Original Article

# A cross-sectional study on the association between obesity and changes in the dimensions of the lumbar vertebral column

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## Abstract

**Aim:** Obesity is considered a major public health problem and is becoming very common among the population. Impacts of obesity include increased load and weight bearing on the vertebral column, possibly causing alterations in its structure to maintain stability and subsequent disabling lower back pain (LBP). The present study aimed at investigating the association of overweight and obesity with alterations in the lumbar vertebral column as well as LBP. **Methodology:** Thirty female attendants of the clinic were interviewed with the Roland Disability Questionnaire and specific angles were measured on their lateral lumbosacral X-rays. **Results:** Changes in the lumbar vertebral column in both the control and study groups were found, but the association of obesity was only significant with vertebral body height of L2, L3, and L5 as well as the back pain disability score. **Discussion:** The results obtained from this study were comparable and in line with what has been found from previous studies in this field, namely an association between obesity and disabling LBP. While changes in the lumbar angles could not exclusively be correlated with a higher body mass index, changes in the lumbar vertebral height were found to be significantly correlated. **Conclusion:** Obesity in Sudanese females attending the physiotherapy clinic in Ribat National University Hospital has been proven to be associated with disabling back pain and specific radiographic changes in the lumbar vertebral column. Obesity and its risks on the vertebral column is an association that leaves room for a wide range of studies that should be conducted on a larger scale for more applicable results.

**Key words:** Angle of curvature, back pain disability score, lumbosacral angle, obesity, vertebral body height

## INTRODUCTION

Obesity is becoming a very common and serious problem. According to the WHO fact sheet, updated in 2014, worldwide obesity has doubled since 1980, with >1.4 billion adults aged 20 and above being obese in 2008. Adolescents and children are also included in this pandemic, i.e., growing worldwide, in both developed and developing countries.[1-3] In this modern age, a combination of affordable high-calorie foods and sedentary lifestyle can be implicated as one of the main causes of these rising statistics. Obesity, which is a preventable condition, is defined as an abnormal or excessive accumulation of body fat in relation to the individuals' height that may impair health.[3]

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Various parameters are used to give obesity a reliable numerical value;[4] the most frequently used parameter being the body mass index (BMI) calculated as the person's weight in kg divided by their height in meters squared. A value ≥25 is considered overweight, whereas obesity falls in the range of ≥30 (also classified as Grade 1 if >30, Grade 2 if ranging from 35 to 40, and Grade 3 if >40).[5]

Concerns regarding obesity stem from its high association with diseases and physical problems[6] as well as its rapid growth rate.[7] Excessive weight results in abnormal mechanics which may explain the musculoskeletal disorders obese patients tend to suffer from.[8,9] Negative effects of obesity on the vertebral column include poor flexibility, increased stiffness, and weak back muscles. The curvature of the vertebral column increases specifically in the lower back, causing an increase in the lumbar lordosis and pelvic tilt.

About 3.4 billion adults die annually from conditions resulting from obesity. Studies have shown that there is an association between high range BMI's, increased waist circumference, and chronic conditions including hypertension, ischemic heart disease, certain cancers (breast, prostate, bowel) and type 2 diabetes mellitus. Earlier onset of obesity (in childhood and adolescence) is more likely to continue into adulthood which has been linked to a 50–100% higher morbidity from obesity-related diseases.Obesity has been linked to psychiatric disorders such as depression and anxiety.

Obesity also causes decreased bone density and strength (osteoporosis) leading to a higher risk of fractures in the vertebral column. Osteoarthritis damages the joints between the facets thereby decreasing their mobility. It is therefore very common for obese people to suffer from chronic back pain.

Obesity has been linked to spinal impairment including disc degeneration, modified spinal posture increased lumbar lordosis angle, which all increase the chances of lower back pain (LBP).[10-12] A vast number of studies have been conducted in relation to this subject and to date, results have either confirmed this association or shown that further research is required to prove that there is one, depending on the aspect of spinal impairment being investigated.

