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Does Motor Development in Infancy Predict Spinal Pain in Later Childhood? A Cohort Study

Work conducted recently by the World Health Organization has shown that low back pain (LBP) is responsible for more years lived with disability than any other health condition.[28] The personal suffering from LBP is compounded by societal costs due to reduced work productivity and to health care service consumption that run into the billions per annum.[4] Despite this, our understanding of the pathology of LBP remains incomplete, perhaps best exemplified by the fact that up to 95% of people presenting for care are given a descriptive diagnosis of nonspecific or idiopathic LBP.[11]

STUDY DESIGN: Longitudinal cohort study.

BACKGROUND: Spinal pain is responsible for a huge personal and societal burden, but its etiology remains unclear. Deficits in motor control have been associated with spinal pain in adults, and delayed motor development is associated with a range of health problems and risks in children.

OBJECTIVE: To assess whether there is an independent relationship between the age at which infants first sit and walk without support and spinal pain at 11 years of age.

METHODS: Data from the Danish National Birth Cohort were analyzed, using the age at which children first sat and first walked without support as predictors. Parents reported the predictors when the children were 6 months and 18 months of age, and also provided information in response to a comprehensive list of covariates, including child sex, birth weight, and cognitive development; socioeconomic indicators; and parental health variables. Outcomes were measured at 11 years of age using the Young Spine Questionnaire, which assesses the presence and intensity of spinal pain. Data were analyzed using multivariable logistic regression models to estimate determinants of neck, thoracic, lumbar, and multisite pain.

RESULTS: The analyses included data from approximately 23 000 children and their parents. There were no consistent independent associations between the age at first sitting or walking and spinal pain at the age of 11. Odds ratios were between 0.95 and 1.00 for the various pain sites.

CONCLUSION: The age at which a child first sits or walks without support does not influence the likelihood that he or she will experience spinal pain in later childhood.

LEVEL OF EVIDENCE: Prognosis, level 4.

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The most consistent risk factor for the onset of LBP in adults is report of previous episodes.[6,10] This, along with evidence establishing the link between experience of back pain in adolescence and chronic back pain in adulthood,[13] has prompted calls for a life-course approach to the study of LBP.[6] A life-course approach involves considering the course of a condition from original onset (often in childhood) throughout the lifespan of the individual, as opposed to treating episodes of LBP as discrete occurrences.[5] It is possible that failure to adequately understand back pain from this perspective is partly responsible for the failure to identify effective strategies to reduce the burden of LBP across the lifespan.[26]

Although the prevalence of back pain in adolescents is high,[33] very little clinical research has been performed on this population. A systematic review[27] identified only 4 randomized clinical trials investigating nonsurgical treatments for children with LBP, in comparison to more than 1500 studies in the adult population (www.pedro.org.au; January 20, 2015).

A large body of experimental and clinical research implicates disordered motor control, or core stability, in adults with LBP.[30] However, the direction of

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the relationship—whether motor control dysfunction is the cause or consequence of LBP—remains in question. One problem that has made delineation of the relationship difficult is the recurrent nature of the condition, particularly because initial onset often occurs in childhood.[18] If motor performance issues do have an influence on the onset or maintenance of back pain, then it is plausible that these issues begin very early in life. Underpinning this hypothesis is evidence that motor development deficits observed in childhood are still apparent in adolescence.[3]

Identification of a relationship between early motor development and later back pain would open at least 2 important lines of inquiry. First, it would indicate the need to explore the mechanisms responsible for the link between gross motor control in childhood and back pain. Second, it would focus efforts on early intervention for young children with delayed motor performance.

The aim of this study was to investigate the independent relationship between measures of early motor development, specifically the age at which the child was first able to sit unsupported and walk independently, and frequent spinal pain at 11 years of age. A secondary aim was to report the prevalence of neck pain, mid-back pain, and LBP in a large, population-based sample of 11-year-old children.

