Kinematic Asymmetries at the Wrist and Elbow During Axillary Crutch Use

Christina Bueckert[1], Gregor Kuntze[2,3], Janet Lenore Ronsky[1,3], Ranita Harpreet Kaur Manocha[3,4]
1. Department of Mechanical and Manufacturing Engineering, University of Calgary, Calgary, Canada
2. Faculty of Kinesiology, University of Calgary, Calgary, Canada
3. McCaig Institute of Bone and Joint Health, University of Calgary, Calgary, Canada
4. Division of Physical Medicine & Rehabilitation, University of Calgary, Calgary, Canada

I. Introduction

Axillary crutches are frequently prescribed to enable patients to ambulate safely. However, crutch use may result in abnormal upper extremity movement patterns, potentially resulting in discomfort or injury. Often, bilateral crutch users who experience injury or pain may do so in only one limb, suggesting that upper limb asymmetries exist during gait. The purpose of this investigation was to quantify wrist and elbow joint angle asymmetries during crutch-assisted swing-through gait (STG) using three methods.

II. Methods

Fifteen healthy adult males (age 24±6 years) performed 10 trials of STG at a controlled velocity of 1.40±0.07ms^{-1}, landing on the left leg. Female participants were excluded due to the testing protocol requiring full upper thoracic exposure and instrumentation. Joint kinematics were recorded using a 10-camera optical tracking system (Motion Analysis, USA; 240Hz). Bilateral elbow and wrist angles were computed using Visual3D (C-Motion, USA) and normalized to 100% of the gait cycle, with 0% being crutch initial contact and 100% being the next ipsilateral crutch contact. Asymmetry was quantified using 3 different approaches: the symmetry index (SI)[1], the normalized symmetry index (NSI)[2], and the symmetry angle (SA)[3]. A custom Matlab (MathWorks, USA) program was used to calculate the percentage of asymmetry at each point in the gait cycle for each of the joints in the x-, y-, and z-directions. A one-way repeated-measures ANOVA (SPSS, USA) was performed to look for differences in crutch stance phase duration.

III. Results

There was no difference in crutch stance phase duration between the left (1.23±0.08s) and right (1.23±0.09s) sides. Joint angle asymmetry varied throughout the gait cycle with all 3 methods. The SI (Fig. 1) and SA produced similar trends in terms of the location of greatest asymmetry during the gait cycle. There was more variation in upper limb asymmetries using the NSI. Maximum wrist radial-ulnar deviation asymmetry was found to be 5.75%, 19.5% and 1.85% for the SI, NSI, and SA respectively and occurred between during crutch mid-swing (80% of the gait cycle). Maximum elbow flexion-extension asymmetry was found to be 11.5%, 14%, and 3.65% for the SI, NSI, and SA respectively and occurred at crutch pre-swing (60% of the gait cycle.

IV. Conclusions

Axillary crutch use results in kinematic asymmetries at the elbow and wrist. These asymmetries vary throughout the gait cycle. In clinical practice, more injuries are seen on the side of the landing leg and the side of the dominant hand. The asymmetry analyses used cannot say whether one side was more at risk for injury, but we will conduct further kinetic analyses to correlate with this clinical finding.

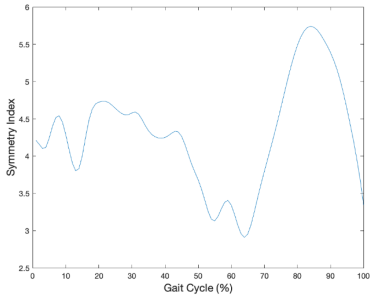

Fig. 1: Symmetry index (SI) for wrist radial-ulnar deviation during the axillary crutch-assisted swing-through gait cycle, where 0% indicates initial crutch contact and 100% indicates the subsequent crutch contact.

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