform optimally even in high-pressure game situations.

Global activity of PR and success rate

The study reveals that the global activity of the PR in players significantly reduces the success rate of TaS. Specifically, in critical zones of the field, the presence of an active PR reduces success rates for passes made from the IZ by 15.5% and from the FZ by 31.8% (Figure 1). This decline is particularly detrimental for performance as these zones often determine scoring opportunities and the overall effectiveness of offensive strategies (Ric et al., 2017).

Additionally, the success rate of defensive actions is diminished in the active PR group. This reduction in performance can be attributed to the concept of space-time, which appears to influence task success. Specifically, when the time available for information processing and action is constrained by the context, such as in fast-paced or high-pressure situations, the active PR group exhibits lower success rates. Our data showed that players with active PRs had lower success rates in rapid-response situations, such as duels and passes under pressure, suggesting that these players may struggle with processing spatial and temporal information during high-intensity gameplay. The associations between active PRs and lower success rates in performance metrics are consistent with findings in the literature, which link motor difficulties to impaired coordination and decision-making under stress (Rousseau et al., 2017; Taylor et al., 2020). Given that psychological factors such as stress and anxiety can severely affect technical and tactical performance (Orosz & Mezo, 2015). While our results suggest a potential impact of active PRs on stress responses during gameplay, this relationship remains to be validated through targeted studies on neurophysiological stress markers in athletes with active PRs (Niklasson & Niklasson, 2022).

For TeS, the proximity with the opponent seems to play a role in capacity to success in duel. The active PR group have shown that success rates are significantly lower for the active PR group. It should be noted that these actions, involving these skills, occur in a short time frame and in a confined space with direct contact with the opponent. Studies have shown that unintegrated PRs can affect motor coordination and response times (McPhillips & Sheehy, 2004), which aligns with our observation that players with active PRs showed lower success rates in dynamic match situations.

Key observations suggest that readings trajectory or game (aerial duel or defensive action) are generally more successful when players do not have active PR. Furthermore, defensive skills appear to be the most adversely affected when players have active PR. This is supported by the findings of González et al. (2008), who demonstrated that residual PR could interfere with the development of precise ocular movements such as saccades. These PRs, when present, can lead to difficulties in reading trajectories, as they disrupt the coordination necessary for smooth and accurate eye movements. Additionally, involuntary movements caused by active PR can negatively impact the perception-action loop. Indeed, disrupted perception-action coupling due to involuntary movements significantly increases the risk of errors and injuries (Eagle et al., 2020). This disruption further explains why players with active PR struggle more with defensive skills, as their ability to perceive and react accurately to dynamic situations is compromised.

PR activity and success rate

The ATNR was particularly detrimental for the active PR group, with a decreased success rate in six of the seven assessed skills. The only skill not affected by ATNR activity was passes made in the AZ. This finding aligns with the findings of E. Gieysztor et al. (2020) which highlighted the negative influence of active PR on motor coordination and performance, including ATNR. In overground duels, players with active ATNR showed a lower success rate, up to 34.2% (Table 4), which is significant given the critical nature of these engagements in maintaining possession and transitioning play. This reduction in effectiveness can be attributed to the involuntary head movements induced by the ATNR (E. Gieysztor et al., 2020), which disrupts balance and coordination. Similarly, the success rate in aerial duels dropped by 26.0% for players with higher PR activity, which can be linked to impaired timing and spatial awareness due to persistent PR (Goddard et al., 2009). The lower success rate of passes made in the IZ and/or FZ zones, as well as in duels, both aerial and overground, highlights the importance of these PR in dynamic and high-pressure environments typical of football matches. Moreover, the difficulty in crossing the midline axis during motor execution (e.g., passing the ball or evading an opponent) can hinder environmental reading during the match, thereby affecting ball trajectory perception and opponent movements (Richards et al., 2022).

