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Lumbosacral Transitional Vertebrae: Prevalence in a Mediterranean population and its association with low back pain

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2021

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Dissertação de candidatura ao grau de Mestre em Medicina, submetida ao Instituto Ciências Biomédicas Abel Salazar- Universidade do Porto

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Mestrado Integrado em Medicina

Instituto de Ciências Biomédicas Abel Salazar, Universidade do Porto

Junho 2021

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Assinatura do Estudante:

Assinatura do Orientador:

Assinatura do Coorientador:

Assinatura da Coorientadora:

Junho 2021

Agradecimentos

Em primeiro lugar, gostaria de agradecer ao Prof. Doutor Ricardo Rodrigues Pinto por ter aceitado ser o meu orientador e pela sugestão deste trabalho. Quero também agradecer toda a disponibilidade, apoio, acompanhamento e incentivo demostrados ao longo deste percurso.

Ao Dr. André Vinha por toda a dedicação, disponibilidade, total apoio e colaboração no solucionar de dúvidas e problemas que foram surgindo ao longo da realização deste trabalho e por todas as palavras de incentivo.

À Doutora Carolina Lemos, que praticamente conheço desde o primeiro ano de curso, o meu muito obrigado pela prontidão demonstrada desde o primeiro momento e pela grande ajuda com a parte estatística.

À Doutora Filipa Cordeiro pela preciosa ajuda na realização dos inquéritos telefónicos.

Resumo

Introdução

As Vértebras de Transição Lombo-Sagradas (VTLS) são uma anomalia congénita comum da junção L5-S1 da coluna vertebral humana. Os estudos disponíveis na literatura mostram uma ampla variação no que diz respeito à sua prevalência e a sua associação com a presença de sintomas clínicos significativos não é consensual. Não são conhecidos na literatura estudos que investiguem a prevalência e o significado desta anomalia na população Portuguesa.

Objetivo

O objetivo deste estudo foi identificar a prevalência de VTLS numa população mediterrânea (Portuguesa), tendo por base tomografias computorizadas toraco-abdomino-pélvicas e avaliar se a presença de VTLS se correlaciona com a existência de lombalgia.

Métodos

Foi realizada uma revisão retrospetiva consecutiva de 639 tomografias computorizadas toraco-abdomino-pélvicas, realizadas na mesma instituição, entre Janeiro de 2019 e Novembro de 2020. A presença de VTLS foi classificada como tipo II, III, IV com base na classificação de Castellvi. Para investigar a associação entre os diferentes tipos de LSTV com dor lombar, foi aleatoriamente selecionado um grupo controlo de doentes sem VTLS ajustado para a idade e sexo. Os pacientes de ambos os grupos responderam aos questionários *Oswestry Low Back Disability Questionnaire* (ODI) e *EuroQol-5D-3L Questionnaire* para avaliar a presença de dor lombar.

Resultados

Após aplicados os critérios de inclusão e exclusão, foram incluídos 571 indivíduos no estudo. A prevalência de VTLS foi de 24,9% (142 de 571). Dos 142 indivíduos com VTLS, 37,3% eram tipo IIb (pseudoarticulação bilateral), 31,0% eram tipo IIa (pseudoarticulação unilateral), 13,4% eram tipo IIIa (fusão unilateral), 9,9% eram tipo IIIb (fusão bilateral) e 8,5% eram tipo IV (pseudoarticulação tipo II unilateral e fusão tipo III no lado contralateral). Indivíduos com VTLS foram mais propensos a reportar dor lombar do que indivíduos sem VTLS (OR: 0,392, 95% CI: 0,192-0,802, p=0,010). O tipo IV de Castellvi demonstrou um ODI significativamente maior em

comparação com o tipo II (OR:1,059, 95% CI:1,019-1,100, p=0,04). O grupo com VTLS apresentou um ODI significativamente maior e, consequentemente, maior incapacidade (OR: 1,050, 95% CI: 1,029-1,072, p<0,01). Não houve diferença estatística significativa na pontuação do *EuroQol-5D-3L* entre os dois grupos (OR:1,085, 95% CI: 0,459-2,560, p= 0,852).

Conclusão

Este estudo de base populacional adiciona à literatura a prevalência de LSTV numa população mediterrânea. A presença de VTLS foi associada a maior dor lombar e maior incapacidade relacionada com a dor lombar. No entanto, esta diferença não se traduziu numa perda de qualidade de vida. O tipo IV foi associado a uma maior incapacidade funcional quando comparado com o tipo II.

Palavras-Chave

Vértebra de Transição Lombo-Sagrada, Dor lombar, tomografia computorizada, Incapacidade, Prevalência

Abstract

Introduction

Lumbosacral transitional vertebra (LSTV) is a common congenital anomaly of the L5-S1 junction in the human spine. The studies available in the literature show a wide variation regarding its prevalence, also its association with the presence of significant clinical symptoms is not consensual. Investigation of the prevalence and significance of this anomaly in the Portuguese population is lacking.

Objectives

The aim of this study was to identify the prevalence of LSTV in a Mediterranean (Portuguese) population, based on thoraco-abdomino-pelvic CT-scans and to assess whether the presence of LSTV correlates with the existence of low back pain.

