

Association of lumbar disc prolapse with obesity in north Indian population

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Abstract: *Background:* Lumbar disc prolapse is one of the causes of low back pain. The inner segment of the intervertebral disc bulges into and ruptures through the outer segment of the disc into the spinal canal. The disc prolapse starts as a result of lumbar disc degeneration which is an age related process influenced by mechanical and genetic factors. The present study aimed to find the association of disc prolapse with obesity, one of the risk factor, in the north Indian population. *Methods:* A total of 200 subjects (100 cases and 100 controls) were finally selected for this study. All the subjects were from north India. The cases were patients who came to Rama Medical College Hospital and Research Centre with complaint of low back pain and diagnosis of lumbar disc prolapse was confirmed by MRI and clinical examination. The controls were volunteers from the general population. Odds ratios with 95% confidence intervals were calculated using unconditional logistic regression analysis. *Results:* The risk of disc prolapse increased with the increase in weight in both sexes. In female subjects, the risk of lumbar disc prolapse increased with the increase in BMI. The highest risk of lumbar disc prolapse in male subjects was seen in overweight subjects (BMI 25-30 kg/m²) but declined with further increase in BMI. *Conclusion:* The present study found direct association between obesity and the lumbar disc prolapse in the north Indian population.

Keywords: Low back pain, BMI, Disc degeneration, MRI, North Indian population

Introduction

Low back pain (LBP) is one of the most common causes of disability worldwide and it affects the economy and the quality of life of the patients. Low back pain is ranked sixth in terms of disability adjusted life years (DALYs) according to the 2010 Global Burden of Disease Study. Initially the back pain was reported mainly in the developed countries and most of the studies were done in these countries [1-7]. But the prevalence is now increasing even in developing countries. This is because of the ageing populations in the developing countries [8-9]. WHO Study on Global AGEing and Adult Health (SAGE) found past-month back pain prevalence of 39.1 % in a study sample of 6,329 Indian subjects aged 50 years or more [10].

Lumbar disc disease (LDD) is one of the leading causes of low back pain [6, 11-15]. Lumbar disc

disease starts with degeneration of the disc material which is an age related process influenced by mechanical as well as genetic factors [16-18]. This causes reduction in vertebral body height leading to more stress on the weakened disc. Over a period of time, this stress can cause outward bulging of the disc into the spinal canal. Lumbar disc prolapse or herniation develops from bulging of the nuclear material throughout the enveloping annulus fibrosus capsule.

The inner layer, nucleus pulposus, bulges into and even ruptures through the outer layer of the disc, annulus fibrosus, into the spinal canal. As ligaments are present on the front and back of the intervertebral disc, most herniations occur on either side and compress the spinal nerve on that side. This is the reason why symptoms mainly occur in only one leg. The prolapsed disc compresses the

nerve root leading to radiating pain along the nerve pathway in affected dermatome. The various factors related to disc degeneration and prolapse are genetic factors, age, height, obesity, occupation and smoking [17-25].

The objective of the present study is to analyze the association of lumbar disc prolapse with obesity in the north Indian population and find out whether overweight or obesity increases the likelihood of developing disc prolapse irrespective of other risk factors.

Material and Methods

The study was approved by the institutional ethical committee and informed consent was obtained from all subjects. The patients from the north Indian states coming to Rama Medical College Hospital and Research Centre with symptoms of low back pain constitute the sampling frame from which the sampling was done. The cases were selected from the patients who came to the hospital with complaint of low back pain during the 2 year time period from 2018-2020 (purposive sample). The controls were volunteers from the general population from the same locality, age and weight matched and without any history of back pain/other symptoms. The sample size was calculated according to the

$$\text{formula } n = \frac{z^2 \times p \times q}{e^2}$$

where n = number of subjects (cases or controls)

z = standard normal deviate (1.96 for 95 % confidence interval)

p = expected prevalence

q = 1-p

e = margin of error (10% for the study)

Earlier studies [26-29] have shown that the prevalence of disc prolapse range from 27-84%. To get the maximum number of participants for the study, the p value was taken as 0.5 (50%) leading to the value of q as 0.5. Putting all these values in the formula gives rise to the value of n as 96. So total of 200 subjects (100 cases as well as 100 controls) were finally selected for this study. All the subjects were from north India. The

diagnosis of lumbar disc prolapse was made by MRI and clinical examination. MRI cost was waived by the hospital for all the patients who participated in the study. Patients with a history of spine deformity, metabolic bone disease, spinal infection, or tumors were excluded from the study.