The connection between PR and skills is further illustrated by the negative impact of STNR on the players' ability to gather and process information. Players with active STNR showed significantly lower success rates in aerial duels, highlighting the detrimental effect of this PRs on trajectory reading. Indeed, the STNR affects the coordination between eye and hand movements (Goddard, 1995), which is crucial for accurate passing and spatial orientation on the field. Indeed, significant associations between remaining PR such as STNR and saccadic eye movements have been found (González et al., 2008). Additionally, in aerial duels, the required leg impulse causes an extension of the legs. With this PR, when there is an impulse from the legs, the upper body and head curl up, resulting in a body form that is not optimal for performing well in aerial contests.

The MR is the second (with the STNR) PR that shows a lower success rate when active in players. All defensive skills (defensive actions and both duels) exhibit a lower average success rate when the MR is active. The success rate in the FZ similarly decreases, indicating that this PR is one of the factors contributing to reduced success rates for the active PR group. This observation aligns with other research that highlights the effects of this PR when active, such as hypervigilance and stress (Goddard, 1995; Rousseau et al., 2017). Additionally, from a motor perspective, it results in loss of balance and poor coordination (Edwards & Khalili, 2023; Niklasson & Niklasson, 2022; Rousseau et al., 2017).

The TLR (in both positions) appears to be one of the PR with the least impact on players' success rates when active. Only two skills, defensive actions and aerial duels, showed a lower success rate when the TLR is active. However, the TLR is not consistently the least impactful in various studies; its effect depends on the context and the persistence of other active PRs (Pecuch et al., 2021). One hypothesis for the relatively low impact of TLR could be that, while this PR is often present in this population (34.7% for TLR FLX and 52.2% for TLR EXT with scores of 1 or 2), it is not frequently exhibited at its most active level (4.3% for TLR FLX and 2.9% for TLR EXT with scores of 3 or 4 during testing) (Bastiere et al., 2024). Therefore, the level of activity of this PR might be a determining factor in its negative impact on skill execution.

Table 4. The success rate of technical skills (TeS) for each primitive reflex (PR) and both active and inactive PR groups.

TeS	Primitive reflex	Inactive PR group Mean ± SD	Active PR group Mean ± SD	Mean Difference	Cohen's d
Overground duel (%)	MR	**57.9 ± 23.7**	**33.4 ± 19.6**	−24,5	−1,13
	ATNR L	**58.8 ± 27.9**	**45.1 ± 21.6**	−13,7	−0,55
	ATNR R	**74.9 ± 15.0**	**40.7 ± 21.4**	−34,2	−1,85
	STNREXT	**57.4 ± 25.8**	**40.7 ± 20.8**	−16,7	−0,71
	STNRFLX	54.2 ± 36.5	45.0 ± 22.1	−9,2	−0,30
	TLREXT	54.6 ± 24.7	49.7 ± 25.2	−4,9	−0,20
	TLRFLX	60.7 ± 23.5	46.6 ± 24.9	−14,1	−0,58
Aerial duel (%)	MR	**71.0 ± 28.4**	**51.5 ± 33.2**	−19,5	−0,63
	ATNR L	**73.1 ± 28.7**	**59.8 ± 31.7**	−13,3	−0,44
	ATNR R	**83.7 ± 14.4**	**57.7 ± 32.8**	−26	−1,03
	STNREXT	**78.9 ± 24.1**	**44.5 ± 28.9**	−34,4	−1,29
	STNRFLX	**72.6 ± 27.5**	**53.4 ± 33.2**	−19,2	−0,63
	TLREXT	74.6 ± 16.0	64.2 ± 32.1	−10,4	−0,41
	TLRFLX	**80.4 ± 19.9**	**59.0 ± 32.7**	−21,4	−0,79
Committed fouls (%)	MR	**0.3 ± 0.3**	**0.9 ± 0.7**	0,6	1,11
	ATNR L	0.5 ± 0.6	0.5 ± 0.5	0	0,00
	ATNR R	**0.2 ± 0.3**	**0.6 ± 0.6**	0,4	0,84
	STNREXT	0.4 ± 0.5	0.6 ± 0.7	0,2	0,33
	STNRFLX	0.4 ± 0.5	0.6 ± 0.6	0,2	0,36
	TLREXT	0.4 ± 0.6	0.5 ± 0.6	0,1	0,17
	TLRFLX	0.5 ± 0.5	0.5 ± 0.6	0	0,00

ATNR = asymmetrical tonic neck reflex; STNR = symmetrical tonic neck reflex; TLR = tonic labyrinthine reflex; L= left; *R* = right; EXT= extension; FLX = flexion; TeS = Technical Skill. * Significant difference between inactive PR and active PR groups ($p \leq 0.05$) are reported in bold.

