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ORIGINAL ARTICLE

Early risk factors for lumbar discectomy: an 11-year follow-up of 57,408 adolescents

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Abstract There is a lack of longitudinal studies on the risk factors of lumbar discectomy. Using combined population survey and hospital discharge register data in a prospective longitudinal design, we investigated the association between adolescent risk factors and lumbar discectomy until early middle age. A prospective cohort of health survey respondents ($n = 57{,}408$) aged 14–18 years was followed for 651,000 person-years (average follow-up, 11.3 years). Study endpoints were lumbar discectomy, death or end of follow-up. Participants' mean age at the end of follow-up was 27 years. In multivariate Cox's regression analysis, the significant risk factor for lumbar discectomy among male respondents was daily smoking, HR being 1.5 (95% CI 1.1–2.2). In females, frequent participation in sports clubs (HR 2.7, 95% CI 1.1–6.3) and overweight (HR 2.1; 95% CI 1.1–4.1) were significantly associated with an increased risk of lumbar discectomy. Daily smoking in males and frequent participation in sports clubs and overweight in females measured at adolescence were statistically associated with lumbar discectomy at an 11-year follow-up, although the hazard ratios were relatively small. Further study of these common risk factors and their modifications may lead to a better understanding of the causes of lumbar disc herniation.

Keywords Lumbar disc herniation · Epidemiology · Risk factors · Cohort study

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Introduction

Lumbar disc herniation is a common disorder among adults, with reported lifetime occurrence figures up to 40% [3]. Population-based studies show that lumbar disc herniation is very uncommon among children [9, 19, 25] but a rapid increase in occurrence is evident from the age of 18 [25].

Lumbar discectomy is the generally used treatment method for severe lumbar disc herniation and herniated lumbar disc not responding to conservative care [4]. The frequency of lumbar disc surgery and lumbar disc herniation in Finland is approximately equal to that in most Western countries but lower than in the United States [1, 7].

Risk factors for lumbar discectomy have not been studied using longitudinal population-based study designs. A retrospective study from Switzerland showed that adolescents undergone lumbar discectomy had significantly higher body mass index that their healthy peers [20]. Considering that only a few selected patients require surgery for lumbar disc herniation, the existing literature describing risk factors of lumbar disc herniation in general should be interpreted with caution. There is evidence from cross-sectional selected cohorts that frequent non-occupational as well as occupational lifting are associated with lumbar disc herniation [12, 17]. The association between smoking and lumbar disc herniation has been studied widely, but according to recent research, no association exists [5].

It has been suggested that, given the early onset of lumbar disc herniation, research should focus on risk factors in the young not yet showing symptoms of low-back disease [25]. The aim of this population-based cohort study was therefore to assess the socioeconomic, health and health behavioural risk factors among adolescents with lumbar discectomy.

Subjects and methods

Baseline cohort

The Adolescent Health and Lifestyle Survey in Finland is a nation-wide monitoring system of adolescent health and health-related lifestyles, and has been conducted as a postal questionnaire survey biennially since 1977 [22]. Two reminder questionnaires are sent to non-respondents after 3 and 7 weeks. The sample of 14, 16 and 18-year-olds is drawn from the National Population Register Centre through the selection of all Finns born on certain days in June, July or August. The birthday sample was used in order to minimise the variation in the chronological age of each age group. The materials with respect to sampling, research methods, questions, and time of enquiry have been maintained as similar as possible for each year. The mean ages of the respondents are 14.6, 16.6 and 18.6 years. For this study, the information collected between 1979 and 1997 was used as the baseline data. This baseline population comprised 72,378 persons, of whom 57,408 responded to the survey (Table 1). The average response rate was 79%.

Table 1 Age, number and response rates of the study participants

Baseline year	Age at follow-up in 2001 (years)	Age at baseline (years)	Number of participants		Response rate (%)	
			Boys	Girls	Boys	Girls
1979	37	14	564	535	86	91
	39	16	528	577	83	91
	41	18	528	512	78	86
1981	35	14	488	548	87	92
	37	16	535	529	85	92
	39	18	518	524	81	88
1983	33	14	429	482	79	86
	35	16	414	511	75	91
		18	–[a]	–[a]	–	–
1985	31	14	395	433	75	88
	33	16	455	499	77	87
	35	18	408	470	67	83
1987	29	14	1,674	1,789	81	89
	31	16	1,383	1,479	80	89
	33	18	1,012	1,274	74	89
1989	27	14	360	431	75	90
	29	16	362	380	70	82
	31	18	326	407	63	80
1991	25	14	1,629	1,837	74	87
	27	16	1,562	1,912	71	87
	29	18	1,286	1,626	61	82
1993	23	14	1,861	2,008	75	88
	25	16	1,655	1,943	71	87
	27	18	1,460	1,791	67	84
1995	21	14	1,177	1,301	75	85
	23	16	1,232	1,469	72	88
	25	18	1,071	1,313	67	86
1997	19	14	1,168	1,346	69	84
	21	16	1,126	1,379	68	87
	23	18	1,088	1,414	60	83
Total			26,688	30,719	72	87