Height was measured in the standing position. The subjects were lightly clothed but without shoes. Standing height was measured to the nearest 0.5 cm. Body weight was recorded in kilograms with subjects in light clothing and without shoes. The weight was recorded to the nearest 0.1 kg. Body mass index (weight/height²) was calculated from weight and height measurements and was used as a measure of obesity.

Statistical analysis was done with SPSS software (version 20). Subjects were divided into 4 groups according to BMI. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated with logistic regression analysis. The statistical analyses were conducted separately for men and women. Potential confounders were included in the multivariate analysis. Test for trend analysis was done and p value less than 0.05 was considered as significant.

Results

Table 1 shows the demographic profile of the cases and controls. The mean age of cases was 45.62 years and of controls was 46.73 years. Out of 100 patients with lumbar disc prolapse, 57 were male and 43 were females. 55.48 % of cases were manual labourers while the rest were office or desk workers. There was history of previous injury in the lumbar spine in cases (22) as well as in control subjects (25).

Table 2 shows the level of disc prolapse in different age groups. The most common level of disc prolapse was L4-L5 followed by L5-S1 irrespective of age. Out of 100 cases, 25% were having disc prolapse at 2 or more sites. Majority of the patients of disc prolapse were in the age group of 30-50 years.

		Cases (n=100)	Control (n=100)
Age (years)		45.62±7.29	46.73±8.18
Gender	Male	57	60
	Female	43	40
BMI(kg/m ²)		24.17±4.27	23.36±5.14
Smoking	Yes	24	28
	No	76	72
Manual labourer	Yes	55	52
	No	45	48
Lumbar injury	Yes	22	24
	No	78	76

Age (years)	1 disc prolapse					≥ 2 disc prolapse
	L1-L2	L2-L3	L3-L4	L4-L5	L5-S1	
<20	0	0	0	2	3	1
21-30	0	0	3	7	3	5
31-40	1	1	2	13	10	7
41-50	0	1	2	10	7	7
51-60	1	0	2	1	1	2
61-70	0	1	1	0	1	2
>70	0	0	0	1	1	1
Total	2	3	10	34	26	25

To find the association of lumbar disc prolapse with BMI, odds ratios (OR) were calculated for male and female separately. Table 3 and 4 show the odd ratios for different BMI groups in men and women respectively. Tests for trends were statistically significant in both groups. The risk of lumbar disc prolapse in males increased gradually with the increase in BMI but the highest risk of lumbar disc prolapse was seen in overweight subjects (BMI 25-30). It declined further in the

obese subjects (BMI ≥30). In female subjects, the risk of lumbar disc prolapse increased with the increase in BMI and the women with BMI ≥ 30 had double the risk of disc prolapse compared to women with BMI < 20. These associations of disc prolapse with BMI were seen even after adjusting the confounders (age, height, smoking, occupation).

BMI (kg/m ²)	Cases	Controls	OR	95% CI	OR*	95% CI
<20	6	9	1.0	-	1.0	-
20-25	21	24	1.4	0.42-4.50	1.2	0.38-4.22
25-30	25	21	1.8	0.55-5.84	1.7	0.46-5.53
≥30	5	6	1.5	0.32-6.94	1.4	0.29-6.68
			p [#] =0.005		p [#] =0.007	
* Adjusted for age, height, smoking and occupation; # p values show the result for trend test						

Table-4: Lumbar disc prolapse and BMI in females						
BMI (kg/m²)	Cases	Controls	OR	95% CI	OR*	95% CI
<20	17	21	1.0	-	1.0	-
20-25	12	10	1.5	0.52-4.26	1.3	0.49-3.97
25-30	10	7	1.8	0.55-5.62	1.6	0.47-5.57
≥30	4	2	2.4	0.40-15.15	2.1	0.38-15.98
			p [#] =0.001		p [#] =0.004	
* Adjusted for age, height, smoking and occupation; # p values show the result for trend test						