This study being one of the first in this field, its results need to be confirmed and validated in other populations. Our data indicate that active PRs correlate with reduced performance in specific football skills under spatial-temporal constraints. Future research should further investigate these findings by examining neurocognitive processing in players with active PRs during high-pressure scenarios. Moreover, this study has several limitations that should be acknowledged. Firstly, the sample size of 58 players may be too small to generalize the findings to the broader population of high-level football players. Secondly, the evaluation over a single football season limits understanding of the long-term impact of active PRs on performance. Longitudinal studies spanning multiple seasons would be beneficial. While matches were conducted at home, this approach was deliberately chosen to reduce variability due to differing playing conditions, such as unfamiliar fields or travel fatigue. Although it may reduce variability and isolate the variable of interest, it could also be considered a limitation as it does not reflect the players' performance under away game conditions, where environmental and psychological factors might differ. The impact of active PRs might vary under different conditions and levels of competition. It would be interesting to investigate in an interventional study whether a reduction in PR activity through integration exercises alters the success rates of TaS and TeS. The assessment of PRs used a subjective scale, which could introduce measurement biases. More objective and standardized measures could enhance precision, but currently, none exist.

Practical implications

The practical implications of these findings suggest that coaches and physical trainers should integrate neurodevelopmental rehabilitation programs into their training routines, particularly focusing on exercises designed to mitigate the impact of active PRs in young athletes. Utilizing programs such as those proposed by the INPP could be particularly effective. For example, exercises that mimic stages of motor development such as balancing, rolling, crawling, and quadrupedal movements can support the integration of PRs like the ATNR, the TLR, and the STNR. These activities might help in re-establishing fundamental movement patterns, improving coordination, and reducing the residual influence of active PRs (Blythe, 2005; Grigg et al., 2023). These exercises can be implemented as part of warm-ups or specific neurodevelopmental training sessions to support fundamental movement patterns and enhance coordination. Additionally, it is essential to implement continuous monitoring of PRs to identify athletes at risk, allowing for the timely adaptation of training and rehabilitation programs. Educating staff on the significance of PRs and their potential influence on player performance is crucial for enhancing recognition and management of these factors. Adopting a holistic training approach that encompasses not only technical and tactical skills, but also neuro-motor development can help reduce the adverse effects of active PRs and promote overall athletic performance.

Conclusion

This study demonstrates that having active PRs significantly impair both TeS and TaS in players, particularly in high-stress scenarios. The ATNR and MR were found to be particularly important, reducing success rates of TaS and TeS such as passes in the IZ and FZ and in both overground and aerial duels. These findings highlight the importance of addressing PR integration in athletic training to enhance overall performance and reduce the likelihood of errors in critical match moments.

List of abbreviations

PR	Primitive reflex
ATNR	Asymmetrical tonic neck reflex
STNR	Symmetrical tonic neck reflex
TLR	Tonic labyrinthine reflex
L	Left
R	Right
EXT	Extension
FLX	flexion
GS	Global score
TaS	Tactical Skill
TeS	Technical Skill

Acknowledgments

We especially thank the three video analysts who participated in this study, whose contributions were invaluable to the quality of the research work.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

The author(s) reported there is no funding associated with the work featured in this article.

ORCID

Julie Bastiere http://orcid.org/0000-0002-9707-4537

Ethics approval

The study was conducted according to the guidelines of the Declaration of Helsinki.

Data availability statement

The data supporting reported results can be obtained directly from the correspondent author who deals with data storage.

Consent statement

Informed consent was obtained from all subjects and from the parents for children under 16 involved in the study.

