NET JOINT KINECTS IN THE HIND LIMB OF CALVES DURING STANCE PHASE OF NORMAL GAIT

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SUMMARY

The main objective of this study is quantify the net joint kinetics (net joint moments and net joint reaction forces) in hind limbs of healthy calves during stance phase on normal gait. Kinematic (100Hz video recordings) and kinetic (1-kHz force plate measurements) data were collected from 4 calves and combined with body segment parameters. Net joint kinetics was calculated by using a 2-dimensional inverse dynamic solution. Inverse dynamics have, to our knowledge, not been applied in calves before. In hind limb joint, the vertical force peaked at 31% of the stance and there was a reduction of 21% of the peak for the reaction force in the pelvis joint, around 36% of the body weight. The maximum moment occurs at 35% of the stance phase to the pelvis and hock joints the, which showed predominant features of extensor moments on stance. In summary, this study provided a basic characterization of the physiological load joints of the hind limb during stance for a sample homogeneous healthy Holstein calves while moving.

INTRODUCTION

kinematic study of cattle and determination of internal forces allow simulations of motion and mechanical load imposed on the locomotor system, aiding in the search of parameters for development of materials and devices for implants, as well as techniques of internal fixation for reduction of long bone fractures common in large animals (Rodrigues et al., 2008). The inverse dynamics analysis in quadrupeds have been used to characterize the gait (Colborne et al, 1998; Clayton et al, 2000, 2001; Thorup et al, 2008), but studies of the dynamics of cattle gait are rarely found in the literature. The purpose of this study is to obtain internal forces and moments on the pelvic limb segments of calves by 2-D inverse dynamic analysis during the stance phase

METHODS

Animals

The kinematic data and force were collected from four Black and White Holstein calves aged between 35 and 45 days, mean weight of 59 ± 10 kgf and mean withers height 82.2 ± 6cm. All animals were clinically healthy, without historical fractures. This study was approved by the Ethics Committee for Animal Experimentation of UFMG (protocolo145/04 and 136/09).

Data Collection

A video camera (Basler A640 pi) recording at 100 frames per s, was placed in position of 6m perpendicular to the line of progression of the calves therefore filming from the right lateral side. Five markers was fixed on joint axes of rotation of the (Fig.1) pelvis (E), stifle (D), hock (C) and fetlock joints (B). The ground reaction forces (GRF) and moments were sampled at 1kHz from a force plate (AMTI model OR6-7). The animals were led in a straight line during operation so that was printed on the platform only the force of the right rear paw during the walking. The software was used to include automatic synchronization force plate and video. The SimiMotion was used to obtain displacements of the joint points and angle of segments with the horizontal axis.

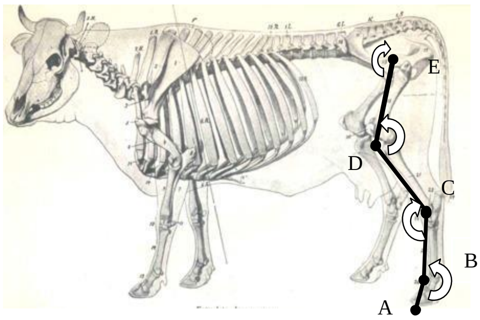

Figure1: Markers locations. Joint flexion is indicated by the arrows. The marker A is contact ground point.

Inverse Dynamic

The kinematic and kinetic data obtained were filtered and interpolated combined with the mass, length and relative center of mass location and moment of inertia that it was obtained through CT image segment cadaveric applying the methodology of the elliptical stem as adjustment of study proposed by Durkin and Dowling, 2006. The moments and GRF were calculated by using 2-dimensional (2D) inverse dynamics, linked segment model using routines developed in Matlab R2011b.

RESULTS AND DISCUSSION

The mean result of vertical forces are shown in Fig.2. The maximum braking peaking around 25% of the stance phase.

