ESTIMATION OF JOINT CONTACT FORCES IN THE EQUINE DIGIT

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INTRODUCTION

In order to explain better the correlation between mechanical loading and osteoarticular disorders, joint contact forces and internal bone forces were recently investigated in human biomechanical studies [1,2]. Little research has yet been done on this subject in the horse, indeed this study describes a procedure estimating joint contact force in the equine digit during the stance phase of a trot simulation (4 m/s).

METHODS

Three Warmblood horses were used (mean body mass 510 kg). Right distal forelimb segments and joint centres were identified and morphometric data (body mass (Mt), segmental length (L), segmental angle (α) made by the segment with the vertical direction in the square standing position, moment arms of muscles (dm) for the coffin and for the fetlock joints) were measured. From all the collected parameters and using published kinematic [3,4,5] and kinetic [6] data, an inverse dynamic analysis was executed. The joint contact forces were estimated for the coffin joint and for the fetlock joint during the stance phase of the trot (4m/s) (Figure 1).
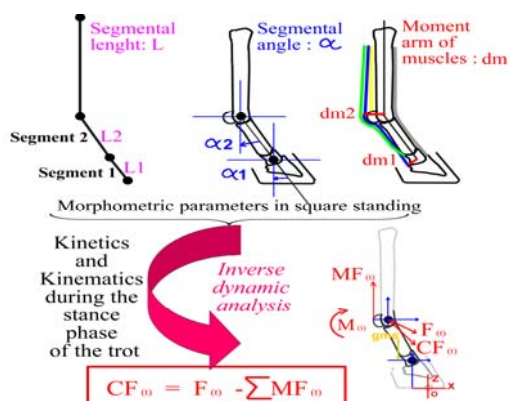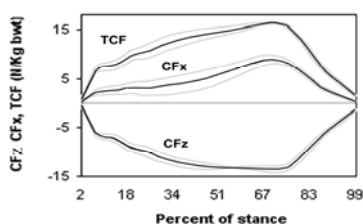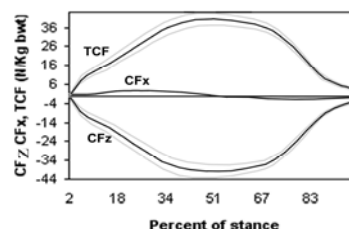

Figure 1: Estimation of the joint contact force (CF(t)). MF(t) and F(t) are respectively the muscle force and the net joint force.

RESULTS AND DISCUSSION

Per unit body weight (BW), the mean peak vertical joint contact force was found to be 1.4 BW and 4 BW respectively for the coffin and for the fetlock joints (Figure 2).

a

b

Figure 2: Joint contact force components in vertical and horizontal direction (CFz, CFx) and joint contact force norme (TCF= $\sqrt{CFz^2 + CFx^2}$) for the coffin joint **(a)** and for the fetlock joint **(b)** during the stance phase of the trot (4m/s). Values represent the ensemble average for 3 horses $\pm$ one s.d.

Traditionally, external reaction forces have been used to investigate experimentally the relationship between mechanical loading and contact areas or pressure distribution [7]. Typically, ground reaction forces have been estimated to be 0.9 BW in the trotting horse [8] and 2 BW in the running human (4 m/s) [9]. Nevertheless, external reaction force, corresponding to the sum of forces acting in opposite directions (joint contact force, muscle forces), only represents a resultant value of a subtraction. Like one modelling study estimated that muscles crossing the human ankle joint contribute to an additional 7 BW of force during running (4 m/s) [1], this analysis showed that muscles crossing the fetlock and the coffin joint contribute respectively to an additional 3 BW and 0.4 BW of force during trotting (4 m/s).

CONCLUSIONS

A model estimating joint contact force in the equine digit during the stance phase of a trot simulation was developed. The results of this application could be compared with a thorough in vivo dynamic equine gait study and could be associated with a biomechanical model studying dynamic stresses.

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