Comparing continuous relative phase computed by segmental and joint angles	Busquets, A., Marina, M., y Angulo-Barroso, R.

I.Introduction
Coordination as the stable spatial-temporal relationship among movement system components can be assessed by the continuous relative phase (CRP). Authors in the literature used segment angles or joint angles to compute CRP indistinctively. However, recent studies suggest that calculating CRP from joint angles is not appropriate due to the nature of joint angle time series. A direct comparison of the results yielded by CRP computed from segmental or joint angles of the same movement could aid in this controversy. In this study, longswing in the high bar performed by expert gymnast were used to compute CRP from segmental angles (arm and leg) and joint angles (shoulder and hip). Arm and leg segmental angles are calculated in relation to an external and fixed reference system resulting in positive angular velocities during the entire movement; while a local reference system fixed to one segment is used to compute shoulder and hip angles obtaining positive and negative values of angular velocities. The aim of this study was to compare relevant longswing coordination variables obtained from the CRP computed from segments or joint angles.

II.Method
Nine gymnasts (19.0±4.5 years; 1.59±0.13 m; 54.9±15.3 kg) from the national team performing consecutive longswings in the high bar were filmed with two digital video cameras. The best longswing of each gymnast was analyzed. We defined three events independently for hip (H) and shoulder (S) angle joints: the smallest angle during downswing (P1H, P1S); the largest angle after P1 (P2H, P2S); and the smaller angle during upswing (P3H, P3S). In addition, handstand after the upswing was defined as final position (Pf). For the saggital plane, angular movements at the hip were derived from the angle between the right thigh and trunk and movements at the shoulder from the angle between the right upper arm and trunk. Where as segmental angles of the arm and thigh were calculated relative to the horizontal axis (x-axis). We normalized angular displacements and velocities of the segmental and joint angles. CRP of the arm-leg (AL) and hip-shoulder (HS) were computed from normalized angular data. Segmental CRPs and joint CRPs were quantitatively described with mean absolute relative phase (MARP) and positive and negative areas. We computed these variables over the interval between consecutive events of the same joint and final position (P1-P2, P2-P3, P3-Pf) for both AL CRP and HS CRP.

III.Results
Significant differences between AL CRP and HS CRP variables using paired students' t-test were found, specially in P1-P2 and P3-Pf. Despite differences in the variables magnitude, coordination in P1-P2 showed larger negative areas in both AL CRP and HS CRP revealing that leg and hip moved faster than arm and shoulder respectively. In P3-Pf, larger positive areas were observed for the AL CRP indicating faster movements of the arm. In contrast, HS CRP showed similar positive and negative areas denoting that shoulder and hip velocities were comparable during the last part of the longswing.

IV.Conclusions
Comparison of the segmental or joint CRPs showed similar outputs during the longswing, except for phases in which segmental angular velocities decrease and joint negative angular velocities (i.e. extension of the joint) increase. We suggest that both methods to compute CRP can be used but their use and interpretation need to be in agreement with the aim of a particular study.

Palabras clave (máximo 3): Coordination; Reference system; Gymnastics.