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Body Mass Index in Patients with Degenerative Spondylolisthesis: A descriptive cross-sectional study

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ABSTRACT

Background

Low back pain is a leading cause of disability globally. Obesity, a product of modern lifestyle, is a well-established risk factor for many diseases including spine pathologies. Degenerative lumbar spondylolisthesis is a significant cause of low back pain in the middle-aged and elderly population. However, the literature on relationship between high body mass index and degenerative spondylolisthesis is inconsistent.

Objective

To investigate prevalence of obesity among the patients with degenerative spondylolisthesis.

Method

This cross-sectional study was conducted at Tribhuvan University Teaching Hospital, Nepal, involving 81 patients aged ≥ 40 diagnosed with degenerative spondylolisthesis at various lumbar vertebral levels and grades. Anthropometric measurements were obtained and analyzed using an Independent t-test to compare the mean age, height, weight, and body mass index across different levels, grades, and between sexes.

Result

Among the 81 patients, 59 were female, and 22 were male. The mean age and, BMI were 59.41 ± 10.97 years, and 26.04 ± 4.41 kg/m^2, respectively. A notable 59.3% of patients had Body Mass Index ≥ 25. Patients with grade II spondylolisthesis exhibited significantly higher weight and Body Mass Index compared to those with grade I spondylolisthesis (p = 0.031, 0.013), particularly in female population (p = 0.003, 0.007) and at L4-L5 level (p = 0.003, 0.004).

Conclusion

Body mass index and weight were significantly higher in patients with grade II spondylolisthesis compared to grade I. This finding underscores the need for further research to understand the relationship between obesity and degenerative spondylolisthesis.

KEY WORDS

Body mass index, Epidemiology, Obesity, Spondylolisthesis

INTRODUCTION

Degenerative Lumbar Spondylolisthesis (DLS) is a notable cause of low back pain in middle aged and elderly individuals. DLS is the anterior displacement of vertebral body in relation to its adjacent one without any defect in the pars interarticularis with degenerative changes in facet joint and disc.[1,2]

Body Mass Index (BMI) is a widely accepted anthropometric tool, categorizes individuals as either normal (18.5 - 25 kg/ m^2) or overweight (≥ 25 kg/m^2).[3] The modernization of the human lifestyle has led to the obesity, an established risk factor for several pathologies including spine pathologies.[4]

The prevalence of BMI ≥ 25 in DLS varies, ranging from 28-71% across various studies.[5,6] Some authors established a significant association of BMI with DLS, while others failed to demonstrate such relation.[5,6-10] This study aims to fill the data gap and enhance our understanding of the prevalence of obesity in DLS.

METHODS

This was an observational cross-sectional study conducted at Tribhuvan University Teaching Hospital, Department of the orthopedics and trauma surgery from January 2022 to May 2023 after receiving ethical clearance from the Institutional Review Committee. The study's objective was to study the prevalence and association of high Body Mass Index (BMI) in subjects with Degenerative Lumbar Spondylolisthesis (DLS).

Sample size of 78 was calculated using the Cochran's formula with prevalence of 28% obesity in DLS, 95% confidence interval, and margin of error of 10%.6

Formula: $n=Z^2 pq/(d^2)$

Where Z= 1.96 at 95% of the Confidence interval

p = Percentage of overweight patient with degenerative spondylolisthesis = 28.2[6]

q = 100-p = 71.8

d = maximum tolerable error 10%

Patients presenting with low back pain evaluated with Xray of lumbosacral spine showing DLS as per the definition of North American Spine Society (NASS) from L1-S1 level, with ≥ 3 mm of anterior translation and age ≥ 40 years were included in the study.[11] Pertinent history was taken and LS spine AP view was evaluated to rule out any other types of spondylolisthesis and to identify any pathologies that comes under the exclusion criteria of degenerative or idiopathic scoliosis, previous history of spine tumor, spine fracture or spine surgery, and pregnancy. A written consent was taken, and preformed pro forma was filled. Height and weight were measured using the technique described by the WHO STEPwise approach to non-communicable disease risk factor surveillance manuals' guide to physical measurement.[12] Height was measured using a stadiometer in meters (m) and weight using a digital weighing machine in kilograms (kg). BMI was calculated using the following formula.[4]

