Author(s): C.E. Gillmana, A.L. KilBride, P. Ossent and L.E. Green

Article Title: A cross-sectional study of the prevalence and associated risk factors for bursitis in weaner, grower and finisher pigs from 93 commercial farms in England

Year of publication: 2008
Link to published version:
http://dx.doi.org/10.1016/j.prevetmed.2007.09.001
Publisher statement: None

A cross sectional study of the prevalence and associated risks for bursitis in 6250 weaner, grower and finisher pigs from 103 British pig farms

Gillman CE[a]*, KilBride AL[a], Ossent P[b] and Green LE[a]

[a]Ecology and Epidemiology Group, Department of Biological Sciences, University of Warwick, Coventry CV4 7AL

[b]Institute for Veterinary Pathology, University of Zürich, Winterthurerstrasse 268, CH-8057 Zürich, Switzerland

*Corresponding author. Tel.: +44 2476 572714; fax: +44 2476 524619.

Email address: c.gillman@warwick.ac.uk

Abstract

A cross-sectional study of 103 pig farms across Britain was carried out to estimate the prevalence and associated risks of bursitis. A total of 6250 pigs aged 6 to 22 weeks were examined for presence and severity of bursitis. Details of pen construction, pen quality and farm management were recorded including floor type, presence of bedding, condition of the floor and floor materials. The crude mean prevalence of bursitis was 40.6% and increased with age. Two-level logistic regression models were developed with the outcome as the proportion of pigs affected with bursitis in a pen. Pigs kept on soil floors with straw bedding were used as the baseline. In comparison to soil floors, the associated risk for bursitis increased on deeply bedded concrete floors (OR 4.6), deep/sparse bedded concrete floors (OR 3.7), part slatted floors (OR 8.0), sparsely bedded concrete floors (OR 9.0) and fully slatted floors (OR 18.7). Slip or skid marks in the dunging area (OR 1.5), pigs observed slipping during the examination of the pen (OR 1.3) and wet floors (OR 3.6) were also associated with an increased risk of bursitis. These results indicate that the associated risks for bursitis were a lack of bedding in the lying area, presence of voids and pen conditions which increased the likelihood of injury.

Keywords: Pig; Bursitis; Floor; Bedding; Logistic regression; Welfare

1. Introduction

Bursae are fluid-filled sacs that occur naturally throughout the body to decrease friction at points where muscles and tendons glide over bones (McFarland et al., 2000). Adventitious bursitis in pigs commonly arises below the hock joint on the lateroplantar, plantar and medial planes of the hind limbs and at a lower prevalence on the forelimbs. The bursal sac cavities are thought to disappear over time, leaving behind a mass of fatty connective tissue (Smith, 1993). It is undisputed that their development is associated with trauma (e.g. Smith, 1993; Lyons et al., 1995; Mouttotou et al., 1998a). Infection is not thought to play a primary role in the pathogenesis of bursitis (Marchant, 1980; Smith, 1993). Bursae are removed at the abattoir and also lead to the rejection of potential breeding stock.

Bursitis is a prevalent lesion amongst pigs in Britain; Mouttotou et al., (1999) reported a prevalence of 63.4% in a survey of 912 live pigs aged 8-28 weeks from 17 farms. A range of values for the prevalence of bursitis have been estimated from abattoir surveys of finished pigs; 51% of 3989 pigs on 21 units in south-west England (Mouttotou et al., 1998a), 73.4% of 11811 pigs from one abattoir in Somerset (Penny & Hill, 1974), 85.4% of a cohort of 672 pigs from one farm in Somerset (Mouttotou et al., 1998b) and 87% of 14046 pigs from 5 abattoirs supplied by 146 farms in Scotland (Smith, 1993).

Previous evidence has indicated that bursitis is more common (Mouttotou et al., 1999) and more severe (Bäckström & Henricson, 1966) in older pigs and prevalence and severity of bursitis are associated with a hard environment that increases pressure and impact on pigs’ limbs (Smith, 1993; Lyons et al., 1995; Mouttotou et al., 1998a). One hypothesis is therefore that bursitis forms whilst pigs are lying (Mouttotou et al., 1998a).

Mouttotou et al., (1998a) reported that pigs kept on solid concrete floors with deep bedding had the lowest prevalence of bursitis, followed by pigs kept on solid concrete with sparse bedding, then those on part slatted floors and finally, fully slatted floors. Slatted floors have a smaller surface area and therefore provide less support for the weight of the pig when lying (Mouttotou et al., 1998a). In addition, pigs spend a greater proportion of time lying inactive on slatted floors compared with straw floors (Guy et al., 2002b; Scott et al., 2006) possibly because pigs on slatted floors tend to be more highly stocked. Smith (1993) reported an increased risk of bursitis with more closely stocked pigs. Slat material may also be important; metal bars have been associated with a higher prevalence of bursitis than plastic-coated bars (Smith, 1993). The presence of slats indicates a lack of bedding and Mouttotou et al., (1999) concluded from 17 farms that the use of bedding, particularly in the lying area, was associated with a reduced prevalence of bursitis by decreasing the pressure on the weight-bearing surfaces of the pig when lying.

Factors relating to the ease with which pigs move around their pen are also important. Steps and wet or slippery floors (Mouttotou et al., 1999), altered posture (Berner et al., 1990) and rough or damaged floors (Lahrmann et al., 2003) have been associated with an increased prevalence of bursitis.

There are intrinsic factors associated with the susceptibility of individual pigs to bursitis. Pigmented pig breeds (either Chinese Meishan pigs or Duroc x Landrace x Hampshire cross) were less susceptible to bursitis than non-pigmented pig breeds (Landrace x Large White) reared in comparable conditions (Smith & Morgan, 1994). Pigmented pig breeds tend to have greater amounts of subcutaneous fat (Penny &

Hill, 1974, Smith & Morgan 1994) and thicker skin (Smith & Morgan 1994) than non-pigmented pig breeds. Pigmented pig breeds are likely to be kept outdoors on soil and therefore not exposed to voids and hard surfaces. Guy et al., (2002a) reported no additional effect of breed once floor type had been accounted for.

