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Rural and Urban: comparison of lumbar pathologies in two British medieval populations

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Abstract. The rapid growth of global urbanisation has led to more people adopting urban-related lifestyles, which have been shown to impact human health. This study compares the effects of different lifestyles in two medieval British populations, rural Poulton and urban Gloucester, on the prevalence of lumbar vertebral pathologies. The study used descriptive diagnostic techniques to identify osteoarthritis, spondylosis and Schmorl's nodes, and applied inferential statistics to compare and analyse the prevalence of each pathology. The analysis revealed that Schmorl's nodes prevalence differs significantly between males and females in Gloucester but not in Poulton. Gloucester males presented higher frequencies of Schmorl's nodes than Poulton males, while no significant differences were found for osteoarthritis and spondylosis. The study highlights that the impact of lifestyle on lumbar vertebral health is more complex than previously assumed, as the intertwined influences of the two environments make it difficult to attribute pathological patterns exclusively to a single lifestyle. Further research is recommended to enhance our understanding of the complexities related to urban and rural living and their effects on lumbar spinal pathologies.

Keywords: Schmorl's nodes, osteoarthritis, spondylosis, lifestyle, Medieval health.

Introduction

The study of skeletal remains offers essential evidence regarding past populations' lifestyles, health, activities, and interactions with their

environments, this information can lead to practical applications and theoretical insights into modern public health issues.

Urbanisation is rapidly increasing, with an estimated 68% of the world's population inhabiting cities by 2050 (United Nations Human Settlement Programme, 2025). The urban lifestyle has been continually linked with reduced human health, from tuberculosis and lung cancers of the Industrial Revolution (Boyd, 2022), to the correlation between increasing COVID-19 cases and high population density (Gurram *et al*., 2022). While the general effects on human health are well documented, research regarding the impact of lifestyle on skeletal health remains limited.

This study addresses this issue through analysing and comparing the prevalence of lumbar pathologies in two contrasting medieval populations: urban Gloucester and rural Poulton. The investigation seeks to understand how lifestyle differences between these populations may have impacted lumbar health, providing a proxy to explore and improve understanding of the implications of rural versus urban living. The urban-rural distinction is understood through key differences in economy, population and occupational diversity. Medieval Gloucester defines an urban centre, characterised through the presence of numerous trades, a growing population and progressive development. While medieval Poulton represents a rural population, with a reliance on agriculture and physical labour.

The lumbar vertebrae were selected due to their crucial biomechanical role and association with lower back pain, a major global health concern (Buchbinder *et al*., 2018). Investigation into lumbar health in past populations can highlight whether lifestyle has historically influenced spinal pathology trends and patterns, aiding in the connection from past to present. Previous comparative studies between urban and rural populations have concentrated on degenerative pathologies, trauma analysis (Collier and Primeau, 2019), and respiratory infections prevalence (Krenz-Niedbala and Lukasik, 2020). These studies often compared populations from geographically and environmentally distinct regions, typically from the northern and southern extremes of the study region. Research on British medieval populations has primarily focused on highly urbanised centres, such as the St Mary Spital (Walter and DeWitte, 2017) and St Brides collections from London (Arnett, 2022).

Considering the areas of underdeveloped research, the current comparison of Gloucester and Poulton provides data from geographically proximate sites and includes an urban context that is less developed than other well-documented collections.

