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INTRA-OPERATOR RELIABILITY OF SKIN MARKER PLACEMENT IN KINEMATIC STUDIES OF THE PIG

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SUMMARY
The purpose of this study was to assess the extent of skin marker misplacement when employing a clinically relevant marker set consisting of 17 markers on each side of the pig. The proposed marker set constitutes a uniplanar, linear kinematic model [1], is quick and easy to apply and may be deployed in studies involving multiple animals or measures. Intra-observer reliability was excellent to moderate based on differences measured in segment lengths depending on segment location when compared with the level of accuracy achieved in recent human and horse applications [5] [6].

INTRODUCTION
There is growing interest in quantitative gait assessment methods for pigs since leg disorders are one of the major problems afflicting the modern pig industry [2]. Joint angles receive increased attention, since variations of these form part of a so-called leg weakness syndrome in pigs [3]. Kinematics, especially optoelectronic techniques, would be a valuable tool to investigate joint movement; however, there appears to be no published study on marker placement reliability in pigs. When not in a recumbent position, pigs tend to be continuously active and their movement is difficult to control. It is therefore important to find landmarks which are meaningful, but quick and easy to identify to ensure repeatability in this species.

METHODS
Three pigs were prepared twice per day on five consecutive days with a total of 34 reflective markers over anatomical landmarks by the same operator possessing a veterinary medical education and previous experience in marker placement. No remnants of material or memory could indicate previous marker position. Kinematic data of the pigs during walking were captured using a 3D optoelectronic system (Vicon T20, Oxford, UK). Data were used to calculate segment lengths assuming that skin marker misplacement, if present, would be best detected in segment measures. Since the capture of static trials with equally distributed body weight over all four legs proved difficult and inconsistent in pigs, body segment length was calculated from the segment lengths obtained during the stance phases of gait cycles. Segment length differences were assessed using a method proposed by Bland and Altmann (1986) [4], which analyses agreement by means of descriptive statistics of error (the differences) distributions. Based on the assumption that the mean of all measures obtained for a single segment represented the 'true' segment length, and the difference from this true length on every placement occasion represented the misplacement, an estimate of 'precision' by means of proximity to the 'true' value was derived. Repeatability was derived by means of the relative frequency of a particular proximity to the 'true' length. Four segments in the hind and four segments in the front leg are presented here. Wilcoxon tests were used to compare front and hind leg differences and proximal and distal differences.

RESULTS AND DISCUSSION
The hind leg (total mean differences (error): 5 mm, SD 2.8) was more prone ($P=0.033$) to differences in the measurements of the same length than the front leg (3 mm, SD 0.9). In the hind leg, proximal differences were greater compared to distal differences ($P<0.001$). Differences showed a similar size and location variability to those observed in human [5] and quadruped kinematic studies [6]. Greatest error source was the femoral segment in the hind leg. Differences at the shoulder and elbow joint were limited in this application. For all segments, except the femoral (at 27%), the relative error frequency above the band of 0-10 mm did not exceed 7%.
The total mean limits-of-agreement interval for the intra-operator repeatability was 11± 4.5 mm, meaning that 95% of all measures obtained by this particular operator will differ by 11mm.

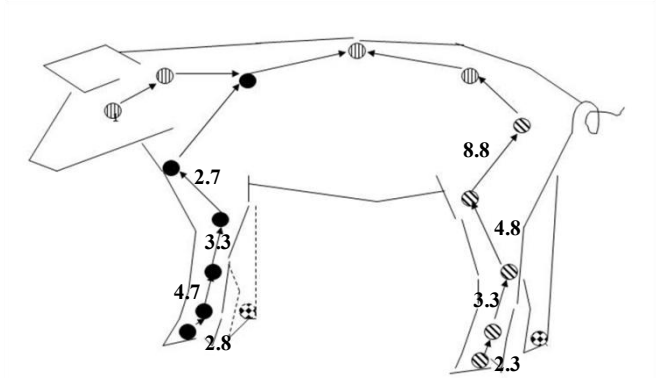

Figure 1: Mean differences (mm) in segment length for repeated marker placements.

CONCLUSIONS

It is concluded that well trained operators may use a similar marker set for pigs to that proposed in this study with a relatively limited error rate. The proposed marker set is suitable for studies involving multiple animals or measures and could be used for epidemiological investigations into lameness. It must be emphasized, however, that number of subjects within an experimental group of interest (pigs exposed to a factor assumed to cause lameness for example) should be large enough to increase the chance of detecting a true gait deviation, particularly if this deviation is expected to be related to angular measurements in the proximal hind leg. Another possibility would be to perform repeated measures on the same individual over a short period of time with repeated marker placements only for the 'problem zones'. This will yield a within-subject and inter-session average which will be a better estimate of the true value. Gait measurements associated with high error sources should be interpreted with caution.

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