In the past, bursitis was not thought to be associated with restricted movement and reduced welfare (Bäckström & Henricson, 1966; Orsi, 1967) however, more recent research by Berner et al., (1990) indicated that bursitis may be associated with abnormal posture of the hind limbs. An association has recently been established between bursitis and abnormal locomotion in finishing pigs using the same data as this current study (Green et al., in preparation). This is one of the first indications that bursitis may have a detrimental effect on pig welfare.

The majority of previous work has viewed capped hock; a bursa occurring on the point of the hock (tuber calcanei), as the same lesion to bursitis in the more distal sites of the hind leg. Although it is an adventitious bursa, more recent work has indicated that risk factors for bursitis in the other localisations are different from those of capped hock (KilBride et al., submitted). Therefore, unlike previous studies (e.g. Mouttotou et al., 1998a; Mouttotou et al., 1999) the prevalence and associated risks reported here exclude capped hock. This paper presents an estimate of prevalence from 93 pig farms representative of the English pig population (Woodbine et al., submitted) and associated risks of bursitis from 103 British pig farms. Population attributable fractions are used to estimate by how much the % of affected pigs would be reduced if a risk factor for bursitis were removed from the population.

2. Materials and methods

2.1. Study population

2.1.1. Farm selection

A total of 549 pig farms from England and Wales were randomly selected from the NPA (National Pig Association) database which holds data on approximately 85% of the national pig herd. The criteria for selection from this database were breeder to finisher farms with more than 100 breeding sows. Of the 549 pig farmers contacted, 101 agreed to take part, of which 7 were used in a pilot study to test the scoring systems and to train observers. The remaining 94 farms were used in the main study. A further 9 farms were non-randomly selected for participation; 5 farms in Scotland were recruited by QMS (Quality Meat Scotland) and 4 farms in England were recruited via their veterinarian.

2.1.2. Pig selection

On each farm, one pen containing pigs of each of the following ages was randomly selected; 6 and 8 weeks (weaners), 10, 12 and 14 weeks (growers) and 18 and 22 weeks (finishers). When the sample ages were not available the nearest age was selected. If there were less than 10 pigs in the pen, all animals were examined, if there were more, 10 pigs were randomly selected.

2.2. Examination of pigs

All four limbs were examined for evidence of bursitis while the pig moved freely around the pen. Severity of individual bursae was scored 0-3 as follows; 0 = no visible swelling, 1 = <25% swelling, 2 = 25-50% swelling and 3 = >50% swelling in comparison with the size of the carpal/tarsal joint. This was adapted by the scoring system developed by Mouttotou *et al.,* (1998a). Mouttotou *et al.,* used absolute size of bursa to measure severity, but as this does not take account of the size of the pig, a relative measure was devised. When there was more than one bursa on the same limb, only the most severe was scored. Recordings were made on the number of pigs in the pen, how long pigs had been in the pen and whether pigs were seen slipping on the floor whilst the pen was observed. Eight observers scored the pigs.

2.3. Examination of the environment

Data were collected on the condition and construction of the pen. The following construction data were recorded; pen dimensions, pen design (width restrictions and steps), floor type (slatted, part slatted or solid), floor material (concrete, metal or plastic), slat dimensions (slat and void width and length) and slat characteristics (slat surface, slat profile, and void shape). In addition, observations were made on the condition of the floor and bedding (depth, cleanliness and dryness). Bedding depth was recorded as either deep (the whole pen was covered with bedding and none of the floor was visible), deep/sparse (only part of the pen was deeply bedded, the rest was either sparse or completely bare) or sparse (there was only a thin layer of bedding and the floor was clearly visible). The condition of the floor was scored as presence/absence of wetness, wear, sharp edges, damage, wet slurry, dry slurry, fresh dung and slip marks in four key pen areas. These areas were the lying and dunging areas and under the feeder and drinker; 11 observers recorded data on the pen characteristics.

2.4. Interview with farmer

A detailed interview was conducted with each farmer at the time of the farm visit. Information was obtained on herd size and breed lines. Breed was used to create a binary, farm-level variable for pigmented/non pigmented pig breeds. Farms were classified as using pigmented pig breeds if there was Hampshire, Duroc or Meishan in their breed lines.

2.5. Data analysis

2.5.1. Data entry checking

Data were entered into Microsoft Access 2003 databases by research assistants and a professional data entry company. The databases were checked for errors and outliers and any obvious incorrect codes were re-checked against the raw data.

In order to calculate the prevalence of bursitis, all pigs from non-randomly selected farms and the single Welsh farm were excluded to provide an estimate of the prevalence in England (n = 93). Prevalence was calculated as:

$$\frac{\text{No. of pigs affected with bursitis}}{\text{No. of pigs examined on randomly selected farms}}$$

2.5.2. Bursitis prevalence

A pig was defined as affected with bursitis if at least one lesion greater than score 0 was present on at least one of the four limbs. The sample of pigs examined in each pen was used to calculate the outcome variable, which was estimate of proportion of pigs affected within each pen, as follows;

$$\frac{\text{No. of pigs with bursitis per pen sample}}{\text{No. of pigs examined per pen (max.10)}}$$

2.5.3. Logistic regression

The outcome was proportional data at pen level as there were no predictor variables measured at pig level. Pens within farms had a lower variance than equivalent pens within different farms. To account for the clustering of both pigs within pens and pens nested within farms, a 2-level binomial logistic regression model was used. A binomial model was used instead of a general linear model as severity score was not a continuous outcome with a normal distribution. MLwiN version 2.01 (Rasbash et al., 1999) was used for all multilevel analysis. All non-randomly selected farms were included (n=103).