METHODS

The Danish National Birth Cohort (http://www.ssi.dk/English.aspx) is a cohort study initiated in the mid-1990s designed to follow children from the intrauterine stage throughout life.[29] Assessment was conducted by telephone interviews with the mothers of participants at several points: twice while the participants were in utero, and at the ages of 6 and 18 months. This was followed by questionnaire surveys sent to the parents when their children were 7 years and 11 years of age. These assessments included measurement of a range of sociodemographic, anthropometric, health-related, and behavioral variables of the mothers and the children. These variables included measures of motor performance at the age of 18 months, specifically, "How old was he/she when he/she could sit with no support?" and "How old was he/she when he/she could walk alone without support?" Responses were provided in months.

At 11 years of age, the children were asked to participate in a survey that asked questions about their mental health, physical symptoms, and thoughts and behaviors, as these items were considered to be more accurately reported by the children/adolescents themselves. A validated questionnaire inquiring about the presence of spinal pain was administered to the children at the 11-year follow-up. The Young Spine Questionnaire[21] includes assessment of the presence, frequency, and intensity of neck pain, mid-back pain, and LBP. Specific questions were, "How often have you had pain in the neck? Middle of the back? Lower back?" Response options were "often," "once in a while," "once or twice," and "never."[21] The Young Spine Questionnaire includes the Faces Pain Scale-Revised (FPS-R), a series of 6 line drawings of faces that depict increasing pain intensity, with 1 representing no pain and 6 representing the most severe pain.

We defined the outcome of neck pain (yes/no) as report of neck pain occurring "often" or "once in a while," with an FPS-R score of 4 or greater. Mid-back pain and LBP were defined similarly, using the children's answers in questions about mid-back pain and LBP experiences. Multisite pain was defined as presence of pain in more than 1 of the 3 regions, occurring "often" or "once in a while," with an FPS-R score of 4 or greater. These data were presented descriptively to fulfill the secondary aim of reporting the prevalence of spinal pain in this sample.

The exposures of interest were the age when the child was able to sit unsupported (in months) and the age when the child was able to walk unsupported (in months).

The covariables, selected a priori, were maternal smoking during pregnancy ("Have you smoked since the last interview?" [last trimester of pregnancy, no/yes]), maternal alcohol consumption during pregnancy ("During pregnancy, how many times have you had 5 or more drinks in 1 event?" [last trimester of pregnancy, none/1 or more]), parental educational attainment (primary or lower education only, high school partially completed or basic vocational training, high school completed [when child was 18 months old]), household income (in Danish kroner when child was 18 months old), maternal musculoskeletal conditions reported during pregnancy (yes/no), and a variety of child characteristics: birth weight (grams), sex, attention (ability to remain occupied alone for 15 minutes at 18 months old), cognitive development (ability to retrieve a specific object on request at 18 months old), and presence of other physical or developmental problems at 18 months old. Potential confounders were chosen prior to analysis on the basis of theoretical associations with the exposure and outcome and retained in the final, fully adjusted models. See the **APPENDIX** (available at www.jospt.org) for further details.

Logistic regression models were used to assess the crude and adjusted associations, expressed as odds ratios (ORs) with 95% confidence intervals (CIs), between age at sitting and at walking and the 4 outcomes of interest.

Sensitivity analyses were conducted by rerunning models with the pain-intensity threshold on the FPS-R moved from 4 or greater to 5 or greater.

RESULTS

Analyses were conducted on data from children who provided information about their spinal pain experience at the 11-year follow-up (n = 45 682). Of these, approximately 35 000 had measures of the exposure and the outcome, and were included in the unadjusted models; approximately 23 000 participants had exposure, outcome, and covariate data, and were included in the multivariable models. There were no substantial differences between those in the study sample and those lost to follow-up (**TABLE 1**).

TABLE 1	Description of the Participants*	
	Study Sample	**Lost to Follow-up**
Sex (female), %	51.7	45.5
Birth weight, g	3602 ± 554	3551 ± 614
Presence of physical or developmental problems at 18 mo, %	1.0	1.6
Sitting age, mo	6.5 ± 1.2	6.5 ± 1.4
Walking age, mo	12.6 ± 1.9	12.6 ± 2.0
Ability to walk up stairs at 18 mo, %	2.9	3.0
Maternal alcohol consumption during pregnancy, %	21.2	20.7
Maternal smoking during pregnancy, %	14.4	22.4
Maternal musculoskeletal pain condition during pregnancy, %	9.0	10.4
Maternal highest education level, %		
Primary school	9.3	15.0
Basic vocational training	17.9	23.1
Upper high school	70.4	58.8
Neck pain, often or once in a while, and FPS-R ≥4 at 11 y, %	7.5	...
Mid-back pain, often or once in a while, and FPS-R ≥4 at 11 y, %	4.3	...
Low back pain, often or once in a while, and FPS-R ≥4 at 11 y, %	3.7	...
Multisite pain, often or once in a while, and FPS-R ≥4 at 11 y, %	2.9	...