BMI = (Weight in kg)/(Height in m X Height in m)= (kg)/m^2

The forward displacement was measured from the cortex of the posterior aspect of the caudal slipped vertebra to the cortex of the rostral slipped vertebra's posterior aspect with the greatest amount of displacement as per the Tallard's method.[13,14] The level and grade of DLS was noted from lateral radiograph with a cutoff value of 3 mm slip of vertebrae.[2] The percentage slip was calculated as A/ BX100% as shown in figure 1. The grading of the slip was noted according to Meyerding´s grading, up to 25% slip as grade I, 25-50% as grade II, 50-75% as grade III and 75-100% as grade IV.[15]

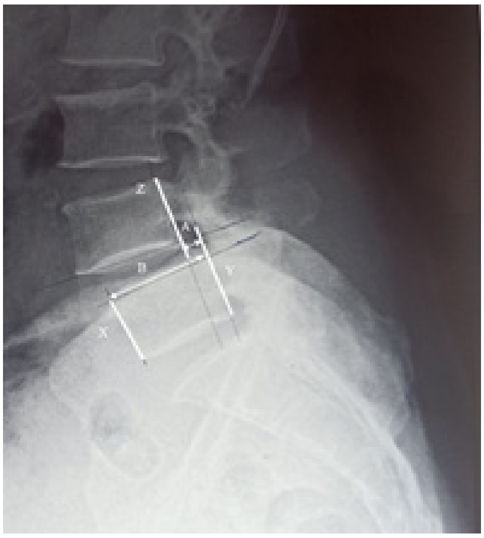

Figure 1. Measurement of DLS as per Tallard's method.

Statistical Package for Social Sciences (SPSS) 22.0 version was used for data processing and analysis. Continuous variables, including age, height, weight, and BMI were presented as mean ± standard deviation. BMI was categorized into two with the cutoff value of 25. BMI < 25 included underweight and normal BMI subjects, whereas BMI ≥ 25 included overweight and obese subjects. The Independent t-test was used to compare means between two continuous groups. Categorical data were presented as number (percentage). Chi-square test was performed to compare categorical data. The p value of 0.05 was considered significant.

RESULTS

Out of the 81, 59 were female and 22 were male with female to male ratio of 2.7: 1. The mean age, height, weight and BMI are as shown in table 1.

Table 1. Patients Demographic and Anthropometric parameter.

	Total	Male	Female	Range
Age (years)	59.41±10.97	64.45±8.55	57.53±11.23	40-81
Height (m)	1.52±0.08	1.58±0.08	1.43±0.03	1.36-1.70
Weight (kg)	60.43±12.82	64.66±11.46	58.85±13.03	35-85
BMI (kg/m^2)	26.04±4.41	25.93±3.66	26.08±4.69	17.82-37.22

Table 2 shows the distribution of cases as per level and grades. There were 8 male and 25 female with BMI < 25 and 14 male and 59 female with BMI ≥ 25 with 59.3% categorized as overweight/obese. Chi-square test showed no significant association between the categories of BMI and sexes (p = 0.624). Three female patients were underweighted (BMI < 18.5), while two female patients had Grade II Obesity (BMI 35-39.9).

Table 2. Distribution across Levels and Grades.

Level	Grade I	Grade II	Total
L3-L4	2	0	2
L4-L5	40	9	49
L5-S1	22	8	30
Total	64	17	81

As shown in table 3, the weight and BMI of patients with Grade II DLS (66.35 kg, 28.40 kg/m^2) was significantly higher than that of Grade I DLS (58.82 kg, 25.42 kg/m^2) (p=0.031, 0.013). Among the female population, the weight and BMI of patients with Grade II DLS (69.00 kg, 29.48 kg/m^2) was significantly higher than that of Grade I DLS (56.52 kg, 25.31 kg/m^2) (p = 0.003,0.007). The mean height in men with grade I DLS (159.75 m) was significantly higher than grade II DLS (151.83 m) (p =0.029).

Table 3. Comparison of age, height weight and BMI among grade and sexes (n=81).

	Grade		
	I	II	p value
Age (year)	60.36±11.05	55.82±10.17	0.131
Male	65.31±8.69	62.17±8.52	0.456
Female	58.71±11.34	52.36±9.60	0.091
Height (m)	1.52±0.08	1.52±0.08	0.805
Male	1.60±0.07	1.52±0.08	0.029*
Female	1.49±0.06	1.53±0.08	0.126
Weight (kg)	58.82±11.84	66.35±14.92	0.031*
Male	65.84±8.94	61.50±17.17	0.442
Female	56.52±11.84	69.00±13.67	0.003*
BMI (kg/m^2)	25.42±4.06	28.40±5.03	0.013*
Male	25.76±2.77	26.41±5.75	0.720
Female	25.31±4.42	29.48±4.45	0.007*

*With p value < 0.05 considered significant, there is statistical significance between the two groups.

