

# Spinal shrinkage as a measure of spinal loading in male Saudi university students and its relationship with body mass index

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## ABSTRACT

**الأهداف:** مقارنة درجة انكماش العمود الفقري وكتلة الجسم ومدى العلاقة بينهما عند عينة من الشباب السعودي الذي يعاني من السمنة والذي لا يعاني من السمنة.

**الطريقة:** أجريت دراسة شملت 123 من الطلاب الذكور السعوديين في كليتي الطب والأسنان بجامعة الملك فيصل بالدمام - المملكة العربية السعودية، خلال عام 2006م. تم قياس الوزن، الطول قائماً، والطول مستلقياً. قُسم الطلاب إلى مجموعات وفقاً لمؤشر كتلة الجسم (BMI): النطاق الطبيعي ( $BMI < 25$ )، زيادة الوزن ( $BMI = 25-29.9$ )، السمان ( $BMI > 30$ ). تم حساب انكماش العمود الفقري بطرح الطول مستلقياً من الطول قائماً لكل شخص. تم قياس تأثير مؤشر كتلة الجسم (BMI) على درجة انكماش العمود الفقري باستخدام ANOVA. كما تم قياس مدى العلاقة بين مؤشر كتلة الجسم (BMI) ودرجة انكماش العمود الفقري باستخدام اختبار Pearson's correlation test.

**النتائج:** تبين أن نقص الطول قائماً عند السمان (1.6%) من الطول مستلقياً يعتبر أكبر، بالمقارنة مع أصحاب الأوزان الطبيعية (1%) بدرجة معتبرة إحصائياً ( $p=0.019$ ). كما تبين أن انكماش العمود الفقري له علاقة إيجابية مع الوزن ( $r=0.369$ ).

**خاتمة:** انكماش العمود الفقري له علاقة إيجابية بمؤشر كتلة الجسم (BMI)، والذي يمثل ضغط مستمر على العمود الفقري عند السمان. هذا التأثير السلبي للسمنة والذي يمكن قياسه بسهولة وتوضيحه للناس يمكن استخدامه كوسيلة لتحفيز السمان على تغيير نمط حياتهم.

**Objective:** To compare spinal shrinkage in obese and non-obese young male adults and to find any correlation between them.

**Methods:** In 2006, 123 second-year male students studying in the Colleges of Medicine and Dentistry, King Faisal University, Dammam, Kingdom of Saudi Arabia, were examined for their weights, standing heights, and recumbent lengths. In this cross-sectional observational study, the students were grouped according to body mass index (BMI): normal range  $BMI < 25$ ; overweight  $BMI = 25-29.9$ ; obese- $BMI > 30$ . Spinal shrinkage was calculated as the difference between standing height and the recumbent length of the subject. Influence of BMI on the magnitude of spinal shrinkage was compared by analysis of variance, and the relationship between spinal shrinkage and BMI was tested with Pearson's correlation test.

**Results:** The obese group presented a significantly greater reduction in standing height (1.6% of recumbent length) compared to the normal group (1%) ( $p=0.019$ ). Spinal shrinkage was found to be positively correlated with level of obesity ( $r=0.369$ ).

**Conclusion:** Spinal shrinkage is positively correlated to BMI, which represents a persistent load on the spine in obese individuals. This conveniently demonstrable adverse effect of obesity might well be used as an instrument to inspire individuals to change their lifestyles.

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Obesity is rapidly becoming a major health problem throughout the world,<sup>1-3</sup> including Saudi Arabia.<sup>4-6</sup> A number of diseases including diabetes, stroke, and cancer have been proven to be associated with obesity leading to increased morbidity and mortality in persons carrying the extra weight.<sup>7-9</sup> One of the problems linked to excessive weight in obese people is low back pain (LBP), which is a common and serious public health problem.<sup>10</sup> Body mass index (BMI) is an index of obesity, and is calculated by dividing the patient's weight in kilograms by height in meters squared ( $\text{kg}/\text{m}^2$ ).<sup>11</sup> It is widely accepted, easily measured, and predicts morbidity and mortality in many populations.<sup>1,2</sup> Obesity is generally defined as a BMI of  $30 \text{ kg}/\text{m}^2$  and higher. Overweight is defined as a BMI between 25 and  $30 \text{ kg}/\text{m}^2$ .<sup>11-13</sup> Excessive weight in people with a high BMI could lead to persistent load on the back that might be implicated in genesis of low back pain.<sup>10,14</sup> Spinal shrinkage is recognized as an index of the compressive forces acting on the spine.<sup>15</sup> This shrinkage is caused by viscoelastic creep from compression of vertebral discs. When the discs are unloaded as in reclining position this process is reversed leading to an increase in length of spine. The spine represents approximately 40% of the total body length, and the intervertebral discs occupy approximately one third of the total spinal column length. Thus, the changes in the spine length may be quantified by measuring the total body length,<sup>16</sup> and these changes in stature can give an index of the load imposed on the spine.<sup>17,18</sup> This study is aimed at comparing the extent of spinal shrinkage in obese and non-obese young Saudi males and ascertaining a correlation of BMI, if any, with spinal shrinkage.

