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Parent–Infant Attachment and Gross Motor Development During the First 2 Years of Life: A Systematic Review

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ABSTRACT

The attachment system is crucial in several aspects of child development. We aimed at synthesizing the existing knowledge on the association between mother/father attachment to the infant and gross motor development during the first 2 years of life. A systematic review following PRISMA standards was preregistered in PROSPERO (CRD42022308841) in April 2022 and conducted in May 2022 (updated: July 2023, July 2024, and January 2025). PubMed, Web of Science, APA PsycINFO, and PSICODOC databases were searched. Peer-reviewed observational studies in English or Spanish with a minimum score of five on the Newcastle–Ottawa Scale, used for assessing bias risk, were included. Results are critically presented and synthesized. Ten studies were selected out of the initial pool of 813 records. Findings are described based on the parent–infant attachment and gross motor development, the association of parental roles and co-parenting dynamics, and the effect of stress on motor development. Positive early parent–infant interactions and secure parent–infant attachment are associated with better infant motor development. Studies with larger samples and more specific motor assessments are suggested for the advancement of the field.

1 | Introduction

Optimal motor development has been found to contribute to infants' well-being in multiple ways, promoting children's participation in activities of daily life (Bretz et al. 2022), in social interaction contexts (Eggebrecht et al. 2017), and overall physical fitness (Hulteen et al. 2018). In addition, early motor development influences the progression of executive functioning, exerting positive effects on cognitive performance and behavioral development at the preschool stage (Li et al. 2022; Wu et al. 2020). Improving knowledge of the factors that contribute to optimal motor development is, therefore, an area of research of considerable interest for the future physical and psychological well-being of infants.

The theoretical framework of motor development has been expanded, shifting from a hierarchical and innate acquisition model to a more comprehensive perspective that acknowledges the influence of environmental factors (Hadders-Algra 2010, 2018). In particular, gross motor development (i.e., changes in gross motor behavior throughout life, involving both quantitative and qualitative factors) is no longer considered to depend on individual aspects, but rather on a combination of trial-and-error learning, influenced by the interaction between biological,

Summary

- Secure infant attachment is associated with better motor development.
- Research on attachment and motor development primarily focuses on mothers.
- Health professionals could enhance motor skills by fostering positive interactions.

familial, and environmental factors (Hadders-Algra 2000; Piallini et al. 2016). From an environmental perspective focused on family relationships, attachment theory (Ainsworth and Bowlby 1991) provides a solid theoretical framework to understand these dynamic processes by rooting them in the primary caregiving relationship.

During the first 2 years of life, when infants undergo important developmental changes, they also form a specific and particularly relevant type of relationship with their primary caregivers: this is called attachment, and it is defined as a special dyadic affective bond (Cassidy and Shaver 2008). These relationship patterns vary in several ways, including differences in the quality of interaction and care (Weinfield et al. 2008). According to attachment theory, because of the responsive care they receive from a primary caregiver, infants with a secure attachment pattern develop a mental representation of the caregiver, someone who can serve as a secure base from which to explore the environment and as an effective safe haven to return to in times of need (Ainsworth et al. 1979; Ainsworth and Bowlby 1991). The perceived predictability of the caregiver translates into the child's secure attachment and influences the development of key aspects of child development, such as behavioral and physical, emotional regulation and social competence (see meta-analyses: Groh et al. 2017; Hornor 2019). For this reason, the attachment system and the environmental scanning system are adaptive structures that are in constant dynamic equilibrium (Cassidy and Shaver 2008). Upon being faced with a threat or a situation of uncertainty, the attachment system activates mechanisms to ensure the infant's proximity to the caregiver and its emotional survival. This activation of the attachment system reduces opportunities to develop the physical skills necessary for autonomous movement by deactivating the exploration system. When the attachment figure fulfills the function of restoring security, the attachment system can be deactivated, allowing exploration to resume.

In consequence, the presence and perceived availability of the attachment figure provides the necessary conditions for the infant to explore the environment (Bretherton 1985; Cassidy and Shaver 2008; Powell et al. 2014). The acquisition of autonomous movement marks the beginning of physical distance from the attachment figure. Despite this theoretical link seeming clear, the influence that attachment has on the acquisition of gross motor milestones is less investigated. Rocha et al. (2019) reviewed the influence of the mother–infant relationship on infant development during the first year of life, observing in most studies a positive association between the quality of mother–infant interaction and motor development. However, since the attachment relationship with the primary caregiver typically solidifies in the second year of life (Prior and Glaser 2006), it is crucial to extend such analysis to the first 2 years of life. Moreover, previous literature (e.g., Chiang et al. 2015) warrants the need to deepen the examination of the effect of the father figure or co-parenting. Therefore, the present review aims to clarify existing knowledge about the association between parent–infant attachment and infants' motor development in the first 2 years of life.