Osteoarthritis (OA) is a degenerative condition of the synovial joints (Waldron, 2019) which develops within the vertebral apophyseal facets,

resulting in the breakdown of facet cartilage (Lewin, 1964). Progression of OA leads to a subchondral bone reaction (Lovell, 1994) and an eburnated appearance (Howell *et al*., 1976). While OA has been extensively studied, there are several factors believed to cause the disease, including age (Weiss and Jurmain, 2007), mechanical loading (Jurmain and Kilgore, 1995), genetics, and trauma (Howell *et al*., 1976). Schmorl's nodes (SNs) are vertebral lesions associated with the weakening of the interverbal disc, causing the protrusion of the nucleus pulposus through the cartilaginous and bony endplates into the adjacent vertebrae (Mattei and Rehman, 2014). SNs vary in size and position but are typically characterised by depressions on the vertebral body surface surrounded by sclerotic bone (Brito and Santos, 2024). Current research indicates that SNs develop independently of ageing (Brito and Santos, 2024), and may be linked to other aetiological factors, including trauma (Ustundag, 2009) and degenerative conditions (Peng *et al*., 2003). Spondylosis (SP) is a general term that describes osseous reactions in the vertebrae due to intervertebral disc degeneration (Middleton and Fish, 2009). SP occurs when intervertebral disc height is reduced through dehydration, leading to a narrowed disc space (Klassen *et al*., 2011). To counteract the pressures of the degenerated disc, osteophytic bone develops at the margins of adjacent vertebrae (Klassen *et al*., 2011). Several factors are linked with the aetiology of SP, including mechanical activity (O'Neill *et al*., 1999), ageing, and trauma (Beresford, 1952).

The present study aims to compare the prevalence of osteoarthritis, spondylosis, and Schmorl's nodes in two British medieval populations: urban Gloucester and rural Poulton, assessing the populations from both demographic and sex-based perspectives. While, also considering potential causative factors such as lifestyle differences, further aiming to understand how these differences may have influenced the observed results. Considering the lifestyle distinctions between the two populations, initial expectations of the study suggest that this same contrast may be reflected within the observed results.

Materials and Methods

This study examined skeletal remains from two collections, Gloucester and Poulton, curated at Liverpool John Moores University (LJMU). Gloucester is located in southwest England, in the county of Gloucestershire (Fig. 1). In medieval times, Gloucester was regarded as a stable and well-connected town, with efficient road systems linking it to both South Wales and London (Casson and Casson, 2016). Medieval Gloucester was a prosperous urban hub; information on the mid-15th century rentals in Gloucester suggests an

abundance of 900-1000 properties (Langton, 1977), with varying occupations, including a strong involvement in ironworks (Richardson, 2018). The LJMU Gloucester collection consists of 232 skeletons (Burell, 2018) excavated from the medieval cemetery of St Owen's church, Southgate Street (Atkin and Garrod, 1990). Poulton is a small village in the north-west of England, in the county of Cheshire (Fig. 1). From medieval to modern contexts, it has maintained its status, with a consistent reliance on agriculture remaining the primary means of subsistence of the local population (Burell, 2018). A defining moment in Poulton's history was the 12th century migration of Cistercian monks to Poulton Abbey, providing the town with a stronger identity and recognition (Richardson, 2018). The LJMU Poulton collection consists of 737 skeletons excavated from the Poulton Chapel and graveyard site through the efforts of the Poulton Research Project (Cootes *et al*., 2023).

