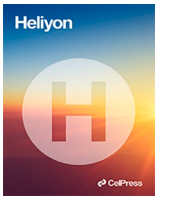
Heliyon 9 (2023) e20372

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Motor development of first born compared to later born children in the first two years of life – A replication

Heinz Krombholz

Bavarian State Institute for Early Childhood Research and Media Literacy (IFP), Munich, Germany

A R T I C L E I N F O

Keywords:
Early childhood
Motor development
Motor milestones
Manual dexterity
Position in the sibling row

A B S T R A C T

Purpose: The motor development of firstborns compared to children having an older sibling in the first two years of life was examined.
Method: The data of the study come from an ongoing research project with citizen participation, which is investigating the development of motor milestones in the first and second years of life. Parents report online their children's developmental progress using a development calendar. 18 motor skills from birth until children manage walking alone are recorded, 14 relate to gross motor skills and four to hand motor skills.
Results: Children with siblings achieved higher values at birth in terms of Apgar-score, height, weight, BMI and parental satisfaction with the health and development of the child compared to firstborns. However, no differences could be found at the ages of 10–12 months and 14 months. Firstborns reached five fine motor and manual dexterity milestones earlier than children with siblings. In contrast, when mastering 13 gross motor milestones, no differences could be found between firstborns and children with siblings.
Conclusion: Motor development at an early age is considered to be largely genetically controlled, analogous to physical development. However, the faster development of the fine motor skills of the firstborns could be related to the fact that parents interact more intensively with their firstborn than with later born children and – unlike gross motor skills – in fine motor skills not only genetic factors but also learning processes are effective from a very early age.

1. Introduction

Infancy and early childhood are characterized by rapid developmental processes that are reflected in physical changes (growth) and the expansion of motor skills and competencies. After the necessary maturation of the nervous and muscular system, the elementary motor skills develop in the first two years of life (e.g. sitting, crawling, standing, walking, and also grasping). There are significant inter-individual differences in the time of onset of these basic forms, but only minor differences between boys and girls [1,2]. Motor development in infancy is of outstanding importance as an index for the quality of the developmental process, since it requires organized interaction between different neurological centers in addition to physical maturation processes [3,4]. And motor development is an ideal model system for the study of psychological development [5].

The impact of existing siblings and position in the sibling line on personality development has long been discussed [6]. According to longitudinal studies with several thousand participants in Germany, Great Britain, and the USA, firstborns achieved higher values in intelligence tests than later borns, but no differences were found in other personality traits [7]. However, it is assumed that siblings

E-mail address: heinz.krombholz@ifp.bayern.de.

https://doi.org/10.1016/j.heliyon.2023.e20372
Received 24 September 2022; Received in revised form 16 September 2023; Accepted 20 September 2023
Available online 21 September 2023

have a significant influence on motor and athletic development [8,9]. Firstborns practice less high-risk sports than later borns [10], top athletes more often have older siblings than less capable athletes and it is assumed that siblings play an important role in the decision to take up a career and succeed in competitive sports [11].

Regarding the relationship between position in the sibling line and motor development in childhood different hypotheses compete [3,12]: (a) Children with older siblings benefit from the role model effect of existing siblings, and/or (b) firstborns or only children receive more attention and support from their parents, or (c) firstborns and only children are overprotected and restricted in their range of motion, which impairs their motor performance. However, the impact of birth order on motor development in childhood has not received much attention, and research that has been done does not provide a clear understanding of the impact of birth order. Although Zareian, Saeedi & Rabbani [13] found better results for 94 s-born boys aged 9–11 years in a balance test, most studies did find no relation between the presence of older siblings and motor skills in preschool and elementary school age, and also the assumption that the sex of the older siblings influences the motor skills of the offspring could not be confirmed [3,12,14]. Cruise & Reilly [15] found higher motor performance in children without siblings compared to children with siblings at 9 months of age. In contrast, Koutra, Chatzi, Roumeliotaki et al. [16] found that children with siblings achieved better gross motor skills at 18 months of age. Moreover, according to Rebelo, Serrano, Duarte-Mendes et al. [17], who examined the development of 405 children in the first two years of life with the Peabody Developmental Motor Scales-2, children with older siblings were in advantage in terms of their gross and fine motor development over only children. In contrast, Leonard & Hill [18] found no differences between children with and without siblings and emphasize that the current data do not support the assumption that older siblings are a positive role model for motor skills acquisition in infants.