2 | Methods

A systematic review was conducted, as described in the PRISMA 2020 Statement (Page et al. 2021), to synthesize the existing knowledge regarding the mother/father–infant attachment relationship and its association with motor development during the first 2 years of life. Prior to the search, the review was registered in PROSPERO (reference code: CRD42022308841) on the 11th of April 2022.

2.1 | Search Strategy

The initial search took place in May 2022. As more records might have emerged since the initial search, the search has been updated alongside the writing process—including two intermediate updates of July 24, 2023 and July 3, 2024. The final (third update) search was conducted on January 22, 2025. In all cases, the search was the same, taking place in the following databases: PubMed, Web of Science, APA PsycINFO, and PSICODOC. The search strategy and string were the same in all databases, which is shown below: ((AB = ("motor skills" OR "motor development" OR "motor ability" OR "motoric" OR "gross motor" OR "locomotion" OR "motor function")) AND AB = (("attachment" OR "bonding" OR "connection" OR "relationship" OR "mother–child relation" OR "mother child relation" OR "mother infant dyadic" OR "parental engagement" OR "early interactions" OR "maternal sensitivity" OR "socioemotional development"))) AND AB = ("toddler*" OR "infant*").

2.2 | Study Selection

The retrieved articles were collected in the web-based reference manager Zotero, and discrepancies in selecting the final articles for inclusion were discussed and resolved among the four authors of the study. The first author (A.V.-M.) removed duplicates and, together with another author (M.G.) independently screened the papers according to the defined inclusion and exclusion criteria. Selected records were then stored in Excel for the subsequent stage. Studies that did not meet the inclusion criteria when reading the title or abstract were excluded in this first selection. The same two authors (A.V.-M. and M.G.) reviewed the full texts to assess eligibility. Inter-rater agreement was high (96.5%). For the quality assessment, two of the authors (A.V.-M. and C.L.-N.) independently reviewed the records taking into account the Newcastle–Ottawa Scale (NOS). This scale is recommended for assessing the quality of nonrandomized studies in systematic reviews,

and has demonstrated content validity and inter-rater reliability (Wells et al. 2021). Inter-rater agreement exceeded 85%, with discrepancies resolved by consensus. This assessment was performed at the full-text eligibility stage. Studies with a longitudinal follow-up of the sample of less than 1 year were not scored in the section on sufficient longitudinal follow-up. Studies with a score of less than five were excluded.

2.3 | Inclusion/Exclusion Criteria

The following inclusion criteria were used for the registries: (a) observational studies in peer-reviewed publications, (b) that analyzed the relationship between parent–infant attachment and gross motor development during the first 2 years of life, and (c) written in English or Spanish. The following criteria were employed for exclusion: (a) documents evaluating any attachment intervention, (b) samples of children with pathologies or diagnosed disabilities, (c) documents other than peer-reviewed scientific articles (i.e., gray literature, conference abstracts, and trial registries), (d) studies targeting nonhuman samples, and (e) studies with a score lower than five on the NOS scale.

2.4 | Data Extraction and Analysis

From the final articles included, the first author (A.V.-M.) extracted the following information from each article to complete the results table shown in Table 1: authorship and year, participants, study design, attachment, and motor development measures and summarized results. The data described in Table 1 were reviewed by two other authors (A.V.-M. and I.A.-A.). The results of the present systematic review derive from a qualitative analysis. Given the methodological and conceptual heterogeneity among the included studies, a quantitative meta-analysis was deemed unfeasible. The studies differed substantially in design (descriptive, cross-sectional, or prospective longitudinal), and in the assessment of both parent–infant interaction (e.g., observed attachment classification, parent-reported questionnaires) and motor development (e.g., Bayley Scales, Ages and Stages Questionnaire, parent-reported locomotor skills). These inconsistencies prevented the calculation of comparable effect sizes and the reliable aggregation of quantitative findings.

3 | Results

The initial search identified 813 records, of which 10 articles were eventually included in the study after the filtering and screening stage. Figure 1 shows the flowchart of the study selection process.

3.1 | Study Characteristics

A general description of the characteristics of the articles included in the review is presented in Table 1. The selected articles were published between 2007 and 2021 and were conducted in nine countries, representing different sociocultural settings (Iran, the Netherlands, USA, Taiwan, UK, Australia, Germany, Norway, and Palestine). The result of the NOS scores of the included articles is detailed in Table 2.