Abbreviation: FPS-R, Faces Pain Scale-Revised.
**Values are mean ± SD unless otherwise indicated.*

Association Between First Sitting and Walking Age and Neck Pain

The univariate association between first sitting age and neck pain at 11 years of age was statistically significant, but this relationship disappeared when confounders were added to the model. The univariate relationship between first walking age and neck pain at 11 years of age was statistically significant, but this relationship disappeared when confounders were added to the model (**TABLE 2**).

Significant confounders in the model were sex (girls had greater odds of reporting pain), birth weight (higher birth weight increased the odds of pain), and income (higher income decreased the odds of pain). Maternal smoking during pregnancy (maternal smoking increased the odds of pain) was of borderline significance (**APPENDIX**).

When a sensitivity analysis using a higher threshold of pain intensity was conducted, the pattern of associations between the predictors and neck pain was not changed (**APPENDIX**).

Association Between First Sitting and Walking Age and Mid-Back Pain

Neither the univariate nor the adjusted association between first sitting age and mid-back pain at 11 years of age was statistically significant. Both the univariate and adjusted relationships between first walking age and mid-back pain at 11 years of age were statistically significant. For each month later that a child first walked, there was a 4% reduction in the odds of mid-back pain at 11 years of age (OR = 0.96; 95% CI: 0.92, 1.00; P = .04) (**TABLE 2**).

Significant confounders in the model were sex (girls had greater odds of reporting pain), maternal smoking (maternal smoking increased the odds of pain), and maternal education (higher maternal education decreased the odds of pain) (**APPENDIX**).

In the sensitivity analysis using a higher threshold for pain intensity, both the univariate and adjusted associations for both predictors were not statistically significant (**APPENDIX**).

Association Between First Sitting and Walking Age and LBP

Neither the univariate nor the adjusted association between first sitting age and LBP at 11 years of age was statistically significant. The univariate association between first walking age and LBP at 11 years of age was statistically significant (**TABLE 2**), but the relationship disappeared when confounders were entered into the model.

Significant confounders in the model were sex (girls had greater odds of reporting pain), maternal smoking (maternal smoking increased the odds of pain), income (higher income decreased the odds of pain), and maternal report of musculoskeletal conditions (maternal report of musculoskeletal conditions increased the odds of pain) (**APPENDIX**).

When a sensitivity analysis was conducted using a higher threshold of pain intensity, neither the univariate nor the adjusted association between first sitting age and LBP was statistically significant. Both the univariate and adjusted relationships between first walking age and LBP were statistically significant. For each month later that a child first walked, there was an 8% reduction in the odds of LBP at 11 years of age (OR = 0.92; 95% CI: 0.86, 0.99; P = .02) (**APPENDIX**).

Association Between First Sitting and Walking Age and Multisite Pain

The univariate relationship between first sitting age and multisite pain at 11 years of age was statistically significant, but this relationship disappeared when confounders were added to the model. The univariate relationship between first walking age and multisite pain at 11 years of age was statistically significant, but this relationship disappeared when confounders were added to the model (**TABLE 2**).

TABLE 2 Odds Ratios for Predictors in Relation to Different Locations of Spinal Pain