**Methods.** This cross-sectional, observational study was conducted in September 2006, at King Faisal University (KFU), Dammam, Kingdom of Saudi Arabia, after approval from the University Ethics Committee. A total of 123, Saudi male students (aged 19-20 years) studying in the second year of the College of Medicine and College of Dentistry, KFU, took part in the study. All the students attending physiology from the 2 above-mentioned colleges were enrolled for the study, except those with musculoskeletal abnormalities such as kyphosis and scoliosis. After obtaining written consent, they were examined for their weights and heights. Weight was measured in light clothing without shoes on a weighing balance to the nearest 0.5 kg. Standing height was measured in centimeters barefoot against a wall with the help of a measuring tape to the nearest 0.2 centimeter. The measurement was carried out with heels close to the wall and feet close together so that weight was equally distributed, and the head in Frankforts plane (straight with neck neither flexed

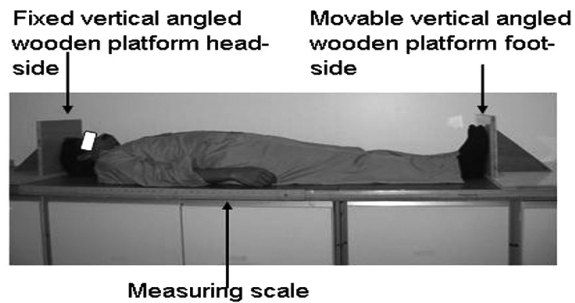
nor extended). Standing height was always taken first followed by the measurement of recumbent length. Recumbent length was measured on a wooden desk fixed to the wall after a uniform settling down period of 2 minutes fixed arbitrarily (Figure 1). Measurement was taken with the help of a measuring scale and vertical purpose-built right-angled wooden platforms. The head end platform was fixed perpendicular to the wall, and the foot end platform could be slid against the wall. The recumbent length of each subject was taken when the head firmly touched the fixed top platform, and the feet touched the adjustable platform so the soles of both feet came in firm contact with the platform (at toes and at heels, so that the tips of toes faced vertically up) with legs close together and body lying straight (no sideward curves). Spinal shrinkage was measured as the difference between the recumbent length and the standing height. Percentage spinal shrinkage was calculated as:

$$\frac{(\text{recumbent length} - \text{standing height})}{\text{recumbent length}} \times 100$$

Body mass index (BMI) was calculated by dividing the weight taken in kilograms by the square of the standing height taken in meters. Subjects were divided into various groups according to the standard criteria: underweight (UW) BMI < 18.5; normal weight (NW) BMI = 18.5-24.9; overweight (OW) BMI = 25-29.9; and obese (OB) BMI  $\geq 30$ .<sup>11,12</sup>

**Statistical analysis.** The data were analyzed using the Statistical Package for Social Sciences (SPSS version 10). Analysis of variance (ANOVA) was used to compare spinal shrinkage between the 4 BMI groups (UW, NW, OW, OB). A correlation between BMI and spinal shrinkage was tested using Pearson's correlation coefficient. A  $p < 0.05$  was considered statistically significant.

**Results.** The mean body weight of all subjects ( $n=123$ ) was  $72.1 \pm 15.7 \text{ kg}$ , the mean standing height was  $170.6 \pm 5 \text{ cm}$ , and the mean recumbent length was  $172.5 \pm 5 \text{ cm}$ . The mean BMI was 24.75 and the mean spinal shrinkage was  $1.9 \pm 0.9 \text{ cm}$  ( $1.1 \pm 0.51\%$ ) of recumbent length. Of the 123 males, 40.7% were either obese or overweight (Table 1). Table 2 shows that there are no significant differences in the standing height or the recumbent length of the individuals in different BMI based groups, but the actual spinal shrinkage in the obese group was significantly more compared to the underweight, normal, or overweight groups ( $p=0.03$ ). Figure 2 shows a trend of spinal shrinkage in different groups of individuals as we move from lower BMI towards higher BMI. The percentage spinal shrinkage was least in underweight subjects ( $0.82 \pm 0.49$ ) and highest in obese subjects ( $1.57 \pm 0.47$ ). When comparing