3.2 | Sample Characteristics

A total of 5573 parent–infant dyads participated in the 10 studies analyzed, with sample sizes ranging from 40 to 1718 participants. Regarding infants, 47.10% were girls and 52.90% were boys. Only two studies (Chiang et al. 2015; Parfitt et al. 2014) included fathers. All dyads consisted of biological parents, with the exception of one sample composed of adoptive mothers (Van Londen et al. 2007). The samples were homogeneous in terms of educational attainment, with 84.19% of the participants having completed secondary education (all but one study provided this information; see Table 1 for specific breakdown). Regarding setting type (urban/rural), only one study (Qouta et al. 2021) provided information.

3.3 | Employed Assessment Tools

Despite a relatively low number of studies meeting the inclusion criteria, various assessment tools developed from different perspectives of attachment were employed: CARE Index (Crittenden 2004), Maternal Antenatal Attachment and Maternal Postnatal Attachment (Condon and Corkindale 1998), and Strange Situation (Ainsworth et al. 1979). However, there was greater consistency across studies in the scales used to assess infant motor development, utilizing the Bayley II (Bayley 1993) and Bayley III (Bayley 2005) scales of infant development and the Ages and Stages Questionnaire (ASQ-3; Squires and Bricker 2009).

3.4 | Quality Assessment-Related Results

In our review, the methodological quality of the included studies was assessed using the NOS, which is structured around three main domains: selection, comparability, and outcomes. Scores between 7 and 9 indicate low risk of bias and scores between 5 and 6 represent moderate risk (Zeng et al. 2015). Several recent systematic reviews and meta-analyses (e.g., Yirdam et al. 2025; Zong et al. 2024) have adopted a cutoff score of ≥ 5 on NOS to delineate studies of at least acceptable methodological quality. As shown in Table 2, lower scores were mainly driven by limitations in sample representativeness, partial control of confounders, and incomplete or insufficiently reported follow-up rates.

Among the studies rated as low risk of bias (Chiang et al. 2015; Garthus-Niegel et al. 2017; Haselbeck et al. 2019; Hendrix and Thompson 2011; Khandan et al. 2018; Le Bas et al. 2021; Qouta et al. 2021; Van Londen et al. 2007), more consistent and direct associations emerged between parental or environmental factors and infant motor and cognitive development. These higher-quality studies, often based on large or well-characterized cohorts, employed validated developmental measures and robust statistical control, which strengthened the reliability of their findings. For instance, Chiang et al. (2015) and Le Bas

TABLE 1 | General description of the characteristics of the included studies.

Authors (year)	Participants	Country (income level)	Study design	Attachment and motor skills measures	Results
Aiello and Lancaster (2007)	71 Adolescent mother–infant dyads 67.6% had not completed high school schooling (over half would be expected to have completed high school according to their age)	Australia (high income)	Longitudinal	– Global Maternal Attachment (8 weeks, 6 months, 12 months) – Maternal Separation Anxiety (6 and 12 months) – Bayley Scale of Infant Development II (6, 12, and 24 months)	Infants born to mothers who cohabited with their parents in the first postpartum months showed stronger mother–infant attachment ($r = 0.29$; $p < 0.05$), but had poorer gross motor development in the second year of life ($r = -0.32$; $p < 0.01$)
Chiang et al. (2015)	Mother and fathers with infants: 1718 (motor skills complete) and 1600 (motor skills incomplete) Mothers' education: 82.8% at least high-school (40.7% also university) education	Taiwan (high income)	Longitudinal	– Infant motor development (6 and 18 months) – Parent–child interaction (6 and 18 months)	The time spent in parent–infant interaction influenced infant's gross motor development (i.e., being incomplete vs. complete) both for mothers at Time 1 (OR = 1.24; 95% CI [1.002–1.524], $p < 0.05$) and fathers at Time 2 (OR = 1.18; 95% CI [0.993–1.404], $p < 0.10$)
Garthus-Niegel et al. (2017)	1472 Mother–child dyads No socioeconomic information provided	Norway (high income)	Longitudinal	– Impact of Event Scale (8 weeks postpartum) – Edinburgh Postnatal Depression Scale (8 weeks postpartum) – Child development: Ages & Stages Questionnaire (2 years) – Ages and Stages Questionnaire—social–emotional (2 years)	No relation was observed between mother's post-traumatic stress disorder symptoms and later infant's gross motor development ($r = -0.03$, $p =$ ns) Gross motor development at 2 years of age was associated with lower socioemotional development ($r = -0.13$, $p < 0.001$)
Haselbeck et al. (2019)	51 Mother–child dyads 98% at least high-school education level (84.3% with a university entrance diploma)	Germany (high income)	Longitudinal	– Maternal distress scales – Interpersonal Reactivity Index – Child's development: *Entwicklungstest* ET 6–6 (12 months) – Child's attachment: Strange Situation (12 months)	Infants of mothers who had experienced a higher level of prenatal distress, when showing a secure attachment style, they exhibited slightly better gross motor development ($r = 0.261$, $p < 0.05$)

