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Motor Profile of Late Preterm Infants: A Systematic Review of the Last Decade

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Abstract

Motor development at late preterm infants has significant importance as it composes the picture of the severe evidences of motor impairments or other developmental difficulties. Early detection is crucial as early intervention is the unique immediate solution option to catch up the developmental milestones. Method: A systematic search for scientific articles of the decade 2010-2020 investigating the motor profile of late preterm infants was conducted. Results: The search identified 9 studies, many of which highlighted the risk of motor and developmental delays even at 36 months of age. Conclusions: The stability of motor and developmental delays indicates the need of further investigation at a later age and intervention to avoid possible academic difficulties.

Keywords

Late Preterm Infants, Motor Profile, Infancy, Motor Development

1. Introduction

Preterm delivery is crucial for neonatal mortality and morbidity [1]. Motor development constitutes the first path that could provide quite enough evidence that motor impairments or other growth difficulties are at risk to be occurred. This early detection is necessary as early intervention is the only option to catch up the developmental milestones. As motor and cognitive domains are significant correlated [2], motor development recommends the springboard to examine difficulties that will be occurred in many aspects of later life. Late preterm infants are those who are born between the 340/7 - 366/7 weeks of gestation and they are less mature than term infants [3]. According to bibliography late preterm consists the 75% of preterm infants [4] and they confront pathological

problems, learning and academic difficulties, high morbidity, and long-term morbidities as adults [5].

As the literature reveals late preterm infants are at increased risk to demonstrate medical and academic issues [5]. In view of this fact, a systematic literature review was conducted to investigate the motor characteristics of late preterm infants. Our review of literature aims to produce current data that could lead scientists to further research on certain motor domains at late preterm infants or provide them the current preliminary data that could be used in order to design an appropriate intervention program.

2. Method

2.1. Research Strategy

Literature search was conducted to identify literature correlated to the purpose of this study from 2010-2020. The electronic databases that searching took place were Pubmed, PsycInfo and Scopus, inspection of bibliography of the retrieved articles also was committed. The key words that used were the following: infant, preterm, late preterm, 34 - 36 weeks, prematurity, early childhood, movement, motor profile, motor development, motor assessment, infant motor test, motor skills. **Figure 1** shows the single database research strategy.

2.2. Selection of Eligible Studies

The studies that were reviewed included articles regarding motor performance of late preterm infants up to 36 months old, as it is presented by scientists the last decade. Studies were excluded if they met any of the following criteria: studies that included late preterm infants with other preterm groups (mixed preterm groups), studies included developmental assessment over 36 months years of age, studies not included late preterm group in the comparison groups, studies that were not included at least one domain of gross or fine motor development and studies not publish in English language. While reviewing procedure, firstly, studies were excluded by titles and abstracts, only if they met the referred criteria of exclusion, or if there were duplicates. Secondly, two researchers reviewed the full text of all the papers and agreed on the inclusion of articles. Finally, articles references were reviewed also for relevant articles.

2.3. Data Extraction

Data extraction forms were designed that included the following characteristics: authors name and year of publication, location that the study took place, type of study, age of assessment, size of the study and control group samples, tools, aim of the study and results. Available summary results were then tabulated.

2.4. Quality Assessment

Critical Appraisal Skills Program (CASP), section A for cohort studies was used to evaluate the studies included in this review (**Figure 1**). Section A from CASP

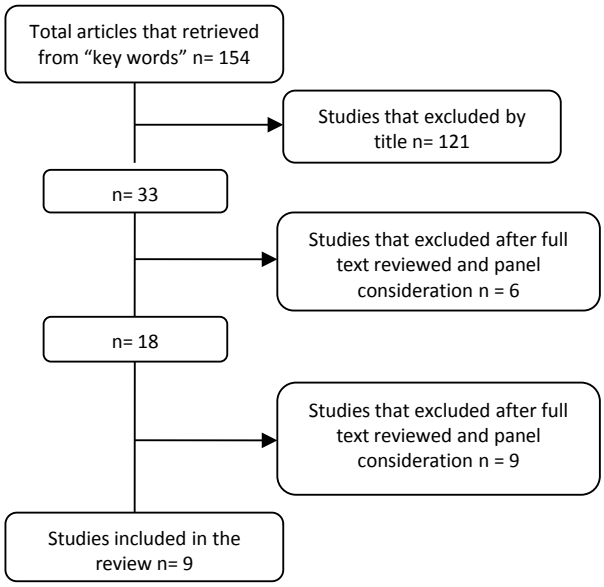

Figure 1. Diagram of study selection.