Discussion

The study was done to find association between obesity and lumbar disc prolapse in north Indian population. BMI was taken as a measure of obesity. In this study, majority of the patients of lumbar disc prolapse were in the age group of 30-50 years. The most common site of disk prolapse was L4-L5 and L5-S1 irrespective of age and sex. This finding is similar to earlier studies [30-33]. The high risk of disc prolapse in L4-L5 and L5-S1 segments is because of the increased weight bearing in these areas and the large range of movement happening at these spine levels [34]. The risk of lumbar disc prolapse increased with the increase in BMI. Obese females (BMI≥30 kg/m²) were found to have twice the risk of lumbar disc prolapse compared to females with BMI<20 kg/m². In case of male subjects, the highest risk of disc prolapse was found in overweight subjects (BMI 25-30 kg/m²).

Heliovaara [35] found body mass index to be an independent risk factor for herniated lumbar disc. The association between BMI and lumbar disc prolapse was seen in men but not in women. The relative risk was minimum for persons with BMI below 22.0 kg/m² and increased gradually upto BMI values 29.9 kg/m²(RR=3.7), but declined again for the most obese men(BMI>30 kg/m²). In a German multi-center case-control study (EPILIFT), Schumann et al. found generally higher risks of lumbar disc prolapse with increasing BMI in both sexes [36].

In male subjects, the highest risk was observed in men who were slightly overweight (BMI 24.3-29.21kg/m²) compared with those of the lowest BMI quartile (adjusted OR 2.1, CI 1.3-3.6). In obese males having BMI more than 29.21 kg/m², the risk was found lower than the overweight. In

women, the relative risk of lumbar prolapse increase with the increase in BMI. Women with a BMI≥29.21 kg/m² had more than double the risk of disc herniation than women with a BMI of less than 21.88 (adjusted OR 2.0, CI 1.1-3.7). A 4 year follow up study done by M Liuke et al found overweight at young age to be a stronger predictor of lumbar disc degeneration in later years [37].

129 working middle-aged men (40-45 years) were selected from a group of 1832 men representing different occupations. The subjects' BMI were calculated at the time of study and at the age of 25 years. Based on the BMI at two ages, subjects were divided into 3 categories: no overweight (BMI <25 kg/m² at the age of 25 and 40-45 years), persistent overweight (BMI ≥25 kg/m² at the age of 25 and 40-45 years) and other (BMI ≥25 kg/m² at either 25 or 40-45 years age). MRI images of the lumbar spines were obtained at baseline and at 4 year follow-up. Persistent overweight (BMI ≥25 kg/m² at the age of 25 and 40-45 years) was strongly associated with disc degeneration at follow-up (adjusted OR 4.3, CI 1.3-14.3). The relative risk of 4 year progression of disc degeneration was highest in the persistent overweight group (adjusted RR 3.8, CI 1.4-10.4).

In a cross sectional study [38], both an increased BMI and a tall stature was found to have a clear association with the lumbar disc prolapse requiring surgery. The preoperative height and BMI of 1128 patients of lumbar disc herniation were compared with the corresponding values from a sample of general population. The subjects were divided into age and gender specific groups. It was found that patients undergoing surgery for

disc prolapse were more obese and taller than the general population in the age and gender specific group. This finding was seen in all age groups except in the oldest age group (50-59 years).

Intervertebral discs are disc like structures present between the vertebrae. The discs are heterogeneous, fibrocartilage structure which provide flexibility and help in load support in the spine region. The disc consists of two layers, the inner nucleus pulposus surrounded by the outer annulus fibrosus. The central layer, nucleus pulposus (NP), is gel like in consistency and contains proteoglycans, water and various types of collagens. Aggrecan is the major proteoglycan in NP. Being hydrophilic, it absorbs water and is responsible for hydrostatic pressure of the inner layer [38- 39].