(Continues)

TABLE 1 | (Continued)

Authors (year)	Participants	Country (income level)	Study design	Attachment and motor skills measures	Results
Hendrix and Thompson (2011)	40 Mother–infant dyads All parents were high-school graduates; over 75% had education beyond high school	USA (high income)	Longitudinal	– Maternal interview reporting child's locomotor skills (6 months) – Observation coding of maternal proactive control: providing an object for the child to play with, interaction or pleasant talk to the child (8 months)	No differences were found in maternal proactive behavior to facilitate locomotion skills between transitioning and nonlocomotor groups (MANOVA statistic value is not provided)
Khandan et al. (2018)	260 Mothers with infants Mothers' education: 95.4% at least high-school (57% also university) education	Iran (upper–middle income)	Cross-sectional	– Attachment to the Child subscale of the Adaptation to a maternal role in Primiparous Women Questionnaire – Ages and Stages Questionnaire for child's development	Father's role in coparenting was not associated with better infant motor development ($r = -0.01$, $p =$ ns) Mothers' lower levels of worry and anxiety about parenting were slightly associated with infants' better gross motor development ($r = -0.13$, $p = 0.03$), but mothers' attachment to child was unrelated ($r = 0.02$, $p =$ ns)
Le Bas et al. (2022)	1347 Mother–child dyads 94% at least high-school education (68% also university education). General socioeconomic status: 4% low, 29% medium, and 67% high	Australia (high income)	Longitudinal	– Maternal Antenatal Attachment Scale (prenatal), and Maternal Postnatal Attachment Scale (8 months) – Edinburgh Antenatal and Postnatal Depression Scale (during pregnancy, and postnatal 8 weeks and 12 months) – Bayley Scale III of Infant Toddler Development (12 months)	A stronger bond was observed between mother's stronger attachment and child's motor developmental scores, both at the initial trimester of pregnancy ($\beta = 0.07$, $p < 0.05$) and 8 weeks postpartum ($\beta = 0.07$, $p < 0.05$)
Parfitt et al. (2014)	42 Mothers and fathers with infants 85% had undergone higher education	United Kingdom (high income)	Longitudinal	– CARE-index (3 months) – Bayley Scale of Infant Development III (17 months)	A perceived better father–infant relationship showed a low-to-moderate correlation with better motor development ($r = -0.26$, $p < 0.05$)

(Continues)

TABLE 1 | (Continued)

Authors (year)	Participants	Country (income level)	Study design	Attachment and motor skills measures	Results
Qouta et al. (2021)	502 Mother–infant dyads 73.6% at least gymnasium education	West Bank and Gaza (lower–middle income)	Longitudinal	– Infant–mother interaction: Emotional Availability-Short Report (6 months) – Bayley Scales III of Infant Development (6 and 18 months)	Close and positive mother–infant interaction was positively associated with better motor skills of the infant ($r = 0.31$, $p < 0.001$), whereas distant mother–infant interaction, with difficulties in calming the infant, was negatively associated ($r = -0.24$, $p < 0.001$)
Van Londen et al. (2007)	70 Internationally adopted infants and their adoptive mothers No socioeconomic information provided	The Netherlands (high income)	Cross-sectional	– Maternal sensitivity (14 months) – Child's attachment: Strange Situation (14 months) – Psychomotor development: Bayley Scales (14 months)	Maternal sensitivity aspect of mother–child relationship was a protective factor associated with motor development ($\beta = 0.24$, $p < 0.05$) Child attachment security was associated with motor development ($r = 0.23$, $p < 0.05$). Moreover, children with disorganized attachment showed lower levels of motor development than nondisorganized children ($r = 0.40$, $p < 0.001$)

