A STUDY ON THE REPRESENTATIVE POINT OF HORSE'S CENTER OF GRAVITY

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The purpose of this study was to explore are there bony landmarks on the horse body's surface matching the motion of center of gravity. The relationship between the bony landmarks and the center of gravity during actual race under Buchner and Kubo horse inertial models were analyzed. Results showed Buchner and Kubo models had high consistency on the kinematic parameters of the center of gravity. Comparing the relationship of the middle of mesoscapula and tail root with the center of gravity in displacement, velocity and the absolute difference, it was found that the middle of mesoscapula under Kubo model is a suitable represent point of the center of gravity among the characteristic points of two models in the motion of observed race horses.

KEY WORDS: racehorse, inertial model, characteristic point.

INTRODUCTION: There is unique role of the center of gravity in the movement analysis of horses like human body. Due to the center of gravity is calculated from the inertial parameters model and placing marks on the horse body surface for actual race is difficult, some particular body part (point) were used to represent the motion of the horse's center of gravity as well as the whole body (Pfau, T. et al, 2009, Li, S. et al, 2009). While, the selection of this part (point) was usually not based on a quantitative basis. The purpose of this study was to identify which bony landmark of the horse body's surface, the middle of mesoscapula or the tail root, is better matching the motion of center of gravity during actual race (gallop) based on the calculation under Buchner (Buchner, H.H.F. et al, 1997) and Kubo (Kubo, K. et al, 1992) horse inertial models. The Buchner model have 26 segments and calculated from 6 horses. The Kubo model have 20 segments and calculated from 3 horses. The six segments of Buchner model over that of Kubo model are: the scapula-brachium segment in Kubo model was divided into scapula and brachium segments; both the digit forelimb and hind limb were divided into pastern and hoof segments. The relationship of the center of gravity of two models was also investigated.

METHODS: The kinematic parameters of the center of gravity, middle of mesoscapula and tail root of six thoroughbred horses in 1200 m race in 2014 China Speed Racing Open were studied based on the Buchner and Kubo models. The input points under the Kubo model were upper lip, first cervical vertebra, seventh cervical vertebra, middle of mesoscapula, hip joint, cubitus joint, carpal joint, fetlock joint, forehoof, stifle joint, tarsal joint, fetlock joint and hind hoof. There were several changes in the input points under the Buchner model: the upper lip was replaced by the middle point of cheek and the shoulder joint was added.
The one gait cycle 2D sagital images of each horse in the site of 100 meters from the track's end were shot and analyzed. One cycle of gait was calculated from the touching down of horse's left forehoof to it touching down again. The shooting frequency was 200 fps and the basic shooting distance to the inside of the track was 30 meters. Then the scale was calibrated every 2 meters from the inside of the track so that the nearest calibrated scale could be used to analyze the motion of the target horse. In order to facilitate the data analysis, the original data within a gait cycle were normalized. The correlation coefficient and absolute difference of kinematical parameters was used to measure the relationship of the characteristic points with the center of gravity.

RESULTS: The correlation coefficients of the center of gravity between Buchner (BCG) and Kubo (KCG) model on the displacement were 1.0 (horizontal) and 0.738 ($p<0.01$,vertical), on the velocity were 0.801 ($p<0.01$, horizontal) and 0.937 ($p<0.01$, vertical), respectively.

Under the Buchner model, the correlation coefficients of BCG and the middle of mesoscapula was 0.669 ($p<0.01$), BCG and tail root was 0.851 ($p<0.01$) on the vertical displacement. The correlation coefficients of BCG and the middle of mesoscapula was 0.762 ($p<0.01$), BCG and tail root was 0.461 ($p<0.01$) on the vertical velocity.
Under the Kubo model, the correlation coefficients of KCG and the middle of mesoscapula was 0.627 ($p<0.01$), KCG and tail root was 0.075 on the vertical displacement. The correlation coefficients of KCG and the middle of mesoscapula was 0.694 ($p<0.01$), KCG and tail root was -0.35 on the vertical velocity.
The range of absolute difference of the vertical displacement between the middle of mesoscapula and KCG under Kubo model was 4.788, the standard deviation was 1.601. These values were the lowest values of absolute difference and standard deviation respectively in both characteristic points as well as two inertial models.