Methods

A retrospective review of 639 thoraco-abdomino-pelvic consecutive CT-scans between January 2019 and November 2020 was performed. The presence of LSTV was classified into type II, III, IV based on Castellvi's classification. To investigate the association between different types of LSTV with low back pain, an age and sex-matched control group of individuals without LSTV was randomly selected to be compared to the LSTV group. Individuals from both groups answer the *Oswestry Low Back Disability Questionnaire* (ODI) and the *EuroQol-5D-3L* questionnaire to evaluate their back pain history.

Results

After application of inclusion and exclusion criteria 571 individuals were included in the study. The prevalence of LSTV was 24,9 % (142 of 571). Of the 142 individuals with LSTV, 37,3% were type IIb (bilateral pseudoarticulation), 31,0% were type IIa (unilateral pseudoarticulation), 13,4% were type IIIa (unilateral fusion), 9,9% were type IIIb (bilateral fusion) and 8,5% were type IV (unilateral type II transition with a type III fusion on the contralateral side). Individuals

with LSTV were more likely to report low back pain than individuals without LSTV (OR:0,392, 95% CI:0,192-0,802, p=0,010). Castellvi´s type IV showed a significantly higher ODI when compared to type II (OR:1,059, 95% CI:1,019-1,100, p=0,04). The LSTV group was associated with a significantly higher ODI, and consequently higher disability (OR: 1,050, 95% CI: 1,029-1,072, p<0,01). There was no statistical difference in the *EuroQol-5D-3L* score between the two groups (OR:1,085, 95% CI: 0,459-2,560, p=0,852).

Conclusion

This population-based study adds to the literature the prevalence of LSTV in a Mediterranean population. LSTV was associated with low back pain and low back pain associated disability. However, this difference did not translate into a loss of quality life. Type IV was associated with higher functional disability when compared with type II.

Keywords

Lumbosacral Transitional Vertebra, Low back pain, Computed tomography imaging, Disability, Prevalence

List of Abbreviations

LSTV- Lumbosacral transitional vertebrae

LBP- Low Back Pain

ODI- Oswestry Low Back Pain Disability Questionnaire

CT- Computed Tomography

BMI- Body Mass Index

CI- Confidence interval

OR- Odds ratio

TTO- Time-trade off

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Introduction

Lumbosacral transitional vertebra (LSTV) is a common congenital anomaly of the L5-S1 junction of the human spine[1], in which an elongated transverse process of the last lumbar vertebra fuses in a varying degree to the first sacral segment.[2] As a morphologic variant of the normal anatomy, LSTV includes a spectrum from partial/complete L5 sacralization to partial/complete S1 lumbarization. When there is a complete fusion of the L5 vertebra to the sacrum, only 4 lumbar vertebrae exist, whereas when there is an entire separation of S1 from the sacrum, 6 lumbar vertebrae exist.[3] Therefore, according to the transition type, the lumbosacral junction is renamed to L4-S1 in case of sacralisation and L6-S1, in case of lumbarisation. However, in the majority of cases, the transition is incomplete or unilateral.[4]

The LSTV prevalence in previous studies ranges from 4% to over 35%.[5] This broad spectrum may be related to differences in imaging techniques, diagnostic criteria, and confounding factors between the investigated population samples.[4]

In 1917, Bertolotti[6] was the first to describe the association between LSTV and low back pain (LBP) - Bertolotti Syndrome. Since then, this link has remained a matter of discussion in the literature.[7] There are various studies that show no association with clinical symptoms[8] and, conversely, numerous studies that show the association of LBP with specific Castellvi types.[7,9-11] The etiology of LSTV associated LBP may be caused from suprajacent disk pathology, facet joint arthritis, extraforaminal stenosis, or degeneration of the abnormal articulation of LSTV and sacrum.[12] Therefore, the clinical challenge is to determine whether an anatomical substrate related to LSTV is the underlying source of the pain.[3]

The purpose of this study was to determine the prevalence of LSTV in a Mediterranean population, and to investigate its association with low back pain.

Materials and Methods

This study was approved by the local ethic committee (Reference number: 2021-074 (61-DEFI 63-CE)), which waived the requirement for informed consent due to the retrospective nature of the analysis and was conducted in compliance with the standards of the Declaration of Helsinki.[13]

A consecutive retrospective review of 639 thoraco-abdomino-pelvic CT-scans between January 2019 and November 2020 in a single institution was performed. The data was collected from the Hospital picture archiving communication system (SECTRA® version IDS7). All CT-scans were collected regardless of the clinical indication. Demographic and clinical data were obtained from the electronic medical data using the software SClínico® v.2.3. Exclusion criteria were paediatric age (< 18 years old), severe deformity, unavailability or incomplete image of spine and previous spine surgery. After application of inclusion and exclusion criteria, 68 individuals were excluded, leaving 571 subject CT-Scans to be included in the study.

Data compilation consisted of subject's gender, age at the time of imaging, number of ribs, number of lumbar vertebrae until the last mobile vertebra before the sacrum.

For numbering the transitional vertebrae, the first thoracic vertebra was identified by searching for the first thoracic rib. From there, 12 vertebrae were counted inferiorly to identify T12 and verified if it corresponded to the origin of the lowest rib. Number of lumbar vertebrae were counted until the last mobile vertebra. Coronal, sagittal and axial imaging planes were utilized for the analysis.