answer to 8 questions regarding results' validity (bias). Answers are simply according to given criteria and refers to "yes = 1, no = 0 or not clear = 0". Eight points is the highest value. According to CASP Section A, all included studies were assessed between 0 - 8 points.

3. Results

3.1. Included Studies

As Figure 1 presents, nine studies met the inclusion criteria. Initially 154 papers were retrieved, from those 121 were excluded as there were either duplicates (15) or excluded based on the title and abstracts (106). Abstracts revealed mixed preterm infants' groups and another 15 articles were excluded. Finally, after full text review another 6 articles were excluded for mixed preterm infants' groups in their results. At last two researchers agreed to the nine studies that constituted the current literature review.

3.2. Description of Included Studies

The nine studies that met the criteria are described in Table 1. All of them have studied the usual developmental domains such as social, motor, cognitive skills, and neuro-developmental outcomes. Their results are produced by either battery/observation tests (6) or parent questionnaires (3). The present literature review aims to present exclusively motor development results of late preterm infants till the third year of age. Most of the studies took place in high income countries such as USA (1), Canada (3), Brazil (1), China (1), France (1), Israel (1) and South Africa (1) which is a low or medium income country. All studies were completed the last decade, actually 2013 - 2020. Six of them where longitudinal studies, two were comparative studies and one study described motor invention program.

Table 1. Description of included studies.

	Description of the final sample size							
Author Year Location	Study design	Age	Preterm	Control group	Parents	Exclusion	Tools	Aim of the study
You et al. 2019 China	comparative	24 30	61	85			Gesell Development Diagnosis scale Normal Development of Social Skills from Infants to Junior High School Children scale	To compare the social competence, motor development, and cognition of late preterm infants (LPIs) with full-term infants
Benzies et al. 2017 Canada	Longitudinal	4 8 18			82	-	Ages and Stages Questionnaires	To examine longitudinal patterns of early development in Canadian children born late preterm
Ballantyne et al. 2016 Canada	Descriptive comparative	12 ± 2 weeks.	52	156		SGA Genetic disorders and relative abnormalities	Ages and Stages Questionnaires 3	The aim of this study was to compare the risk of developmental delay between late preterm and full-term Canadian born infants at age 12 months, and to determine infant and maternal factors associated with risk of delay
De Almeida Soares et al. 2015 Brazil	Intervention program		12	12				To compare the effects of a short bout of practice on reaching behavior between late preterm and full-term infants at the onset of goal-directed reaching
Bélanger et al. 2018 Canada (North Ontario)	Longitudinal	2 6 9 12 18 24	Extremely preterm 15 Very preterm 34 medium preterm 25 late preterm 23	-		Genetic disorders	Alberta Infant Motor Scale (AIMS) Early Intervention Developmental Profile (EIDP)	To provide preliminary data on the gross motor outcomes of children born prematurely and to determine the proportion and characteristics of the children who had maintained delays over the course of follow-up
Mirzakhani et al. 2020 USA	Longitudinal	24 36	42	593	635	Medium and extremely preterm infants	Ages and Stages Questionnaires 3	To examine the stability of potential delays across developmental domains at 24 and 36 months of age in late preterm (34 36 weeks) and term (≥37 weeks) children and whether the risk of delays remained high at 36 months

Continued

Petkovic et al. 2016 France	Longitudinal	6 12	12	10		Peabody Developmental Motor Scales, Bimanual coordination and handedness tests	To examine visuo-manual coordination and gross motor development at late preterm and full term infants
Ramdin et al. 2018 South Africa	Longitudinal	9 12 15 18	56	50	Genetic disorders Trisomy 21	Bayley scales of infant and toddler development 3	To determine the neuro developmental outcome of late preterm infants in Johannesburg South Africa in comparison to a group of term control infants
Morag et al. 2013 Israel	Longitudinal	6 12	124	33		Alberta Infant Motor Scale (AIMS) Griffiths Mental Development Scales (GMDS)	To longitudinally assess the neuro developmental outcomes of late preterm infants (LPI) through the first year of life and to investigate for perinatal conditions that may affect developmental outcomes