Pain Location/Predictor	n	Odds Ratio*	*P* Value
Neck pain			
Unadjusted sitting age	34205	0.96 (0.93, 0.99)	.02
Adjusted sitting age†	22910	0.98 (0.94, 1.03)	.45
Unadjusted walking age	36222	0.96 (0.94, 0.98)	<.01
Adjusted walking age†	22910	0.99 (0.96, 1.02)	.48
Mid-back pain			
Unadjusted sitting age	34182	0.98 (0.94, 1.02)	.38
Adjusted sitting age†	22901	1.00 (0.94, 1.06)	.96
Unadjusted walking age	36197	0.96 (0.93, 0.98)	<.01
Adjusted walking age†	22901	0.96 (0.92, 1.00)	.04
Low back pain			
Unadjusted sitting age	34189	0.96 (0.91, 1.00)	.08
Adjusted sitting age†	22896	0.99 (0.92, 1.05)	.67
Unadjusted walking age	36205	0.95 (0.92, 0.98)	<.01
Adjusted walking age†	22896	0.97 (0.93, 1.01)	.14
Multisite pain			
Unadjusted sitting age	34084	0.95 (0.93, 0.98)	<.01
Adjusted sitting age†	22838	0.98 (0.94, 1.02)	.46
Unadjusted walking age	36093	0.95 (0.94, 0.97)	<.01
Adjusted walking age†	22896	0.98 (0.96, 1.00)	.07

**Values in parentheses are 95% confidence interval.*
†Adjusted for child birth weight, sex, attention, cognitive development, presence of other physical or developmental problem at 18 months, as well as maternal smoking during pregnancy, maternal alcohol consumption during pregnancy, education, household income, and maternal musculoskeletal conditions.

Significant confounders in the model were sex (girls had greater odds of reporting pain), birth weight (higher birth weight increased the odds of pain), and income (higher income decreased the odds of pain). Maternal smoking during pregnancy (maternal smoking increased the odds of pain) was of borderline significance (**APPENDIX**).

When a sensitivity analysis was conducted using a higher threshold of pain intensity, neither the univariate nor the adjusted relationship between first sitting age or first walking age and multisite pain was statistically significant.

Prevalence of Spinal Pain in 11-Year-Old Children

Using pain that was experienced often or once in a while as a threshold, and a pain intensity of 4 or greater on the FPS-R, we found prevalences of 7.5% for neck pain, 4.3% for mid-back pain, 3.7% for LBP, and 2.9% for multisite pain.

DISCUSSION

Once adjusted for potential confounders, there appeared to be no consistent relationship between the age at which children first sat and first walked and the experience of spinal pain at 11 years of age. Only 1 of the adjusted estimates showed a statistically significant relationship between the age at which the children first walked and thoracic pain, but the size of the association was very small (OR = 0.96) and might be a chance finding due to multiple analyses. These data provide evidence against the hypothesis that motor development in infancy is an important factor in determining the likelihood of musculoskeletal pain in later childhood.

Several key issues are relevant when interpreting these results. First, while the ages of first sitting and walking are plausible indicators of early motor development, they do not capture the entirety of the construct, because the timing of sitting and walking may not be directly related to the quality or competence in performance of these activities. The proficiency with which an infant performs particular motor skills may be a better predictor of pain later in life than the age at which the infant performs them. Second, evidence from systematic reviews[15,19] shows that the prevalence of spinal pain is low in children and begins to rise steeply during adolescence; adolescence typically begins around or shortly after the age of our study sample. This increase in pain prevalence may be due to the onset of puberty,[20] but the hypothesis remains unconfirmed. It is possible that a relationship exists between the indicators of motor development and pain in adolescence, rather than at 11 years of age.

The ages at which children in the sample sat unassisted (mean ± SD, 6.5 ± 1.2 months) and first walked alone (12.6 ± 1.9 months) fell within the normal ranges for these developmental milestones (3.8 to 9.2 months and 8.2 to 17.6 months, respectively), as reported by the World Health Organization Motor Development Study.[34] The prevalence of pain was also reflective of that found in similarly aged samples.[1,17,22] These data suggest that the sample is representative of a normal population with respect to early motor development.

There is evidence to suggest that impaired motor development may be associated with lower levels of physical activity in children, both concurrently and in later years.[7,32] As children grow older, there appears to be a robust association between fundamental movement skills, which include locomotor, manipulative, and balance skills, and physical activity.[25] Furthermore, there is evidence that the level of early motor competency tracks into adolescence,[3] and also that age at first walking is related to motor development later in childhood, but this association is weak and of questionable clinical importance.[9] Much of the research investigating impaired motor development in infants is specific to populations with congenital abnormalities, developmental delay, or to premature babies. Overall, the significance of the timing of motor milestones in population-based samples of infants is unclear.