Ethics statement

South Mediterranean 4 Ethics Committee ID-RCB: 2019-A03012-55.

References

Akenhead, R., & Nassis, G. P. (2016). Training load and player monitoring in high-level football: Current practice and perceptions. *International Journal of Sports Physiology & Performance*, *11*(5), 587–593. https://doi.org/10.1123/ijspp.2015-0331

Ali, A. (2011). Measuring soccer skill performance: A review. *Scandinavian Journal of Medicine & Science in Sports*, *21*(2), 170–183. https://doi.org/10.1111/j.1600-0838.2010.01256.x

Bangsbo, J., Mohr, M., & Krustrup, P. (2006). Physical and metabolic demands of training and match play in the elite soccer player. *Journal of Sport Science*, *24*(7), 665–674. https://doi.org/10.1080/02640410500482529

Bastiere, J., Lussiana, T., Young, D., Gindre, C., & Mourot, L. (2024). Persistence and activity levels of primitive reflexes in young high-level football players. *Frontiers in Sports and Active Living*, *6*, 6. https://doi.org/10.3389/fspor.2024.1409257

Blythe, S. G. (2005). Releasing educational potential through movement: A summary of individual studies carried out using the INPP test battery and developmental exercise programme for use in schools with children with special needs. *Child Care in Practice*, *11*(4), 415–432. https://doi.org/10.1080/13575270500340234

Bogdanoviča, I., & Lāriņš, V. (2020). Case study of primitive reflexes impact on swimming skill acquisition by healthy children. *Undefined*, *6*, 89. https://doi.org/10.17770/SIE2020VOL6.5180

Bozkurt, S., & Kucuk, V. (2018). Comparing of technical skills of young football players according to preferred foot. *International Journal of Human Movement and Sports Sciences*, *6*(1), 19–22. https://doi.org/10.13189/saj.2018.060103

Caetano, F. G., Silva, V. P. D., Torres, R. D. S., Anido, R. D. O., Cunha, S. A., & Moura, F. A. (2019). Analysis of match dynamics of different soccer competition levels based on the Player dyads. *Journal of Human Kinetics*, *70*(1), 173–182. https://doi.org/10.2478/hukin-2019-0030

Caicedo-Parada, S., Lago-Peñas, C., & Ortega-Toro, E. (2020). Passing networks and tactical action in football: A systematic review. *International Journal of Environmental Research and Public Health*, *17*(18), 1–19. https://doi.org/10.3390/ijerph17186649

Capute, A. J., Shapiro, B. K., Accardo, P. J., Wachtel, R. C., Ross, A., & Palmer, F. B. (1982). Motor functions: Associated primitive reflex profiles. *Develop Med Child Neurol*, *24*(6), 662–669. https://doi.org/10.1111/j.1469-8749.1982.tb13677.x

Clemente, F. M., Martins, F. M. L., Couceiro, M. S., Mendes, R. S., & Figueiredo, A. J. (2016). Developing a tactical metric to estimate the defensive area of soccer teams: The defensive play area. *Proceedings of the Institution of Mechanical Engineers, Part P: Journal of Sports Engineering & Technology*, *230*(2), 124–132. https://doi.org/10.1177/1754337115583198

Damasceno, A., Delicio, A. M., Mazo, D. F. C., Zullo, J. F. D., Scherer, P., Ng, R. T. Y., & Damasceno, B. P. (2005). Primitive reflexes and cognitive function. *Arquivos de Neuro-psiquiatria*, *63*(3 A), 577–582. https://doi.org/10.1590/s0004-282x2005000400004

Duarte, R., Araújo, D., Freire, L., Folgado, H., Fernandes, O., & Davids, K. (2012). Intra- and inter-group coordination patterns reveal collective behaviors of football players near the scoring zone. *Human Movement Science*, *31*(6), 1639–1651. https://doi.org/10.1016/j.humov.2012.03.001

Eagle, S. R., Kontos, A. P., Pepping, G. J., Johnson, C. D., Sinnott, A., LaGoy, A., & Connaboy, C. (2020). Increased risk of musculoskeletal injury following sport-related concussion: A perception–action coupling approach. *Sports Medicine*, *50*(1), 15–23. https://doi.org/10.1007/s40279-019-01144-3

