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Original article

Obesity and Chronic Low Back Pain: Clinical and Sagittal Outcomes Based on Roussouly Classification

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Abstract

The aim of this study is to evaluate the impact of obesity on clinical outcomes and sagittal alignment in patients with chronic low back pain, using the Roussouly classification. A total of 105 patients with chronic low back pain were included in this retrospective cross-sectional study based on medical record review. Patients were divided into two groups: obese (n = 53) and non-obese (n = 52) based on their body mass index. Demographic data, Oswestry Disability Index, Visual Analog Scale and sagittal spinal profiles classified by the Roussouly system were analyzed. Statistical comparisons were performed using Student's t-test, Mann–Whitney U test, chi-square test, or Fisher's exact test as appropriate. A p-value <0.05 was considered statistically significant. The mean age of the cohort was 42.0 ± 12.7 years, with 57 females (54.3%) and 48 males (45.7%). While age and gender distributions did not differ significantly between the groups, Roussouly Type 3 was the most frequent sagittal profile overall. Type 4 was observed more frequently in the obese group (30.2% vs. 17.3%), although this difference did not reach statistical significance. Clinical assessments revealed that obese patients had significantly higher Oswestry Disability Index scores (71.6 ± 5.1 vs. 65.3 ± 6.1; p<0.001) and higher, Visual Analog Scale pain scores (8.2 ± 1.2 vs. 7.6 ± 1.3; p=0.026). Obesity is associated with increased pain severity and impaired functional capacity in patients with chronic low back pain. Although Roussouly Type 4 appeared more common in obese individuals, no statistically significant relationship was found between obesity and sagittal spinal profiles. These findings highlight the importance of weight management and lifestyle modification strategies in the comprehensive management of chronic low back pain.

Keywords: obesity, chronic low back pain, sagittal alignment, Roussouly classification, Oswestry Disability Index, Visual Analog Scale.

1. Introduction

Obesity is a multifactorial disease and represents a significant public health burden [1]. The relationship between obesity and chronic low back pain (cLBP) has been previously investigated [2]. A comprehensive meta-analysis by Shiri et al. confirmed that overweight and obesity are significant risk factors for the prevalence of low back pain (LBP) [3].

The sagittal alignment of the human spine is fundamental for maintaining postural stability, optimizing mechanical efficiency, and ensuring balanced load transmission. The morphological parameters of the spinopelvic segment—such as pelvic incidence (PI), sacral slope (SS), pelvic tilt (PT), and lumbar lordosis (LL)—serve as fundamental reference indicators for assessing the biomechanical relationship between the spine and the pelvis [4].

PI, as described by Duval-Beaupère and Legaye, represents a morphological parameter that remains constant for an individual once skeletal maturity has been reached, and it is not influenced by posture or pelvic position [5].

cLBP is defined as pain persisting in the lumbar region for more than three months [6]. A novel classification system for cLBP that incorporates sagittal alignment and guides treatment decisions has been proposed [7]. One of the key mechanisms contributing to LBP is the disruption of sagittal spinal balance [8]. Disturbances in sagittal alignment increase the energy expenditure required to maintain an upright posture and a horizontal gaze [1]. Patients with LBP are often characterized by reduced distal lordosis, more proximal lumbar lordosis, and a more vertical sacrum [7].

The pelvis and spine are closely interrelated in both form and function. PI largely determines pelvic morphology and has direct implications for spinal configuration. Over time, specific degenerative changes may develop depending on individual morphology. Sagittal parameters can thus serve as predictive markers of spinal and pelvic morphology. A clearer understanding of this relationship may improve the diagnosis of degenerative spinal disorders and contribute to more effective treatment strategies [9].

This study aimed to evaluate the relationship between obesity and cLBP in terms of clinical outcomes and sagittal spinal alignment, and to explore the potential contribution of the Roussouly classification in this context. We hypothesized that identifying the Roussouly type in obese patients with cLBP may enhance clinical assessment and guide treatment strategies, particularly in the planning of conservative approaches.

2. Materials and Methods

Study Design

This was a retrospective analytical cross-sectional study conducted between January 2022 and December 2024. The study included 105 patients aged 18–65 years who presented with cLBP. Exclusion criteria were vertebral fracture, spinal infection, tumor, inflammatory disease, previous spinal surgery, or pregnancy. All procedures were conducted following the Declaration of Helsinki.