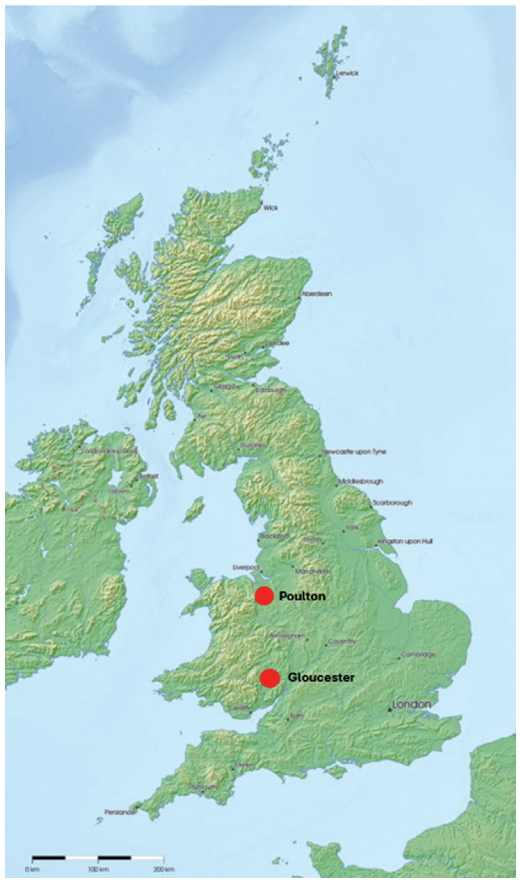

Fig. 1. *Map of the United Kingdom with the approximate locations of Poulton and Gloucester.*

A selection of 60 individuals were analysed in this study: 30 from Poulton and 30 from Gloucester, including 15 males and 15 females within each population sample. The sex and age of the remains analysed had been previously assessed by a PhD thesis at LJMU (Davenport, 2017).

All individuals included in the analysis were aged 35-50 (middle adult) and 50+ years (old adult) to ensure complete vertebral fusion and a comparable level of development and age-related changes across all vertebrae. Additionally, this age range allowed for precise identification and analysis of pathologies, as such conditions are known to become increasingly pronounced and advanced with age.

A total of 287 lumbar vertebrae were analysed, including 145 from Poulton and 142 from Gloucester (Tab. 1). With 146 female and 140 male lumbar vertebrae analysed, the number of both sexes in each age category is summarised in Tab. 2. Poorly preserved or severely fragmentary vertebrae (less than 50% complete) were excluded from the analysis; a minimum of three complete lumbar vertebrae was required for an individual to be included in the study. Prior to analysing the lumbar region, the skeleton's identification number, sex, and age were recorded.

Non-destructive techniques, including visual inspection and manual examinations, were employed to identify pathologies present on each lumbar vertebra, and detailed descriptions were provided for all observed conditions.

POPULATION	L1	L2	L3	L4	L5	TOTAL
Gloucester	29	29	28	29	27	142
Poulton	29	28	29	30	29	145

Tab. 1. *Number of each lumbar vertebra within the populations.*

POPULATION	AGE RANGE	MALES	FEMALES	TOTAL
Poulton	35-50 50+	10 5	11 4	21 9
Gloucester	35-50 50+	9 6	7 8	16 14

Tab. 2. *Distribution of Males and Females by age range in each population.*

Spondylosis (SP) was recorded as present based on the presence of pitting or porosity on the vertebral body surface and marginal osteophyte formation (Rogers, 2000).

Osteophytes were graded using a modified interpretation of Stewart's (1958) five-stage grading system (Fig. 2), where Grade 0 indicated the absence

of osteophytes, and Grade 1 represented minimal osteophyte development or early margin remodelling. Grade 2 corresponded to significant margin remodelling or the presence of large/multiple osteophytes; Grade 3 described severe rim remodelling or markedly projecting osteophytes. Grade 4 denoted the most severe osteophyte formation, characterised by projecting osteophytes in contact with, or fused to, adjacent vertebrae (Stewart, 1958).

Osteoarthritis (OA) was recorded as present using the criteria for palaeopathological diagnosis determined by Waldron (2019); the criteria suggest that eburnation alone is sufficient for diagnosis (Waldron, 2019). In the absence of eburnation, at least two of the following pathognomonic features must be present for sufficient diagnosis: marginal osteophytes, new bone formation on the joint surface, altered joint contour (Fig. 3), and porosity on the joint (Waldron, 2019) (Fig. 4).

Schmorl's nodes presence was identified by a depression in the vertebral body, with dense sclerotic margins (Dar *et al.*, 2009) (Fig. 5). For each lesion, the position and size were recorded.

In the case where multiple SN_s were observed on a single vertebra, the total number was recorded. However, for statistical analysis, SN_s were recorded simply as present or absent, with multiple lesions on the same vertebra considered as a single occurrence. Although lesion size and the presence of multiple SN_s were not used in the current study, this data could provide useful comparative information for future study involving other skeletal populations.