Edwards, C. W., & Khalili, Y. A. (2023). Moro Reflex. *Encyclopedia of the Neurological Sciences*, 99. https://doi.org/10.1016/B978-0-12-385157-4.01046-0

Gieysztor, E., Pecuch, A., Kowal, M., Borowicz, W., & Paprocka-Borowicz, M. (2020). Pelvic symmetry is influenced by asymmetrical tonic neck reflex during young children's gait. *International Journal of Environmental Research and Public Health*, *17*(13), 1–12. https://doi.org/10.3390/ijerph17134759

Gieysztor, E. Z., Choińska, A. M., & Paprocka-Borowicz, M. (2017). Persistence of primitive reflexes and associated motor problems in healthy preschool children. *Archives of Medical Science*, *14*(1), 167–173. https://doi.org/10.5114/AOMS.2016.60503

Goddard, S. (1995). The role of primitive survival reflexes in the development of the visual system. *Journal of Behavioral Optymetry*, *6*(2), 31–35.

Goddard, S., Beuret, L. J., & Blythe, P. (2009). *Attention, balance, and coordination: The A.B.C. of learning success* (1st ed.). Wiley-Blackwell.

Goddard-Blythe, S. (2005). *The well balanced child: Movement and early learning* (2nd ed.). Hawthorn press.

Goddard Blythe, S. (2015). *Neuromotor immaturity in children and adults. The INPP screening test for clinicians and health practitioners*. Wiley-blackwell.

González, S. R., Ciuffreda, K. J., Hernández, L. C., & Escalante, J. B. (2008). The correlation between primitive reflexes and saccadic eye movements in 5th grade children with teacher-reported reading problems. *Optometry & Vision Development*, *39*(3), 140–145.

Gréhaigne, J. F., & Godbout, P. (1995). Tactical knowledge in team sports from a constructivist and cognitivist perspective. *Quest*, *47*(4), 490–505. https://doi.org/10.1080/00336297.1995.10484171

Grigg, T. M., Culpan, I., & Fox-Turnbull, W. (2023). Primitive reflex integration and reading achievement in the classroom. *Journal of Neurology and Experimental Neuroscience*, *09*(1). https://doi.org/10.17756/jnen.2023-103

Iaia, F. M., Rampinini, E., & Bangsbo, J. (2009). High-intensity training in football Brief Review. *International Journal of Sports Physiology & Performance*, *4*(3), 291–306. https://doi.org/10.1123/ijspp.4.3.291

Illingworth, R. S. (1987). *The development of the infant and young child: Normal and abnormal* (9th ed.). Churchill Livingstone.

Kraynik, Y., Mulik, V., & Lebediev, S. (2019). Performance indicators of the technical and tactical actions of young football players of 13-14 years of various game roles. *Science & Sport*, *7*(5), 48–52. https://doi.org/10.5281/zenodo.3596563

Low, B., Coutinho, D., Gonçalves, B., Rein, R., Memmert, D., & Sampaio, J. (2020). A systematic review of collective tactical behaviours in football using positional data. In *Sports medicine* (Vol. 50, Issue 2, pp. 343–385). Springer. https://doi.org/10.1007/s40279-019-01194-7

McPhillips, M., & Sheehy, N. (2004). Prevalence of persistent primary reflexes and motor problems in children with reading difficulties. *Dyslexia (Chichester, England)*, *10*(4), 316–338. https://doi.org/10.1002/DYS.282

Mohr, M., Krustrup, P., & Bangsbo, J. (2003). Match performance of high-standard soccer players with special reference to development of fatigue. *Journal of Sport Sciences*, *21*(7), 519–528. https://doi.org/10.1080/0264041031000071182

Niklasson, M., & Niklasson, I. (2022). The importance of an early suppression of the moro reflex. *Physical Medicine and Rehabilitation - International*, *9*(2), 1200. https://doi.org/10.1155/2012/191562