Our models were adjusted for a range of potential confounders. The variables that remained significant in the fully adjusted models were quite consistent across all pain locations. Female sex and maternal smoking were significant in all 4 models; low birth weight was significant in 2 models; maternal education and maternal report of musculoskeletal problems were significant in 1 model; and income was significant in 3 models. There is some heterogeneity in the literature as to the influence of sex on back pain prevalence, as illustrated by the conclusions of 2 recent systematic reviews that evidence for this association is inconsistent.[16,19] Maternal smoking is a commonly reported risk factor for poor child health generally, including childhood obesity and overweight,[31] cardiac defects,[23] and asthma.[2] The relationship between maternal smoking and pediatric pain is not well established. Low birth weight and socioeconomic disadvantage (of which maternal education level and family income are common measures) are also recognized risk factors for poor health outcomes in children, although this relationship is questionable in relation to back pain.[12,14,24]

The prevalence of the different types of spinal pain in the sample ranged from 2.9% for multisite pain to a maximum of 7.5% for neck pain, estimates that are lower than those generally reported in other studies for this age group.[15] A possible source of the discrepancy is the combination of pain frequency and intensity criteria that were part of our definition of pain. We contend that such criteria are important to differentiate between transient pain and pain likely associated with meaningful impact on the lives of study participants.

The large sample, which is representative of the Danish population, is a strength of this study, as this enables precise estimates of associations and speaks to the generalizability of the findings. We categorized our pain "cases" according to a stringent threshold of frequency and intensity of pain. This ensured that our models only identified risk factors associated with a clinically important level of pain. The robust modeling approach, including a range of plausible confounders, is also a strength, although the fact that we were limited to those available in the data set could be considered a limitation. As with most large population-wide surveys with long follow-up periods, there was considerable attrition between recruitment and measurement of outcome at 11 years of age. This loss to follow-up is a source of potential bias. It is unknown whether this attrition is systematic, but it is unlikely that a systematic bias would influence our 2 primary variables (motor development and spinal pain) differently and thereby skew the results. This is supported by data from Greene et al,[8] who found minimal influence of attrition bias on selected associations in the same cohort. As noted, we did not have access to a comprehensive measure of motor development in infancy, so we cannot directly assess its impact on the report of pain in preadolescents. However, our findings do add to our understanding of the relationship between simple, commonly used developmental indicators and the construct of pain.

From a clinical perspective, our findings do not support the view that the timing of independent sitting and walking is a useful predictor of the experience of pain in preadolescence. Encouraging early achievement of these milestones is also not likely to influence pain later in childhood. With regard to future research, addressing this question with more comprehensive measures of early motor development will provide further insight. Investigating the relationship with pain in later adolescence, when prevalence of pain report is higher, may also be worthwhile.

CONCLUSION

There appears to be no causal relationship between age at first sitting and walking and report of spinal pain at 11 years of age. Whether spinal pain in late childhood is related to strength and general coordination early in life remains unexplored and should be the focus of future investigations. ◉

KEY POINTS

FINDINGS: The ages at which an infant first sits and walks independently do not have a causal relationship with spinal pain in later childhood.

IMPLICATIONS: Programs aimed at encouraging infants to meet these motor milestones earlier are unlikely to have an impact on spinal pain report later in childhood. Future research that investigates the impact of early motor development on pain should consider a wider conception of the construct.

CAUTION: Although the sample collected for this study is large, there was considerable loss to follow-up between measures taken in infancy and at 11 years of age, which may impact the generalizability of the findings.

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APPENDIX

CONFOUNDERS

- Child birth weight (grams)
- Child sex (male/female)
- Attention: can the child be occupied for 15 minutes without adult participation at 18 months? (no/yes)
- Cognitive development: can the child go and get something and bring it back if asked at 18 months? (no/yes)
- Other musculoskeletal problems: does the child have any serious physical or developmental problems at 18 months? (no/yes)
- Maternal smoking: have you smoked since the last interview? (last trimester of pregnancy; no/yes)
- Maternal alcohol consumption: during pregnancy, how many times have you had 5 or more drinks in 1 event? (last trimester of pregnancy; none/1 or more)
- Maternal education: primary or lower education only, high school partially completed or basic vocational training, high school completed (when child was 18 months old)
- Maternal musculoskeletal pain: have you ever had disease in the muscles of joints? (first trimester of pregnancy; no/yes)
- Income: how much was your family's gross annual income (before tax)?