All thoraco-abdomino-pelvic CT-Scans were independently read by two researchers (JB and AV) and all disparities were settled by a third researcher (RRP). LSTV anomalies were identified and categorized according to the Castellvi classification.[14] Type I is a unilateral (Ia) or bilateral (Ib) dysplastic transverse processes, with a measured width of at least 19 mm (craniocaudal dimension). Type II is an incomplete unilateral (IIa) or bilateral (IIb) lumbarization/sacralization with an enlarged transverse process, which has a diarthrodial joint between itself and the sacrum. Type III is a unilateral (IIIa) or bilateral (IIIb) lumbarization/sacralization with complete osseous fusion of the transverse process(es) to the sacrum. Type IV is a unilateral type II transition, with a type III on the opposite side (Figure 1).[1] Castellvi types II, III, and IV were included as transitional states. Type I LSTV were not included as they lack clinical and surgical significance.[3,15] Data were documented as type II to IV.

To investigate the association between different types of LSTV with respect to clinically significant symptoms (low back pain), an age and sex-matched control group of individuals

without LSTV (LSTV(-)) was randomly selected to be compared to the LSTV (+) group. Individuals from both groups answered a set of questionnaires regarding their back pain history by telephone. The questionnaires applied were *Oswestry Low Back Disability Questionnaire 2.0-ODI (*Portuguese version)[16] and *EuroQol-5D-3L* (Portuguese version).[17] The ODI questionnaire, which evaluates the degree of disability caused by lumbar pain, is constituted by 10 items, each one of them is scored from 0 to 5, the total is added and multiplied by 2. Therefore, the ODI ranges from 0 to 100 %. However, as the purpose of this study was to apply this questionnaire via telephone, the question regarding the subject's sexual life was omitted to safeguard the subject's privacy and prevent discomfort.[18] Thus, 9 out of 10 items were applied, and the Oswestry Disability Index was calculated based on the following formula: ($\frac{Total\ Score}{45}$)x 100. [18]

The EuroQol-5D-3L descriptive system comprises the following five dimensions: mobility (MO), self-care (SC), usual activities (UA), pain/discomfort (PD) and anxiety/depression (AD). Each dimension is punctuated from 1 to 3, as the subject refers no problems, some problems, and extreme problems, respectively. Thus, this questionnaire produces a 5-digit health state profile that represents the reported problems. Subsequently, the 5-digit state profile may be converted into a single summary number (index value), which reflects how good or bad a health state is according to the preferences of the general population of a country/region. This index ranges from states worse than dead (< 0) to 1 (full health), anchoring dead at 0, it can be calculated based on the following formula: V = 1 – α – MO – SC – UA – PD – AD – N3 (1 represents the value of perfect health; α is a constant that represents the non-coincidence of the value of any dimension in relation to level 1; N3 is another constant that corresponds to the presence of the level 3 in any dimension; MO, SC, UA, PD, AD are the 5 dimensions to be evaluated).[19]

To access the pain location the following questions were performed: “Have you had LBP during the previous 12 months?”; “What type of LBP have you had: lumbago (meaning a sudden attack of LBP) or lumbar pain with radiation?”. Furthermore, individuals were also asked about their profession, scholarity, smoking history and presence of psychiatric pathology (anxiety and depression). To classify the professions, the Large Group Portuguese Classification of Professions created by the National Institute of Statistics[20] was adopted, which is characterized as follows: 1- Armed Forces Professions; 2- Representatives of the legislative and executive bodies, directors, officers and executive managers; 3- Specialists in intellectual and scientific activities; 4- Intermediate level technicians and professions; 5- Administrative staff; 6- Personal service, security, safety workers and salespeople; 7- Farmers and qualified

workers in agriculture, fisheries and forestry; 8- Qualified workers in industry, construction and craftsmen; 9- Plant and machine operators and assembly workers; 10- Non-qualified workers. However, due to the large number of subgroups, to perform the statistical analyses, professions from 1 to 6 were regrouped together as they represent intellectual professions or less physical demanding professions; in contrast, professions from 7 to 10 were regrouped together as they represent more physical demanding professions and an inactive category (made up of students, unemployed and retired) was created.

Data were deidentified and collated using standardized Microsoft Excel (Microsoft Corp., Redmond, Washington, United States) spreadsheets. Descriptive statistics were performed to characterize the sample and analysed using IBM SPSS Statistics v.27.

Results

Of the 639 subject images reviewed, 68 did not fill the inclusion criteria and were therefore excluded from the analysis leaving 571 subject CT-Scans for final analysis. LSVT was identified in 142 subjects, indicating a prevalence of 24,9%. This corresponded to 82 men (57,3%) and 61 women (42,7%) with an average age of 65,47 years (range 19-93 years). The most common anatomical variant was Castellvi type IIb, in 53 individuals (37,3%), followed by Castellvi type IIa (31,0%), type IIIa (13,4%), type IIIb (9,9%) and type IV (8,5%) (Table I and Figure 2).

LSTV and Low Back Pain

From the 142 individuals with LSTV, 48 subjects were excluded due to the following criteria: didn't answer our call to take the questionnaires; refused to answer the questionnaires; died; were completely disabled or totally confined to bed with severe illness and therefore not capable of completing the questionnaire. Consequently, the LSTV (+) group consisted of 95 subjects, 53 men and 42 women, mean age 64,53 ± 16,647 years.

To establish a comparison with this group, an age and sex-matched control group of individuals without LSTV was randomly selected from the remaining 429 individuals. The control group, LSTV (-), consisted of 98 subjects, 53 men and 45 women, with a mean age 62,37 ± 14,145 years. There was no significant statistical difference regarding age (p= 0,332) and sex (p=0,812) between the two groups.

