Upper Extremity Kinematics: Normal Three-Dimensional Motion

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Introduction: The use of 3-dimensional upper extremity (UE) motion analysis has lagged behind lower extremity (LE) analysis, particularly because of the lack of scientific attention in the literature[1,2]. One reason may be the lack of standardization in methodology among investigators[3]. This may be due, in part, to the fact that the shoulder joint is complex and difficult to describe kinematically[2]. However, most clinicians want a simple objective tool to identify what compensations are being used to place the hand in a functional position[4]. Therefore, the purpose of this study is to determine the feasibility and utility in developing a normal kinematic database for neck, trunk, shoulder, elbow, and hand motions necessary for the performance of cardinal plane motions and basic motions essential for activities of daily living (ADLs).

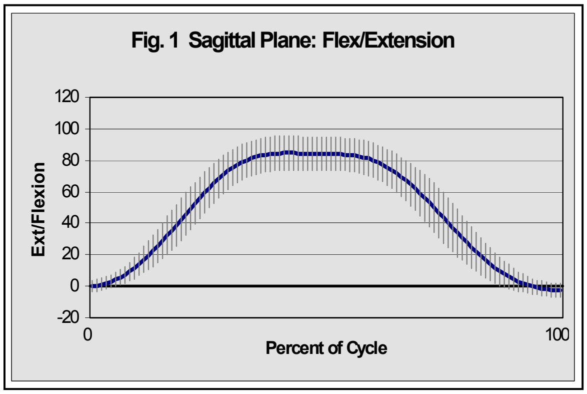
Statement of Clinical Significance: This study begins the formulation of a normal database to which pathological upper extremity movements can be compared. As a result, clinical decisions concerning the need for therapeutic intervention, rehabilitative planning and assessment of functional outcomes will be improved.

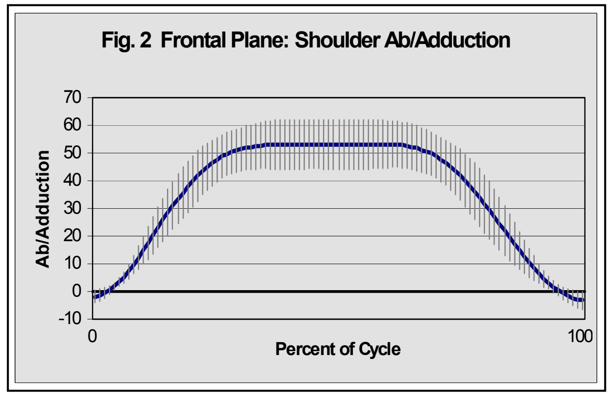
Methods:

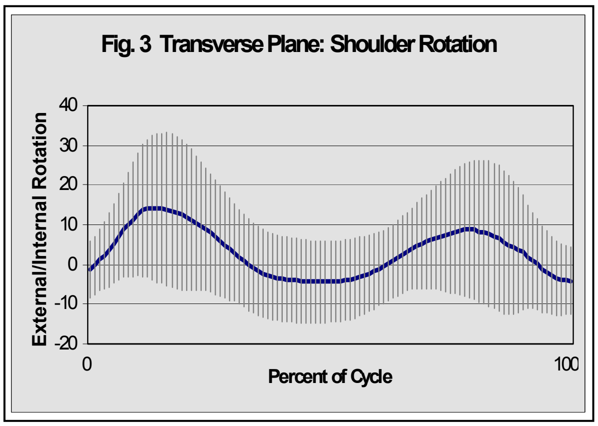
Subjects: A convenience sample of 5 subjects (3 males, 2 females) was recruited for this study. Mean age was 20.8 years with a range of 22-30 years. Mean body mass index (BMI) was 25.0 with a range of 21.7-33.9. Participants had no history of pathology of the UE, neck or trunk. Verbal consent was obtained from each subject.

Motion Analysis: Bilateral kinematic data was collected using a custom set of 13 markers and a 10 camera RealTime Motion Analysis system (Motion Analysis Corp., Santa Rosa, CA). Data was processed using custom software. Kinematic data was collected while participants performed 3 repetitions, at a self-selected speed, of cardinal plane shoulder motions: flexion, extension, abduction, internal rotation, and external rotation. Data was also collected while each subject performed 3 additional repetitions of motions commonly involved with ADLs: hand to mouth, hand to top of head, hand to back of neck, hand to back pocket, and hand to opposite shoulder. Start and end points of each repetition began and ended with the UE resting at the side of the participant.

Results: Preliminary results demonstrate uniformity of movement in each anatomical plane with each motion studied. Because of the small sample size, statistical significance was not calculated. All studied motions are described kinematically in three dimensions. Kinematic data describing the motion of the shoulder as the hand is placed on the top of the head is shown in Figs. 1-3. For brevity, only shoulder kinematic data is shown. Similar to gait analysis, UE motion is normalized to percent of cycle with the average motion curve and standard deviation band representing variability among subjects. Other joint kinematic data, including trunk and neck motion help to describe how the UE moves to place the hand on the head.







Discussion: According to O'Neill et al, the hand is the main effector of the UE[4]. Since hand position is dependent on the movement of the UE, most clinicians are simply interested in how the wrist, elbow and shoulder act to place the hand in a functional position[4]. Other authors have pointed out that the diagnosis and treatment of orthopedic and neurological disorders of the UE can benefit from 3-dimensional motion analysis and that the management of movement disorders depends largely on the ability to objectively quantify changes in performance[5,6]. Ramos et al points out that clinical assessments tend to be subjective, monitor only gross changes in functional performance and lack the sensitivity required to detect subtle yet critical changes in performance[6]. It is believed this study helps develop an objective tool which can provide valuable information about the effectiveness of clinical treatment programs and rehabilitation planning. Three-dimensional UE kinematic motion analysis and the continued formulation of a normal database describing UE motions for basic cardinal plane and for activities of daily living will become a vital tool that clinicians can use to compare pathological movements to normal[6].

References:

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