Many of the pen variables were correlated with floor type e.g. the presence of width restrictions and steps were associated with part slatted floors. It was therefore necessary to analyse sections of the data separately. As the presence of bedding and slats were mutually exclusive, the floor data were split into two groups; slatted or part slatted (and consequently non-bedded) floors (model A) and solid floors with bedding (model B). Pen design and pen construction variables were investigated with the full data set (model C).

Since presence of bedding was highly correlated with solid floors, a 6-level variable was created that combined floor type and bedding depth. Solid floored pens were divided into soil floored pens (outdoor), deeply bedded concrete floors, deep/sparse bedded concrete floors and concrete floors with sparse or no bedding. All non-soil solid floors were made from concrete. The majority of soil floors were deeply bedded and therefore soil floors were not split by bedding depth. Slatted floors were categorised into part slatted or fully slatted.

The prevalence of bursitis increased with age and age was a strong confounder with many pen construction variables e.g. concrete slats were mainly used for finishing pigs. Age was therefore included as a continuous variable throughout the initial (bivariable) investigations. Herd size and the number of pigs in pens were added to the models to check for any confounding.

All models were built using the same process; all continuous variables were checked for linearity and categorised into 5 groups if non-linear. Variables that were significant at $p<0.2$ in the bivariable analysis were taken forward to the multivariable stage (Dohoo *et al.,*, 2003 p.321-322). Models A, B and C were initially built for each age group separately (weaners, growers and finishers) to establish any variables important by age.

When a pair of variables were correlated the most biologically plausible variable was selected. Both forward and backward elimination were used (Dohoo et al., 2003 p.327-328) and variables were retained when they improved the model fit by $p<0.05$. Finally all remaining variables were re-introduced in the model to check for residuals confounding (Cox & Wermuth, 1996). The model took the form:

$$Y_{ij} = \beta 0 + \sum \beta n X_{ij} + \sum \gamma n X_j + v0_j + u0_{ij}$$

Where $\beta 0$ is the intercept, β = coefficients for X_{ij}, X_{ij} = variables varying between pens, γ = coefficients for X_j, X_j = variables varying between farms, $v0_j$ = residual error between farms, $u0_{ij}$ = residual error of the model.

The fit of model A was checked using the Hosmer Lemeshow goodness-of-fit statistic (Dohoo *et al.*,, 2003 p360-361).#

2.5.4. Population attributable fractions

Population attributable fractions were calculated (Dohoo et al., 2003 p.128) to estimate the proportion of affected pigs with bursitis that would be reduced if a particular risk factor was removed and the pigs were housed instead on the baseline with the lowest prevalence of bursitis. Population attributable fractions (expressed as a percentage) were calculated for all variables significant in the final model, either within age groups or for the whole dataset, depending on whether age was an important confounder of that variable. The calculation was as follows (Dohoo et al., 2003 p. 128-130):

$$AF_p = [RD * p(E+) / p(D+)]*100$$

Where AF_p is the population attributable fraction (expressed as a percentage), RD is the risk of bursitis in the exposed group minus the risk of bursitis in the unexposed group, p(E+) is the proportion of pigs on each floor type and p(D+) is the proportion of pigs with bursitis on each floor type.

2.6. Pathology

Nine pigs of 9 to 16 weeks were selected from two farms (five from a farm with fully solid concrete floors with bedding and four from a farm with fully slatted concrete floors). Two bursitis lesions from each severity score and two controls were collected from each farm. Gross and histo- pathological examinations were carried out on each lesion.

3. Results

3.1. Summary of the data

6250 post-weaning pigs from 646 pens on 103 farms in Britain were examined between 23rd September 2003 and 2nd August 2004. Of these farms, 21 (20.4%) reared at least some stages of pigs outdoors. There were 58 pens with a soil floor (9.0%), 249 pens (38.5%) with a solid floor, 162 pens (25.1%) that were part slatted and 175 (27.1%) were fully slatted. 283 (43.8%) solid pens had bedding. A median of 64 pigs were sampled from each herd (range 19-70). There was no difference between observers for the mean bursitis score by pen type. Three farms had less than 100 sows due to changes in circumstance since publication of the NPA database. The median herd size was 317 breeding sows (range 20-2300) and the median group size (number of pigs in the pen) was 30 (range 5-400). The sample of farms was representative of Britain in both farm size and distribution (Woodbine et al., in press) and the proportion of outdoor and indoor pigs and herds.

3.2. Prevalence of bursitis

The overall prevalence of pigs affected with bursitis in randomly selected farms in England was 40.6% of 5561 pigs, ranging from 0-92.5% per farm and 0-100% per pen. Bursitis increased with age (OR 1.1) both in prevalence and severity (Figure 1), reaching a maximum prevalence of 59.3% in 732 pigs at 22 weeks of age. 50.0% of all pigs with bursitis had a maximum severity score of 1, 36.4% had a score of 2 and 13.5% had a score of 3 on any one leg.

3.3. Associated risks for bursitis

Sub-models were created to examine the risk factors within slatted pens only (model A; Table 1), and bedded pens only (model B; Table 2) before creating a model which encompassed all pens (model C; Table 3). Within model C, using soil floors as the baseline for comparison, there was an increased prevalence of bursitis associated with all other floor types; deeply bedded concrete floors (OR 4.6), deep/sparse bedded concrete floors (OR 3.7), sparsely bedded concrete floors (OR 9.0), part slatted floors (OR 8.0) and fully slatted floors (OR 18.7) (Table 3). An average of 61.5% of the pigs on fully slatted floors were affected with bursitis compared with 4.4% on soil floors (Figure 2). Estimates of population attributable fractions indicated that housing pigs on soil floors instead of fully slatted floors would result in between 32.1% and 45.7% reduction in the prevalence of bursitis depending on age (Table 5). When compared with a baseline of deeply bedded concrete floors there was no significant difference in the risk of bursitis in pens with deep/sparse bedded concrete floors. However there was a significant increase in risk associated with sparsely bedded concrete floors (OR 1.9). In addition, fully slatted floors (OR 2.3) were associated with a greater risk of bursitis than part slatted floors.