Variables and Measurement Methods

For each patient, demographic data including age, sex, height, weight, and radiographic measurements were collected. Standing whole-spine radiographs were obtained in a standardized posture with the fingertips placed on both clavicles. Body mass index (BMI) was calculated as weight (kg)/height (m^2) and categorized according to the definitions of the National Institutes of Health and the World Health Organization. Patients were divided into two groups: Group I (BMI <30 kg/m^2, non-obese) and Group II (BMI ≥30 kg/m^2, obese). Clinical evaluation included the Oswestry Disability Index (ODI) and pain intensity assessed with the Visual Analog Scale (VAS). The VAS consisted of a 10-cm horizontal line ranging from 0 (no pain) to 10 (worst possible pain), on which patients indicated the point that best represented their pain level.

Determination of the Roussouly Type

The Roussouly classification offers a reliable framework for analyzing sagittal spinal profiles by categorizing individuals into four morphological types based on sacral slope and the location of the lumbar lordosis apex [10]. Type 1 presents with a short hypolordotic curve and low sacral slope, Type 2 with a flat lumbar spine, Type 3 with a well-balanced curve and average sacral slope, and Type 4 with a long hyperlordotic curve and high sacral slope [9, 10]. In this study, radiographic measurements and classification were conducted according to standardized criteria to maintain consistency (Figure 1).

Schematic illustration of the four morphological types according to the Roussouly classification. The shape of lumbar lordosis depends on the orientation of the sacral slope (SS). In Types 1 and 2, SS < 35°; in Type 3, 35° < SS < 45°; and in Type 4, SS > 45°. Typically, a low PI is observed in Types 1 and 2, whereas a high PI is more common in Types 3 and 4. Redrawn and adapted based on Roussouly et al. (Spine, 2005).

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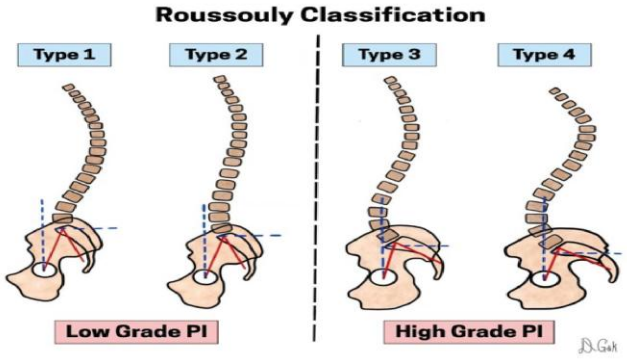

Figure 1 – Roussouly Classification

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics, version 28.0 (IBM Corp., Armonk, NY, USA). The distribution of continuous variables was assessed using the Shapiro–Wilk test. Descriptive data are expressed as mean ± standard deviation (SD) for continuous variables and as frequencies with percentages for categorical variables.

Comparisons between obese and non-obese groups were carried out using the independent-samples Student's t-test for normally distributed continuous variables, and the Mann–Whitney U test for non-normally distributed variables. Categorical variables, including sex and Roussouly type distribution, were analyzed with the chi-square or Fisher's exact test, as appropriate.

Associations between body mass index (BMI) and sagittal spinal parameters, including lumbar lordosis (LL) and Roussouly classification, were examined using Spearman's rank correlation. A two-tailed p-value <0.05 was considered statistically significant for all analyses.

3. Results

A total of 105 patients with chronic low back pain were included in the study, consisting of 57 females (54.3%) and 48 males (45.7%), with a mean age of 42.0±12.7 years. There were no significant differences between obese and non-obese groups regarding age (42.4±13.6 vs. 41.6±11.9 years, p=0.743) or sex distribution (female: 59.6% vs. 49.1%, p=0.373) (Table 1).

Table 1 – Demographic and clinical characteristics by obesity status

Characteristic	Non-obese (n=52)	Obese (n=53)	*p*-value
Age (years, mean ± SD)	42.4 ± 13.6	41.6 ± 11.9	0.743
Female, n (%)	31 (59.6%)	26 (49.1%)	0.373
Male, n (%)	21 (40.4%)	27 (50.9%)	0.373
Roussouly Type 1, n (%)	6 (11.5%)	4 (7.5%)	0.483
Roussouly Type 2, n (%)	5 (9.6%)	6 (11.3%)	0.483
Roussouly Type 3, n (%)	32 (61.5%)	27 (50.9%)	0.483
Roussouly Type 4, n (%)	9 (17.3%)	16 (30.2%)	0.483
ODI (mean ± SD)	65.3 ± 6.1	71.6 ± 5.1	< 0.001
VAS (mean ± SD)	7.6 ± 1.3	8.2 ± 1.2	0.026

Note: Values are presented as mean ± standard deviation (SD) or number (percentage)

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Analysis of sagittal spinal profiles showed that Roussouly Type 3 was the most common in both groups (obese: 50.9%, non-obese: 61.5%). Type 4 was more frequent among obese patients compared with non-obese patients (30.2% vs. 17.3%), although the difference did not reach statistical significance (p=0.483). Type 1 and Type 2 were relatively uncommon in both groups.