With respect to risk factors for LBP, the Body Index Mass (BMI) mean for the LSTV group was 25,20 kg/m^2 and for the control group 25,63 kg/m^2. Regarding smoking history, in the LSTV group 61 subjects (64,2%) were non-smokers, 25 (26,3%) were ex-smokers for more than one year and 9 (9,5%) were current smokers, in the control group 50 subjects (51%) were non-smokers, 30 (30,6%) were ex-smokers for more than one year and 18 (18,4%) were current smokers. In the LSTV group 87 subjects didn't report psychiatric pathology and 8 reported, in the non-LSTV group 80 subjects didn't report psychiatric pathology and 18 reported. In the LSTV group 30 subjects (31,6%) had an intellectual profession, 61 (64,2%) had a more physically demanding profession and 4 (4,2%) were inactive; in the non-LSTV group 35 subjects (35,7%) had an intellectual profession, 58 (59,2%) had a more physically profession and 5 (5,1%) were inactive. Between the two groups, there was no significant statistical difference regarding BMI (OR: 1,036, 95% CI: 0,972-1,104, p= 0,282) and professions: intellectual

(p=0,674), more physical demanding (OR:0,756, 95% CI: 0,407-1,406, p=0,377), inactive (OR:0,881, 95% CI: 0,212-3,781, p=0,881). The individuals from the non-LSTV group were more likely to report psychiatric pathology (OR: 2,447, 95% CI: 1,008-5,937, p=0,048) and smoking (OR:2,684, 95% CI:1,083-6,654, p=0,033) (Table II).

In terms of pain and its location in the previous 12 months, in the LSTV (+) group, 31 subjects (32,6%) referred no pain, 35 (36,8%) referred LBP and 29 (30,5%) referred LBP with radiation. In the control group, 47 individuals referred no pain (47,96%), 22 (22,45 %) referred LBP and 29 (29,59%) referred LBP with radiation. A Logistic Regression adjusted to age and sex, showed that LSTV individuals were more likely to declare LBP than individuals without LSTV (OR:0,392, 95% CI:0,192-0,802, p=0,010). Individuals without LSTV were more likely to declare no pain (p=0,037). (Figure 3).

The *Oswestry Low Back Pain Disability Questionnaire*, was 24,45 % ± 20,301 in the LSTV (+) group and 10,90 % ± 13,092 in the non-LSTV group (p<0,01). Compared to the control group, the LSTV group was associated with a significantly higher ODI, and consequently higher disability (OR:1,050, 95% CI: 1,029-1,072, p<0,01) (Figure 4). Within the LSTV (+) group the subjects with Castellvi type IV had significantly higher disability than subjects with Castellvi IIa (OR:1,059, 95% CI:1,019-1,100, p=0,04) (Figure 5).

The *EuroQol-5D-3L* score was comparable between both groups, being 0,5907 ± 0,3478 in the LSTV (+) group and 0,5819 ± 0,3110 in the LSTV (-) group (OR:1,085, 95% CI: 0,459-2,560, p=0,852).

Discussion

To our knowledge, this is the first study to investigate the prevalence of LSTV in a Mediterranean population. The reported prevalence of LSTV in the literature ranges from 4% to over 35%, since it was first reported. French *et al*[15] reported a prevalence of 9,9%, in a review of 5941 anteroposterior radiographs in the Australian Population. Hanhivaara *et al*[12], in a review of 3855 abdominal CT scans reported the prevalence of LSTV anatomy as 28,6%. A study using MRI in a young men population with low back pain, reported a prevalence of LSTV of 32%[21]. This wide variability of range can be related to different factors such as differences in individual diagnostic and classification criteria, sample size, selection criteria (symptomatic or asymptomatic), vertebral numbering technique, observer error, imaging modality and confounding factors. As preceding studies have detailed, the prevalence of LSTV was superior in studies that selected subjects for LBP, while a lower prevalence was observed in community-based studies. In the present study, low back pain was not an inclusion criteria, the subjects were from a local population, and the prevalence of LSTV identified (24,9%) was identical to that of community-based studies. In addition, the distribution by gender and age group in our study sample was similar to that of the Portuguese population[22].

In this study, type I was not included as a transition state due to its questionable relationship to clinically significant problems and the definition of an enlarged transverse process is also somewhat vague. Castellvi et al[14] stated that this type was not clinically relevant and was just a "*forme fruste*" of LSTV. Nardo et al [10]also verified that pain was less frequent in this type of LSTV. Overall, the prevalence per subtype of LSTV in the present study is in line with other studies that did not include type I, with the most common types being II and III and with type IV being the least frequent.[15,23]

LSTVs can be identified on all imaging modalities. The 30° angled anteroposterior X-Ray view (Ferguson view) of the lumbar spine was chosen as the original and first radiographic tool to determine and classify lumbosacral transitional vertebra according to the Castellvi classification[2]. However, the ability of this method to detect LSTV does not mean it can classify LSTV types accurately. In fact, Hou et al[24] stated that coronal CTs can provide a more reliable LSTV type identification when compared to anteroposterior radiographs. This author goes further to advocate the use of coronal CTs as gold standard in the classification of LSTV in studies investigating the relationship between LSTV type and their clinical significance.