In pens containing slats (model A), there was a significant increase in bursitis prevalence associated with metal slats (OR 1.7) in comparison with concrete slats. However, there was no significant difference between plastic slats and either metal or concrete slats (Table 1). Slat material was correlated with other slat characteristics e.g. concrete slats tend to have the smallest void to slat ratio (18.4% void), the largest void area (203cm^2), a flat slat profile and sharp edges (Table 4).

When the data were grouped by age, the same association was seen between bursitis and floor/bedding type within the growers and finisher age groups. This was not seen for weaners, where soil floors were not associated with a significantly lower prevalence of bursitis compared with solid concrete floors with deep or deep/sparse bedding.

Additional factors associated with an increased risk of bursitis were; pigs observed slipping during the visit (OR 1.3), slip or skid marks in the dunging area (OR 1.5), wear/visible aggregate in the pen (OR 1.3) and food on the floor of the lying area (OR 1.6) (Table 3). On deeply bedded and soil floors, pigs were rarely observed slipping (12.2% and 14.0% of pens respectively), compared with sparsely bedded (53.7%), part slatted (56.1%) and fully slatted floors (51.9%). In farms where wet food was provided, the average proportion of slip and skid marks rose by 11.6% in weaners, 15.6% in growers and by 27.4% in finishers. Within the weaner age group, the only significant factors associated with bursitis were floor type and bedding; pen conditions at this early age were not significantly associated with bursitis.

Within slatted pens (model A), wear/visible aggregate under the feeder (OR 1.7) was associated with a greater prevalence of bursitis (Table 1). Within solid floor pens with bedding (model B), pens where there was fresh dung under the drinker were associated with a reduced risk of bursitis (OR 0.6) as were pigmented pig breeds (OR 0.4). Pigmented pig breeds were associated with a reduced risk of bursitis for both growers and finishers, but there was no effect within the weaner age group. 59% of outdoor pens contained pigmented pig breeds. There was a greater risk of bursitis in bedded pens when the floor was wet (OR 3.6) or damaged (OR 1.6) (Table 2). Wet floors were most common in sparsely bedded pens (100% of pens) and least common in soil pens (77% of pens).

Herd size and group size (number of pigs in the pen), stocking density and time in the pen had no significant effects in the models and therefore did not affect the accuracy of the prevalence estimate. The Hosmer Lemeshow statistic was non-significant, indicating a good fit between the model and the data ($\chi^2 = 0.904$, $p>0.5$).

3.4. Pathology

On examination of the lesions, 12 had a lumen and remnants of slight older haemorrhage. Some had scattered inflammatory cells in the bursal wall (Figures 3 and 4). Two (clinical score 3) had no bursal sac, instead there were large solid areas of connective tissue (Figure 5). When examining the live pigs there was no discernable difference on palpation of the swellings with and without bursal sacs. There was no indication of a difference in the pathological severity of the lesions by clinical size.

4. Discussion

The mean prevalence of bursitis from the random sample of units was 40.6%; this is possibly the most accurate prevalence estimate to date for weaner-finisher pigs on commercial farms in England. The 93 randomly selected farms were representative of the overall population of pig farms in England in both size and geographical distribution (Woodbine et al., in press). This allowed population attributable fractions to be calculated to estimate the effect of the associated risks in the population, assuming that the associated risks were causal. A prevalence of 63.4% (which included capped hock) was recorded in the only other comparable research on bursitis in live pigs (Mouttotou et al., 1999). However, the capped hock prevalence was only 0.7% and therefore unlikely to explain this difference in bursitis prevalence. The work by Mouttotou et al., (1999) involved 17 farms in the south-west of England all serving 1 abattoir and was not representative of pigs in England in geographical distribution. Only the grower and finisher age groups were examined which is likely to account for the greater prevalence.

However, there may have been a sampling bias in this study towards farms with higher health and welfare standards as the sampling frame was farms belonging to an assurance scheme and participation in the study was voluntary. Any bias should be minimal due to the high proportion of all farms belonging to the NPA. Although the prevalence may be accurate for commercial farms with over 100 sows, the prevalence on smaller farms may differ.

The associated risks for bursitis can be considered in terms of floor type and floor condition. The relationship between floor type and bedding with the risk of bursitis indicated that slatted floors and floors with little or no bedding were both associated with an increased prevalence of bursitis. Whether deep bedding is throughout the pen or just in the lying area had no significant effect on the associated risk of bursitis, whereas having sparse bedding in the lying area was associated with a significantly greater risk of bursitis, implying that these lesions may be a response to lying rather than walking on a hard surface. Soil floors may provide a softer lying surface compared with concrete floors over and above the effect of deep bedding. However, there may have been some confounding between pigs kept outdoors on soil and pigs with pigmented skin. There was a protective effect of pigmented pig breeds observed within bedded pens (model B), possibly indicating a small protective effect from the cushioning provided by greater amounts of fat and thicker skin compared with non-pigmented in outdoor conditions, but this effect was not consistent across all floor types or all ages. However, Guy et al., (2002a) conducted a thorough investigation of breed and reported that it had little effect on bursitis prevalence.

Fully slatted floors (and therefore a slatted lying area) were associated with a greater risk of bursitis than part slatted floors (and therefore a solid lying area) indicating that lying on slats was associated with a risk of bursitis over and above that of lying on a hard floor. Slatted floors provide a smaller surface area on which to distribute weight and therefore put additional pressure on the parts of the pig in contact with the floor. It may be for this reason that concrete slats are associated with a lower prevalence of bursitis compared with metal. Concrete slats also had the smallest void to slat ratio. However, slat material dictates the majority of other slat properties (Table 4) and so it is possible that it was not surface area, but one of the other properties that were associated with bursitis. Older pigs are more likely to be kept on slats which may account for the increase in prevalence with age, in conjunction with a greater body weight exerting additional pressure on the limbs and a greater proportion of time spent lying (Ekkel et al., 2003). The lack of difference within the weaner age group between soil floors with bedding and deeply bedded concrete floors may indicate that, providing the bedding is deep, the surface underneath makes little difference due to the lower body weight of weaner pigs.