When independent t-test was applied among the two levels excluding the L3-L4 level with two cases, the results were as shown in table 4. The weight and BMI of patients with grade II DLS (71.11 kg, 30.05 kg/m^2) was significantly higher than grade I DLS (58.31 kg, 25.27 kg/m^2) (p=0.003, 0.004) at L4-L5 level compared to L5-S1 level. The mean age of subjects with grade I DLS at L4-L5 level was higher (59.60 ± 10.36 years) compared to grade II DLS (51.89 ± 6.97) (p = 0.039) at the same level. No significant differences were noted in age, height, weight and BMI among the two grades in L5-S1 level though the mean BMI, mean weight was higher in Grade II DLS.

Table 4. Comparison of age, height, weight, BMI, Level, and Grade of DLS (n=79).

		Grade		
		I	II	p value
Age (year)	60.58±11.14	55.82±10.17	0.117	
	L4-L5	59.60±10.36	51.89±6.97	0.039*
	L5-S1	62.36±12.49	60.25±11.78	0.681
Height (cm)	1.51±0.08	1.52±0.08	0.777	
	L4-L5	1.52±0.08	1.54±0.05	0.429
	L5-S1	1.52±0.08	1.51±0.01	0.735
Weight (kg)	59.14±11.85	66.35±14.92	0.039*	
	L4-L5	58.31±11.13	71.11±13.07	0.004*
	L5-S1	60.64±13.20	61.00±15.87	0.950
BMI (kg/m^2)	25.56±4.01	28.40±5.03	0.017*	
	L4-L5	25.27±3.97	30.05±5.11	0.003*
	L5-S1	26.11±4.13	26.53±4.52	0.811

*With p value < 0.05 considered significant, there is statistical significance between the two groups.

On comparing the mean age, height, weight and BMI, no statistically significant data was found among the level and sexes as shown in table 5.

Table 5. Comparison of Age, Height, Weight, BMI among Level of DLS and Sexes (n=79)

		Level		
		L4-L5	L5-S1	p-value
Age (year)	58.18±10.22	61.80±12.14	0.160	
	Male	62.43±7.25	68.00±9.97	0.146
	Female	56.49±10.81	59.55±12.27	0.328
Height (m)	1.52±0.07	1.51±0.09	0.808	
	Male	1.59±0.06	1.55±0.10	0.222
	Female	1.49±0.06	1.50±0.08	0.517
Weight (kg)	60.66±12.42	60.73±13.67	0.981	
	Male	65.46±8.09	63.25±16.39	0.674
	Female	58.74±13.40	59.82±12.86	0.766
BMI (kg/m^2)	26.15±4.54	26.22±4.16	0.941	
	Male	25.82±2.62	26.13±2.24	0.855
	Female	26.28±5.14	26.26±3.84	0.987

*With p value < 0.05 considered significant, there is statistical significance between the two groups.

DISCUSSION

The mean age was found to be 59.41 ± 10.97 (Range 40-81) years with mean male and female age being 64.45 years and 57.53 years respectively. The age range was comparable to studies done by Jacobson et al. and AO Spine Asia Pacific.[15] Former findings suggest DLS is a disease of elderly, with both men and women developing DLS after the age of 50 and rate of development is faster in women than in men.[13]

Our finding of female preponderance with female to male ratio of 2.7 : 1 is comparable to the finding if previous studies where female to male prevalence ranged from 2: 1 to 5.28 : 1.[5,7,10] This dichotomy in the gender specific distribution has been attributed to the association of hormonal factors and has been demonstrated with various studies based on the influence of generalized joint laxity, estrogen receptors, pregnancy and oophorectomy.[2,8] Elderly women have been found to have more severe disc narrowing than their male counterparts.[13] This higher grade of disc degeneration in elderly women may be the potential cause for the higher prevalence of DLS in women than in men.[13]