Considering the functional anatomy of the vertebral column, it is arranged such that it has an anterior weight bearing portion and a posterior portion that serves to protect the spinal cord and its associated structures.[13-15]

Impairment of the vertebral column as a result of obesity has been studied using a number of techniques including the evaluation of lateral lumbosacral X-rays and magnetic resonance imaging (MRI).[16] Specific angles and measurements are taken on these images and correlated with parameters used to define obesity. These include the lumbosacral angle, which is regularly quoted as an important measurement in evaluating the etiology of LBP. The lumbar lordosis angle defines the curvature of the lumbar portion of the vertebral column, which is a significant weight bearing segment. It serves to reduce stiffness and absorb impact. The intervertebral discs (IVDs) also play a major role in stabilizing the vertebral column while and distributing forces during its movement. Damage and effects on the IVD may be reflected as disc degeneration, reduction of specific angles on X-ray or altered signal frequencies on MRI images.[17,18]

This study aimed to investigate whether obesity in Sudanese females suffering from LBP was associated with changes in the lumbar vertebral column, testing the hypothesis that a BMI of >30 is more likely to be associated with changes in the lumbar vertebral column.

## METHODOLOGY

This study was conducted as a cross-sectional study at the physiotherapy clinic at Ribat National University Hospital in the time period between November 2014 and early January 2015. A total of 30 females with LBP were included in the study; those with a BMI of <25, history of back trauma or spinal surgery were excluded from the study. All subjects were given a verbal explanation of the project and participated in the study voluntarily after giving consent. For scoring of their back pain, each patient was interviewed with the Roland Disability Questionnaire (RDQ) (12 item version).[19-21] Following the interview, each patient's weight was taken using a standard bathroom scale and their height was measured as well. They were then requested to take a lateral lumbosacral X-ray, which was used for the measurement of the lumbar dimensions.

Measurements on the lumbosacral X-rays involved the following procedures;

### The lumbosacral angle

A line was drawn following the lower margin of L5 and another one following the upper margin of S5. The two lines were extended until they intersected and the angle between them was measured [Figure 1].

### The angle of curvature

A line was drawn along the upper margin of L1 as well as the lower margin of L5. Both lines were extended to their point of intersection then bisected at 90°. The acute angle formed by the intersection of these bisecting lines was then measured [Figure 2].

### The intervertebral discs angle between L4 and L5

A line was drawn along the lower border of L4 and another one along the upper border of L5. The angle between these two lines was measured [Figure 3].

### Midline height of the vertebral bodies

Lines were drawn along the upper and lower borders of each vertebral body from L1 to L5. The midpoint of these lines was measured and connected to measure the mid-height of each vertebral bod [Figure 4].

All lines were drawn on the X-rays using an erasable red marker. Each measurement was taken twice and the average recorded on the designated form.

Statistical analysis was done using SPSS (Version 19) (IBM Corp. Released 2010. IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp). Descriptive analysis included the calculation of the means and standard deviations for all measurements attained. Association was measured using the independent *t*-test with a significant relationship being a numerical value of 0.05 or less ($P < 0.05$).

## RESULTS

Thirty female subjects were included in the study, all complaining of LBP for more than a years' duration. The youngest participant was 26-year-old, whereas the eldest was 60 years of age; the average age of the subjects included in the study was 45 years. The control group included any female with a BMI ranging from 25 to 29. This group comprised 10 out of the total 30 females. Their average BMI was 27.3. The remaining 20 were classified as the study group, including females with a BMI of 30 or higher. Their average BMI was 36 [Figure 5].