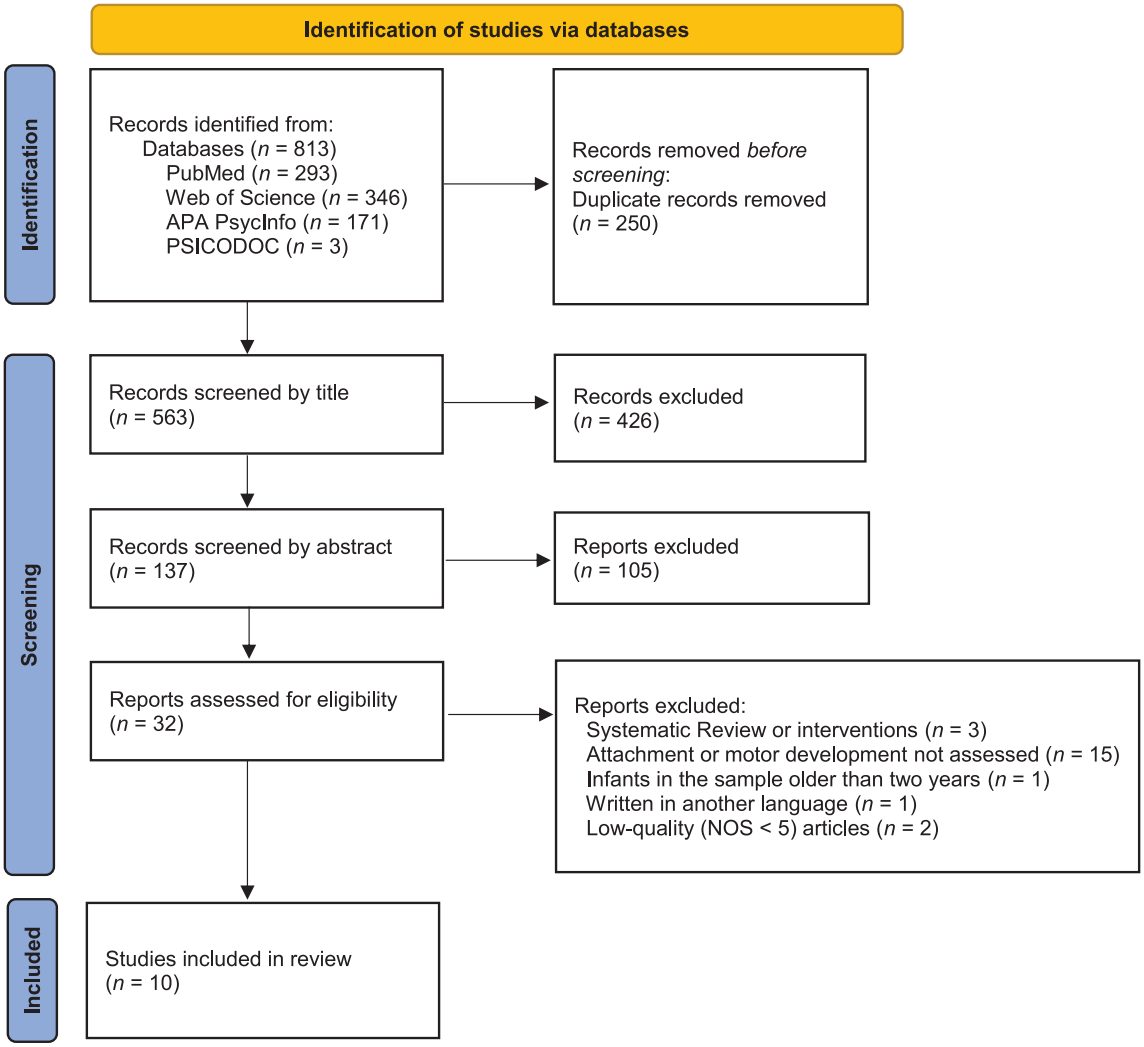

FIGURE 1 | Flowchart of the study selection following PRISMA guide.

TABLE 2 | Results of the Newcastle–Ottawa Scale (NOS) evaluation for the reviewed studies.

Author (year)	Selection				Comparability	Outcomes			Total score
Aiello and Lancaster (2007)	*	*	*		*	*	*		6
Chiang et al. (2015)	*	*	*	*	**	*	*	*	9
Garthus-Niegel et al. (2017)	*	*	*	*	**	*	*	*	9
Haselbeck et al. (2019)		*	*	*	*	*	*	*	7
Hendrix and Thompson (2011)		*	*	*	*	*	*	*	7
Khandan et al. (2018)	*		*		**	*	*	*	7
Le Bas et al. (2022)	*	*	*	*	**	*	*	*	9
Parfitt et al. (2014)	*		*	*	*	*		*	6
Qouta et al. (2021)	*	*	*	*	**	*	*	*	9
Van Londen et al. (2007)	*		*	*	**	*		*	7

et al. (2021) reported clear predictive links between parenting roles, bonding, and developmental outcomes, while Qouta et al. (2021) and Garthus-Niegel et al. (2017) identified indirect pathways mediated by maternal stress or trauma.