[a] In 1983 no persons aged 18 were included in the sample

Lumbar discectomy data

The follow-up in this prospective cohort study started at the survey endpoint on April 30 of each data collection year. The endpoints of our study were the date of lumbar discectomy obtained from the National Hospital Discharge Register, date of death from the Official Cause-of-Death Statistics ($N = 421$) or end of study on December 31, 2001. The cohort (survey respondents) was followed for an average of 11.3 years. The total duration of follow-up was 651,027 person-years. The mean age of the participants at the end of follow-up was 27.2 years.

The data regarding lumbar discectomy were obtained from the statutory, computer-based National Hospital Discharge Register of Finland, which collects information equally from all hospital categories (private, public, other). The outcome variable was defined as lumbar discectomy first by the ICD code 9211 (1979–1996) and then by the new codes ABC07, ABC16 and ABC26 (1997). Persons hospitalised due to non-specific back-related diagnosis ($n = 18$) and those diagnosed with lumbar disc herniation ($n = 8$) before the survey date were excluded from analysis. The data concerning deaths were obtained from the Finnish Official Cause-of-Death Statistics, which is also a statutory, computer-based register covering the entire population [18]. Approval was obtained from the Institutional Review Board of the National Research and

Development Centre for Welfare and Health (6267/54/2002) for the use of the National Hospital Discharge Register and from Statistics Finland (TK-53-1526-04) for the use of the Official Cause-of-Death Statistics.

Background variables

Altogether 16 categorical variables from the Adolescent Health and Lifestyle Survey were used to explore associations between them and lumbar discectomy (Table 2). The questionnaire is available at http://www.stm.fi/Resource.phx/publishing/documents/7661/index.htx. The variables were adolescent self-reports with the exception of age, sex and urbanisation level of residence derived from the sample information (Population Register Centre). There were two exclusion criteria: first, non-respondents to the questionnaire; and second, respondents who had not answered the questions involved were excluded from further analysis (Table 2). Respondents' socioeconomic background was measured by father's or other guardian's occupation and education, family composition and urbanisation level of residence (Table 2).

Adolescents' health was assessed on the basis of their self-reports on perceived health status, chronic disease or disability restricting daily activities and by counting a summary index of eight stress symptoms (stomach aches, tension, irritability, sleep difficulties, headache, trembling of hands, feeling tired or weak, feeling dizzy) perceived weekly. Body mass index (BMI) was calculated by dividing weight (kg) with the square of height (m), and the cut-off points of overweight were set according to Cole et al. [2]. The timing of puberty was assessed by questions about the respondent's age at the time of first ejaculation (boys) and first menstruation (girls). We classified the timing of puberty into three categories: early (age 12 or younger in boys and age 11 or younger in girls), average (age 13 or 14 in boys and age 12 or 13 in girls), and late (age 15 or older in boys and age 14 or older in girls).

Adolescents' health compromising behaviours were described by daily use of tobacco and drinking style (abstinence, occasional drinking, recurrent drinking, recurring drunkenness), and health-enhancing behaviours by frequency of participation in sports clubs and other physical activity (including physical labour). The latter was measured by combining three variables describing physical activity: (1) organised by school or workplace, (2) organised by associations other than sports clubs and (3) done alone or with friends or family members.