The average height of the population was 1.52 ± 0.08 m (male 1.58 ± 0.08 m, female 1.43 ± 0.03 m). These values are comparable with the Nepalese national average of 1.60 m for men and slighlty lower than national average of 1.50 m for women of age 45-69 years.[16] The height of the subjects were less than those in the European studies and comparable to the findings in an Asian study.[5,6,9,10] The mean weight of all the subjects in our study was 60.43 ± 12.82 kgs (men 64.66 ± 11.46 kg and women 72.36 ± 9.04 kg). The average weight of Nepalese population for age group 45-69 years is 58.8 kg for men and 51 kg for women.[16] Our findings are much higher than the average Nepalese population. The average weight for men in the Norwegian study was 80 for men and 67 for women and 72.7 kg in the French study.[5,10] Comparing the national average of the Danish, French, Indonesian and the Nepalese population, the Asian people have smaller anthropometric values compared to the Europeans population.[17] The variation in the height and weight could be contributed to racial and ethnic variations, nutritional factors and lifelong health advantages.[17] Middle-aged women irrespective of their menopausal status have higher weight and menopause accelerates accumulation of abdominal visceral fat.[18] Thirty six of the 81 subjects were women of age group 40-60 years leading to higher overall weight in female subjects.

In our study, the mean BMI in our study was 26.04 ± 4.41 kg/m^2; 26.09 ± 4.58 kg/m^2 for women and 25.93 ± 3.67 kg/m^2 for men. Of the total 81 subjects, notable 48 (59.26%) had BMI ≥ 25. 34 (57.63%) of the total female had BMI ≥ 25 while 14 (63.64%) of the male had BMI ≥ 25. For age group 45-69, the national average of mean BMI for men was 23.0 kg/m^2 and women was 22.4 kg/m.[1,16] Among the population of 45-69 years, the national data shows only 21.2% of men and 22.1% of women have BMI ≥ 25 with only 21.6% of the community being overweight.[16] Our subjects with DLS had BMI much higher than the general Nepalese population. In the Danish community based longitudinal study by Jacobsen et al., the mean BMI was 26.4 kg/m^2 for men and 25.7 kg/m^2 for women.[10] In the French study the mean BMI was 28.2 kg/m^2 in a group of 49 patients with 71.4% of the population being overweight or obese with only 50% of reference group being overweight or obese.[5] They had significantly high BMI compared to their reference group of population (p=0.030).[5] In another community based study by He et al., the mean BMI was 23.79 kg/m^2 and 24.59 kg/m^2 for male and female respectively.[9] They had included patient of age 65 years and above only. Our selection of younger patients of age ≥ 40 had more young, and healthy subjects as the mean age of our subject was 59 years. Body composition alters with ageing, fat mass increases while the muscle mass and bone mineral density decreases.[19] In the study by Tedyanto et al., they have not differentiated the BMI among two group with and without DLS.[6] The mean BMI of the overall population was 23.44 with 28.2% of total subjects with DLS being overweight. However, they found that overweight BMI subjects have greater positive DLS than who have normal BMI with odds ratio of 6.089.[6] Our study has findings consistent with the existing literature. Mean BMI in our study was 26.04 kg/m^2 which belong to overweight category. Also, the proportion of patients having DLS with BMI ≥ 25 is also high.

Distribution of DLS levels revealed two L3-L4, 49 L4-L5 and, 30 L5-S1. Grade I and II DLS constituted 64 and 17 cases respectively. There were 64, 79% of grade I DLS and 17, 21% of grade II DLS in our study. No cases had DLS at level higher than L3-L4 and more than grade II. In the community based longitudinal study by Jacobsen et al., they had 12.4% cases at L3-L4 level, 67.8% cases at L4-L5 level and 16.26% L5-S1 cases.[10] Jacobsen et al. had 94% cases with grade I DLS and 6% cases of grade II DLS.[10] He et al. in their community based study from Hongkong China have found 8.03% of L3-L4, 71.38% of L4-L5 and 20.28% of the spondylolisthesis with 95% of Grade I and 3.8% grade II spondylolisthesis spread across various level.[9] L4-L5 level DLS are the most common type of DLS.[1,15] In the multicenter, multiethnic study by AO Spine Asia Pacific Research Consortium, 74.7% cases were L4-L5 followed by 12.9% of L5-S1 and 12.4% of L3-L4 cases.[7] The biggest limitation with the study by He et al. was the assumption of all the subjects to be of degenerative type considering the old age and their failure to differentiate between the spondylotic and degenerative type of listhesis.[9]