Orosz, R., & Mezo, F. (2015). Psychological factors in the development of football-talent from the perspective of an integrative sport-talent model. *Journal for the Education of Gifted Young Scientists*, *3*(1), 58–76. https://doi.org/10.17478/JEGYS.2015112018

Pecuch, A., Gieysztor, E., Wolańska, E., Telenga, M., & Paprocka-Borowicz, M. (2021). Primitive reflex activity in relation to motor skills in healthy preschool children. *Brain Sciences*, *11*(8), 967. https://doi.org/10.3390/BRAINSCI11080967

Portillo, J., Abián, P., Calvo, B., Paredes, V., & Abián-Vicén, J. (2020). Effects of muscular injuries on the technical and physical performance of professional soccer players. *The Physician and Sportsmedicine*, *48*(4), 437–441. https://doi.org/10.1080/00913847.2020.1744485

Ric, A., Torrents, C., Gonçalves, B., Torres-Ronda, L., Sampaio, J., & Hristovski, R. (2017). Dynamics of tactical behaviour in association football when manipulating players' space of interaction. *PLoS One*, *12*(7). https://doi.org/10.1371/journal.pone.0180773

Richards, L., Avery, R., Gray, S., Price, R., & Author, P. (2022). Relationship of retained primitive reflexes and handwriting difficulty in elementary-age children. *The American Journal of Occupational Therapy*, *76*(Supplement_1), p76105050101–p76105050101. https://doi.org/10.5014/AJOT.2022.76S1-RP10

Rousseau, P. V., Matton, F., Lecuyer, R., & Lahaye, W. (2017). The Moro reaction: More than a reflex, a ritualized behavior of nonverbal communication. *Infant Behavior and Development*, *46*, 169–177. https://doi.org/10.1016/j.infbeh.2017.01.004

Sabarit, A., Reigal, R. E., Morillo-Baro, J. P., de Mier, R., Franquelo, A., Hernández-Mendo, A., Falcó, C., & Morales-Sánchez, V. (2020). Cognitive functioning, physical fitness, and game performance in a sample of adolescent soccer players. *Sustainability 12*(13), 5245. https://doi.org/10.3390/su12135245

Stéphane Héros. (2022). Les fondements cognitifs et sensibles de l'activité des footballeurs professionnels. Étude de la diversité interindividuelle lors des phases de jeu en lien avec les transitions défensives hautes. *Éducation, Université Clermont Auvergne*. Document en français. NNT : 2022UCFAL014.

Taylor, B., Hanna, D., & McPhillips, M. (2020). Motor problems in children with severe emotional and behavioural difficulties. *The British Journal of Educational Psychology*, *90*(3), 719–735. https://doi.org/10.1111/bjep.12327

Teodorescu, S., & Gheorghe, D. (2014). Methods for increasing the game action performance in football by valorizing the cognitive processes. *Procedia - Social & Behavioral Sciences*, *117*, 361–366. https://doi.org/10.1016/J.SBSPRO.2014.02.228

Williams, A. M., & Reilly, T. (2000). Talent identification and development in soccer. *Journal of Sports Sciences*, *18*(9), 657–667. https://doi.org/10.1080/02640410050120041

Annexe A

ATNR = asymmetrical tonic neck reflex; STNR = symmetrical tonic neck reflex; TLR = tonic labyrinthine reflex; L= left; R = right; EXT= extension; FLX = flexion. No significant differences ($p > 0.05$) are reported.

Table A. Distribution of general characteristics of participants by primitive reflex (PR) and position.