Models Including All Confounders

Pain Location	OR	*P* Value
Neck pain: fully adjusted		
Predictors		
Sitting age	0.98	.45
Walking age	0.99	.48
Confounders		
Sex	1.35	<.01
Birth weight, g	1.00	<.01
Attention	1.01	.87
Cognitive development	1.14	.56
Child health problem	0.96	.90
Maternal smoking in pregnancy	1.15	.05
Maternal alcohol in pregnancy	0.99	.81
Maternal musculoskeletal problem	1.01	.91
Maternal education	0.95	.23
Family income, DKK	1.00	.02
Mid-back pain: fully adjusted		
Predictors		
Sitting age	1.00	.96
Walking age	0.96	.04
Confounders		
Sex	1.49	<.01
Birth weight, g	1.00	.35
Attention	1.10	.29
Cognitive development	1.23	.51
Child health problem	1.61	.20
Maternal smoking in pregnancy	1.30	<.01
Maternal alcohol in pregnancy	1.02	.85
Maternal musculoskeletal problem	1.20	.10
Maternal education	0.87	<.01

Table continues on page C2

APPENDIX

Models Including All Confounders (continued)

Pain Location	OR	*P* Value
Family income, DKK	1.00	.29
Low back pain: fully adjusted		
Predictors		
Sitting age	0.99	.67
Walking age	0.97	.14
Confounders		
Sex	1.24	<.01
Birth weight, g	1.00	.79
Attention	1.16	.06
Cognitive development	1.11	.66
Child health problem	1.12	.75
Maternal smoking in pregnancy	1.22	.01
Maternal alcohol in pregnancy	0.88	.08
Maternal musculoskeletal problem	1.25	.01
Maternal education	0.94	.17
Family income, DKK	1.00	<.01
Multisite pain: fully adjusted		
Predictors		
Sitting age	0.98	.46
Walking age	0.98	.07
Confounders		
Sex	1.35	<.01
Birth weight, g	1.00	<.01
Attention	1.01	.87
Cognitive development	1.14	.57
Child health problem	0.96	.91
Maternal smoking in pregnancy	1.15	.05
Maternal alcohol in pregnancy	0.98	.79
Maternal musculoskeletal problem	1.02	.84
Maternal education	0.95	.21
Family income, DKK	1.00	<.01

Abbreviations: DKK, Danish kroner; OR, odds ratio.

APPENDIX

Sensitivity Analysis (Outcome of Pain Intensity of 5 or Greater on Faces Pain Scale-Revised)

Pain Location/Predictor	n	Odds Ratio*	*P* Value
Neck pain			
Unadjusted sitting age	34205	0.96 (0.91, 1.02)	.18
Adjusted sitting age	22910	1.04 (0.96, 1.12)	.37
Unadjusted walking age	36222	0.95 (0.91, 0.98)	<.01
Adjusted walking age	22910	0.97 (0.92, 1.02)	.23
Mid-back pain			
Unadjusted sitting age	34182	1.00 (0.93, 1.07)	.97
Adjusted sitting age	22901	1.06 (0.97, 1.16)	.20
Unadjusted walking age	36197	0.98 (0.93, 1.02)	.30
Adjusted walking age	22901	0.97 (0.91, 1.03)	.33
Low back pain			
Unadjusted sitting age	34189	0.94 (0.88, 1.01)	.12
Adjusted sitting age	22896	0.98 (0.89, 1.08)	.69
Unadjusted walking age	36205	0.93 (0.89, 0.98)	<.01
Adjusted walking age	22896	0.92 (0.86, 0.99)	.02
Multisite pain			
Unadjusted sitting age	34084	0.98 (0.88, 1.08)	.65
Adjusted sitting age	22838	1.06 (0.93, 1.20)	.40
Unadjusted walking age	36093	0.96 (0.90, 1.02)	.16
Adjusted walking age	22896	0.93 (0.85, 1.01)	.10

**Values in parentheses are 95% confidence interval.*