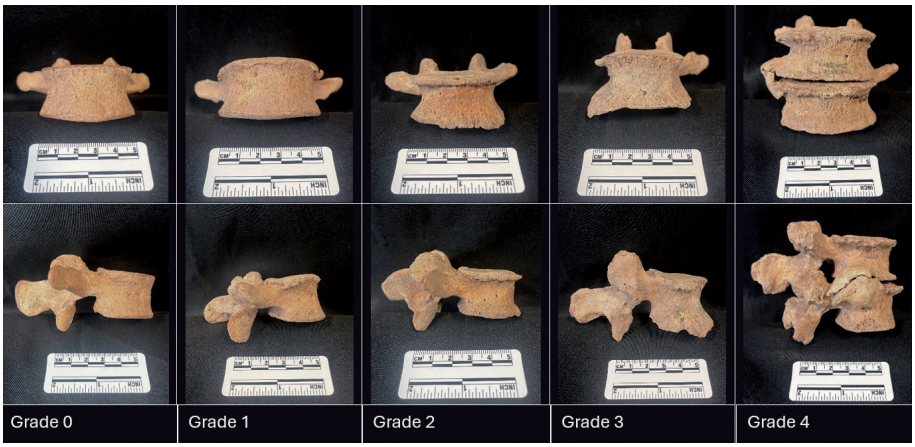

Fig. 2. *Example of the five osteophyte grades interpreted from Stewart (1958) using lumbar vertebrae from Poulton and Gloucester.*

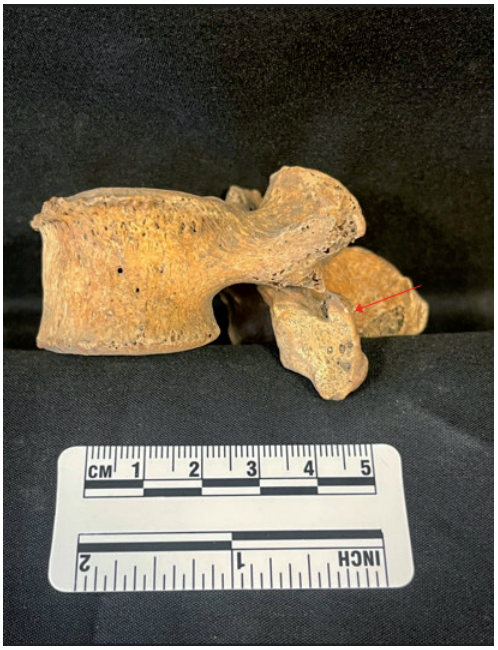

Fig. 3. *Altered joint of left inferior apophyseal facet of L5 of GLC-0171, identified by the red arrow.*

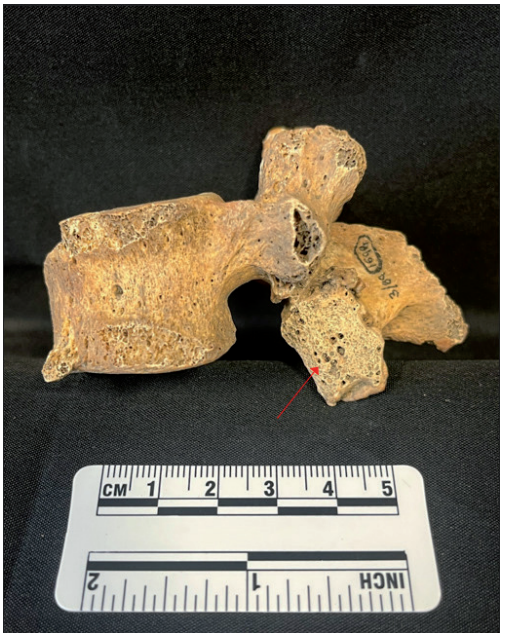

Fig. 4. *Porosity on the surface of the left inferior apophyseal facet of L2 of GLC-0036, identified by the red arrow.*