The present study examines the development of gross and fine motor milestones in infancy and factors that are assumed to influence development in the first years of life. A direct role model effect of older siblings in the first few months of life on motor development is unlikely to be of any importance. On the other hand, subsequent births should benefit from their better developmental status at birth. In addition, the proportion of premature and caesarean births is higher in primiparous women and the birth weight of their newborns is lower. These factors can delay development [19–22]. However, parents concern themselves more intensively with their firstborns than with later borns and devote more attention and support to them [23]. Krombholz [24] predicted that children with siblings would master the elementary motor milestones earlier than firstborns due to their better physical starting conditions. However, children with siblings did not show any advantages in reaching gross motor milestones compared to firstborns and firstborns were superior in manual dexterity. This surprising finding could be related to the fact that parents pay more attention to firstborn children. Since no other studies are known to date to confirm this finding a replication of the study of Krombholz [24] was carried out on the connection between motor development and the presence of siblings with a larger sample.

2. Methods

The data come from an ongoing research project at the State Institute for Early Childhood Research and Media Literacy (IFP Munich)[1], in which more than 3200 parents are currently taking part. Using a "citizen science approach," parents report their children's developmental progress online using a development calendar that includes 18 motor skills from birth until children manage walking alone (around 14 months of age). Citizen science is the practice of public participation and collaboration in scientific research to increase scientific knowledge, people share and contribute to data monitoring and collection [25,26].

2.1. Parent recruitment and participation

To recruit participants in the study the project was presented in magazine articles and radio and television reports. Parents register and report online the data on the developmental steps of the children to the IFP. To determine possible influencing factors on the development of the children, parents answer an online questionnaire with information on age and educational qualifications, language, place of residence, apartment, course of pregnancy, type of birth, birth size and weight, existing siblings. As soon as the target child had mastered the milestone ("free and safe walking"), at an average age of 14 months, the parents were asked again: e.g. about the care situation, and health (illnesses, developmental problems, allergies) and on the child's diet (how long breastfed).

This study was approved by the Advisory Board of the IFP (W–K 2013). Since participants were free to take part in the study and they had to give neither names nor addresses, there were no ethical considerations to comply with in this research and consent was assumed by participation [27].

2.2. Variables

18 motor skills are recorded, 14 relate to gross motor skills and four to hand motor skills. A description of these milestones is given in Table 1. The observation sheet for parents [28] can be found at:
https://www.ifp.bayern.de/imperia/md/content/stmas/ifp/entwicklungskalnder_meilensteine.pdf.
In addition to the age at which the children complete the specified milestones, the following variables were used.

[1] The Bavarian State Institute for Early Childhood Research and Media Literacy (IFP), Germany, is a research centre focusing on innovative projects in early childhood education, research into early learning and knowledge transfer for practitioners and policy-makers.

Table 1
The collected milestones and their description.