Regarding clinical outcomes, obese patients demonstrated significantly higher ODI scores compared with non-obese patients (71.6±5.1 vs. 65.3±6.1, p<0.001). Similarly, VAS pain scores were significantly higher in the obese group (8.2±1.2 vs. 7.6±1.3, p=0.026) (Table 1). No significant correlations were observed between BMI and LL or Roussouly classification (all p>0.05).

4. Discussion

This study evaluated the impact of obesity on sagittal spinal alignment and clinical outcomes in patients with cLBP. Our findings showed that obese patients reported significantly higher pain intensity (VAS) and poorer functional capacity (ODI) compared with non-obese patients. Roussouly Type 3 was the most common sagittal profile in both groups. Although Type 4 was more frequent among obese patients, this difference was not statistically significant. These results are consistent with previous epidemiological studies identifying obesity as a major risk factor for LBP [3, 11] and align with findings that emphasize its negative impact on functional outcomes [6]. The trend toward a higher prevalence of Type 4 among obese patients is consistent with evidence suggesting that increased BMI may influence spinopelvic parameters [1] and corresponds with the biomechanical implications described in sagittal classification studies [4, 7, 10].

When the lumbar spine is hypolordotic or straightened, load distribution becomes uneven, predominantly affecting the anterior column and intervertebral discs, thereby increasing intradiscal pressure [12]. According to Roussouly and colleagues, Type I spines are associated with a high prevalence of degeneration at L4–S1, and hyperextension at this level may result in so-called “nutcracker” L5 spondylolysis [4]. Type II spines, often described as a “flat back,” are nearly sagittal straight and have been reported to be more susceptible to lumbar disc degeneration and LBP. Type III spines demonstrate an average morphology without marked degenerative features, whereas previous studies have suggested that Type IV spines may be less frequently associated with LBP [9]. However, in our cohort, Type IV was more frequently observed among obese patients, although this difference did not reach statistical significance. Thus, our findings do not support a protective role of Type IV against pain when obesity is present.

The main strength of this study lies in its comprehensive evaluation of the relationship between obesity and sagittal alignment, integrating both clinical outcomes (VAS, ODI) and the Roussouly classification. Nonetheless, several limitations should be acknowledged. First, the relatively small sample size and single-center design may limit the generalizability of our findings. Second, the retrospective cross-sectional design precludes definitive conclusions regarding causality between obesity and LBP. Third, beyond its biomechanical effects, obesity is also associated with metabolic and inflammatory mechanisms, which were not specifically assessed in this study. Nevertheless, our findings indicate that obesity is an important factor in the management of cLBP and may contribute to greater pain severity irrespective of sagittal alignment. Therefore, in patients with cLBP, obesity should not only be identified but also actively addressed. Future studies examining the impact of weight reduction, structured exercise programs, and lifestyle modifications on clinical outcomes may yield valuable insights for the comprehensive management of this patient population.

Conclusions

This study demonstrated that obesity is associated with greater pain intensity and poorer functional capacity in patients with chronic low back pain. Obese individuals had significantly higher VAS and ODI scores, underscoring obesity as an important factor in clinical management. While Roussouly Type 3 was the most common sagittal profile in both groups, Type 4 was observed more frequently in obese patients, although this difference was not statistically significant.

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These findings suggest that obesity may exacerbate pain severity and impair functional outcomes, highlighting the value of incorporating weight management, exercise, and lifestyle modifications into treatment strategies for chronic low back pain.

Conflicts of Interest. Author declares no conflicts of interest.

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Author contributions: H.G. conceived and designed the study, collected the data, performed the analysis, interpretation and revised the manuscript.

Informed Consent Statement. The study protocol was approved by the institutional Ethics Committee, which waived the requirement for informed consent owing to the retrospective design.