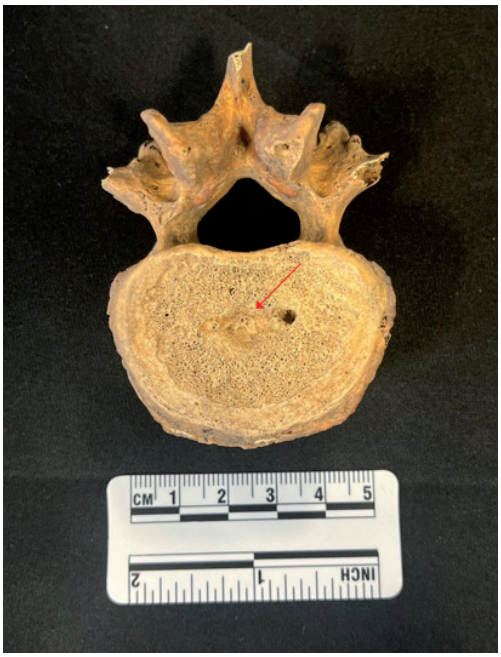

Fig. 5. *Schmorl's node on the inferior vertebral body surface of L3 of GLC-0041, identified by the red arrow.*

Statistical Analyses

The age distributions of the two populations differed, with Poulton containing twice as many «old» than «middle adults» whereas, Gloucester presented a more balanced ratio (Tab. 2). In response to this issue, a chi-squared test (X^2) was used to compare the age distributions of Gloucester and Poulton. Among the subgroups, Gloucester females presented a more equal age distribution (Tab. 2). A series of X^2 tests were completed to determine whether this distribution differed significantly from the other subgroups. Additional X^2 tests were conducted to evaluate differences in the overall prevalence of OA, SNs and SP between the two populations. For each test, the null hypothesis (H_0) stated that there would be no significant difference in pathology prevalence between Gloucester and Poulton. Further X^2 analyses were conducted to assess sex-stratified interpopulation differences in pathology prevalence, comparing Gloucester males with Poulton males and Gloucester females with Poulton females. The H_0 in each test assumed no significant difference in pathology prevalence between populations when analysing sexes separately. Intrapopulation sex comparisons were conducted using X^2 tests to assess

differences in pathology prevalence between sex-subgroups. The H_0 stated in each case there would be no significant sex-based differences. All statistical analyses were performed within IBM SPSS 29.0.2.0. Statistical significance was defined using a probability level of $P < 0.05$.

Results

The X^2 test found no significant difference in the age distribution of the Gloucester and Poulton samples. The series of X^2 tests identified no significant differences in the age distributions of Gloucester females and the three other subgroups.

Gloucester presented a non-significant but higher total frequency of each pathology compared to Poulton (Tab. 3). No significant differences (Tab. 4) were identified in the overall prevalence of each pathology between the two samples. Within both populations the prevalence of OA and SP did not differ significantly by sex (Tab. 5). SNs prevalence also showed no significant sex-based differences in Poulton, while, in Gloucester, a significantly higher prevalence of SNs in males than females was observed (Tab. 5). Sex-stratified interpopulation analyses found no significant differences in all pathologies between Gloucester and Poulton females; comparisons found no significant difference in both OA and SP prevalence between Gloucester and Poulton males, while in contrast, a significant difference was identified between Gloucester and Poulton males regarding SN prevalence (Tab. 6).