Respondents' school success at age 14 was measured by self-assessment of his or her position in the class comparing the preceding end-of-term school report grades to those of the class or course (good, better than average, lower than average, poor). For the age groups 16 and 18,

Table 2 Age-adjusted hazard ratios (HR) by adolescent background variables for lumbar discectomy during follow-up as estimated in separate Cox's regression models

Background variable	HR (95% CI) for lumbar discectomy	
	Males	Females
Urbanisation level of residence		
Capital area (Helsinki and adjoining towns)	1	1
Large town (population over 100,000)	1.7 (0.8–3.7)	0.7 (0.2–2.6)
Small town	1.5 (0.9–2.9)	2.0 (0.8–4.7)
Village	1.7 (0.9–3.2)	1.6 (0.7–3.9)
Sparsely populated rural municipality	1.9 (1.0–3.8)	1.6 (0.6–4.1)
Father's or other guardian's occupation		
Upper white-collar employee	1	1
Lower white-collar employee	1.2 (0.7–2.0)	1.0 (0.5–1.8)
Farmer	1.6 (0.9–2.9)	0.6 (0.3–1.5)
Blue-collar employee	1.3 (0.8–2.2)	0.9 (0.5–1.7)
Unskilled	1.5 (0.6–3.3)	0.2 (0.1–1.6)
Father's education		
High	0.8 (0.5–1.3)	0.8 (0.4–1.6)
Middle	0.6 (0.3–1.0)	0.6 (0.3–1.4)
Low	1	1
Family composition		
Both parents	1	1
Other	0.8 (0.5–1.2)	1.4 (0.9–2.2)
Perceived health status		
Excellent	1	1
Good	1.2 (0.8–1.7)	0.7 (0.4–1.2)
Poor	0.8 (0.5–1.4)	0.6 (0.3–1.2)
Chronic disease or disability		
No	1	1
Yes	1.0 (0.6–1.7)	0.6 (0.2–1.4)
Number of stress symptoms weekly		
0	1	1
1	1.0 (0.7–1.6)	1.2 (0.6–2.3)
2	1.0 (0.6–1.8)	1.7 (0.9–3.4)
3+	1.1 (0.7–1.9)	1.4 (0.8–2.6)
Overweight		
No	1	**1**
Yes	1.3 (0.8–2.0)	**2.1 (1.1–4.0)**
Smoking		
Not daily	**1**	1
Daily	**1.6 (1.2–2.2)**	0.7 (0.4–1.2)
Drinking style		
Abstinence	1	1
Occasional drinking	0.9 (0.6–1.4)	1.2 (0.7–2.1)
Recurrent drinking	1.2 (0.7–1.8)	1.0 (0.5–2.0)
Recurring drunkenness	1.4 (0.8–2.4)	0.8 (0.2–1.7)

Table 2 continued

Background variable	HR (95% CI) for lumbar discectomy	
	Males	Females
Frequency of participation in sports clubs		
Never	1	**1**
2–3 times a week or less	0.7 (0.5–1.0)	**1.5 (0.9–2.4)**
4–5 times a week or more	1.0 (0.6–1.7)	**2.5 (1.1–5.8)**
Frequency of other leisure-time physical exercise		
Never	1	1
2–3 times a week or less	2.9 (0.4–21.1)	0.8 (0.1–5.9)
4–5 times a week or more	3.4 (0.5–21.1)	2.2 (0.3–16.2)
Timing of puberty		
Early	**1**	1
Normal	**0.7 (0.5–1.0)**	1.0 (0.5–1.9)
Late	**0.6 (0.4–0.9)**	0.7 (0.3–1.5)
Respondent's school success		
Excellent	1	1
Good	0.9 (0.5–1.6)	1.3 (0.7–2.3)
Satisfactory	1.3 (0.8–2.0)	1.4 (0.8–2.4)
Poor	1.3 (0.3–1.5)	0.7 (0.3–1.5)

Statistically significant variables in bold font

school success was determined by the combination of the school type attended (upper secondary, vocational school, trade course, course for the unemployed), and school success (excellent, good, satisfactory, poor).

Statistical methods

Incidence of lumbar discectomy was calculated by dividing the number of lumbar discectomies in a specific sex and age group by the amount of exposure time correspondingly. Number needed to treat per year figures were obtained by 1/absolute risk reduction per year. Statistical analyses were carried out in two stages, separately for males and females because statistically significant interactions existed between background variables and sex. First, hazard ratios for first lumbar discectomy were analysed by using Cox regression with age at baseline forced into the model. Finally, an age-adjusted (age during follow-up) forward stepwise regression model was conducted, which included variables significantly associated ($p < 0.05$) with the outcome in the baseline-age-adjusted univariate models. Hazard ratios (HRs) and 95% confidence intervals (95% CIs) were calculated. Frequency of missing values varied between 0 and 6% in the univariate and between 3 and 11% in the multivariate models and these were excluded from the analysis.