By contrast, the studies classified as having moderate risk of bias (i.e., Aiello and Lancaster 2007; Parfitt et al. 2014) presented a more heterogeneous pattern of associations. Although these studies found positive relations (such as the links between

secure attachment, maternal role adaptation, or caregiving competence and infant outcomes), they also reported weaker or nonsignificant effects. In some cases, the association with developmental indicators appeared indirect or context-dependent, influenced by maternal psychosocial variables or family dynamics. These results suggest that study design quality, sample size, and analytic rigor meaningfully influenced the strength and consistency of observed associations.

3.5 | Parent–Infant Attachment and Gross Motor Development

In a longitudinal study, Haselbeck et al. (2019) examined the association between prenatal maternal stress and subsequent infants' attachment and motor development. They observed that infants with a secure attachment style, whose mothers went through high levels of prenatal stress, had slightly better gross motor development. In other words, infants' secure attachment may have a protective effect on their gross motor development in the context of prenatal maternal stress. On the other hand, Van Londen et al. (2007) examined infant attachment and mental and motor development shortly after adoption. They found that staying in a foster family, earlier age of arrival, and maternal sensitivity—i.e., an aspect of caregiving competence involving responsiveness to infant cues—were protective factors for motor development. They also found that children with disorganized attachment had lower levels of gross motor development.

In addition, other studies have demonstrated the relation between maternal attachment and infant motor development. For example, the study by Le Bas et al. (2022) analyzed the influence of prenatal and postnatal maternal attachment on infant motor development during the first year of life. This study found that positive attachment during both pregnancy and in the first postpartum trimester was associated with higher motor development scores in the infant during the first year of life. In another study, Aiello and Lancaster (2007) investigated the influence of maternal attachment and maternal separation anxiety in a sample of adolescent mothers on the infants' mental and motor development during the first 2 years of life. They observed that infants of mothers who lived with their parents, exhibited a secure attachment style in the postpartum period, in contrast to those who did not live with their parents. However, these infants had poorer motor development outcomes in the second year of life.

3.6 | Father Figure, Quality of Dyadic Interaction Co-Parenting and Infant Motor Development

Three of the reviewed studies examined the association between the father figure and infant gross motor development, either as a secondary interaction figure (Chiang et al. 2015; Parfitt et al. 2014) or as a supportive partner in caregiving (Khandan et al. 2018). A high-quality father–infant interaction was associated with motor development outcomes (Parfitt et al. 2014), and a positive perception of the supportive paternal role was linked to better infant motor development (Chiang et al. 2015). These findings highlight the relevance of the paternal role in relation to infant motor development, specifically the quality of father–infant interaction and co-parenting dynamics.

More specifically, the results showed that both maternal and paternal (perceived) parenting competence was positively associated with infant motor development (Chiang et al. 2015). Similarly, some aspects of the quality of dyadic interaction, such as maternal closeness and emotional availability, were also associated with better motor development (Qouta et al. 2021).

As for concrete indicators of motor development, Hendrix and Thompson (2011) evaluated the association between mother–infant interaction and the acquisition of walking in the first year of life. This study is the only one to observe the links between the quality of the interaction and the acquisition of a specific motor milestone. The findings suggest that proactive maternal behavior during the interaction does not accelerate the process of locomotion acquisition.

3.7 | Infant Interaction Quality, Stress and Motor Development

One aspect that merits particular attention is the effect of maternal posttraumatic stress on infant motor development. The findings of the review studies differed. Garthus-Niegel et al. (2017) did not observe a positive association between maternal postpartum posttraumatic stress symptoms and difficulties in infant motor development. Qouta et al. (2021) investigated the impact of maternal and infant exposure to traumatic war events on maternal mental health, mother–infant interaction, and infant gross motor development. These authors observed that dyads exposed to traumatic scenes (witnessing deaths, explosions, or bombings) exhibited a positive association with high levels of infant gross motor development at 18 months of age. In conclusion, maternal mental health or exposure to traumatic events does not necessarily directly influence the quality of mother–infant interaction.

4 | Discussion

This review aims to elucidate the existing knowledge on the relation between parent–infant attachment and infant motor development, providing a critical analysis that can enhance the understanding of professionals and families alike. Overall, the findings suggest that a secure infant attachment may be associated with better motor development, whereas a disorganized attachment style may be associated with less optimal motor development: out of the 10 revised studies, seven support the association in this direction (vs. two showing an unrelated pattern, and one showing mixed results).