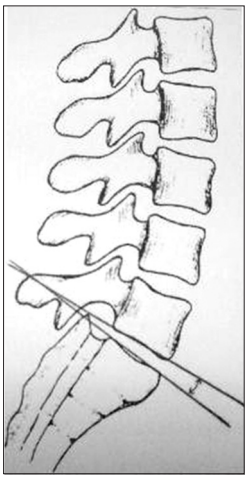

**Figure 1:** Measurement of the lumbosacral angle. Source: www.quia.com

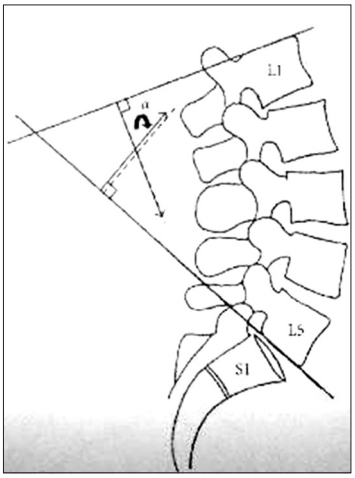


**Figure 2:** Measurement of the angle of curvature. Source: www.hindawi.com

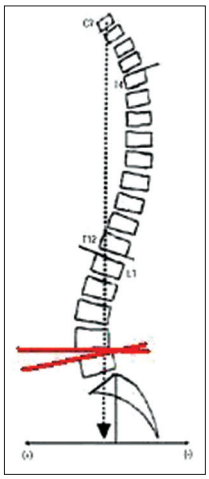

**Figure 3:** Measurement of the intervertebral disc angle

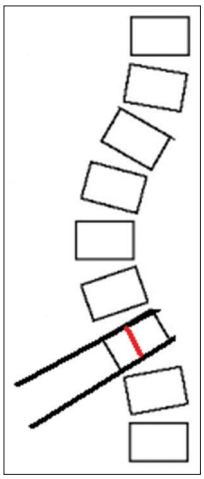

**Figure 4:** Measurement of mid vertebral height

Seventy-three percent of the subjects (22 out of the 30) had a lumbosacral disc angle value of less than the normal range (15–20°), whereas 20% of them (6 out of the 30) fell within the normal range. The remaining 7% (2 subjects) had a lumbosacral angle of >20 [Figure 6].

A larger proportion of the subjects (57%, 17 out of the original 30) had an angle of curvature (lumbar lordosis angle) more than the upper limit of normal (45°) indicating hyperlordosis [Figure 7].

Vertebral height averages for all subjects were 2.2 cm (L1), 2.8 cm (L2), 3.0 cm (L3), 2.8 cm (L4), and 2.7 cm (L5) [Figures 8-10].

Considering the disability due to back pain scores, the average score for participants was 8. This is considered severe disability if taken in the context of the RDQ scoring system where a 40–60% score is interpreted as severe[22] and the average score in this study was 66%.

## DISCUSSION

Taking advantage of X-ray survey of forward and lateral projections can be sufficient to fully appreciate the bone component parameters of the lumbar spine. In this study, lateral images of the lumbar vertebral column were utilized.

The WHO classifies people with a BMI of 25 as being overweight while those with a BMI of 30 as being obese and as stated earlier, increased weight leads to increased forces acting on the vertebral column requiring functional adjustments.

While changes in the lumbar dimensions were found in both groups [Table 1], statistical analysis of the data indicated that very few of these differences were actually significant enough to prove an association with a higher BMI.

The values for the lumbosacral angle ($P = 0.073$), angle of curvature ($P = 0.4$), and IVD angle between L4 and L5 ($P = 0.365$); all had $P > 0.05$ and were therefore not considered significantly associated with a BMI of >30. These results are comparable to the work conducted by Romero-Vargas. The parameters investigated in that study were spinopelvic but did include part of the lumbar column; their results indicated a poor correlation similar to the poor association found in this study.

When considering the lumbar vertebral height, a significant $P$ value was found for lumbar vertebrae numbers 2 ($P = 0.000$) 3 ($P = 0.000$) and 5 ($P = 0.005$) [Table 2]. Information from review of the literature did not yield any information regarding the vertebral body height and

