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Enhancing walking analysis accuracy by real-time tracking of the femoral head with ultrasonography

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Gait analysis is an important tool for surgeons and therapists to assess neuromusculoskeletal and neurological disorders in children and adolescents and to improve their quality of life.

Traditional gait analysis typically involves marker-based optical systems to biomechanically model limb movements by tracking skin markers and determining the joint centres. Unlike other joints, determining the hip joint centre (HJC) presents unique challenges due to overlying soft tissues and other artifacts.

Approaches used to estimate HJC have included predictive and functional methods. These approaches are largely based on the anatomy of healthy adults or require large ranges of thigh movement, limiting their accuracy and feasibility, particularly in children and individuals with physical impairments. Errors associated with HJC estimation can culminate in inaccurate pelvis and knee dynamics (Kainz et al., 2015). An error of 30 mm in estimating HJC can cause 20% errors in hip joint moments (Stagni et al., 2000).

In this study, to address these issues, I developed a method to improve the accuracy of HJC estimation using three-dimension free hand ultrasonography (3DUS). This method involved real-time monitoring of the femoral head during walking using deep neural network algorithms (DNN), and comparing to the Harrington method (Harrington et al., 2007). Harrington's method estimated the HJC to be 19.46 mm more medial and 14.48 mm more anterior than the 3DUS-based measurement, resulting in an approximate 3° error in hip joint angles. In this presentation, I will discuss the importance of HJC estimation in gait analysis, the limitations of Harrington's predictive approach, the restricted applicability of functional methods in individuals with physical impairments, and DNN-tracked 3DUS video of HJC during movement as a promising alternative for clinical and physiotherapy assessments.

Keywords
Hip joint centre, Deep learning, Functional method, Predictive method, Accuracy

References

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