Milestone	Description
Gross motor skills	
1 Bring hands together	Lying on the back, the child brings the hands together over the middle of the body
2 Lift head on stomach	In prone position, head can be lifted for at least 3 s
3 Roll to prone	In supine position, the child turns onto tummy, observed at least 3 times
4 Roll to suspine	From the prone position, the child turns onto the back, observed at least 3 times
5 Sitting with support	When the child is seated, it remains seated freely with a straight back for at least 10 s
6 Sit up unsupported	Sits down independently and remains seated without supporting itself with its hands
7 Belly crawl	Moves forward using the hands or arms, the legs are not actively involved
8 Hands and knees crawling	Crawls on hands and knees or feet, the stomach is raised off the floor - at least 3 movements of arms or legs in a row
9 Standing up with support	Stands up independently by supporting or holding on (e.g. a chair) and remains standing for at least 10 s
10 Standing with help	Placed carefully, the child can stand freely for at least 10 s
11 Walk sideways with hold	Can walk at least 5 steps if it is holding on to furniture, for example
12 Pull to stand	Can stand up independently and then stand for at least 10 s without holding on
13 Walking alone	Can walk at least 5 steps freely without help
14 Walking alone and safely	Can walk freely and safely while avoiding obstacles, at least 10 steps
Manual dexterity	
15 Grasp after things	Grasps an object and holds it with one or both hands
16 Pass an object to the other hand	An object is safely passed from one hand to the other
17 Tweezer grip	A small object is grasped with the extended thumb and index or middle finger
18 Pincer grip	A small object is grasped with crooked thumb and forefinger

- Due date and calculated due date *
- Body length (cm) and weight (kg) at birth and the age of 10–12 months *
- Apgar-score: the value after 5 min is used *
- Type of delivery: spontaneous vaginal delivery, with suction cup or forceps, cesarean section *
- Age, school, and professional qualifications of mother and father
- Existing siblings
- Care situation, allergies, serious illnesses, diagnosed developmental abnormalities
- Question about breastfeeding: Answer option: Yes, exclusively breastfed until … month/Currently still exclusively breastfed/Yes, partially breastfed from …. by … month/no/no answer
- "Satisfaction with health" and "satisfaction with development" at the 1st and 2nd survey: "How satisfied are you currently with the health/development of your child?" (Scale: very satisfied (1), satisfied (2), rather dissatisfied (3), dissatisfied (4)).

* Collected as part of the preventive medical check-ups for children U 1 and U 2.

2.3. Data analysis

The statistics program package SPSS (version 28.0.1.1) was used for all calculations. Group comparisons were made using t-tests. The normality of the distributions was checked using the Shapiro-Wilk test. To estimate the practical significance of the effects Cohen's *d* was calculated. A *d* of 0.2 or smaller is considered to be a small, a *d* of 0.5 a medium, and a *d* of 0.8 or larger a large effect size.

3. Results

More than 3200 children are currently enrolled in the study, 49.0% are female, 49.3% male, and for 1.7% of the babies, no gender information exists. On average, the newborns are 51.3 cm ($SD = 3.0$ cm) in length and weigh 3.38 kg ($SD = 0.6$ kg), the BMI is 12.8 ($SD = 1.4$), the Apgar-score (5) 9.5 ($SD = 0.9$). The questionnaire at the beginning of the study was answered for about 3000 children, at the end of the study for 500, however, not all questions were answered. Almost all babies were born in hospitals (93%), outpatient or home births were rare. The proportion of multiples, almost exclusively twins, was 3.9%. The mean age of the mother at the birth of the milestone baby is 31, that of the father 34 years. Roughly the same number of parents live in rural areas, in small and medium-sized towns and cities and they usually have sufficient living space at their disposal, on average more than 100 square meters. About a third of the parents already have a child. In almost all of the families participating, German is predominantly spoken (86%). There are also bilingual families in the sample (including German and Spanish, German and English). 63% of the mothers have a high school diploma, 12% a technical college diploma, and 14% a secondary school diploma. The fathers have slightly lower school qualifications. The level of education and professional qualifications of the sample is higher than in the resident population of Germany [29].

More parents with firstborns use early support programs and firstborns are more often cared for by their grandparents than children with siblings (38 vs. 11%). On the other hand, children with siblings attend crèches and toddler groups more often than only children. No differences could be found in the other care and support options (other caregivers, parent-child gymnastics, baby swimming).

