Motor Development Problems in Infancy Predict Mental Disorders in Childhood: Longitudinal Child Cohort Study

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Short Report

Keywords: Children, longitudinal study, community health nurses, infants, mental disorders, motor development problems.

Posted Date: December 8th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-1118170/v1>

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Abstract

The aim was to examine whether motor development problems in infancy predicted mental disorders later in childhood, taking a wide array of potential confounder variables into consideration. This longitudinal study included an unselected study population of 33,238 newborn children from the Copenhagen area in Denmark. Data on the predictor variable motor development problems at age 8-10 months was obtained from the community health nurses' systematic evaluation of the child's motor development problems during a home visit stored in the Child Health Database. Data on outcome, diagnosed mental disorders before age 8 years, was obtained from the Danish National Patient Register. The study included potential confounders obtained from the Child Health Database, the National Birth Register, and the Civil Registration System. The prevalence of motor development problems at age 8-10 months was 19.3% and the incidence of any diagnosed mental disorder from age 11 months to the 8th birthday was 4.0%. Motor development problems were associated with an overall increased risk of being diagnosed with a mental disorder before the 8th birthday, adjusted odds ratio (AOR) 1.47 (1.29-1.67), in particular diagnosed neuro-developmental disorders, AOR 1.77 (1.52-2.06), such as autism-spectrum disorders, AOR 1.63 (1.31-2.03), hyperactivity/ attention deficit disorders, AOR 1.29 (1.03-1.61) and disorders of intellectual disability, AOR 3.28 (2.39-4.49). *Conclusion:* Motor development problems as early at age 9-10 months are predictive of neurodevelopmental disorders at age 1-8 years. The findings call for clinical attention and more research in the preventive potentials in the community child health care.

What Is Known

- Children with ASD, ADHD, and intellectual disability have high prevalence of early motor development problems.

What is new

- Motor development problems in infancy predicted neuro-developmental disorders before the 8th birthday
- This observation could improve early identification and prevention of mental health problems in childhood

Introduction

Available research suggest that motor development problems in infancy may be predictive of childhood neuro-developmental disorders, such as autism spectrum disorder (ASD) [1–6], disorders of hyperactivity and inattention (ADHD) [2, 7, 8], and disorders of intellectual disability (ID) [4]. None of the studies published so far have explored the predictiveness of systematically assessed motor development

regarding the range of mental disorders seen in childhood, considering unmeasured confounding due to child and family variables [1, 3–7]. Moreover, there is a need to examine whether the municipal child health system can be used to identify children who are at a developmental risk regarding severe mental disorders. Therefore, the aim of this study was to use a large community based cohort to examine whether motor development problems in infancy predicted mental disorders later in childhood, taking a wide array of potential confounder variables into consideration.

Methods

Setting

In Denmark, the municipal health care system offers all families with newborn children a series of home visits delivered free of charge by a community health nurse (CHN) [9]. CHNs are registered nurses with a 1½ year further education comprising training in assessment of health and development in children. Approximately 97% of all families participate in these home visits. Most municipalities comply with recommendations from the National Health Authority and offer at least five home visits (a) a few days after delivery, (b) 1-2 weeks, (c) 2-3 months, (d) 4-6 months and (e) 8-10 months after delivery. CHNs in a range of municipalities have organized a clinical database – the Child Health Database - with standardized data from their records. The health visitors apply a manual of definitions to ensure comparability and stimulate validity of data in their records. The records include the child's unique person identification number which make it possible to link data with data from national health and sociodemographic registers which cover the total population in Denmark.

Study design and study population: Longitudinal study of children from birth to their 8th birthday using clinical data from the Child Health Database and register data from the National Birth Register, the Danish National Patient Register, and the Civil Registration System. Inclusion criteria: 1) All children from 16 municipalities in the Copenhagen region in Denmark born between 1st January 2002 and 31st December 2010 and having their 8th birthday before 1st January 2019 (n=47,167) and 2) included in the Child Health Database. Exclusion criteria: 1) Mental disorder diagnosed at hospital within the first 10 months of the child's life (n=946); 2) missing data on motor development problems (n=8,634) or any applied control variable (n=4,349), leaving a final sample of 33,238 children.