A positive association between the number of pigs seen slipping and the presence of slip and skid marks with the prevalence of bursitis indicated an association between bursitis and injury. An increased risk of bursitis associated with slip and skid marks in the dunging areas indicated that slipping and injury may be occurring in areas likely to be slatted and where pigs are walking rather than when getting up or lying down. The fact that pigs were less commonly seen slipping on deep bedding may indicate that bedding adds some degree of friction to a surface. Pigs were also more frequently observed slipping on concrete slats compared with metal or plastic – however pigs observed slipping during the visit were adjusted for in model A and so it is possible that the extra support provided by a larger slat surface area, and a smaller total proportion of void area outweighs any negative effect of slipperiness on concrete slats. Wet solid floors may prove hazardous as the lack of drainage may make them particularly slippery. Feed on the floor, particularly liquid feed, may also increase the difficulty of walking on a surface. Factors associated with damage to the floor such as a worn floor under the drinker or damage in bedded pens may contribute to the likelihood of injury or may be associated with an increase in bursitis as a direct result of lying on these surfaces. It may also be possible that these uneven surfaces cause damage to feet which leads to a greater proportion of time spent lying (Mouttotou *et al.*,, 1998a). The mechanism by which fresh dung under the drinker was associated with reduced prevalence of bursitis is unclear and it may be that this variable was correlated with another variable that was not measured in this study.

Previous research has reported that stocking density (Smith, 1993) and a step of >3cm between the solid and slatted areas (Mouttotou et al., 1999) are associated with an increased risk of bursitis. However, neither of these variables were significant in this study. It may be that there is no longer as much variation in stocking density that was observed in 1993 and therefore any effect on prevalence may be difficult to detect. A step in the pen may have been acting as a proxy for floor type as steps are most common on part slatted floors; making the actual effect of a step hard to distinguish.

Some variables in the models (e.g. pigs observed slipping during the examination of the pen) had odds ratios with confidence intervals touching unity. Although this means that we can not be so certain about their effect, the fact that these variables tended to be the less robust ones and still show significance was remarkable and meant that the variables were included in the models.

Two principal hypotheses emerged from this paper on the possible causes of bursitis. One is that bursitis occurs whilst lying; as a response to floors without bedding and floors with a reduced surface area to support the weight of the pig. The second is that bursitis is a result of injuries from knock and bumps incurred whilst moving around the pen. A combination of both hypotheses is possible.

Whether bursae arise as a protective response to pressure and/or impact, or have a negative effect on pig welfare is not clear (e.g. Bäckström & Henricson, 1966; Orsi, 1967). The association between bursitis and gait score (Green et al., in preparation) indicates that these swellings may be associated with discomfort or may be a correlate for other factors causing poor gait (Moutottou et al., 1998a). The position (in an area where there is no restriction on the bursa size) and nature of the bursae suggest that they may not be particularly painful. This indicates that the bursal lesions were unlikely to have been associated with poor gait in this study. Regardless of their function and level of discomfort caused, bursae are not a normal part of the anatomy and cause a loss to the pig industry from the removal of the lesions at slaughter and the rejection of potential breeding animals. Cohort and intervention studies investigating the development of these lesions would be of considerable use to investigate aetiology and pathogenesis of bursae.

5. Conclusion

The current estimate for bursitis in England was 40.6%. This highly prevalent lesion may have important welfare consequences. When compared with the baseline of soil floors with bedding, concrete floors with deep bedding and floors where no deep bedding was available in the lying area were associated with an increasingly greater risk of bursitis. A fully slatted lying area was associated with a greater risk of bursitis than a solid lying area. Factors which may result in the pig slipping and injuring itself were also associated with a greater risk of bursitis. Although these risk factors have been alluded to in past research, this is the first study to find so many similar factors important. Population attributable fraction calculations indicated the importance of some of these factors in the development of bursitis.

Acknowledgements

We thank the farmers and veterinarians who kindly agreed to participate in the project. The field technicians and research staff who helped in collecting the data; Jane Slevin, Kerry Woodbine, Megan Turner, Emma Novell, Charlotte Boss, Fiona Boyd, Martin Crockett, Maureen Horne, Lucy Wilson and Bart van den Borne.

This project was funded by Department for Environment, Food and Rural Affairs project number AW1021.

References

Bäckstöm, L., Henricson, B., 1966. Studies of adventitious bursitis of the hock in pigs. Nord. Vet. Med. 18, 305-313. ABSTRACT ONLY

Cox, D.R., Wermuth, N., 1996. Multivariate dependencies: Models, analysis and interpretation. Publisher Chapman & Hall. ISBN 0-412-75410-X.

Dohoo, I., Martin, S.W., Stryhn, H., 2003. Veterinary Epidemiologic Research, Publisher AVC. ISBN 0-919013-41-4.

Ekkel, E.D., Spoolder, H.A.M., Hulsegge, I., Hopster, H., 2003. Lying characteristics as determinants for space requirements in pigs. App. Anim. Behav. Sci. 80, 19-30.

Green, L.E., Gillman, C.E., KilBride, A.L. Associations between poor locomotion and severity of limb lesions in finishing pigs (in preparation).

Guy, J.H., Rowlinson, P., Chadwick, J.P., Ellis, M., 2002a. Health conditions of two genotypes of growing-finishing pig in three different housing systems: implications for welfare. Livestock Production Sci. 75, 233-243.

Guy, J.H., Rowlinson, P., Chadwick, J.P., Ellis, M., 2002b. Behaviour of two genotypes of growing-finishing pig in three different housing systems. App. Anim. Behav. Sci. 75, 193-206.