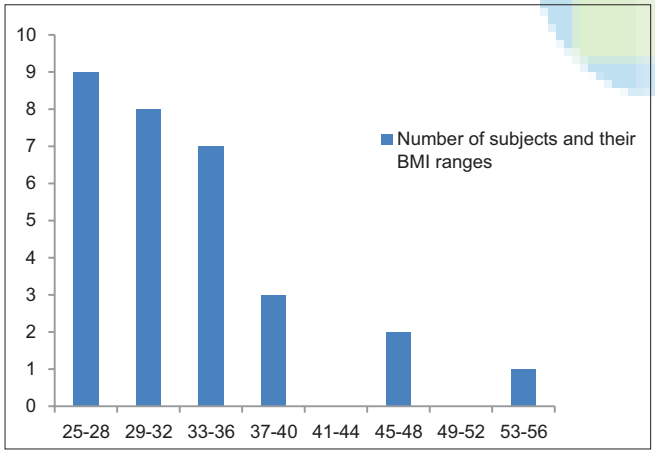


**Figure 5:** Number of subjects and their body mass index ranges

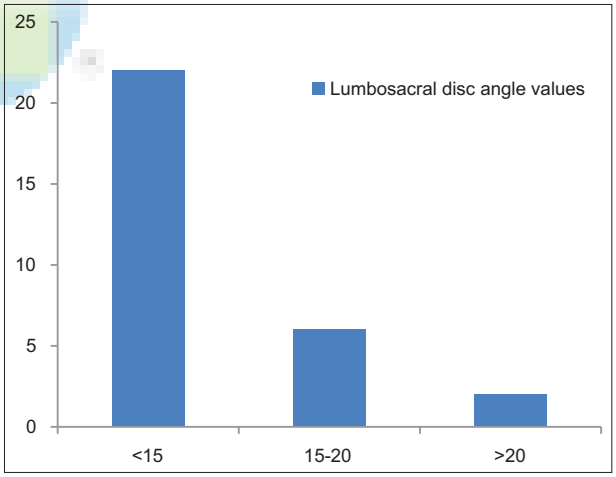


**Figure 6:** Lumbosacral disc angle values

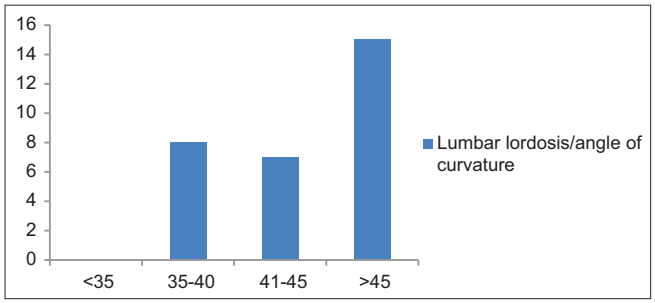


**Figure 7:** Lumbar lordosis/angle of curvature

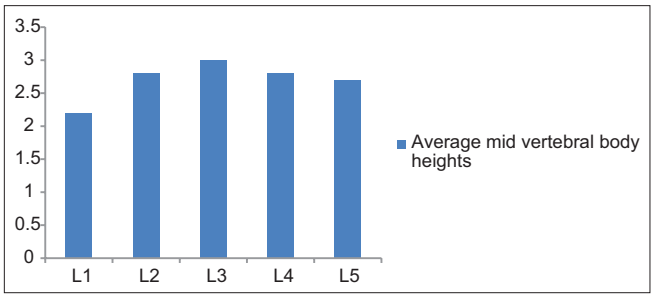


**Figure 8:** Average mid vertebral body heights

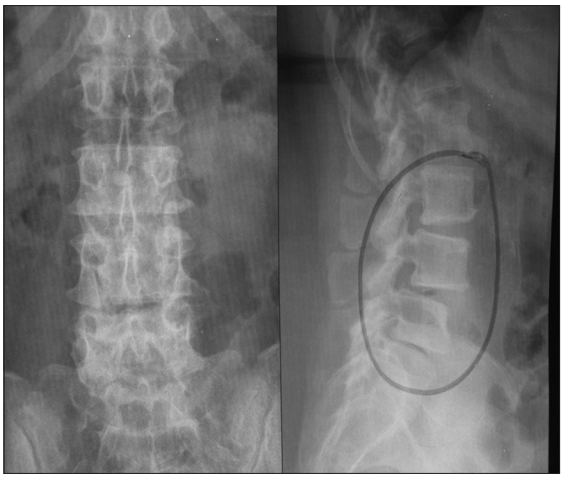

**Figure 9:** Narrowing of the disc space

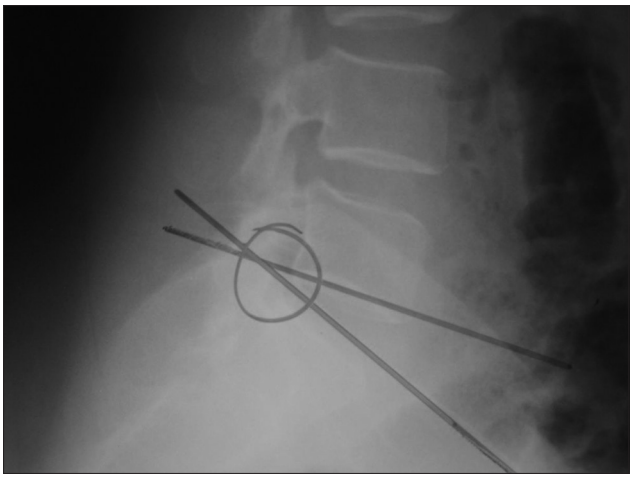

**Figure 10:** Intersection of the measurement lines within the intervertebral foramen

**Table 1: The results of the measurements obtained for the lumbar parameters of the control (body mass index <30) and study (body mass index >30) groups**

| Parameter | Control group | | Study group | |
|---|---|---|---|---|
| | Mean | SD | Mean | SD |
| Lumbosacral angle | 10.70 | 1.567 | 13.45 | 4.501 |
| Angle of curvature | 45.10 | 2.726 | 43.85 | 4.196 |
| Intervertebral disc angle (L4 and L5) | 12.60 | 0.516 | 13.95 | 4.582 |
| Mid vertebral body height | | | | |
| L1 | 2.510 | 0.1912 | 2.080 | 0.4720 |
| L2 | 3.230 | 0.1252 | 2.410 | 0.4278 |
| L3 | 3.690 | 0.1912 | 2.480 | 0.3901 |
| L4 | 2.980 | 0.0632 | 2.680 | 0.5126 |
| L5 | 2.980 | 0.0632 | 2.415 | 0.5788 |

SD: Standard deviation

**Table 2: The results of the statistical analysis obtained to compare the parameters between the control and study group using the independent *t*-test**

| Parameter | *t*-test | Significant |
|---|---|---|
| Lumbosacral angle | 1.862 | 0.073 |
| Angle of curvature | −0.852 | 0.4 |
| Intervertebral disc angle (L4 and L5) | 0.921 | 0.365 |
| Mid vertebral body height | | |