This association may align with the infants' instinctual need to seek proximity to their safety figure when exploring the environment, reinforcing effective motor strategies essential for safety and survival (Cassidy 1986; Cassidy and Shaver 2008). Based on the general assumption that motor development is enriched by interaction with the environment (Ferreira et al. 2018), it follows that interaction with the caregiver is also part of the external information received by the infant to stimulate its development (Bradley and Corwyn 2005). Indeed, the human brain's capacity for emotional comprehension, which is supported by mentalization and the mirror neuron system, is situated within the

same frontal cortex regions where the frontal sensorimotor and premotor areas are also located, as are the primary sensory regions (Fonagy et al. 2007). Thus, individuals' motor learning receives continuous information from actions observed in social interaction (Bonini et al. 2022). In support of this view, Hadders-Algra (2018) proposes a conceptual framework on motor development that would explain its relation to attachment security: motor behaviors initiate in the premotor cortex and are subsequently influenced bidirectionally by factors including the quality of interaction with the family and the sociocultural environment.

On one hand, regarding the quality of family interaction, several studies describe the influence of the quality of early dyadic interaction between caregivers and infants on socioemotional (Keller 2018; Laurin et al. 2021) cognitive and language development (Endevelt-Shapira et al. 2024; Topping et al. 2013). The results of this review show that a high-quality parent–infant interaction is positively associated with infant motor development (Parfitt et al. 2014). Similarly, another review also reported a positive association between early dyadic interaction quality and infant motor development in the first year of life (Rocha et al. 2019). These observations are consistent with mirror neuron theory, which highlights imitation as a key mechanism of motor learning in infancy (Meltzoff et al. 2009). They also confirm that the environmental context and social interaction of the person imitating influence how motor behavior is learned (Bonini et al. 2022).

On the other hand, the quality of dyadic interaction and other contextual factors were observed in the studies analyzed in this review. These included situations involving adoptive mothers, adolescent mothers, mothers with postpartum posttraumatic stress syndrome and dyads exposed to war events and their influence on attachment and motor development. Specifically, in the study by Qouta et al. (2021) conducted with a sample of mothers/children exposed to traumatic events, it was observed that environmental characteristics and positive interactions—such as sensitive, responsive, and emotionally supportive exchanges—may serve as protective factors for attachment quality and gross motor skill development. In addition, there are studies that examine the neurobiological consequences of stressful traumatic attachment experiences and their influence on the pathophysiology of attachment through intrauterine information and genetic interaction (for a review, see Arancibia et al. 2023). Van Londen et al. (2007) stated that maternal sensitivity may have a protective effect on motor development. In support of these claims, Bakermans-Kranenburg et al. (2003), in a meta-analysis of the effectiveness of interventions to improve dyadic attachment, also assert that maternal sensitivity exerts a positive change in infant attachment patterns. Understanding the contextual factors that may influence the bonding capacities of both paternal and maternal caregivers and infants is essential, as attachment dynamics may be susceptible to change depending on the experienced pathways (for a review, see Opie et al. 2020). However, parental sensitivity, as an element of caregiving competence, may have a protective effect on attachment, interaction quality and infant motor development (Cozodoy et al. 2024).

Regarding fathers and mothers, a limited number of studies have included both figures in their samples, but all of them report positive associations among secure attachment, high-quality dyadic interactions, relevance of co-parenting, and infant motor development. The joint influence of both parental attachment figures on socioemotional development has been described (Dagan and Sagi-Schwartz 2017; Kim et al. 2021; Khandan et al. 2018; Lux and Walper 2019), and father involvement in infant care has also been associated with better cognitive and socioemotional developmental outcomes in infants (e.g., Kochanska and Kim 2012; Newland et al. 2013). However, to date, the maternal figure has been more commonly considered the primary source of attachment (Branjerdporn et al. 2017; Bretherton 2010; Parfitt et al. 2013; Rocha et al. 2019) and its relation to infant gross motor development has been the subject of examination.

Parfitt et al. (2014) described that a less optimal perceived father–infant relationship was moderately associated with poorer infant motor development. One possible explanation for these findings is that fathers generally encourage exploratory autonomy by participating in more energetic and physically stimulating activities (Frosch et al. 2019), which have been associated with better outcomes in infant gross motor development (Majdandžić et al. 2015). In the same vein, Kato et al. (2023) found in a Japanese sample that fathers' involvement in childcare was linked to a lower risk of delayed motor development and served as a mediator in maternal stress. Therefore, it seems that paternal attachment and the quality of father–infant interaction in the analyzed studies and countries may contribute to stronger stimulation of gross motor milestones, similar to its established connection with improved outcomes in cognitive and socioemotional development. Yet, it is important to note that few studies have analyzed this issue and that cross-cultural differences in fathers' roles and involvement in child-rearing may apply and account for the observed links. This sets an avenue for future research.