The babies were in overall good health, with 98% of the babies having an Apgar-score (5 min) greater than or equal to 7 ($M = 9.48$, $SD = 0.98$). Few infants suffer from serious or chronic diseases or allergies. 78% of parents are "very satisfied" with the health of their babies immediately after birth, 20% are "satisfied" and only two percent are "rather dissatisfied" or "dissatisfied". A similar picture

emerges when assessing the general development: 82% of the parents are "very satisfied", 17% "satisfied", and only one percent "(rather) dissatisfied". The positive evaluation also applies to the final survey when the children are older than one year.

Most of the children in the sample are firstborns (70%), 23% have one sibling, and 7% have two or more siblings. No relation was found between the number of children and the level of education of the mothers ($Chi^2 = 0.9$, $df = 1$, $p = .33$).

Anthropometric characteristics for firstborns and later borns at birth and at one year and parents' satisfaction with health and development first few weeks and on reaching the milestone "Free and safe walking" are presented in Table 2. In addition, the length of breastfeeding and the age of the mother are given. Compared to firstborns, later borns had higher scores for height and weight at birth and parental assessments of development but not of health in the first few weeks of life, but no differences were found by the age of one year. Connections between existing siblings and breastfeeding could not be proven. First-time mothers were younger than mothers who already had children.

Significant complications during pregnancy reported 3.7% of mothers; no differences were found between primiparous women and women who had already given birth. The proportion of caesarean births and premature births in the sample was 25.6 and 7.8%, respectively; suction cups or forceps were used in 10.0% of the births. Firstborns were delivered more frequently with technical aids (9 vs. 1%) or by caesarean section than children with siblings (28 vs. 20%, $Chi^2 = 74$, $df = 2$, $p = .001$), the proportion of premature births is 9 among firstborns and 5% among later borns ($Chi^2 = 11$, $df = 1$, $p = .001$).

Milestone achievement results for firstborns and later borns are presented in Table 3. No differences in gross motor milestones were found, except for bringing hands together. The differences in dexterity skills were statistically significant, and the practical significance of these effects was medium. Children without siblings mastered the milestones bringing hands together, passing objects, targeted grasping, tweezers, and pincers earlier.

4. Discussion

The relationship between sibling status and child development has long been the subject of hypotheses and studies. However, investigations into the motor development of only children and children with siblings have not produced any clear results [18]. The study presented here therefore intended to analyze the connection between the position in the sibling line (firstborn vs later born) and the achievement of 18 elementary motor development steps (milestones) in the first two years of life. The data of the study come from an ongoing research project with citizen participation, which is investigating the development of motor milestones in the first and second years of life (for details see Roth & Krombholz [30]). The involvement of parents in data collection ("Citizen Science") has proven its worth. However, the participants in our study are not a random sample, since the majority of participants are well educated, open to research questions, and "tech-savvy". Therefore, a disproportionately large number of participants belong to the upper social class and non-German-speaking parents are underrepresented. However, no relation was found between social status and motor development in the first two years [31]. Moreover, regarding the anthropometric characteristics, the children in the sample were representative of children in Germany and the perceived satisfaction of the parents with the health and development of the children also corresponds to available nationwide results [32,33].

No relation was found between the educational level of the mothers and the number of children and, unsurprisingly, primiparous women were younger when the target child is born than mothers who already have children. In Germany, the proportion of only children is around 51% [29]. In our sample, there are significantly more parents with firstborns (70%) than with later borns. This suggests that parents are more interested in the development of their firstborn than in that of subsequent children and are more willing or simply have more time to participate in citizen science surveys on child development. It can be assumed that the information

Table 2
Comparison of later borns and firstborns: anthropometric characteristics at birth and aged 1 year and the parents' satisfaction with development and health in the first few weeks and on reaching the milestone "Free and safe walking" as well as length of breastfeeding and age of mother (mean *M*, standard deviation *SD,* number *N,* and results of *t*-test: *p* and Cohen's *d*).