Measures: The *predictor variable* was problems of motor development problems assessed by the CHN at the scheduled home visit at child age 8-10 months. According to the guidelines and the manual for assessments at ages 8-10 months, the health visitor expressed a concern in the record if the child did not meet all these specific developmental milestones: Unable to roll over from back to stomach and reverse, unable to sit independently, unable to move things from hand to hand, do not put things into the mouth, unable to crawl forwards and/or backwards, unable to pull to a standing position. We summarized the assessment into a dichotomous variable, +/- motor development problems.

The *outcome variable* was any mental disorder diagnosed in hospital settings from child age 11 months to the 8th birthday, obtained from *the Danish National Patient Register* which includes all in- and

outpatient and emergency hospital contacts with a 100% coverage [10]. In these settings, medical doctors conclude on the clinical and paraclinical data to diagnose mental disorders in accordance with the defining criteria of the International Classification of Mental and Behavioral Disorders 10 (ICD-10) [10]. We included the range of mental disorders seen in childhood: General developmental disorders or disorders of intellectual disability (F70-F79), specific developmental disorders (F 80-83), pervasive and other developmental disorders (F84-89), hyperkinetic disorders (F90), attention deficit disorder without hyperactivity (F98.8), mood disorders, emotional and stress-related disorders (F30-F34, F38-F45, F48, F 93), disorders of eating and sleep (F50-F51, F 98.2), and disorders of behaviour (F91-F92) and of social functioning (F94.1-F94.2, F94.8). We summarized the data into three dichotomous variables, diagnosed neuro-developmental disorder including disorders of ID, ASD and ADHD (yes, no), diagnosed behavioural or emotional disorder (yes, no), and at least one diagnosed mental disorder before the age of 8 years (yes, no).

The analyses included the following potential *confounders*: From the *National Birth Register*: Sex, parity, gestational age (born 37th week or later vs. before); birth weight (<2500 g, 2500-3999 g, >3999 g); congenital malformation (yes, no); mother's and father's age at childbirth (<25 vs. $\geq$ 25); pregnancy complications (yes, no); cesarian section (yes, no); and Apgar score (9-10 vs. less). From the *Civil Registration System*: parents' education at childbirth (five levels); parents' employment (2, 1 or 0 employed parents), family composition (child lives with both parents, yes vs. no), and parents' origin (2, 1 or 0 parents of Danish origin). From the *Child Health Database*: Concern about mother's mental health in the first six months after delivery (concern at 0 vs. at least one home visit); and concerns about the parent-child-relationship in the first six months after delivery (concern at 0 vs. at least one home visit).

Statistical procedures

The first step was contingency tables for inspection of data and use of chi²-test for heterogeneity (not shown in table). The second step was logistic regression analysis of the association between motor development problems at age 8-10 months and diagnosed mental disorder from age 11 months to the 8th birthday, adjusted for all potential confounder variables.

Results

Within the study population of 33,238 children, 19.3% had motor development problems at age 8-10 months. The number of children diagnosed with at least one mental disorder from age 11 months to the 8th birthday was 1,331 (4.0%); 878 (2.6%) were diagnosed with a neuro-developmental disorder, and 671 (2.0%) with a behavioural or emotional disorder. Children who had motor development problems at ages 8-10 months had increased risk of being diagnosed with a mental disorder before the 8th birthday, adjusted OR (95% CI) 1.47 (1.29-1.67 (Table 1). The association between motor development problems in infancy and behavioural or emotional disorders was significant in the crude analysis, whereas adjusted analysis showed AOR 1.13 (0.94-1.36). Children with motor development problems in infancy had increased risk of any neuro-developmental disorder (AOR=1.77 (1.52-2.06)) and more specifically

increased risk of ASD (AOR=1.63 (1.31-2.03)), disorders of hyperactivity and inattention (AOR=1.29 (1.03-1.61)) and mental retardation (AOR=3.28 (2.39-4.49)). These estimated attenuated only slightly when adjusted for child and family adversities, such as prematurity, pregnancy and birth complications, low parental education, and maternal and relational problems in infancy.