3.3. Motor Profile of Late Preterm Infants – Gross and Fine Motor Development

According to gross and fine motor development 3 longitudinal studies which used observation and motor battery tests indicate delays up to 30 months of age. Three longitudinal studies used a parental questionnaire and the results confirmed gross motor delays even up to 36 months old. One study examined coordination and found significant difficulties for the preterm group. Only one study examined the effect of a short motor intervention program in late preterm infants. **Table 2** summarizes the main results of the studies.

Specifically, [6] examine motor, cognitive and social skills in late preterm infants at 24 and 30 months of age to 112 late preterm and 179 full-term infants. They used Gesell Development Diagnosis Scale and the Normal Development of Social Skills from Infants to Junior High School Children Scale. Results according gross motor showed that motor development (gross and fine) and social skills are significant correlated in the domains of self-help and locomotion abilities. Significant lower scores between late preterm and full-term infants were mentioned at both gross and fine domain. [7] assessed 15 extremely preterm infants, 34 very preterm infants, 25 medium preterm infants and 23 late preterm infants, including SGA. They used the Alberta Infant Motor Scale (AIMS) [8] and the Early Intervention Developmental Profile (EIDP) [9]. Assessing took place at 2, 9, 12, 18 and 24 months. The researchers referred that late preterm infants remain at the same risk of developmental delays as the very preterm infants. [10] noted that late preterm infants had significant lower scores at 6 and 12 months old in gross motor development. Although, there were no significant differences, when consider age correction.

Table 2. Main results of included studies.

	Description of the final sample size								
Author Year Location	Study design	Age of assessment	Preterm	Control group	Parents	Exclusion	Tools	Aim of the study	Main results
You et al. 2019 China	comparative	24 30	61	85			Gesell Development Diagnosis scale Normal Development of Social Skills from Infants to Junior High School Children scale	To compare the social competence, motor development, and cognition of late preterm infants (LPIs) with full-term infants	Gross and fine motor skills were significant associated with social skills. Late preterm infants were at risk of motor developmental delays
Benzies et al. 2017 Canada	Longitudinal	4 8 18			82	-	Ages and Stages Questionnaires	To examine longitudinal patterns of early development in Canadian children born late preterm	At 4 and 8 months of age late preterm infants had significant lower scores at gross motor skills than the full-term infants. At 4 months of age late preterm infant had lower score at fine motor scales that the full tern infants. There were no significant differences at the age of 18 months between groups
Ballantyne et al. 2016 Canada	Descriptive comparative	12 ± 2 weeks.	52	156		SGA Genetic disorders and relative abnormalities	Ages and Stages Questionnaires 3	The aim of this study was to compare the risk of developmental delay between late preterm and full-term Canadian born infants at age 12 months, and to determine infant and maternal factors associated with risk of delay	Late preterm infants were at risk of motor developmental delays at the age of 12 months
De Almeida Soares et al. 2015 Brazil	Intervention program		12	12				To compare the effects of a short bout of practice on reaching behavior between late preterm and full-term infants at the onset of goal-directed reaching	Late preterm infants had great variability of proximal of reaching after practice and exhibited smaller variability for distal adjustments. Late preterm infants had less beneficial from this practice program