KilBride, A.L., Gillman, C.E., Green, L.E. A cross sectional study of the prevalence and associated risks for capped hock and the associations with bursitis in 6,200 weaner, grower and finisher pigs from 103 British pig farms (submitted).

Lahrmann, K.H., Steinberg, C., Dahms, S., Heller, P., 2003. Prevalence of herd specific factors and limb disorders, and their associations in intensive swine production. Berl. Münch. Tierärztl. Wochenschr. 116, 67-73.

Lyons, C.A.P., Bruce, J.M., Fowler, V.R., English, P.R., 1995. A comparison of productivity and welfare of growing pigs in four intensive systems. Livestock Prod. Sci. 43, 265-274.

Marchant, B.A., 1980. Survey of Hind Limb Bursitis and Arthritis in Slaughtered Pigs. State Vet. J. 35, 122-129.

McFarland, E.G., Mamanee, P., Queale, W.S., Cosgarea, A.J., 2000. Management of Olecranon and Pre-patellar Bursitis in Athletes. The Physician and Sports Medicine 28, 40-52.

Mouttotou, N., Hatchell, F.M., Green, L.E., 1998a. Adventitious bursitis of the hock in finishing pigs: prevalence, distribution and association with floor type and foot lesions. Vet. Rec. 142, 109-114.

Mouttotou, N., Sterry, J., Green, L.E., 1998b. Cohort study of the association between adventitious bursitis of the hock and the age at slaughter and carcase quality of the pigs on one farm. Vet. Rec. 142, 52-55.

Mouttotou, N., Hatchell, F.M., Green, L.E., 1999. Prevalence and risk factors associated with adventitious bursitis in live growing and finishing pigs in south-west England. Prev. Vet. Med. 39, 39-52.

Orsi, A., 1967. The occurrence of swelling of the hock region in white pork breeds. Magyar Allatorvosok Lapja. 22, 271-274.

Penny, R.H.C., Hill, F.W.G., 1974. Observations of some conditions in pigs at the abattoir with particular reference to tail biting. Vet. Rec. 94, 174-180.

Scott, K., Chennells, D.J., Campbell, F.M., Hunt, B., Armstrong, D., Taylor, L., Gill, B.P., Edwards, S.A., 2006. The welfare of finishing pigs in two contrasting housing systems: Fully-slatted versus straw-bedded accommodation. Livest. Sci. (in press)

Smith, W.J., 1993. A study of adventitious bursitis of the hock. DVM&S thesis, University of Edinburgh, UK.

Smith, W.J., Morgan. M., 1994. The Relationship between adventitious bursitis of the hock, breed and heritability. Proceedings of the 13th IPVS Congress, Bangkok, Thailand.

Berner, H., Hermans, W., Papsthard, E., 1990. Diseases of the hind legs on pigs with regard to bursitis and their relation to the type of floor. Berl. Münch. Tierärztl. Wochenschr. 103, 51-60.

Woodbine, K.A., Medley, G.F., Slevin, J., KilBride, A.L., Novell, E.J., Turner, M.J., Keeling, M.J., Green, L.E. A pig farm retrospective cohort study of hazards for breakdown with post-weaning multisystemic wasting syndrome. (in press).

Table 1

Model A: 2-level binomial logistic regression model for the associated risks for bursitis with the outcome of proportion of pigs per pen with bursitis; where pens have either part slatted or fully slatted floors

	n	%	b	SE	OR	CI	*P*
Constant			-2.99	0.37			
Age (weeks)	5-23		0.18	0.02	1.2	1.1-1.2	*<0.001*
Floor type							
Part slatted[a]	142	46					
Fully slatted	157	62	0.77	0.15	2.2	1.6-2.9	*<0.001*
Slatted floor material							
Concrete[a]	117	68					
Plastic	121	48	0.31	0.22	1.4	0.9-2.1	
Metal	61	42	0.55	0.24	1.7	1.1-2.8	*<0.05*
Pig seen slipping							
No[a]	134	49					
Yes	165	59	0.30	0.14	1.4	1.0-1.8	*<0.05*
Wear or visible aggregate under feeder							
No[a]	258	52					
Yes	41	69	0.51	0.20	1.7	1.1-2.5	*<0.05*

[a]Reference category

Number of pens in each exposure (n), percentage of pigs affected (%), coefficients (b), standard errors (SE), risk ratios (OR) and 95% confidence intervals (CI)

Table 2

Model B: 2-level binomial logistic regression model for the associated risks for bursitis with the outcome of proportion of pigs per pen with bursitis; where pens have fully solid, bedded floors

	N	%	b	SE	OR	CI	*P*
Constant			-2.39	0.41			
Age (weeks)	5-22		0.64	0.02	1.9	1.8-2.0	*<0.001*
Floor/Bedding							
Soil[a]	39	6					
Solid concrete / Deep bedding	77	26	1.51	0.40	4.5	2.0-10.1	*<0.001*
Solid concrete / Deep/sparse bedding	64	29	1.52	0.39	4.6	2.1-10.0	*<0.001*
Solid concrete / Sparse bedding	38	51	2.26	0.42	9.6	4.1-22.2	*<0.001*
Pigmented breed							
No[a]	106	39					
Yes	112	17	-0.87	0.27	0.4	0.2-0.7	*<0.05*
Fresh dung under drinker							
No[a]	146	29	0.00	1.00			
Yes	72	24	-0.46	0.18	0.6	0.4-0.9	*<0.05*
Wetness on the floor of the pen							
No[a]	25	10	0.00	1.00			
Yes	193	30	1.27	0.32	3.6	1.9-6.8	*<0.001*
Damage on the floor of the pen							
No[a]	185	27	0.00	1.00			
Yes	33	32	0.54	0.21	1.6	1.0-2.4	*<0.05*

[a]Reference category

Number of pens in each exposure (n), percentage of pigs affected (%), coefficients (b), standard errors (SE), risk ratios (OR) and 95% confidence intervals (CI)

Table 3

Model C: 2-level binomial logistic regression model for the associated risks for bursitis with the outcome of proportion of pigs per pen with bursitis for all pens