LBP is an important cause of disability and work absenteeism. To evaluate the functional status and disability of individuals with LBP, the ODI is one of the most common instruments and has become one of the principal condition-specific outcome measures used in the management of

spinal disorders[25]. The version 1.0[26], was the original, however, since its publication several versions and translations to other languages have been made. The ODI remains a valid and vigorous measure of condition-specific disability and version 2.0 is currently the recommended version[18]. The Brazilian-Portuguese version of the Oswestry Disability Index (2.0) showed to be responsive[25]. Commonly, the ODI has been used in outpatient clinics and a face-to-face basis, even so, telephonic administration is scientifically valid and should be an accepted method of data collection for state-level and national-level outcomes projects [27]. The EuroQol-5 Dimension (EQ-5D) is a systematized preference-based instrument created to provide a hint of health-related quality of life in relation to various diseases, including back pain[28]. It can be used in different settings such as hospitals, physiotherapy, rehabilitation, general practice, and primary care. The EQ-5D results can be presented by three methods: as a health profile derived from the descriptive system, as a measure of overall self-rated health status derived from the visual analogue scale and as a country-specific index value derived from preference weights for health states[29]. As health states vary across the countries, the use of a local value set is recommended[30]. Ferreira et al[19] established the validation of the Portuguese version of the EQ-5D and the value set based on the preferences of the Portuguese general population as measured by the TTO (time trade-off).

As aforementioned, the association of LSTV with LBP, so-called Bertolotti syndrome, has been debated since it was first described in 1917. Tini et al[31], in a series of 4000 subjects, found no difference in LBP between individuals with and without LSTV. However, in the present study, LSTV individuals were more likely to report LBP. Other studies support the findings in this study: Oyinloye et al[32] described the association of LBP and LSTV in a cohort of 561 subjects; Quinlan et al[7] also concluded that LSTV should be considered a differential diagnosis when investigating young people with low back pain. Furthermore, individuals with LSTV reported higher disability than those without LSTV. This is supported by Taskaynatan et al[33], which among 881 young male subjects reported that the presence of and LSTV increased the severity of the subject's clinical picture and severity of pain.

Interestingly, in this study, when using a subtype-specific analysis, Castellvi type IV had higher association with LBP, particularly when comparted with type IIa. These results were not in consonance with those of Tini el al[31], who did not observe an association of LSTV with LBP when using subtype-specific analysis, and with those of most of the literature, that often implicate a positive correlation between type II and LBP[10,11]. However, as there was no statistical difference, in our sample, with respect to *EuroQol-5D-3L* score between the two groups, the higher disability verified in the LSTV group was not directly reflected in the loss of quality life. Compared to the non-LSTV group, which overall had mild disability [18](mean ODI

score 10,90 % ± 13,092), the individuals with LSTV had moderate disability[18] (mean ODI score 24,45 % ± 20,301), meaning that these subjects can experience more pain and difficult with sitting, lifting and standing, travel and social life may be more difficult, however personal care and sleeping are not grossly affected and the pain can be managed by conservative means, which may lead to subject's perception of a not markedly affected quality of life.

The pathophysiologic mechanism of LSTV associated pain remains uncertain. Luoma et al[8] and Lee et al[23] established that LSTV was associated with increased risk of degenerative changes in the disc above to the transitional vertebrae. This can be explained by a change in normal spinal biomechanics due to the presence of transitional vertebrae, with the suprajacent intervertebral disc being subjected to hypermobility contributing to atypical torque and subsequent disc degeneration[34,35]. This contrasts with the reduced flexibility secondary to the fusion of transverse processes with the sacrum or ilium verified in the inferior intervertebral space, that tends to be protected from degenerative changes. Analogously, as the stress can be dissipated to the superior segments, in unilateral LSTV (type IIa ou IIIa) torque forces can be dissipated to the contralateral facet joint, reflecting contralateral facetogenic pain[2]. Degenerative changes have also been documented in the "false joint" created by the pseudoarticulation in Type II LSTV[36]. Numerous studies have established an association with extraforaminal stenosis secondary to the dysplastic transverse process leading to nerve root entrapment and radiculopathy[2,10]. As aforementioned, diverse pathophysiologic mechanisms have been hypothesized to relate LSTV with LBP and therefore, further studies are needed to better elucidate the pathophysiology inherent in LSTV, particularly involving type IV.

A diversity of individual and environmental characteristics such as poor general health (smoking and obesity), psychological stress (depression, anxiety) and occupational factors have been described to increase the risk of LBP[37,38]. Therefore, the presence of these characteristics can be a confounding factor in the evaluation of LBP and question the association of LSTV as the cause of low back pain. In this study these characteristics were analysed in both groups and no difference was found regarding the BMI. Furthermore, there was a higher number of individuals with psychiatric pathology and smoking in the control group. Thus, the findings in this study strengthen the association of LSTV with low back pain and as a cause of disability.

This study has some limitations. A major limitation was that the sample utilised represents a population that is allocated to a Hospital and although the distribution by age group was similar to that of the Portuguese population it may not be representative of the Portuguese population. Secondly, the sample size is relatively small, compared to other epidemiological

studies. However, contrary to most studies, this was not purely an epidemiologic study as it analysed the clinical relevance of LSTV.

This study has several strengths. Firstly, all abdominal CT-scans were collected regardless of their indication. Secondly, the presence of low back pain was not an inclusion criteria. Both of these factors prevent potential selection bias. Thirdly, poor general health (obesity, smoking) and psychological stress (depression, anxiety), occupational factors (more physically demanding profession) were considered as potential confounding factors in evaluating low back pain. Fourth, an age and sex-matched control group was randomly selected to be compared to the LSTV group regarding clinical symptoms. Fifth, clear images of T1 and T12 vertebrae were available to promote correct identification of LSTV and accurate manual numeric identification of vertebral segments.