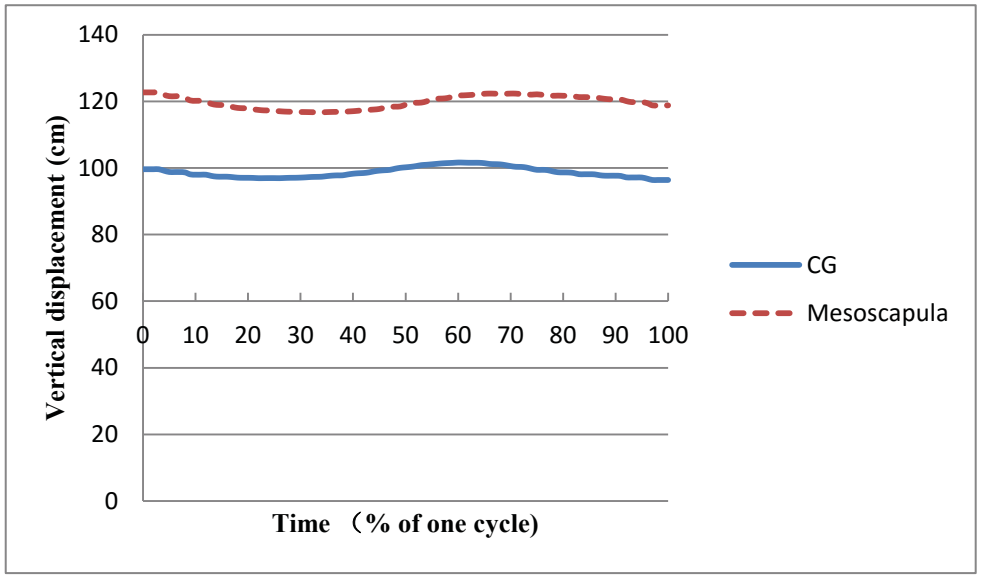

Figure 1. Vertical displacement of CG and mesoscapula under Kubo model.

DISCUSSION: It was showed there were high correlations between the center of gravity of Buchner and Kubo models in all parameters of displacement and velocity.
Under the Buchner model, both vertical displacements of tail root and the middle of mesoscapula had high correlation with the center of gravity. The correlation coefficient of the tail root was higher than that of middle of mesoscapula. It is indicated the vertical displacement of tail root is more fit to that of the center of gravity. There was high correlation coefficient between the middle of mesoscapula and the center of gravity and low correlation coefficient between the tail root and the center of gravity. It means the vertical velocity of the middle of mesoscapula was more fit to that of the center of gravity under the Buchner model.
Under the Kubo model, there were high correlations between the middle of mesoscapula and the center of gravity both in the vertical displacement and velocity. There weren't sure correlations between the tail root and the center of gravity both in vertical displacement and velocity ($p>0.05$). The value of correlation coefficient between the vertical displacement of the tail root and that of the center of gravity was close to 0. There was negative correlation between the vertical velocity of the tail root and that of the center of gravity. It is revealed either the vertical displacement or the vertical velocity of the middle of mesoscapula is more fit to that of the center of gravity under the Kubo model.
The absolute difference analysis presented that there were smallest range of absolute difference and variation for the middle of mesoscapula under Kubo model. It is further illuminated that the middle of mesoscapula is the better fit point to the center of gravity.

CONCLUSION: There was high consistency between the relative kinematic parameters of the

center of gravity under Buchner and Kubo models. Comparing the relationship of the middle of mesoscapula and tail root with the center of gravity in displacement, velocity and the absolute difference, it could be concluded that the middle of mesoscapula under Kubo model is a suitable represent point of the center of gravity among the characteristic points of two models in the motion of observed race horses.

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