	N	%	b	SE	OR	CI	*P*
Constant			-2.54	0.21			
Age (weeks)	5-23		0.11	0.01	1.1	1.1-1.1	*<0.01*
Floor/Bedding							
Soil[a]	45	6					
Solid concrete / Deep bedding	77	24	1.53	0.34	4.6	2.3-9.1	*<0.01*
Solid concrete / Deep/sparse bedding	67	31	1.31	0.34	3.7	1.9-7.3	*<0.01*
Solid concrete / Sparse bedding	45	52	2.20	0.36	9.0	4.4-18.5	*<0.01*
Part slatted / No bedding	149	47	2.08	0.33	8.0	4.1-15.5	*<0.01*
Fully slatted	144	64	2.93	0.32	18.7	9.9-35.5	*<0.01*
Pig seen slipping							
No[a]	313	34					
Yes	214	55	0.24	0.12	1.3	1.0-1.6	<0.05
Food on the floor in the lying area							
No[a]	496	42					
Yes	31	60	0.47	0.22	1.6	1.0-2.5	<0.05
Slip/skid mark on floor in dunging area							
No[a]	433	39					
Yes	94	59	0.42	0.15	1.5	1.1-2.1	<0.05
Wear or visible aggregate on pen floor							
No[a]	327	39					
Yes	200	50	0.27	0.11	1.3	1.1-1.6	<0.05

[a]Reference category

Number of pens in each exposure (n), percentage of pigs affected (%), coefficients (b), standard errors (SE), risk ratios (OR) and 95% confidence intervals (CI)

Table 4

Properties of the three different slat materials

	Concrete slats	Plastic slats	Metal slats
N	132	128	64
Void size cm^2: median (Q1-Q3)	203 (147, 264)	8.5 (5.8, 9.1)	8.4 (6.9, 14.3)
Void width cm: median (Q1-Q3)	2 (2-2.28)	1 (1-1.1)	1 (1-1.4)
Void length cm: median (Q1-Q3)	104 (77.6-120)	8 (6-9)	7.5 (7-8.5)
Percentage void in the slatted area: median (Q1-Q3)	18.4 (17.0, 21.4)	41.1 (34.5, 44.4)	55.6 (46.6, 68.8)
Flat slat profile (%)	81.0	82.1	42.1
Sharp slat edge (%)	51.8	9.9	3.6
Pigs seen slipping (%)	58.3	49.2	42.2

Table 5

Population attributable fractions expressed as percentages for model C for all randomly selected farms in England. Values give the proportion by which the number of affected pigs would be reduced by if the variable were removed from the population and the pigs housed on the reference category condition

Floor/Bedding	Weaners	Growers	Finishers	All ages
Soil[a]				-
Solid concrete / Deep bedding	2.2	9.9	5.8	-
Solid concrete / Deep/sparse bedding	1.2	8.1	12.6	-
Solid concrete / Sparse bedding	7.8	9.0	16.2	-
Part slatted / No bedding	31.1	26.1	25.3	-
Fully Slatted	45.7	32.1	40.1	-
Pigs seen slipping: No[a]	-	-	-	
Yes	-	-	-	18.0
Food on the floor of the lying area: No[a]	-	-	-	
Yes	-	-	-	26.0
Slip/skid marks on floor in dunging area: No[a]	-	-	-	
Yes	-	-	-	71.5
Wear or visible aggregate on pen floor: No[a]	-	-	-	
Yes	-	-	-	13.0

[a]Reference category

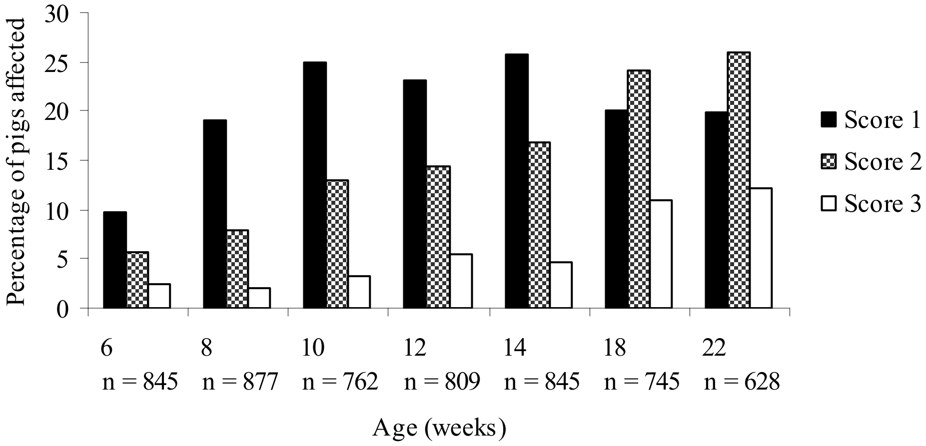

Fig. 1.

Percentage of pigs at each age group affected with bursitis of different severities on randomly selected farms

93 farms 579 pens 5511 pigs

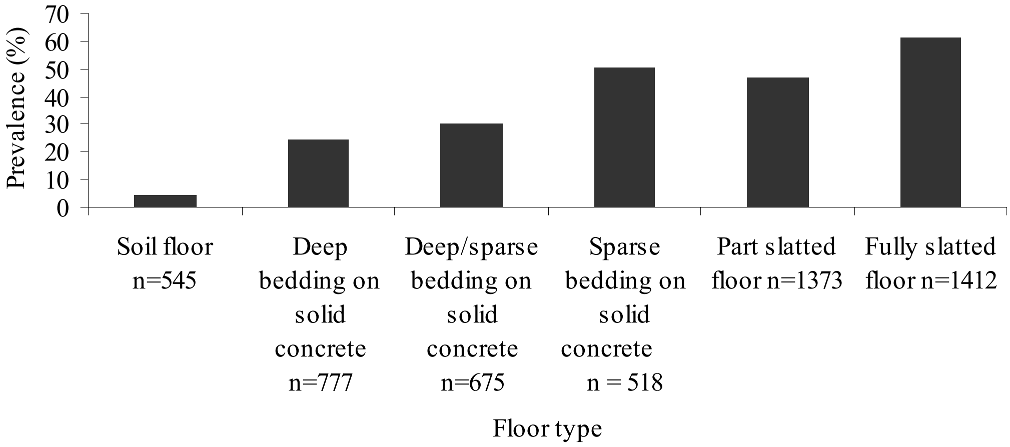

Fig. 2.