Position groups	Variable	Group	MR	ATNRL	ATNR R	STNREXT	STNRFLX	TLREXT	TLRFLX
All	*N*	Inactive PR	42	24	17	35	36	6	17
		Active PR	17	35	42	24	6	53	42
	Age	Inactive PR	17.5 ± 1.4	18.0 ± 1.5	17.7 ± 1.5	17.7 ± 1.6	17.7 ± 1.4	18.7 ± 2.4	17.6 ± 1.7
	(year)	Active PR	18.0 ± 1.5	17.3 ± 1.3	17.6 ± 1.4	17.5 ± 1.2	17.6 ± 5.1	17.5 ± 1.3	17.6 ± 1.3
	Height	Inactive PR	178.5 ± 6.5	179.9 ± 6.6	178.8 ± 6.9	178.3 ± 7.1	178.5 ± 6.9	177.2 ± 3.3	178.5 ± 5.6
	(cm)	Active PR	177.6 ± 5.8	176.8 ± 5.7	177.8 ± 6.0	177.8 ± 4.8	177.4 ± 5.1	178.2 ± 6.5	177.9 ± 6.5
	Mass	Inactive PR	69.2 ± 7.0	70.8 ± 7.5	70.2 ± 7.3	68.7 ± 7.2	69.7 ± 6.9	71.7 ± 3.7	69.7 ± 6.6
	(kg)	Active PR	69.2 ± 5.9	68.1 ± 5.9	68.8 ± 6.4	69.9 ± 5.7	68.5 ± 6.3	68.9 ± 6.8	69.0 ± 6.7
Defensive and offensive midfielders,	*N*	Inactive PR	31	18	13	28	28	4	16
and full and centre back		Active PR	11	24	29	14	14	38	26
	Age	Inactive PR	17. 6 ± 1.3	18.1 ± 1.5	17.5 ± 1.3	17.7 ± 1.5	17.5 ± 1.4	18.5 ± 3.0	17.8 ± 1.7
	(year)	Active PR	18.1 ± 1.8	17.4 ± 1.3	17.8 ± 1.5	17.8 ± 1.3	18.1 ± 1.6	17.6 ± 1.2	17.7 ± 1.3
	Height	Inactive PR	178.1 ± 6.6	179.6 ± 6.4	178.5 ± 6.4	178.5 ± 7.0	178.5 ± 6.7	177.8 ± 3.3	178.8 ± 6.8
	(cm)	Active PR	179.0 ± 6. 3	177.5 ± 6.5	178.3 ± 6.7	178.0 ± 5.5	178.0 ± 6.2	178.4 ± 6.8	178.1 ± 7.1
	Mass	Inactive PR	69.1 ± 6.6	69.6 ± 7.3	68.7 ± 6.2	69.8 ± 6.7	69.1 ± 6.6	71.4 ± 0.8	69.8 ± 6.8
	(kg)	Active PR	69.7 ± 6. 7	69.1 ± 6.0	69.5 ± 6.8	65.8 ± 3.4	69.6 ± 6.6	69.1 ± 6.8	69.0 ± 6.4
Defensive and offensive midfielders,	*N*	Inactive PR	33	18	12	27	28	5	12
full back, winger, and forward		Active PR	16	31	37	22	21	44	37
	Age	Inactive PR	17.5 ± 1.5	18.2 ± 1.7	17.9 ± 1.6	17.8 ± 1.7	17.8 ± 1.4	19.2 ± 2.3	17.9 ± 2.0
	(year)	Active PR	17.9 ± 1.6	17.4 ± 1.4	17.6 ± 1.5	17.5 ± 1.2	17.6 ± 1. 6	17.5 ± 1.3	17.6 ± 1.3
	Height	Inactive PR	176.6 ± 6.2	177.8 ± 6.2	176.8 ± 7.1	176.5 ± 7.0	176.7 ± 6.7	176.4 ± 3.0	175.6 ± 3.3
	(cm)	Active PR	176.9 ± 5.1	176.0 ± 5.5	176.6 ± 5.4	176.9 ± 4.0	176.6 ± 4.6	176.7 ± 6.0	177.0 ± 6.4
	Mass	Inactive PR	67.5 ± 6.5	69.1 ± 7.2	69.0 ± 8.0	67.0 ± 7.0	68.2 ± 6.6	71.6 ± 4.1	66.5 ± 4.3
	(kg)	Active PR	68.6 ± 5.4	67.2 ± 5. 5	67.5 ± 5.5	69.0 ± 4.8	67.5 ± 5.6	67.5 ± 6.3	68.3 ± 6.6