	Later born			Firstborn				
Variable	M	SD	N	M	SD	N	p	d
At birth								
Height (cm)	**51.7**	**3.0**	**845**	**51.2**	**2.9**	**1942**	**.001**	**.18**
Weight (kg)	**3.50**	**.6**	**846**	**3.33**	**.5**	**1945**	**.001**	**.30**
BMI	**13.9**	**1.5**	**843**	**12.7**	**1.5**	**1938**	**.001**	**.26**
Apgar	**9.5**	**.9**	**745**	**9.5**	**.9**	**1591**	**.06**	**.14**
First Weeks								
Health	**1.28**	**.5**	**844**	**1.23**	**.4**	**1947**	**.01**	**.12**
Development	**1.17**	**.4**	**843**	**1.21**	**.4**	**1939**	**.02**	**.09**
Aged 1 year								
Height	**75.0**	**3.3**	**95**	**75.4**	**3.5**	**248**	**.42**	**.01**
Weight	**9.27**	**1.34**	**87**	**9.38**	**1.25**	**237**	**.44**	**.03**
BMI	**16.4**	**1.7**	**87**	**16.5**	**1.7**	**237**	**.46**	**.06**
Health	**1.37**	**.5**	**137**	**1.27**	**.5**	**342**	**.07**	**.21**
Development	**1.16**	**.4**	**139**	**1.22**	**.5**	**352**	**.12**	**.14**
Breastfed (mon)	**4.5**	**5.6**	**154**	**4.8**	**5.8**	**389**	**.67**	**.06**
Age mother (y)	**32.2**	**4.0**	**940**	**30.8**	**4.2**	**1992**	**.001**	**.59**

Table 3
Milestone achievement for later borns and firstborns (days, mean *M*, standard deviation *SD,* number *N*, and results of *t*-test *p* and Cohen's *d*).

	Later born			Firstborn				
Milestone	M	SD	N	M	SD	N	p	d
Bring hands together	**72**	**32**	**373**	**67**	**32**	**914**	**.01**	**.17**
Lift head on stomach	**65**	**39**	**409**	**67**	**39**	**999**	**.47**	**.02**
Roll to prone	**135**	**39**	**384**	**139**	**39**	**905**	**.09**	**.09**
Roll to supine	**151**	**55**	**330**	**155**	**50**	**792**	**.25**	**.01**
Sitting with support	**218**	**44**	**244**	**213**	**46**	**615**	**.13**	**.08**
Sit up unsupported	**258**	**53**	**341**	**259**	**48**	**572**	**.44**	**.05**
Belly crawl	**209**	**43**	**257**	**214**	**48**	**573**	**.08**	**.13**
Crawling	**253**	**52**	**245**	**256**	**53**	**594**	**.51**	**.08**
Stand up w. support	**261**	**49**	**229**	**265**	**49**	**577**	**.14**	**.01**
Standing with help	**343**	**67**	**150**	**350**	**75**	**407**	**.31**	**.09**
Walk sidely w. hold	**306**	**59**	**183**	**307**	**66**	**481**	**.88**	**.01**
Pull to stand	**374**	**68**	**152**	**380**	**74**	**387**	**.20**	**.10**
Walking alone	**388**	**67**	**156**	**391**	**66**	**428**	**.62**	**.01**
Walking safely	**410**	**65**	**136**	**417**	**68**	**378**	**.29**	**.10**
Grasp after things	**101**	**27**	**341**	**95**	**34**	**785**	**.01**	**.34**
Pass an object	**186**	**59**	**223**	**163**	**51**	**578**	**.01**	**.35**
Tweezers grip	**215**	**61**	**181**	**200**	**68**	**483**	**.01**	**.24**
Pincer grip	**250**	**66**	**169**	**233**	**51**	**410**	**.01**	**.35**

provided by the parents regarding the achievement of their children is correct since the milestones are easy to observe, and unlike outside observers, parents are in constant and intense contact with their children. In the WHO study, too, the milestones were recorded by the parents, but the information was also checked by trained external observers at monthly intervals, with hardly any contradictions [34,35]. Again, our results correspond with those of the WHO study and the information provided by Bayley [1,36]. This does not only speak for the reliability of the survey method, but also for the fact that early motor development steps are essentially similar in different populations and cultural milieus, even if significant inter-individual differences can occur. Gender has no impact on achieving motor milestones [2,34,37].