Table 1

Crude and adjusted¹ OR (95% CI) for diagnosed mental disorders from age 11 months to the 8th birthday by motor development problems in infancy (n=33,238)

Outcome measure	Crude OR (95% CI)	Adjusted OR (95% CI)
At least one diagnosed mental disorder	1.57 (1.39-1.78)	1.47 (1.29-1.67)
Disorders of behaviour and emotions	1.20 (1.01-1.43)	1.13 (0.94-1.36)
Diagnosed neurodevelopmental disorder	1.83 (1.60-2.10)	1.77 (1.52-2.06)
Autism-spectrum disorders (F84)	1.64 (1.34-2.00)	1.63 (1.31-2.03)
Disorders of hyperactivity and inattention (F90, F98.8)	1.37 (1.12-1.68)	1.29 (1.03-1.61)
Mental retardation (F70)	3.59 (2.71-4.76)	3.28 (2.39-4.49)
¹ Adjusted for sex, parity, gestational age, birth weight, congenital malformation, pregnancy complications, cesarian section, Apgar score, mother's age, father's age, parents' education, family composition, parents' origin, mother's mental health in the first six months after delivery, concerns about the parent-child-relationship in the first six months after delivery		

Discussion

This longitudinal study showed that motor development problems in infancy was associated with diagnosed neuro-developmental disorders in childhood but not behavioural or emotional disorders. Our findings correspond with the current conceptualization of neuro-developmental disorders [11] as characterized by onset in infancy or early childhood; impairment or delay in the development of functions that are strongly related to the biological maturation of the central nervous system; and a steady course that do not involve remissions and relapses that characterizes many other mental disorders [12]. Due to comprehensive data from national registries, it was possible to adjust for an array of potential confounder of suggested importance in the developmental trajectories of neuro-developmental disorders, including markers of pre- and perinatal adversities. Notably, the associations between motor development problems at ages 8-10 months attenuated only slightly when adjusted for a large number potential confounders.

Overall, our findings of elevated risk for neuro-developmental disorders corresponds with recent studies of ASD and ADHD [1–3, 5–8]. There are several hypotheses that link between motor development problems in early childhood and later neuro-developmental disorders [7, 12]. converging on the genetic/epigenetic, and environmental influences on pre- and postnatal brain maturation and development [12]. However, the present study was not suited to further explore the possible neuro-developmental trajectories.

The strength of the study is the large and unselected study population, the use of standardized data on child development from the CHNs' manualized examinations, the use of validated data on child mental disorders and comprehensive data on child and family variables from population registers, allowing for the extensive control for potential confounders. One limitation is that the validity of the motor skills examination is unknown, although it follows specific guidelines. From a research point of view, there is a need for insight into the neuro-developmental mechanisms which connect motor development problems and neuro-developmental disorders. Further, we need more information on how to help parents and professionals to deal with motor development problems, methods which are sensitive to the course of developmental change in skills over time [1]. The practical and public health perspectives imply that early identification of motor development problems may be an important element to provide a timely diagnosis of neuro-developmental disorders and an early preventive effort to help children at risk [7, 12].

Abbreviations

ADHD: Attention deficit hyperactivity disorder

AOR: Adjusted odds ratio

ASD: Autism spectrum disorders

CHN: Community health nurse

CI: Confidence Interval

ICD-10: International classification of diseases, 10th edition

ID Intellectual disability

OR: Odds Ratio

Declarations

Funding: There is no funding to declare.

Conflict of interest: The authors have no relevant financial or non-financial interests to disclose.

Availability of data and material: *The data underlying this article will be shared on reasonable request to the Principal Investigator, Dr. Trine Pagh Pedersen (tppe@sdu.dk).*

Code availability: *Not applicable.*

Authors' contributions: All authors contributed substantially to the conception and design of the paper, and to the interpretation of data. TPP and SWP acquired the data. SWP and TPP performed the analyses. SWP and BEH wrote the first draft of the manuscript. All authors contributed to the writing of the

manuscript and a critical revision of the intellectual content. All authors have approved the final version of the manuscript and are accountable for all aspects of the work.

Ethical approval: The study was approved by the Danish Data Protection Agency (registration number 10.366, University of Southern Denmark) and complied with national regulations of data protection and consent. Linkage with register data was administered by Statistics Denmark and the involved researchers did not have access to personal identification. According to the Danish legislation, informed consent is not required for register-based studies.

Consent to participate: Not applicable.

Consent for publication: Not applicable.

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