In terms of gross motor milestone assessment scales, most of the studies included in this review used the Bayley Global Infant Development Scale, which has been shown to be a tool of great interdisciplinary applicability for the assessment and diagnosis of developmental delays in early childhood (Jackson et al. 2012). However, this assessment tool analyzes gross motor development quantitatively. That is, scores are based on the acquisition (or not) of motor performance items without taking into account the quality or fluency of movement or motor learning strategies to achieve the function, which is enriched by the information the infant receives both from the environment (Bertenthal 2010) and from imitation of reference figures for motor learning (Meltzoff et al. 2009). This highlights that motor development is intertwined with socioemotional development in the context of caregiver interactions (Adolph and Hoch 2019; Bornstein et al. 2013). To observe the influence of the quality of dyadic interaction on the acquisition of gross motor development, the use of tools that assess the quality of infants' movements and motor behavior could be more in line with the theoretical framework that recognizes the importance of the infant's experience and context in the process of motor learning.

Finally, from a methodological viewpoint, out of the 10 studies reviewed, eight employed longitudinal studies and two were cross-sectional. Yet, none of them employed randomized

controlled designs, limiting causal inference. Therefore, while preliminary associations between early parent–infant interaction and motor development were observed, the use of nonexperimental designs warrants cautious interpretation.

4.1 | Limitations and Future Research Directions

Firstly, the inclusion of studies reported in peer-reviewed articles, and written exclusively in English or Spanish poses the risks of reporting bias that should be mentioned. Despite English being the lingua franca to disseminate scientific knowledge that is commonly used for systematic reviews, and Spanish being a widely spoken language across the world, the use of this exclusion criterion might have left out some pertinent studies that may have been published in other languages. Future studies may benefit from both targeting scientific reports other than peer-reviewed articles (i.e., gray literature, conference abstracts, and trial registries) without positive-results bias, and forming research teams fluent in more languages. Secondly, despite the synthetic value of the present review, it is important to note a limitation regarding the wide diversity of variables in the studies analyzed within parent–child interactions as well as the heterogeneity in outcome measurement tools, which impeded us from conducting a meta-analysis. A meta-analysis could have strengthened the conclusions regarding the link between attachment and motor development. Thirdly, the potential moderating variables identified in the review findings (i.e., maternal stress, paternal affect, and co-parenting) have only been examined in a limited number of studies; thus, the current synthesis is only qualitative and descriptive in nature. Future research should consider designs that account for these moderating variables that could influence the links between attachment and infant motor development. Finally, certain gender bias should be noted in the evidence database; most studies are mother-focused, which limits the generalizability of the results. For that reason, including simultaneously both mother and father in studies would clarify the differential value of each attachment figure on the impact of the parent–infant relationship on gross motor development.

5 | Conclusions

There is preliminary evidence to suggest that positive parent–infant interactions and secure attachment or higher relationship quality in the first 2 years of life are associated with better infant motor development. A positive relationship and interaction of both mother and father with the baby positively associate with the baby's motor development. There are no clear findings on the influence of maternal stress or exposure to traumatic events on the quality of mother–child interaction.

6 | Relevance for Clinical Practice

These findings can guide Pediatric Nurse Practitioners (PNPs) and other health professionals in supporting families and the infant's motor development to encourage and promote positive interactions from an integrative and preventive perspective. In particular, they provide valuable information that could allow PNPs to formulate interventions for children's development. For instance, the implementation of evidence-based interventions, such as parental education or early parenting programs aimed at fostering sensitive responsiveness, structured play, and parent–infant bonding (e.g., Bennett et al. 2025; Gündoğmuş et al. 2024), may enhance the quality of early interactions and, in turn, support optimal motor development. By evaluating developmental milestones and educating parents about socioemotional aspects affecting normal growth, it would be possible to identify and prevent relevant risk factors that could affect infants' early motor development. They may lead both to the improvement of the parent–child relationship and to infants' motor development, considering the interactions between the two.

Author Contributions

Alicia Varas-Meis: conceptualization, investigation, writing – original draft, methodology, validation, visualization, formal analysis, project administration, data curation. **Carmen Lillo-Navarro:** conceptualization, methodology, data curation, investigation, validation, formal analysis, supervision, visualization, writing – review and editing. **Itziar Alonso-Arbiol:** conceptualization, investigation, methodology, data curation, validation, supervision, writing – review and editing, funding acquisition, visualization, formal analysis, project administration. **Miriam Gallarin:** conceptualization, writing – review and editing, methodology, data curation, investigation, validation, formal analysis, supervision, visualization, project administration.

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Ethics Statement

This systematic review was conducted using previously published data, and no new human or animal subjects were involved. As this type of study does not fall under the purview of the ethical approval process, no ethical approval was sought. All the analyzed studies were reviewed and selected based on rigorous inclusion criteria and adherence to ethical guidelines for systematic reviews.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Data S1:** nhs70267-sup-0001-Supinfo.docx.