Preliminary comparison of EOS-derived and geometrically calibrated segment lengths: inter-hip and femur cases

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Nowadays, various toolbox and software have been spread to perform musculoskeletal simulation, generally furnished with models. The kinematical model describes geometrical osteo-articular parameters, such as distances, and degrees of freedom (DOF) which mimic joint functions. Such models can be calibrated to subject specific geometry thanks to simple and affordable geometric calibration methods based on optoelectronic data. These methods minimize the reconstruction error but do not guarantee that the optimized lengths are anatomically consistent. The current study aims at comparing geometrically calibrated segment lengths to measurements derived from medical imaging.

Methods

We recorded functional motions - activating each DOF of the lower limb - of 8 able-bodied subjects using an optoelectronic system. Firstly, a regression method (RM) based on subjects' heights estimated the segment lengths of lower limb, trunk and head models. Secondly, geometrical calibrations (GCn) optimizing segments lengths and joint centres [1] was performed with different sets of frames - n = {3, 10, 50, 100, 500}. Finally, references joint centre positions (two hips, and two knees) were measured in EOS® system [2,3]. Friedman's and Fisher's LSD tests were applied to detect significant differences between EOS, RM and GCn inter-hip and femur lengths. The significance level was set to $p<0.05$.

Results

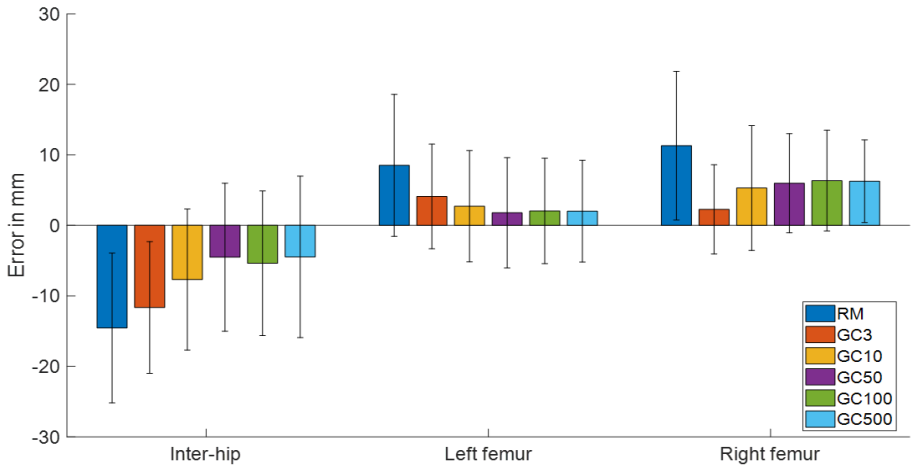

Fig.1 : Mean errors for the inter-hip, left and right femur distances between EOS-derived measures, Regression method (RM) and geometrical calibrations (GCn) with different amounts of frames (3, 10, 50, 100, 500)

No significant difference between methods was found for the left femur length. Indeed, the mean distance between EOS and RM was 8.5 ±10 mm. The mean distance between EOS and GCn was between 4.1±7.4 mm (GC3) and 1.8 ±7.8 mm (GC50), Fig 1. Right femur and the inter-hip distances were significantly different among methods. Fisher's LSD test revealed differences for the right femur distance between EOS, RM and GC50,100,500. Mean distances to EOS were between 2.3 ±6.3 mm (GC3)

and 11.3 ±10.5 mm (RM). EOS inter-hip distance was significantly different from RM and GC3,10. Mean errors were between -14,5 ±10.6 mm (RM) and -4.47 ±11.4 mm (GC500).

Discussion

The results of GCn are promising since it reduced systematically the RM distance to the EOS measurement. Indeed, the number of frames used in GCn influenced the results. For inter-hip distance and left femur, increasing the number of frames tended to minimise the distance to EOS until GC50. For the right femur, the GC3 gave better results, it might be local minimum. Both end points of these measurements are calibrated limiting the efficiency of the comparison. Additional measures in segments' local frames are necessary to complete these comparisons.

References

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