Because the study covered 20 years, we also explored possible time effects by first dividing the baseline data into three time periods (1979–1985, 1986–1991, 1992–1997) and by calculating separate Cox regression models for each time period. Since no time effect was seen (data not shown), all data were combined for the above noted analyses. When the effect of non-response was analysed, it was seen that the non-respondents to the baseline survey had no statistically different occurrence rate of lumbar discectomy during follow-up (0.5 vs. 0.4%, $p = 0.47$).

Results

In our cohort of 57,382 persons, altogether 251 (0.4%) underwent lumbar discectomy during follow-up, resulting in a person-based incidence of 40.8 (95% CI 35.8–45.9) per 100,000 person-years. The sex-specific number and incidence of lumbar discectomy were 166 and 54.8 per 100,000 person-years (95% CI 46.4–63.1) in males and 85 and 24.6 per 100,000 person-years (95% CI 19.4–29.8) in females, respectively. The male-to-female rate ratio was 2.2 (95% CI 1.7–2.9). The median age at the time of lumbar discectomy in our cohort was 27 years (range 15–41) and it was not associated with sex ($p = 0.56$). Ten patients (4.0%) were younger that 18 at the time of surgery, 166 (66.1%) were 18–29 years-old and 75 (29.9%) were older than 30-years at the time of the surgery. The lumbar discectomies were performed in five university hospitals and in 28 central hospitals and no significant variation between hospital district were seen.

In the univariate age-adjusted Cox's proportional hazard models, the strongest risk factor for lumbar discectomy in males was daily smoking, HR being 1.6 (95% CI 1.2–2.2) (Table 2). The incidence of lumbar discectomy among daily smokers was 79.2 (95% CI 59.3–100.0), and the corresponding figure among those not smoking daily was 46.4 (95% CI 38.0–55.6). The number of men who have to restrain from daily smoking for avoiding one case of lumbar discectomy was 3,050 (95% CI 2,510–3,830). Late puberty was associated with a decreased risk for lumbar discectomy during follow-up, HR being 0.6 (95% CI 0.4–0.9). Females with overweight at adolescence had 2.1 times (95% CI 1.1–4.0) the risk of lumbar discectomy compared to females with normal weight. The incidence of lumbar discectomy among those with normal weight was 22.0 (95% CI 16.9–28.4), and the corresponding figure among those with overweight was 44.6 (95% CI 19.2–72.0). The number of women who had to lose weight to normal weight for avoiding one lumbar discectomy case was 4,420 (95% CI 3,170–6,940). Frequent participation in organised sports was associated with an increased risk of discectomy, HR being 2.5 (95% CI 1.1–5.8). The incidence of lumbar discectomy among those not participating in organised sports at all was 22.1 (95% CI 16.2–28.4), and the

Table 3 Age-adjusted hazard ratios (HR) by adolescent background variables for lumbar discectomy during follow-up as estimated in multivariate Cox's regression models all significant variables inclusive

Background variable	HR (95% CI) for lumbar discectomy	
	Males	Females
Overweight		
No	NI	**1**
Yes		**2.1 (1.1–4.1)**
Smoking		
Not daily	**1**	NI
Daily	**1.5 (1.1–2.2)**	
Frequency of participation in sports clubs		
Never	NI	**1**
2–3 times a week or less		**1.5 (0.9–2.5)**
4–5 times a week or more		**2.7 (1.1–6.3)**
Timing of puberty		
Early	1	NI
Normal	0.7 (0.5–1.1)	
Late	0.6 (0.4–1.0)	

Statistically significant variables in bold font

NI Not included

corresponding figure among those participating in organised sports more than three times a week was 41.2 (95% CI 12.3–73.2). The number of women who have to restrain from frequent participation in organised sports for avoiding one lumbar discectomy case was 5,240 (95% CI 3,390–11,800). No significant association between other background variables and lumbar discectomy was found either in males or females.

In the multivariate analysis, which included all significant variables, daily smoking in males (HR 1.5; 95% CI 1.1–2.2) and frequent participation in organised sports (HR 2.7; 95% CI 1.1–6.3) and overweight (HR 2.1; 95% CI 1.1–4.1) in females maintained their statistical significance as risk factors for lumbar discectomy (Table 3).

Discussion

This 11-year follow-up of a large adolescent cohort showed that daily smoking in males and frequent participation in sports clubs and overweight in females were significantly associated with lumbar discectomy, although their respective hazard ratios were relatively small. The clinical relevance of these risk factors of lumbar discectomy must be evaluated with caution, and this requirement is supported by high NNT figures as well. However, the associations between the risk factors and lumbar discectomy were apparent already in early adulthood. The incidence of lumbar discectomy was relatively low in our sample of young adults, but significantly higher in males than females.