POPULATION	OSTEOARTHRITIS	SCHMORLS NODES	SPONDYLOSIS
Gloucester	10/30 (33.3%)	19/30 (63.3%)	28/30 (93.3%)
Poulton	9/30 (30%)	15/30 50%	24/30 (80%)

Tab. 3. *Total OA, SN and SP frequencies in Gloucester and Poulton.*

PATHOLOGY	POPULATIONS	N	n	X^2	DF	P-VALUE
OA	GLC POU	30 30	10 9	0.077	1	0.781
SN	GLC POU	30 30	19 15	1.086	1	0.297
SP	GLC POU	30 30	28 23	3.269	1	0.071

Tab. 4. *X^2 results of pathology prevalence and populations. Where «N» is the number of individuals analysed, and «n» is the number of individuals effected by the pathology.*

PATHOLOGY	POPULATIONS	N	n	X^2	DF	P-VALUE
OA	GLC	30 (15M/15F)	5M/5F	0	1	1.0
	POU	30 (15M/15F)	4M/5F	1.0	1	0.690
SN	GLC	30 (15M/15F)	13M/6F	7.003	1	0.008
	POU	30 (15M/15F)	8M/7F	0.133	1	0.715
SP	GLC	30 (15M/15F)	14M/14F	0	1	1.0
	POU	30 (15M/15F)	12M/11F	0.186	1	0.666

Tab. 5. *X^2 results of intrapopulation sex comparisons for each pathology. Where «N» is the number of individuals analysed, and «n» is the number of individuals affected by the pathology.*

PATHOLOGY	GLC Males	POU Males	X^2 (Males)	P- VALUE	GLC Females	POU Females	X^2 (Females)	P- VALUE
OA	5	4	0.159	0.690	5	5	0	1.0
SN	13	8	3.968	0.046	6	7	0.136	0.713
SP	14	12	1.154	0.283	14	11	2.160	0.142

Tab. 6. *X^2 results of sex-stratified interpopulation analyses.*

Discussion

Exploration into these two populations provided insight into potential differences in lifestyle and livelihood. Historically, Gloucester epitomises an urbanised and developing community, whereas Poulton characterises a more agrarian and modest population. Contrary to the initial expectations of this study, a comparison of the data on the incidence of OA, SN, and SP proved similar across both populations. The study observed no significant differences in the results regarding OA and SP prevalence in all comparison types. The main substantial result shows a significant difference in SNs distribution between Gloucester and Poulton males.

The initial observation of a non-significant but higher frequency of each pathology in urban Gloucester interestingly contrasts with the results of the study of Novak and Slaus (2011). Their research identified a remarkably higher prevalence of these pathologies within the rural sample of Koprivno,

Croatia, compared to urban Sisak, Croatia. However, this discrepancy could be attributed to the larger sample size and the older age profile of the Koprivno sample compared to the Sisak (Novak and Slaus, 2011). Further comparisons can be drawn regarding the higher prevalence of SNs in Gloucester males than in Poulton males, which challenges that of Saluja and colleagues (1986). Their research concluded a significantly higher frequency of SNs on the vertebrae of the 14th-century Aberdeen male population compared to the later 18th-19th century London male population sample, inferring that the Aberdeen population represented the more rural context. The contrasting results to our study may be attributed to methodological differences: Saluja and Colleagues (1986) recorded the number of SNs present, while this study considered only the presence or absence of SNs, questioning how directly the two studies can be compared.

The aetiology of OA has been suggested as multifactorial (Duncan, 2000), including links with age and mechanical trauma (Howell *et al*., 1976). Age is heavily emphasised as the leading factor of OA development, while also linked as a contributor to SP development (McKenzie, 2007). However, age appears less dominant in SP compared to OA, where instead, mechanical stress and spinal curvature are important in SP development (Van der Merwe, 2006). The observed results across all comparison types are not unusual when considering age as a leading aetiological factor of OA, as the study used age-specified samples of mid to older adults. The similar ages of the populations and subgroups may account for the similarity in OA prevalence due to comparable age-related degeneration. The OA results intriguingly contrast Larsen's (1997) statement that a more demanding lifestyle increases OA prevalence. It is important to note that a demanding lifestyle involving frequent physical activities, such as bending and lifting (Middleton and Fish, 2009), places stress on the intervertebral discs. This stress can weaken the intervertebral joints, ultimately contributing to the development of osteoarthritis (OA) and spondylosis (SP) due to mechanical trauma. Historically, it has been observed that daily life in rural areas was often more demanding and strenuous compared to urban settlements. The reliance on agriculture within Poulton to maintain income and resources would require a significant amount of manual labour, including ploughing, harrowing (Kowaleski, 2014) and threshing (Judd and Roberts, 1999), placing mechanical trauma and stress on the lumbar region. Gloucester did not reflect the same exposure through agricultural demands, as the urban population's materials and diets would have been produced rurally and transported to the urban centre (Lewis, 1999). From this perspective, the results are surprising; a higher prevalence of OA and SP within Poulton was expected, given the increased mechanical trauma of lumbar vertebrae associated with farming