Conclusion

In conclusion, this study adds to the literature the prevalence of LSTV, particularly in a Mediterranean population where it had never been analysed. The prevalence of LSTV in this study sample was 24,9%. Importantly, this study found that LSTV is a common normal variant in the Portuguese population and is associated with LBP and LBP related disability. This association, however, did not translate into a loss of quality of life. Castellvi type IV was associated with higher functional disability, when compared with type II.

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Tables

Table I: Prevalence per Castellvi subtype in the LSTV group

Castellvi	Frequency (Number)	Percentage (%)	Valid Percentage (%)
Type IIa	44	7,7	31,0
Type IIb	53	9,3	37,3
Type IIIa	19	3,3	13,4
Type IIIb	14	2,5	9,9
Type IV	12	2,1	8,5
Total LSTV	142	24,9	100
Total sample	571	100	

Valid percentage represents the percentage within the individuals with LSTV; Percentage represents the percentage within the total sample

Table II- Demographic data comparison between subjects with and without LSTV

	LSTV (+)	LSTV (-)	P Value
Number	95	98	-
Age (years)	64,53 ± 16,657	62,37 ± 14,145	0,332
Sex	M:F = 53:42	M:F = 53:45	0,812
BMI (kg/m^2)	25,20	25,63	0.282
Psychiatric pathology			
Not Reported	87	80	0,829
Reported	8	18	**0,048**
Smoking history			
Non-smokers	61	50	-
Ex-smokers	25	30	0,215
Smoking	9	18	**0,033**
Profession			
Intellectual	30	35	-
Physical	61	58	0,377
Inactive	4	5	0,881

Data represent mean ± standard deviation
BMI, Body Mass Index
Ex-smokers: non-smokers for at least one year

Figures

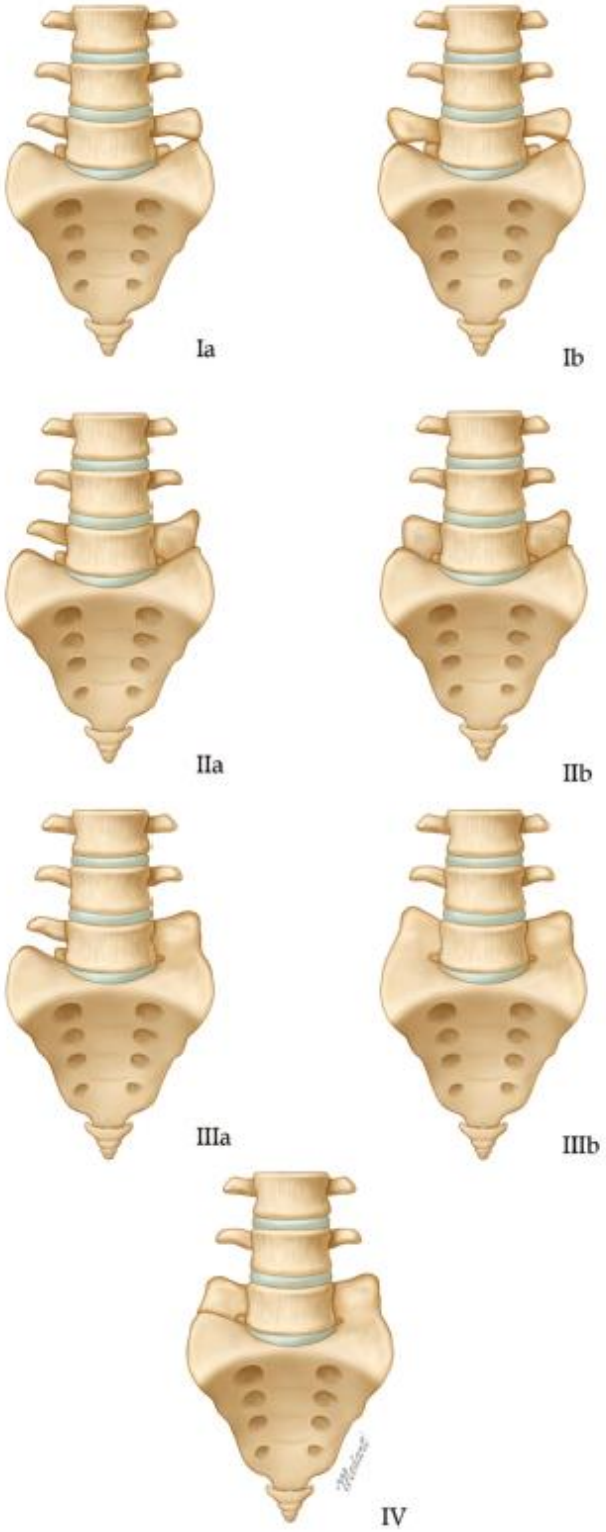


Figure 1- Schematic presentation of LSTV according to Castellvi's Classification. Adapted from Lee et al: Clinical Importance of Lumbosacral Transitional Vertebra in Patients with Adolescent Idiopathic Scoliosis[23]