**Figure 1** - Method of measuring of recumbent length.

**Table 1** - Distribution of subjects according to the level of obesity and weights.

Groups	n (%)	Weight (kg) mean±SD
Underweight, BMI <18.5	8 (6.5)	50.6±4.1
Normal, BMI 18.5-24.9	65 (52.9)	63.9±6.8
Overweight, BMI 25-29.9	35 (28.5)	79.7±6.7
Obese, BMI >30	15 (12.2)	101.7±12.3
Total	123 (100)	72.1±15.7

BMI - body mass index

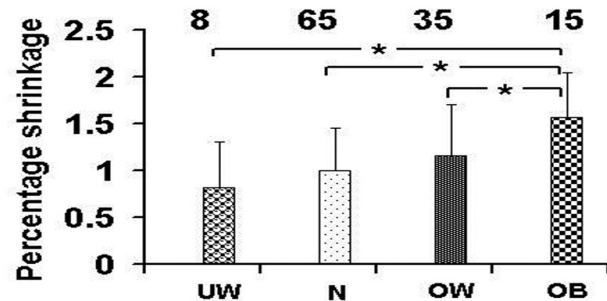
**Table 2** - The standing height, recumbent length, and absolute spinal shrinkage (cm) in relation to body mass index (BMI).

Groups (BMI)	Standing height	Recumbent length	Spinal shrinkage
Underweight (n=8)	171 ± 4.1	172.4 ± 4.3	1.4 ± 0.9
Normal (n=65)	170.7 ± 5.3	172.4 ± 5.3	1.7 ± 0.8
Overweight (n=35)	170.2 ± 4.9	172.2 ± 4.7	2.0 ± 0.9
Obese (n=15)	171 ± 4.3	173.7 ± 4.7	2.7 ± 0.9*
Total (N=123)	170.6 ± 5	172.5 ± 5	1.9 ± 0.9

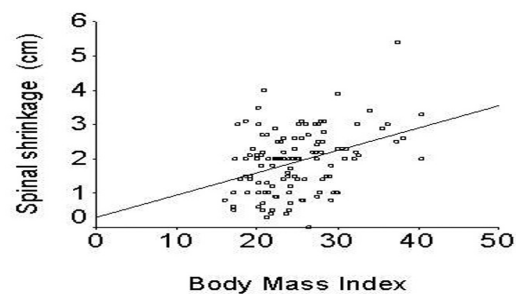
Data are expressed as mean±SD, \* $p < 0.03$ , obese group compared to underweight, normal or overweight groups

different categories for differences in percentage spinal shrinkage, a statistically significant difference was observed only when comparing the heaviest group with the underweight ( $p=0.003$ ), normal weight ( $p=0.0001$ ) or overweight groups ( $p=0.028$ ). Figure 3 shows a significant positive correlation between BMI and spinal shrinkage ( $r=0.369$ ;  $p=0.00091$ ).

**Discussion.** This study reveals a positive correlation between BMI and the degree of spinal shrinkage, a measure of spinal loading considered to be a factor in the genesis of LBP. Obesity can contribute to musculoskeletal problems, and one of the health



**Figure 2** - Percentage spinal shrinkage in different groups based on body mass index. UW - underweight, N - normal, OW - overweight, OB - obese. \* $p=0.028$ , obese group compared to UW, N, OW groups. Numbers on top of bars indicate the number of subjects.



**Figure 3** - Correlation of spinal shrinkage (cm) and body mass index.

consequences of carrying an excess load is an increased risk of LBP.<sup>19</sup> In Saudi Arabia, the problems of obesity<sup>4,5</sup> and LBP are well documented.<sup>20,21</sup>