Proportion of pigs in the random sample with bursitis by floor type

93 farms 576 pens 5300 pigs

Fig. 3.

Bursal swelling with bursal sac (B) containing watery, blood tinged fluid (clinical score 1)

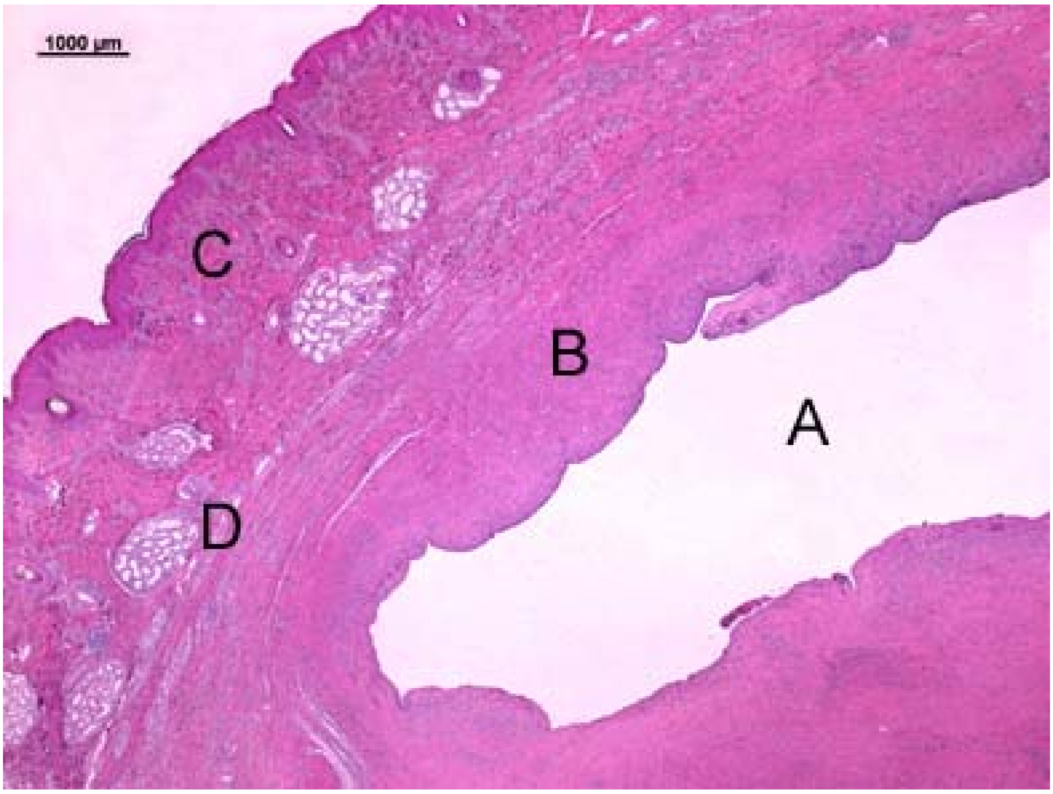

Fig. 4.

Overview of a tarsal bursa showing the lumen (A) and its capsule of dense connective tissue (B) under the haired skin (C) which also contains numerous sweat glands (D)

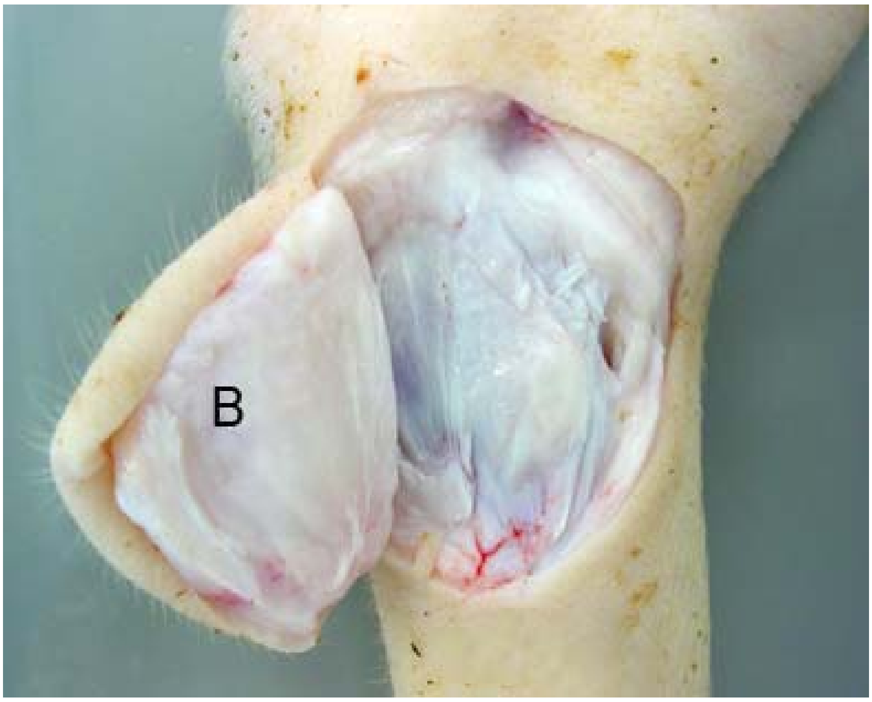

Fig. 5.

Bursal swelling consisting of solid connective tissue (A); there was no bursal sac (clinical score 3)