This study had a number of strengths. Firstly, it involved a large, prospective, nation-wide sample of adolescents over a remarkably long follow-up period (altogether 651,000 person-years). Secondly, medical treatment is equally available to everyone in Finland which ensures that the used hospitalisation database has comprehensive coverage. In addition, the coverage and accuracy of the National Hospital Discharge Register and the Finnish Official Cause-of-Death Statistics have been shown to be very good [13, 24].

There were also some limitations in our study. Although the overall response rates were good, they somewhat declined over the years. However, given the fact that the non-respondents showed a similar frequency of lumbar discectomy (0.5 vs. 0.4%), the authors conclude that the non-response had no effect on the results. Since no differences emerged while comparing the associations between the risk factors and lumbar discectomy across the three time periods, we concluded that these associations have not undergone any significant change over time. In addition, indications for lumbar disc surgery may have varied based on surgeon's opinion and also over time.

The incidence of lumbar discectomy was 41 per 100,000 person-years in our cohort, which corresponds to previously published data [8]. Lumbar disc herniation leading to discectomy is relatively uncommon among this age group and thus may not be considered a major public health problem. There is evidence, however, that the need for lumbar discectomy increases from young adulthood to middle age, and the highest incidence figures are seen among 40-year-olds [10]. However, several studies have shown significant variation in lumbar discectomy rates between countries [8, 10, 23]. According to recent evidence from Finland the lumbar discectomy rates have declined over the past two decades [14]. The median age at the onset of lumbar discectomy in our study was 27 years, which was in agreement with previous findings indicating that lumbar disc herniation leading to lumbar discectomy is relatively uncommon among adolescents and young adults [20].

It seems that health and health behavioural risk factors at adolescence, such as overweight, may increase the risk of lumbar discectomy in adulthood, although the magnitude of these associations was relatively low. Previous investigators have suspected that smoking is a risk factor for lumbar disc herniation [5, 15, 16, 21], although opposite findings have also been published [5]. This prospective cohort study showed that a relationship exists between smoking at adolescence and later lumbar discectomy. Since smoking has also other well-known negative effects on health, this study emphasises the importance of smoking reduction interventions, although no data on lower discectomy rates achieved by reducing smoking have been published. This means also that the NNT figures presented in this report should be judged with caution.

In the current study, males had twice the risk of lumbar discectomy compared to females, which is contrary to previous studies showing lower male-to-female rate ratios [10]. Some attempts may be made to explain this gender difference. Military service in Finland is mandatory for males and voluntary for females, and over 80% of the males and 1–2% of the females in a specific age group complete the service. It is possible that the intensified physical exercise, including repetitive lifting of heavy loads, involved in military training may be associated with increased lumbar disc herniation occurrence in males, which may eventually lead to an increased level in lumbar discectomy.

In the present study, overweight predicted lumbar discectomy in females, a finding which to our knowledge has not been previously published. It is possible that the association is partly related to early biological maturation. Given the recent rapid increase in the prevalence of overweight among adolescents worldwide [6, 11], the finding is alarming, although no corresponding increase in lumbar discectomy rates has been described. However, association between overweight at adolescence and lumbar disc disease in early adulthood clearly warrants further research.

In this study, females who frequently participated in organised sports had a markedly increased risk for lumbar disc surgery and a dose-response effect seemed to exist. To our knowledge the only study previously describing the association between sports activity and lumbar disc surgery has been a study by Mundt and co-workers [17]. A possible explanation is that the increased spinal load associated with high-intensity physical activity and repetitive mechanical extension/flexion loadings leads to lumbar disc herniation. It is also possible that for females actively attending competitive sports, the threshold to operative treatment may be low in order to ensure faster return to sports activities. It is possible that back injuries may predispose lumbar disc herniation and thus, prevention of sports injuries warrants more attention.

Previous studies have demonstrated an association between physically demanding work and lumbar disc disease [12]. We had no information on the person's social class or level of education at adulthood, but parental social class and personal school success as measured at adolescence, which reflect future educational levels, were not associated with lumbar discectomy. However, it is possible that the association between lower social positions and more physically demanding workplaces and lumbar disc disease may become significant later in life.

In conclusion, daily smoking in males and frequent participation in sports clubs and overweight in females measured at adolescence were statistically associated with lumbar discectomy in an 11-year follow-up, although the hazard ratios seen were relatively low. Further study on these common risk factors and their modifications may lead to a better understanding of the causes of lumbar disc herniation and a reduced need for lumbar discectomy.

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