practices.

It has been suggested that rural populations like Poulton provided a less clearly defined sexual division of labour, medieval women of an agrarian background were not discouraged from farming and construction practises (Bardsley, 1999). The equality in physical activity between sexes indicates that both males and females of Poulton were exposed to similar mechanical stress daily. Contrastingly, urban settlements like Gloucester experienced a well-defined sexual division of labour: with females working in the hospitality industry, servitude (Lewis, 2016) and retailing dairy, bread, and fish products (Jewell, 199). Meanwhile, males occupied various factories and trades, including plumbing, tanning, and butchery (Langton, 1977). Given the occupational differences between sexes, a disproportionate level of stress on the lumbar may be expected; however, this was not reflected in the results of the present study. The comparable prevalence of OA and SP between the sexes within Gloucester may indicate an underestimation of the physical exertion of the duties performed by women in urban environments, along with associated mechanical trauma to the lumbar region. The observed results suggest that despite differences in how physical labour was completed between sexes, frequent repetition of workload in both sexes through everyday lives imposed similar levels of mechanical stress. Thus, this challenges the preconception that females of urban medieval populations like Gloucester engaged in less physically demanding activities than males.

The males of both populations presented similar prevalence rates of OA and SP. Although the nature of labour within the male population differed – with Poulton males limited to farming and surrounding practises, and Gloucester males active in various trades – both subgroups were subjected to stress in the lumbar vertebrae through manual labour. While farming activities in rural areas are historically considered more mechanically strenuous, this does not support the fact that these tasks were more biomechanically taxing. The findings align with the societal expectation in medieval Britain, with males obligated to fulfil the role of conventional primary labourers (Bardsley, 1999), regardless of their geographical environment. In both urban and rural environments males faced high demands of intense physical labour, exposing them to repeated mechanical trauma. This shared responsibility between Gloucester and Poulton males may explain the comparable OA and SP prevalence. Similar results were observed among the females in the two populations. However, the difference in female duties has been already examined, suggesting that rural females maintained the household by carrying water, cooking, haymaking, and planting (Wilkinson, 2018), while the urban counterpart was employed in seam stressing, retail, and brewery (Wilkinson, 2018). There is a notable difference in the responsibilities of

women between the two populations analysed. However, it is not possible to conclude that one lifestyle caused more trauma to the lumbar region than the other. Despite these differences, both groups of women experienced occupational mechanical stress that led to similar development of lumbar osteoarthritis (OA) and spondylosis (SP).

The aetiology of Schmorl's nodes differs from the other pathologies, as age is not considered a contributing factor (Dar *et al*., 2009). It is suggested that SNs are not age-related lesions but develop in earlier years, including adolescence (Schmorl and Junghanns, 1971). SNs are frequently associated with acute and repeated trauma (Ustandag, 2009), genetic predisposition, and degenerative conditions (Brito and Santos, 2024). All routes of SNs development involve the weakening of the vertebral endplate, which is particularly observed in the lumbar region due to the biomechanical stress of everyday movement and activity (Plomp *et al*., 2012).