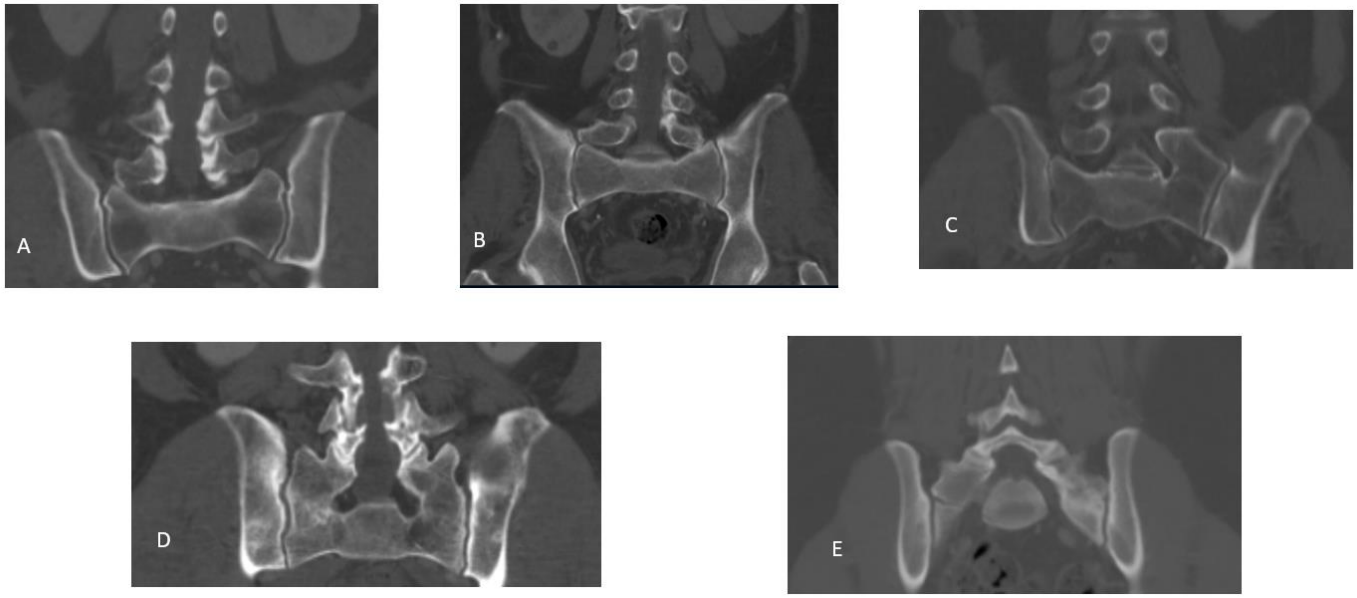


Figure 2- Coronal thoraco-abdomino-pelvic CT-Scans demonstrating Castellvi et al classification[14]. **A**, shows unilateral pseudoarticulation of the transverse process of L5 with the sacrum (Castellvi type IIa) in a 56-year-old-male. **B**, shows bilateral pseudoarticulation (Castellvi type IIb) in a 73-year-old-male. **C**, shows unilateral osseous fusion (Castellvi type IIIa) in a 76-year-old-male. **D**, shows bilateral osseous fusion (Castellvi type IIIb) in a 56-year-old-male. **E**, shows a 28-year-old-woman with Castellvi type IV, unilateral pseudoarticulation and osseous fusion on the opposite site.

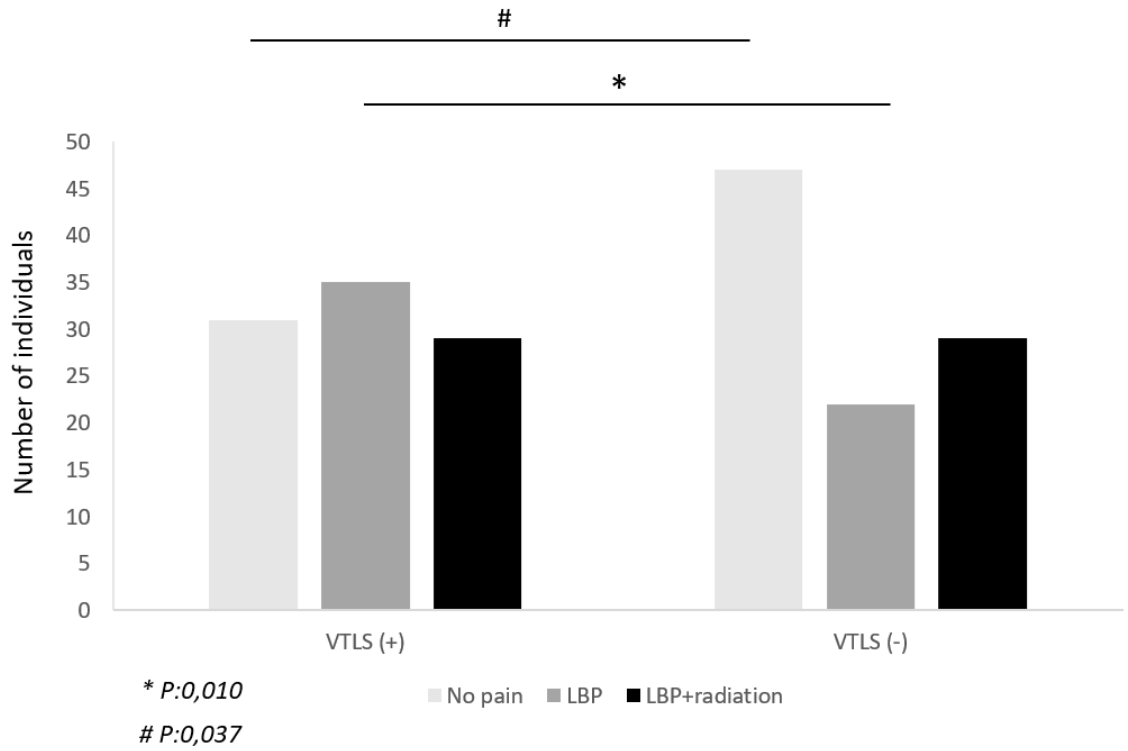


Figure 3- Comparison of pain and its location, in the previous 12 months, between individuals with and without LSTV. Asterisk and cardinal indicate significantly different pain location.