This study has demonstrated that the spinal shrinkage is significantly greater in the heaviest (obese) group of young, Saudi male subjects compared to their counterparts in underweight, normal weight, or overweight groups. A positive correlation exists between BMI and spinal shrinkage in these subjects. Althoff et al,<sup>22</sup> showed a linear relationship in stature decrease and externally applied load on the spine in young and middle-aged persons. Rodacki et al,<sup>23</sup> also observed a similar trend of greater spinal shrinkage in obese subjects compared to non obese subjects who were subjected to an exercise task. Body height changes are known to occur when one moves from a recumbent to an upright position,<sup>24</sup> and has been demonstrated in the sagittal plane model of spine.<sup>25</sup> Spines of people have been demonstrated to change in length over the course of the day,<sup>26</sup> or with activity and rest.<sup>27</sup> The variation in length of the spine is most probably related to loading and unloading during activity and rest.<sup>28</sup> Such changes in body height have been used as a method for measuring spinal load.<sup>29,30</sup> Kaki<sup>20</sup> found LBP to be the most common type of chronic pain in patients referred

to the pain clinic in Jeddah, Saudi Arabia.<sup>20</sup> Bostman et al,<sup>31</sup> observed an association between increased BMI and lumbar intervertebral disc herniations requiring operative treatment. A significant correlation of back pain with body weight was seen in a study in the Qassem area,<sup>21</sup> where individuals with the highest BMI had substantially greater prevalence of LBP as compared to the lightest. Similar observations were also reported by Deyo and Bass.<sup>14</sup> Orloff et al,<sup>32</sup> have also found a link between load carriage and low back problems. A similar trend is seen in the present study where the shrinkage is positively correlated with BMI, but significant differences are only seen in the obese group as compared to the other groups with BMI<30.

Excess load carriage in obesity has been demonstrated to be an important independent predictor of back pain and its severity.<sup>19</sup> Mirtz and Greene<sup>33</sup> have also concluded that those individuals with a BMI of over 30 are at a moderate risk and those with a BMI>40 are at a high risk of developing LBP.<sup>33</sup> Loading history can weaken discs to such an extent that structural failure occurs, leading to LBP.<sup>34</sup> The intervertebral discs respond to the application of the axial loading by expelling fluid through their walls,<sup>35</sup> resulting in a decrease in the disc's height. The reduction in intervertebral disc height is associated with a decrease in the stability of the spinal motion segment and excess stress of other spinal structures that are not designed to withstand load and may be a source of pain.

The present study also corroborates the findings of other researchers on the high prevalence (40.7%) of over nutrition (BMI>25) and sedentary behavior among young Saudi males from this region. Obesity with its associated complications is widely prevalent among the Saudi population both in young and old.<sup>36</sup> Warsy and El Hazmi,<sup>4</sup> in their study spanning over 5 years, and extended to 5 different regions of Saudi Arabia, found an overall prevalence of obesity and overweight in the adult male populations of approximately 40%.<sup>4</sup> Similarly Al-Nozha et al,<sup>5</sup> in their study of 17,232 Saudi subjects aged 30-70 years found that the prevalence of overweight and obesity was 35.5%, while severe (gross) obesity was 3.2%.<sup>5</sup> Al-Almaie<sup>37</sup> also found that approximately 30% of young (16.4±1.7 years old) Saudi students in a sample of 1766 were either obese or overweight.

One major usefulness of this study could be that the young students may be stimulated to alter their eating habits and lifestyle by demonstrating to them an immediate observable effect of carrying a big load (a high BMI) on their backs. The limitation of this study regarding methodology is using simple instruments, which were not designed to measure the lengths in fraction of millimeters. For such measurements, the

use of precision stadiometer is preferred. Nevertheless, simple tools when used with care and caution, provided reasonably accurate measurements of change in stature. These results of the present study are not very different in principle from the ones that have used stadiometers for the same purpose.<sup>27,28</sup> Another limitation is that the study involved only male subjects and the results need to be extrapolated with caution to the female population. It requires further studies to assess the magnitude and relationship of spinal shrinkage to BMI in female subjects, though studies involving certain other situations indicate that the magnitude of spinal shrinkage is similar in females.<sup>38</sup> Lastly, other indices of obesity such as waist circumference, waist to hip ratio, and waist to height ratio are being used more and more, either alone, or in combination, to describe obesity to get a better picture of distribution of fat in individuals.<sup>11</sup> The present study was limited to determine the relationship of spinal shrinkage to BMI only, it might provide more insight if the relationship of spinal shrinkage to other indices of obesity is explored.

In conclusion, there is a positive correlation between BMI and spinal shrinkage with the obese group (BMI>30) exhibiting a significantly greater spinal shrinkage compared to the individuals with BMI<30. This continuous excess loading of spine in obese people could contribute to low back problems and hence it is necessary to encourage a healthier life style in these individuals at risk.

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