The collagen provides structural support. The nucleus pulposus serves to distribute the hydraulic pressure equally in all directions in the disc under compressive loads. The outer annulus fibrosus (AF) is a fibrocartilaginous structure which is made of concentric lamellae or rings. These lamellae are rich in collagen, mainly type I collagen. These collagen rings play important role in maintaining structure, resisting the load or tension, and keeping the nucleus pulposus constrained within the AF [40].

The disc degeneration is believed to start in the second decade of life [41]. With advancing age and under the influences of various factors, the structure as well as function of disc deteriorates. The number of notochordal cells in the nucleus pulposus gradually decreases with advancing age [42-43]. These notochordal cells are of embryonic origin and are involved in the maintenance and regeneration [44]. Proteoglycan and collagen molecules in the disc start decreasing due to increased breakdown by matrix metalloproteinase enzymes. Initially, the disc tries to regenerate by increasing the synthesis of these molecules [45]. But with advancing degeneration, synthesis of these molecules slows down and disc components breakdown [46].

Progressive breakdown of proteoglycan molecules, hydrophilic in nature, leads to decreased water content in the nucleus pulposus. The nucleus loses its gel like consistency and becomes fibrotic. Disc dehydration in nucleus

pulposus impairs its resistance to compression. The arrangement of collagen and elastin networks in the outer layer lamellae becomes irregular. The external layer, annulus fibrosus, becomes disorganized.

The boundary between nucleus pulposus and annulus fibrosus becomes less clear with the age. Cleft formation and fissuring is seen within the disc, especially in the nucleus, with advanced degeneration. The fibrotic nucleus pulposus push outward through the degenerated annulus fibrosus leading to disc bulge. When there is complete rupture of outer layer, the NP protrudes out of the disc leading to disc prolapse or herniation.

The exact mechanism by which overweight causes disc degeneration and prolapse is not clearly known. Both mechanical as well as systemic factors are thought to play role. Increased body weight put extra load on the spine as well as the discs. The increased load on the spinal column increases the risk of disc degeneration leading to disc prolapse over time. Obese persons have higher chances of developing atherosclerosis and various cardiovascular diseases [47].

The cholesterol, triglycerides, glucose and inflammatory markers, which are present in excess amounts in the blood in obese subjects, predispose to atherosclerosis [48-50]. The discs are vascular in children but they gradually become avascular in adults [41]. Nutrition of disc in adult person takes place by diffusion through cartilaginous end plates [51-52]. Atherosclerosis leads to decreased blood flow in the spinal blood vessels which further hampers the nutrient supply to the disc. The cells of the intervertebral disc require nutrients like glucose as well as oxygen to remain viable. The disc cells are sensitive to oxygen tension and pH level. The activity of these cells deteriorates rapidly at low glucose concentration, low oxygen levels and acidic pH [53-54].

These cells do not survive prolonged exposure to acidic pH or glucose concentrations [55-56]. Reduced nutrient and oxygen supply, due to atherosclerosis of blood vessels, leads to low oxygen tension and pH (due to

accumulation of lactic acid). Low oxygen tension and pH affect the normal functioning of the disc cells and they are not able to synthesize the extracellular matrix of the disc. This may lead to disc degeneration over time. A study by Kauppila [57] on 22 cadaveric lumbar spines found direct association between decreased blood supply to the disc and disc degeneration. The result of regression analysis showed that changes in the blood vessels occurred prior to the disc degeneration at every lumbar disc level.

Conclusion

The present study concludes that obesity is directly associated with the lumbar disc prolapse in the north Indian population. The risk of disc prolapse increases with the increase in BMI in both sexes. BMI is one of the modifiable risk factors for lumbar disc prolapse. By keeping

weight under check, one can prevent or slow down the lumbar disc disease. The risk of surgery increases with increasing BMI or weight in patients with lumbar disc prolapse [58]. There is even chance of regression of disc prolapse with weight loss as reported in a case study by Tokmak et al [59].

Our study has some limitations. The sample size was small. The cases were selected from one hospital only, and therefore may not be representative of all patients with lumbar disc prolapse in the general north Indian population. Thus, selection bias was unavoidable.

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