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Current Research and Clinical Applications in Human Motion Analysis

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It is a pleasure to present this series of eight current articles on the topic of Human Motion Analysis. The field of Human Motion Analysis has developed into a major component of orthopedic and rehabilitative medicine. This development has occurred over the last several decades through advances in understanding and application of research findings in clinical practice. It is commonly used today for preoperative planning, postoperative follow-up, evaluation of clinical interventions, and for numerous research purposes. More importantly, we have gained significant insight into pathologies associated with human motion disabilities. This enhanced insight has augmented the acumen of clinicians who routinely evaluate and treat patients with motion related challenges.

Articles selected for this special issue include recognized clinical and technical authors with a focus on current and emerging clinical applications and relevant technical advances. The series emphasizes selected areas of application in established as well as evolving fields. In the broader context, the series addresses recent applications in gait, developments in assistive device assessment as related to the upper extremity joint dynamics, specialized segmental analysis of the foot and ankle, and an integrated modeling approach which combines classical lower extremity and segmental foot and ankle motion analysis.

The gait applications section examines gait kinetics at the ankle in children with Osteogenesis Imperfecta, implications of arm restraint on gait kinetics, and interactions among graft placement, gait mechanics and premature osteoarthritis following anterior cruciate ligament reconstruction. In the first article, Joseph Krzak and colleagues present results from a recent investigation of ankle power generation in children with Osteogenesis Imperfecta. In this study of 24 patients the authors discuss results from an analysis of gait dynamics, strength and pedobarography. Reduced push off power is found to be most likely in participants with both a flat foot and reduced load times at the forefoot during push off. The role of the upper extremities in providing stability and propulsion for the body during ambulation is examined through upper extremity restraint by Long and co-authors in the second article. This study reports on recent examinations of 23 participants tested during four randomly ordered restraint conditions. Temporal spatial parameters and lower extremity dynamics were examined. The authors conclude that upper extremity restraint leads to significant alterations in the tested parameters, most prominently during periods of load accommodation and balance. The third article in the series is by Sean Scanlan and Thomas Andriacchi. The authors note that standard anterior cruciate ligament reconstruction techniques often fail to restore normal ambulatory mechanics or to prevent early onset arthritis. A combination of three dimensional (3D) models of anterior cruciate ligament graft orientation from magnetic resonance imaging and an analysis of knee mechanics during walking demonstrate that alterations in knee rotation are related to non-anatomical graft orientation. The authors highlight the need to evaluate walking mechanics when developing new treatment modalities for the anterior cruciate ligament-injured knee.

The second section of the series assesses kinematics and kinetics of the upper extremity joints during assisted ambulation. Katherine Konop, Kelly Strifling and their team report on a novel study of joint dynamics at the shoulder (glenohumeral), elbow and wrist joints during anterior and posterior walker use. They also report on early investigations of walker handle height and grip orientation changes. The children with cerebral palsy are examined during both anterior and posterior walker use. The authors find no significant differences in upper extremity angles, joint reaction forces, or joint reaction moments between anterior and posterior walkers. Wrist and elbow joint derotation is found to significantly affect joint dynamics. Suggestions for optimizing upper extremity loading to limit later joint pathology are included. Brooke Slavens et al in the next paper present a review of current state-of-the-art dynamic systems for quantifying upper extremity joint kinematics and kinetics during Lofstrand (forearm) crutch-assisted gait. These authors focus on the rehabilitation of children and adults with cerebral palsy, Osteogenesis Imperfecta, myelomeningocele and spinal cord injury. The ISB compliant models developed by this group are applied to a series of nine children with myelomeningocele to assess joint loads during reciprocal and swing-through gait patterns. A novel four-sensor crutch system is presented which isolates cuff kinetics. The system is demonstrated in participants with cerebral palsy, spinal cord injury and Osteogenesis Imperfecta. The authors propose identification of risk factors for joint pathology and subsequent therapeutic planning through further application of the system.

The third section of the series includes two papers. The first by Lori Karol and Kelly Jeans reports on club foot assessment using movement analysis. This thorough review article presents relevant information on current treatment approaches as evolved during the past decade. The authors highlight the important role of gait analysis as an outcome tool to evaluate the function of the foot following both operative and nonoperative club foot treatment. Gait analysis is noted to offer a valid measure of joint motion, powers and plantar pressures that

can be used to ascertain changes following surgical intervention. The second article in this section is by Karl Canseco and colleagues and addresses a recent study of segmental foot kinematics following surgical treatment for rheumatoid arthritis. The prospective study examines 14 feet in 13 patients with forefoot rheumatoid arthritis. Segmental kinematics and temporal-spatial parameters are characterized through application of the Milwaukee Foot Model. The authors conclude that surgery effectively restores foot alignment and weight-bearing capacity. Temporal-spatial parameters and kinematics, however are not restored to control levels, but rather are consistent with joint fusion effects of the first metatarsal phalangeal joint. The importance of quantitative segmental assessment in understanding the geometric and kinematic effects of surgical realignment is highlighted.

The final paper in the special issue provides further insight into novel model development for improved complex motion analysis. Jason Long et al present a combined approach to include functional estimates of hip joint center location, a complete 3D lower extremity model (hip, knee, ankle), and a multi-segmental model of the foot and ankle. The authors examine 10 healthy adults with the new model and critically compare the results to those of two standardized gait models (Plug-In-Gait and Milwaukee Foot Model). Repeatability analysis with the coefficient of multiple correlations (CMC) reports values in excess of 0.9 for 16 of 18 segment/plane couplets. Both correlation and repeatability analyses suggest the new model for further clinical and research applications.

As technology and our understanding of human motion progress, we hope that this special issue will contribute to the continued endeavors of clinicians and researchers who care for those with motion related disabilities.