All the above-mentioned studies are either community based or multicentre multi ethinic large studies. Yet, the higher prevalence of L5-S1 in our study compared to other studies could be because, the caudal level DLS could have been more symptomatic. The normative data of mean AP canal diameter of Indian population as evaluated by Yadav et al. showed increasing canal diameter from L1 to L5 and then decreasing caudally from L5 to S1 level.[20] So, anterior translation of L5 over S1 could easily narrow the canal compared to the same over L4 over L5 and hence predispose to early development of symptoms requiring attention. Being a tertiary level referral center, more symptomatic patients with features of lumbar canal stenosis could have been studied. Also, the asymptomatic low grade DLS recorded in community-based studies could have been eliminated.

On applying the independent t-test, the weight and BMI of patients with grade II DLS was significantly higher than that of grade I DLS (p = 0.031, 0.013). Similarly, among the female population, the weight and BMI of patients with grade II DLS was significantly higher than that of grade I DLS (p=0.003, 0.007). At L4-L5 level, the weight and BMI of patients with grade II DLS was significantly higher than grade I DLS (58.31 kg, 25.27 kg/m^2) (p = 0.003, 0.004). After extensive review of the existing literature, no studies were found where comparison of anthropometric values among the various grades of DLS has been done.

The relationship between overweight and vertical alignment of S1 end plate predisposes the L4 vertebrae to slip over the L5 vertebrae, has been shown in various studies.[5,21] The increased weight and subsequent increase in BMI may lead to further increase load on the facet joint, intervertebral disc and cause further anterior shift of the trunk leading to higher grade of DLS at L4-L5 level. Middle-aged women have higher body weight and menopausal changes favours abdominal visceral fat deposits.[18]

In a study with trunk musculoskeletal model to evaluate to the effect of age, sex, body weight and height on spinal loads by Ghezelbash et al. found that the greater body weight and female gender has greater effect on spinal loading.[22] With equivalent age, height, and bodyweight, female spine tend to experience much higher loads primarily due to the smaller muscle moment arms and passive joint contributors. Similarly, by adding up on the external moments, weight had significant effect on the spinal load however that was counterbalanced by the larger muscle moment arms and passive joint reaction forces. Age per se did not had much effect.[22] In another similar study by Ghezelbash et al., they have highlighted the effect on the biomechanical loading of spine in various types of body weight distribution and found that obesity with abdominal fat predominance, have more loads on spine than those with hip predominant adiposity.[23] The higher body weight of middle aged women, which forms the majority of our subjects, with more abdominal visceral fat may be the possible cause of higher grade of DLS in women.[24]

Uysal et al. in their large CT based study found that the BMI and the abdominal subcutaneous and mesenteric adipose tissue thickness increased with advancing age both in male and female.[24] Pelvic incidence (PI) was found to be positively related with the weight, thickness of mesenteric fat and abdominal subcutaneous fat and negatively with the height. They also found that the pelvic incidence and sacral slope was higher in patients with spondylolisthesis compared to the general subjects. They ultimately concluded with the possibility of increased risk of spondylolisthesis in patient with obesity by altering the pelvic incidence.[24]

Being a tertiary-level, single center-based, convenience sampling study, the study may not have demonstrated the true demographics of the population. The extent of vertebral slippage can fluctuate based on the patient's position and evaluating patients with recumbent Xray's could have under evaluated the grades of DLS.[25] Inter-observer and intra-observer variability exists in evaluating the grade of DLS.[14,26] BMI tends to over simplify the evaluation of obesity. So, only considering the BMI may be inadequate to consider its effect on the spine.[22-24]

CONCLUSION

Our study found a significant link between higher BMI, increased weight, and grade II DLS. These findings were particularly noteworthy in females and at L4-L5 level. The clinical importance of considering the role of obesity in the severity of DLS can guide us for more tailored interventions and improved patient outcome.

Based on our study, we see the need for future studies to further elucidate the relationship between BMI and DLS. Longitudinal, case control and community-based studies can explore the potential of linear progression of DLS with increasing age and changing BMI over time, establish the causal relation between BMI and DLS and true epidemiological profile of the disease respectively. Studies based on the morphogenic pattern of obesity and its effect on spine, consideration of specific position on evaluation of grade can contribute valuable insights in the better understanding of DLS, BMI and guide clinicians develop preventive strategies and targeted interventions for individuals at risk of DLS.

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