Continued

Bélanger et al. 2018 Canada (North Ontario)	Longitudinal	2 6 9 12 18 24	Extremely preterm 15 Very preterm 34 medium preterm 25 late preterm 23	-		Genetic disorders	Alberta Infant Motor Scale (AIMS) Early Intervention Developmental Profile (EIDP)	To provide preliminary data on the gross motor outcomes of children born prematurely and to determine the proportion and characteristics of the children who had maintained delays over the course of follow-up	Late preterm infants were at risk of gross motor delays at all assessments. SGA was a crucial factor for developmental delays and intervention physiotherapy
Mirzakhani et al. 2020 USA	Longitudinal	24 36	42	593	635	Medium and extremely preterm infants	Ages and Stages Questionnaires 3	To examine the stability of potential delays across developmental domains at 24 and 36 months of age in late preterm (34 - 36 weeks) and term (≥37 weeks) children and whether the risk of delays remained high at 36 months	Late preterm infants remained at risk of motor developmental delays at 24 and 36 months of age
Petkovic et al. 2016 France	Longitudinal	6 12	12	10			Peabody Developmental Motor Scales, Bimanual coordination and handedness tests	To examine visuo-manual coordination and gross motor development at late preterm and full term infants	Late preterm infants had significant delays at visuo-manual coordination, grasp, bimanual dexterity, and handedness
Ramdin et al. 2018 South Africa	Longitudinal	9 12 15 18	56	50		Genetic disorders Trisomy 21	Bayley scales of infant and toddler development 3	To determine the neuro developmental outcome of late preterm infants in Johannesburg South Africa in comparison to a group of term control infants	There were no significant differences between the groups. Neonatal and maternal factors were not associated with motor developmental delays
Morag et al. 2013 Israel	Longitudinal	6 12	124	33			Alberta Infant Motor Scale (AIMS) Griffiths Mental Development Scales (GMDS)	To longitudinally assess the neuro developmental outcomes of late preterm infants (LPI) through the first year of life and to investigate for perinatal conditions that may affect developmental outcomes	Late preterm infants had lower scores at every assessed domain, including motor, than the full-term infants at the age of 6 an 12 months

According to the parental questionnaire studies, Ages and Stages Questionnaire—Third Edition (ASQ-3) [11] was used by all three studies. [12] assessed 52 and 156 mothers' of late preterm and full preterm infants respectively. Late preterm infants indicated significant high risk of developmental delays at the age of 12 months at gross motor skills in contrast to fine motor skills. [13] examined 82 mothers' of late preterm infants. Results indicated that at the age of 4 months late preterm infants had lower scores in communication, gross motor and fine motor domains regarding to the ASQ-3 norms. Developmental delays were still occurred at the age of 8 months (excluding fine motor skills) but at the age of 18 months no significant differences were observed. This was the only study which indicated that late preterm infants overlap difficulties at the age of 18 months old. [13] evaluate the stability if developmental delays at 24 and 36 months of age between late preterm and full-term infants. 42 and 593 mothers' of late preterm and full term infants respectively completed ASQ3. This study was a part from another [14] [15]. Results indicated that gross and fine motor delays remained even at the age of 36 months for the late preterm infants.

[16], assessed visuo-manual coordination and gross motor development at 12 late preterm and 10 full term infants at 6 and 12 years of age. Peabody Developmental Motor Scales and Bimanual coordination and handedness tests were used [17]. Results indicate developmental delays at visuo-manual coordination, grasping, bimanual coordination, and handedness even when compared using corrected age in preterm infants. Finally, [18] assessed the effect of a short motor intervention program at the skill of reaching between late preterm and full preterm infants. Researchers mention that late preterm infants were less advanced from this experience than the full-term infants.

3.4. Neuro-Developmental Outcomes

According to the neuro-developmental outcomes, two studies present proportion. [6] refer that the 9.82% of late preterm infants had motor impairments and only the 56% of full-term infants had motor difficulties. [19] evaluated the neuro-developmental outcomes of 56 late preterm and 50 full term infants assessed with Bayley scales of infant and toddler development 3 [20] at 9, 12, 15, and 18 months. Although this is the only study, that referred no differences between the groups for every developmental domain including motor, it manage to refer the same proportion of 7% for developmental difficulties in late preterm infants as high income countries refer. [10] also assessed the neuro-developmental outcomes of 124 late preterm and 33 full term infants at 6 and 12 months of age. The tools that were used were Alberta Infant Motor Scale (AIMS) [8] and Griffiths Mental Development Scales (GMDS) [21] (Griffiths, 1954). Researchers highlighted the fact that late preterm infants do not complete their neuro-developmental maturity in the first year of age.