Data Availability Statement. The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

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Семіздік және созылмалы бел ауруы: Руссули жіктеуі негізінде клиникалық және сагитталды нәтижелер

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Түйіндеме

Зерттеудің мақсаты: семіздіктің созылмалы бел ауруы бар науқастардағы клиникалық нәтижелер мен омыртқаның сагитталды теңгеріміне әсерін Руссули жіктеуі арқылы бағалау. Медициналық құжаттарды талдау негізінде жүргізілген ретроспективті зерттеуге созылмалы бел ауруы диагнозы қойылған 105 науқас енгізілді. Науқастар дене салмағы индексіне сәйкес екі топқа бөлінді: семіздікке шалдыққан (n=53) және семіздікке шалдықпаған (n=52). Демографиялық деректер, Освестри мүгедектік индексі, ауырсынуды бағалау бойынша визуалды-аналогтық шкала және Руссули жүйесі бойынша жіктелген омыртқаның сагитталды профильдері талданды. Статистикалық салыстырулар үшін Стьюдент t-тесті, Манна-Уитни U тесті, хи-квадрат немесе Фишердің дәл тесті қолданылды, $p<0,05$ мәні статистикалық тұрғыдан маңызды деп есептелді. Зерттелген топтың орташа жасы 42,0±12,7 жасты құрады; 57 әйел (54,3%) және 48 ер адам (45,7%) болды. Екі топ арасында жас және жыныс көрсеткіштері бойынша айырмашылық анықталған жоқ. Жалпы алғанда ең жиі кездескен сагитталды профиль — Руссули бойынша 3-типі болды. Ал 4-тип семіздікке шалдыққан науқастарда жиі байқалды (30,2% қарсы 17,3%), бірақ бұл айырмашылық статистикалық мәнге жетпеді. Клиникалық бағалау нәтижелері бойынша семіздікке шалдыққан науқастарда Освестри мүгедектік индексі көрсеткіші айтарлықтай жоғары болды (71,6±5,1 қарсы 65,3 ± 6,1; $p<0,001$) және визуалды-аналогтық шкаланың ауырсыну көрсеткіштері де жоғары болды (8,2±1,2 қарсы 7,6±1,3; $p=0,026$). Семіздік созылмалы бел ауруы бар науқастарда ауырсынудың күшеюімен және функционалдық қабілеттің төмендеуімен байланысты. Руссули бойынша 4-тип семіздікке шалдыққан науқастарда жиі кездескенімен, семіздік пен омыртқаның сагитталды профильдері арасында статистикалық тұрғыдан маңызды байланыс анықталған жоқ. Бұл нәтижелер семіздік кезінде созылмалы бел ауруын кешенді басқаруда салмақты бақылау және өмір салтын өзгерту стратегияларының маңыздылығын көрсетеді.

Түйін сөздер: семіздік, созылмалы бел ауруы, сагитталды теңгерім, Руссули жіктеуі, Освестри мүгедектік индексі, визуалды-аналогтық шкала.

Ожирение и хроническая боль в пояснице: Клинические и сагиттальные результаты в зависимости от классификации Руссули

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Резюме

Целью данного исследование является оценка влияния ожирения на клинические исходы и сагиттальное выравнивание позвоночника у пациентов с хронической болью в пояснице с использованием классификации Руссули. В ретроспективное поперечное исследование были включены 105 пациентов с хронической болью в пояснице на основе анализа медицинских карт. Пациенты были разделены на две группы: с ожирением (n=53) и без ожирения (n=52) в зависимости от индекса массы тела. Были проанализированы демографические данные, индекс инвалидизации Освестри, визуальную аналоговую шкалу боли и сагиттальные профили позвоночника согласно классификации Руссули и индекса инвалидизации Освестри. Статистический анализ проводился с использованием t-критерия Стьюдента, критерия Манна–Уитни, χ^2-теста или точного критерия Фишера, в зависимости от характера данных. Значение $p<0,05$ считалось статистически значимым. Средний возраст пациентов составил 42,0 ± 12,7 года; женщин было 57 (54,3%), мужчин — 48 (45,7%). Возраст и пол между группами существенно не различались. Наиболее распространенным типом сагиттального профиля оказался тип 3 по Руссули. Тип 4 чаще встречался у пациентов с ожирением (30,2% против 17,3%), однако различие не достигло статистической значимости. Клиническая оценка показала, что у пациентов с ожирением значительно выше значения хронической боли в пояснице (71,6 ± 5,1 против 65,3 ± 6,1; $p<0,001$) и визуальной аналоговой шкали боли (8,2

± 1,2 против 7,6 ± 1,3; p=0,026). Ожирение ассоциируется с большей выраженностью боли и снижением функциональных возможностей у пациентов с хронической болью в пояснице. Хотя тип 4 по Руссули чаще встречался у лиц с ожирением, статистически значимой связи между ожирением и сагиттальными профилями позвоночника выявлено не было. Полученные данные подчеркивают важность контроля массы тела и модификации образа жизни в комплексном ведении пациентов с хронической болью в пояснице.

Ключевые слова: ожирение, хроническая боль в пояснице, сагиттальное выравнивание, классификация Руссули, индекс инвалидизации Освестри, визуальная аналоговая шкала.

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