INTRODUCTION

Normative quantitative kinematic and kinetic profiles exist for lower limbs during gait [1]. However, the complexity of neuromuscular control of the upper limb has made it difficult to create similar quantitative kinematic profiles for the upper limbs during activities of daily living (ADLs). This lack of objective measures to quantify upper extremity movement limits description of neurological impairments [2].

Some of these impairments (e.g. apraxia) affect the motor functioning of the non-preferred limb (left hand). Neuropsychological assessment of apraxic patients relies primarily on qualitative analyses of gross movement characteristics from Waterloo-Sunnybrook Apraxia Battery (WatAB), based on location, posture, action, plane and orientation of the upper limb and the hand [3]. Also, to assess apraxia, patients are required to perform gestures and ADLs with their left hand because the disorder affects the left hand, but the assessment neglects to take this into consideration. Due to this, it is difficult to differentiate whether movements of the limb are because the patients are using their non-dominant hand or due to the disorder itself.

These considerations make it critical to develop bilateral normative kinematic profiles for healthy persons. Once achieved, these will provide a basis for comparing and understanding impaired kinematics observed in patients with apraxia [4,5], which will enable more objective initial diagnoses and rehabilitation evaluation. The purposes of this study were to examine bilateral differences in pantomime versus tool use in the production of gestures during ADLs through three-dimensional kinematic analyses.

METHODS

The upper limb and trunk movement of ten healthy (no history of musculoskeletal or neurological conditions) right-handed participants (5M, 5F) were captured via a motion capture system (Vicon, Colorado, USA) during the performance of different tasks included in the WatAB [3]. Forty-five reflective markers were placed on anatomical landmarks of the upper limbs and trunk, in accordance with International Society of Biomechanics (ISB) recommendations [8]. In addition, four markers were placed on the thumb, five on the index, middle, ring, and little fingers and four on the dorsal hand. Markers were also affixed to the manual objects used.

Participants performed two tasks: 1) pantomiming a gesture (e.g. slicing a piece of bread with an imaginary knife); and 2) gesturing using a physical tool. All data was sampled at 100 Hz. Task performances were block randomized by limb, with all gestures performed by both limbs. Three consecutive trials for each movement were completed. All tasks were completed at a self-selected pace.

Raw kinematic data was processed to derive assessment measures by dual low-pass Butterworth filtering at 8 Hz. Wrist velocities were calculated from the midpoint of the two markers on the dorsal hand, just distal to the wrist. Peak velocities from the three trials of each task were averaged to determine average peak velocity. A two factor (task type: pantomime or tool, and limb) repeated measures ANOVA was performed to assess their influence on peak velocities, with significance set at p < 0.05.

RESULTS

Higher peak velocities were observed in the non-preferred limb (left hand) in comparison to the preferred limb (right hand) in both, the cup and the knife conditions (Fig. 1) (cup: F = 6.95, p<0.0137; knife: F = 4.95, p<0.0346).

Further, higher peak velocities existed for the cup condition during pantomime tasks in comparison to the tool use (forward transport: F = 4.63, p<0.04; backward transport: F = 4.61, p<0.04; medial movement: F = 8.37, p<0.01).
Figure 1: Average peak velocity hand differences for the preferred and non-preferred limb for the forward transport in the cup condition (towards body) and forward movement in the knife condition (away from body). Asterisks indicate significant differences between limbs.

Figure 2: Interaction effects between the handedness and the pantomime vs. tool use during tasks. Asterisks indicate significant differences across conditions.

Figure 3: Bilateral peak velocities for cup and knife conditions for both limbs in three directions (X = medial/lateral; Y = forward/backward; Z = up/down). Asterisks indicate significant differences between axes.

However, while higher peak velocities occurred for the pantomime task than tool use in the non-preferred limb (F=5.65, p<0.0248), this difference was absent in the preferred limb. Also, which hand the tool was used with did not make a difference (Fig. 2).

Higher peak velocities for both conditions occurred in the primary movement direction movement (F = 234.86, p<0.0001) (Fig. 3).

DISCUSSION

These results suggest manual performance asymmetries influence ADL performance in healthy persons. Although manipulation of tools reportedly improves movement effectiveness for both hands [4], which is suggested to be related to somaesthetic cues received from the tool, this study supports this only for the non-preferred hand. However, the addition of a tool lowered average peak velocities in both limbs for some conditions (e.g. cup) in this study, consistent with earlier reports [4].

Further, primary planes of movement can be defined based on peak wrist velocities. As the highest peak velocities for the cup condition occurred in the Z and Y directions, ZY is designated the plane of movement; for the knife condition, the highest peak velocities existed in the Y and X directions, making YX the plane of movement. This planarity of movement data enables identification of out-of-plane movements frequently identified in apraxic patients [9].

The ultimate purpose of this work is the generation of normative kinematic profiles of task performance by healthy individuals. These can then be compared with those of patients with disorders such as apraxia, in order to both diagnose and assess rehabilitative effectiveness.

REFERENCES

3. Roy, EA, et al., 1998 (available from Dr. E. Roy, Department of Kinesiology, University of Waterloo, Waterloo, Ontario, Canada, N2L 3G1)