Although primiparous women do not suffer more often from complications during pregnancy than women who have already given birth, there are more complications in the birth of firstborns than in later borns. This affects the proportion of premature births, underweight newborns, the frequency of caesarean sections, and the use of assisted delivery devices. Vaginal delivery and normal birth weight are considered beneficial for the general development of the child [21,22]. However, no disadvantages of caesarean births in terms of motor development could be proven [20] but premature and severely underweight newborns reach the early motor milestones later than term and normal-weight newborns [4,19].

The impressive advances in the newborn's movement repertoire in the first year of life are essentially based on the development of physical characteristics, which are considered to be predominantly genetically controlled. However, the importance of the influence of environmental factors and parents or caregivers on motor development even during the first year of life should by no means be neglected [5,9,38,39].

In the present study - in agreement with available surveys - newborns with siblings were larger, heavier, and more mature than firstborns and their parents were more satisfied with their status of development. Given the better developmental conditions, it is surprising that children with siblings do not show any advantages in reaching gross motor milestones compared to firstborns. However, at the age of one year, the advantage in the physical parameters was no longer detectable.

Contrary to expectations and to the results of available studies [16–18] but in agreement with Krombholz [24] firstborns were superior in manual dexterity, the practical significance of the difference was medium. However, gross motor skills were not affected. This surprising finding could be related to the fact that parents pay more attention and care to their firstborn than to their later born infants. Parents with firstborns are more involved with their child because the situation is new to them, they have more time and resources as there is only one toddler to care for, they are less experienced and nursing measures take more time and they are more interested in the development of the child [23]. Moreover, the greater interest of the parents of firstborns in the development of their children is also reflected in the fact that more of them took part in the present study and used early support programs for newborns, but it could not be shown that the time parents spent caring for firstborn and later born children differed.

Both nurturing (e.g. breastfeeding, bottle feeding, personal hygiene, changing a diaper) and social interactions (e.g. calming, hugging, touching and soothing, gently rocking, singing nursery rhymes) of parents are likely to be more intense with their first child [23]. However, it is unclear why the increased preoccupation of parents with the firstborn has a positive effect on the development of manual dexterity, but gross motor development does not benefit as well.

This could be related to the fact that most of the interaction between parents or caregivers and infants in the first months mostly takes place when the child is lying in his bed, is held in the arms, sitting on the lap or in high chairs with back support not only during meal time. In these positions children have the opportunity for fine motor exploration of food and toys offered by parents, and learn to control their arms and hands. Since parents interact more intense with their firstborns and predominantly fine motor skills are involved, it is not surprising that firstborns outperform in hand dexterity compared to later borns. Gross motor skills are not affected, because they are less encouraged or may be less trainable.

The type of delivery, birth weight, nutrition, but also health-related attitudes, and support measures by parents, which vary with the level of education and social status, have no demonstrable impact on the achievement of motor milestones [20,31,40]. Even a severe limitation in infant mobility has little effect on the age at which the first steps are taken [41] and there are few differences in the early motor development of children living in different regions where material living conditions, cultural traditions, and educational attitudes differ significantly [2,37].

This is true for gross motor skills, however, there are hardly corresponding results for manual dexterity. Although the fine motor milestones examined here are reached on average by the age of eight months, based on the results found in Krombholz [24] and the present study, it can be assumed that hand motor skills, as opposed to gross motor skills, can be influenced by learning processes very early on.

However, further research is needed to study motor development in infancy, especially hand dexterity, and the possible impact of siblings. And the influence of birth size and weight, the type of delivery, the state of health and nutrition should be examined more closely. It should also be checked whether there are connections between the gender and age difference between first and later born children. In particular, the interaction of parents with first-born and later newborns in the first year of life should be analyzed and recorded more precisely.

Author contribution statement

Heinz Krombholz: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper. </p>

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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