3.5. Other Factors for Motor Delays at Late Preterm Infants

Five studies investigated the correlation between motor and neuro-developmental

outcomes with different factors. [19] examined neonatal and maternal factors (antenatal care, antenatal steroids, antenatal magnesium sulphate, maternal HIV, caesarean section delivery, multiple gestation, resuscitated in the delivery room, severe IVH—grade 3 or 4, respiratory distress syndrome, mechanical ventilation, postnatal steroids, necrotising enterocolitis—stage 2 or 3, exchange transfusion, late onset sepsis, breastfed on discharge) which were not correlated with neuro-developmental status. Also [12] did not find any association between mothers' educational level, intensive care unit and breastfeeding and developmental delays. In contrast, [7] whose results indicated that SGA was significant factor and [10] who mentioned that gender (male)emergent cesarean section and higher maternal education were associated with low developmental scores at 12 months of age for the late preterm infants.

4. Discussion

At the present systematic review of literature, published studies regarding motor development of late preterm infants up to 36 months of age are presented. These papers were retrieved from three electronic databases. Considering these results, it is obvious that late preterm infants constitute a group of preterm that underlies the need of further research attention, investigation, and intervention care. The reason why is that the developmental delays in both gross and fine motor skills, could still be observed at the age of 36 months old.

Evaluation and assessment of late preterm infants and their developmental characteristics are essential not only at the early age but there are quite enough data to ensure that should continue at older ages of growth. Assessment of motor development provides useful information for intervention designs. Early detection and intervention play a key role in development.

In this review of literature only one study in South Africa, did not mention significant differences between late preterm and full-term infants [19]. Although, it should be noted that prematurity was determined only by the last menstrual period without antenatal ultrasounds. Moreover, there was a rate of 76.7% of losing follow up and missing data as a result. It also should be mention that despite small size of the sample are the referred limitations, proportion of disability at late preterm infants in South Africa indicate that late preterm infants are in a population at risk.

Generally, almost all included studies mention that motor difficulties remain at a depth of time, the study of [13], underlined the fact that late preterm infants manage to cover the developmental gap between 8 and 18 months of age. Results of this research were based on mother's answers according the developmental status of their infants. Nevertheless, ASQ3 is a widely used norm questionnaire with good validity and reliability levels and strong correlation with scales like Alberta Infant Motor Scale (AIMS) and others [22].

According to the factors associated with motor delays at preterm infants only one study examines co-morbidity and intensive care unit. All studies send up

with the conclusion line that continuous assessment in late preterm infants is essential. Furthermore, this literature review reveals the intervention programs research paucity regarding motor development at late preterm infants the last decade, as only one study was reviewed which in fact had small size sample.

To sum up, the studies that reviewed end up to the following results, regarding motor development of late preterm infants and shaped their motor profile as following:

- A proportion of 7% - 9.8% of late preterm infants with motor disabilities and other developmental delays was identified [6] [19].
- Gross and fine motor skills are associated with social skills. Simultaneously, these are the basic domains that late preterm presented lower scores that full-term infants [6] [23].
- Late preterm infants remain at risk of motor and developmental delays at the 4, 6, 8, 12, 24 and 36 months of age [7] [10] [12] [13] [23].
- Significant low scores are noted in visuo-manual coordination, grasp, bimanual dexterity, and handedness [16].
- There are preliminary data indicating that the effect of a short motor intervention program of 4 minutes on reaching skill, was more beneficial for the full preterm than the late preterm infants [18].
- Small for gestation Age (SGA) infants confronted the same motor and developmental difficulties with very preterm infants and constituted a significant factor of delays [7]
- Factors such as mothers academic level, delivery status, nursing in intensive care unit, breastfeeding, gender and other neonatal and maternal factors stay under investigation as results were doubtful [10] [12] [19].

The aim of this literature review was to identify the motor profile of late preterm infants as it is presenting the last decade. Results underline the need of continuous assessments as motor delays remain even in the age of 36 months of age. It is concluded that motor assessment of late preterm infants should not be underestimated and interrupted early under the excuse of little gestation time left. Finally, the stability of motor and developmental delays indicates the need of further investigation at a later age and intervention to avoid possible academic difficulties.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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