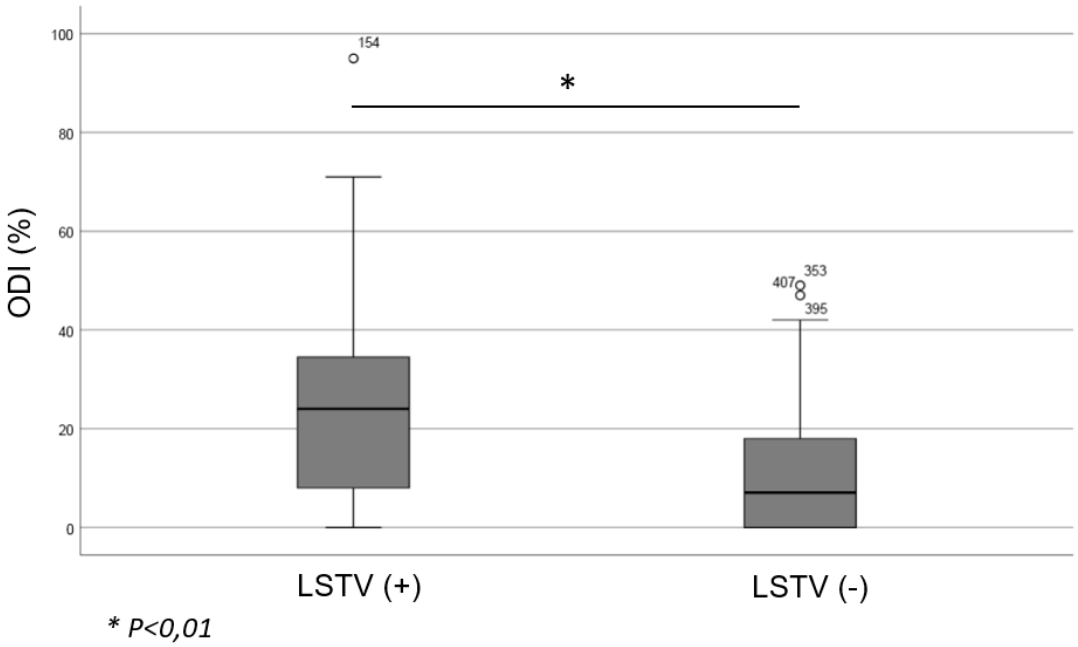
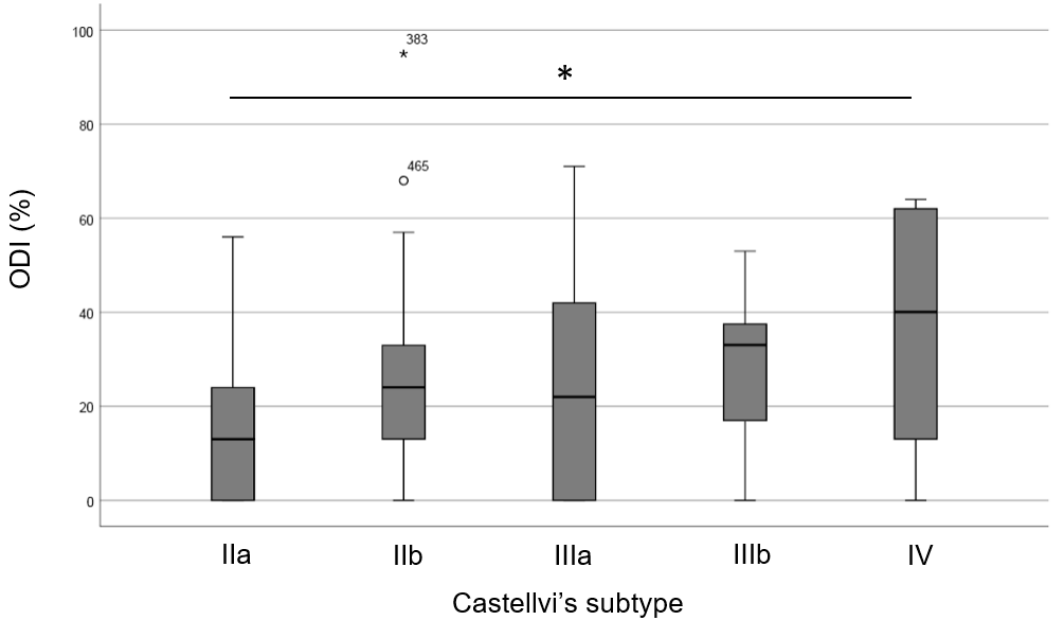


Figure 4- Comparison of the ODI score between individuals with LSTV and without LSTV. Asterisk indicates significantly different ODI score.



** P:0,04*

Figure 5- Comparison of the ODI score per Castellvi subtype in the LSTV group. Asterisk indicates significantly different ODI score.