| L1 | −2.751 | 0.1 |
| L2 | −5.889 | 0.000 |
| L3 | −9.21 | 0.000 |
| L4 | −1.828 | 0.078 |
| L5 | −3.05 | 0.005 |

obesity, so this particular aspect was difficult to compare with previous results. However, these results indicate a significant association between the vertebral heights of these selected vertebrae and a higher BMI.

Finally, a significant association was also found between a higher BMI and the disability due to back pain score ($P = 0.046$) consistent with Guo *et al.*[23] who, using the same disability score found an increased disability score in obese patients. This finding is further supported by several sources from the literature. Adults with disabilities have a higher rate of obesity that those without disabilities.[24-27]

## CONCLUSION

The results of this study are generally in line with what has been found in previous studies, proving that a higher BMI is associated with disabling LBP. The aspect related to changes in the dimensions of the lumbar column indicated that changes, while seen, cannot directly be linked to a higher BMI following comparison of the study and control groups. This may have been due to the small sample size and future research in this area should include a larger sample size as well as BMI ranges that are distinct from each other (for example comparing normal BMI with extremely high BMI groups). Other areas of research regarding this particular topic may be to study the effect of weight loss on the degree of disability and vertebral changes.

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**Conflicts of interest**
There are no conflicts of interest.

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