This study found a significantly higher prevalence of SNs in males than females in Gloucester. As a medieval town, Gloucester provided a range of occupational opportunities not available in Poulton, attracting young migrants of both sexes (Lewis, 2016). During the medieval period, employment typically began around the age of 12 (Lewis, 2016); female children entered domestic service or trained in crafts such as textiles and embroidery (Dinshaw and Wallace, 2003), while young males began apprenticeships in trades such as goldsmithing (Hanawalt, 1995). Both sexes were expected to partake in labour from an early age in urban environments, promoting SNs development from the physical demands of their occupations.

However, young males performed a variety of straining movements with an increased axial load (Judd and Roberts, 1999), resulting in continued mechanical trauma to the lumbar region; and ultimately a greater susceptibility to SNs development. In contrast, young females engaged in sedentary activities of the domestic setting, reducing exposure to mechanical trauma in the lumbar. This dissimilarity between sexes is reflected in the higher prevalence of SNs among Gloucester males. The lack of significant results regarding sex and SNs prevalence in Poulton is as expected considering the less distinct sexual division of labour. The similar SNs prevalence between sexes indicates that the shared occupational stress between sexes was established from early years, continuing into adulthood, with comparable trauma exposure to the lumbar throughout. Considering that SNs are not age progressive, this early equality in labour may explain the similar SNs prevalence between sexes in Poulton.

Males in Gloucester exhibited a significantly higher SNs prevalence than males in Poulton. In contrast, the similar results for OA and SP between the male subgroups may be attributed to similar prolonged mechanical stress

and age-related degeneration. The increased SNs prevalence in Gloucester may suggest greater exposure to repetitive or acute trauma at earlier ages compared to Poulton. A potential explanation for this dissimilarity could be the broader range of trades and crafts available to young males in urban centres like Gloucester. Medieval Gloucester was heavily involved in metal-working (Richardson, 2018) as well as numerous other trades of a typical medieval town. This occupational diversity may have created more opportunities for trauma to the lumbar region of males through stressful physical movements such as bending, lifting and rotation. In contrast, Poulton provided males with a reduced range of occupations. With labour limited to agricultural practises, opportunities for substantial and diverse trauma to the lumbar were reduced in comparison to Gloucester. While both male populations were subjected to mechanical trauma in their earlier years, the specific applications of this trauma varied between the populations, potentially explaining the observed difference in SNs prevalence between the males.

While the current study provides interesting insights that both challenge and support previous understandings, it is not without limitations. The relatively small sample size of 60 skeletons, while sufficient for statistical analysis, may not accurately represent the overall Gloucester and Poulton populations. The sample size was limited due to preservation issues and limited access to only a part of the collection dedicated to the teaching activities, potentially constraining the applicability of the study's interpretations. A second acknowledgement should be made regarding the biological profiles of the remains. The current study did not reassess the sex and ages of the remains analysed, rather the data was obtained from collection databases developed from previous research. Future studies may consider genetically reassessing the sex of the remains to reduce potential inaccuracies in subgrouping.

Conclusion

This research examined the prevalence of three vertebral pathologies in the medieval populations from Gloucester and Poulton. No significant differences in osteoarthritis and spondylosis prevalence were found between populations or by sex. However, Schmorl's nodes were significantly more common in Gloucester males, with additional sex-based differences observed within Gloucester. An expansion of sample sizes and employing alternative data collection methods could improve the reliability and applicability of this data. The results contrast with previous assumptions of a greater pathology prevalence in rural populations like Poulton through associations with an agrarian lifestyle. Instead, the results suggest that urban life in Gloucester presented a multifaceted and increased risk to vertebral health. Future

research should incorporate a broader range of factors contributing to vertebral health, including nutrition and socio-economic status, to enhance the understanding of the relationship between lifestyle and spinal health. Such investigations are essential, as the disparities in life and labour observed in these populations closely mirror those in contemporary communities. Consequently, this research provides valuable insights into the long-term implications of occupational, and lifestyle differences and offers valuable data for assessing potential future outcomes.

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