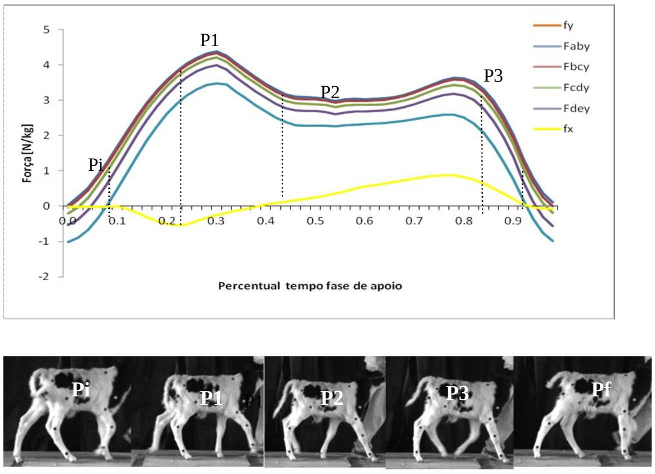

Figure 2: Above, mean vertical reaction forces about net joints: Fy (A), Faby (B), Fbcy (C), Fcdy (D) e Fdey (E). Fx is horizontal force reaction on A. Below, pictures stance phase: Pi (Heel strike), P1 (maximum braking), P2 (midstance), P3 (maximum propulsion) e Pf (push off).

The cranial-caudal force peaked at 78% of the stance and there aren't significant differences to the value of maximum force on the joints of the hind limb. The vertical force peaked at 31% of the stance and there was a reduction of 21% of the peak for the reaction force in the pelvis joint, around 36% of the body weight. The inertial components of the vertical forces sum predominate at the extremes of the curves, they have opposite senses with GRF, therefore they appear on the side negative of the chart. During the greater time of the stance, the vertical contact force is considerably greater than weight and the acceleration of the segments.

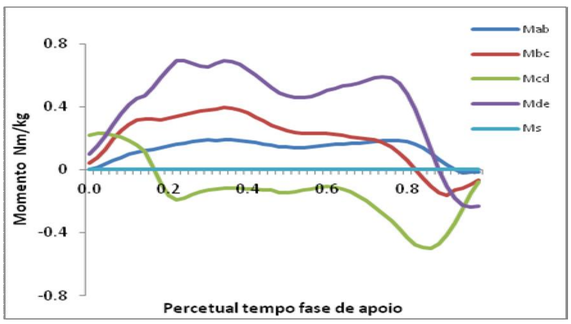

Figura 3: Hind limb segment moments of calves during stance phase.

The moments in each segment are shown in Figure 3. The maximum moment occurs at 35% of the stance phase to the pelvis and hock joints, which showed predominant features of extensor moments on the stance. The largest moments were observed in these joints.

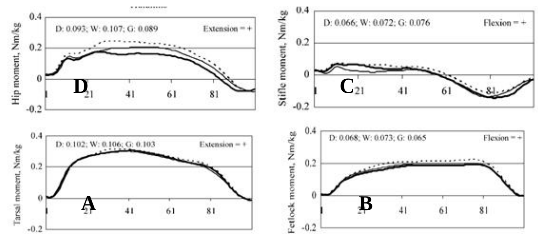

Figura 4: Net joint moments of pigs obtained by Thorup et al, 2008 (A)Fetlock joint (B) tarsal joint, (C) Stifle joint and (D) hip joint.

CONCLUSIONS

Despite the small sample size of this study, it was observed that the behavior of the of reaction force and moment curves of the stance phase of calves resembles the responses to other quadrupeds, getting closer to the march of the pig (Fig.4) presented the study by Thorup et al, 2008, both the behavior of the curves and the magnitude of force and normalized moments, and the differences observed could be attributed to anatomical differences and / or different method of calculation. In summary, this study provided a basic characterization of the physiological load joints of the hind limb during stance for a sample homogeneous healthy Holstein calves while moving.

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