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Characteristic upper extremity kinematic parameters of healthy people during defined motions

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Abstract. One of most common ways to examine the quality of the patient's upper extremity (UE) function is measuring the movement's kinematic parameters during the motion. However, is it reliable to compare a patient's UE motions data with healthy people's characteristic parameters? In this paper is shown that intrapersonal coefficient of variability (CV) in angles amplitudes differs from 3.2% during elbow flexion to 52.9% during wrist abduction and CV in angular velocity differs from 22.1% during shoulder abduction to 66.3% during wrist abduction.

Keywords: upper extremity, objective parameters, motion capturing system, biomechanics.

Introduction

The loss of UE function is one of the most common results after Central Nervous System (CNS) injuries [1] or musculoskeletal impairments [2]. A dysfunction in the UE can significantly limit a person's level of activity and participation in their social and physical environment [3]. The functional tests of UE are classified according to general clinical scales such as Jebsen-Taylor Hand function [4], Arm Research Assessment Test (ARAT) and Nine-Hole Peg Test and specific clinical scales applied to spinal cord injury (SCI) [5], stroke [6] or cerebral palsy (CP) [7]. The best-known ADL measures are Bartel Index [8] or Functional Independence Measure (FIM) [9]. It is clear that only functional and clinical subjective scales are not enough for accurate motion quality measurements and that objective methods are required. Quantitative measures of UE movement's quality can be valuable in the rehabilitation field for evaluating the quality of actual motion and recovery progress [10] which might help physicians to compare accurately healthy and pathological movement conditions in a clinical setting. The purpose of the research was to find if particular kinematic parameters of healthy participant's UE motions are reliable to compare with further experiments results with patients who have UE disability and trying to recover previous movement's conditions.

Methods

The study group included 23 adult participants (10 male and 13 female). The mean age was 29.2 years (range 19–63). Subjects' mean height was 1.71 m (range 1.55–1.85). The lengths of the arm segments were measured with a flexible measuring tape. All of the patients were right-handed. Inclusion criteria: none of the participants had any UE injuries that could influence kinematic results during the experiment. Experiments with all 23 participants were performed at the Coventry University laboratory in United Kingdom.

The three-dimensional motion analysis was performed with a Vicon Motion Capture System (Vicon, USA). Experimental data was transferred to windows-based data acquisition software (Vicon Nexus 1.7.1). Vicon system includes passive markers, sync box (or POE), 12 high resolution cameras with infrared illumination were located on tripods and positioned around the testing area (approx. volume dimensions, m: Height × Width × Length ≡ 2.5 × 1.8 × 1.8).

Measurements were performed at frequencies of 60–100 Hz. Overall system accuracy was 63±5μm and noise level of 15 μm, but during some cases because of dynamic calibration or arbitrary settings accuracy could be lower [11].

The UE experiment used a whole body Vicon system model and 39 passive retro-reflective spherical body markers were positioned at specific anatomical skeletal places [12] on the surface of a special suit.

All participants performed movements with their right and left arms. The subjects stood in a marked experiment area and have been asked to perform hand motions according to the created experiment methodology. Each subject performed 6 sessions during the experiment - three motions with the left side and three with the right side. Prepared hand joints motions chosen according to the possible biomechanical motions in human joints: flexion, extension, abduction, adduction, pronation and supination. During first session, wrist joint flexion, extension, adduction and abduction were examined. The second session investigated elbow joint motions: flexion, extension, pronation and supination. The third session examined shoulder motions: flexion, extension, adduction and abduction (pronation and supination were not tested). All motions were repeated three times.

Results

Mean (M) of measured amplitudes and calculated angular velocities with its standard deviations (SD) from all 23 participants data were used to determine intraperson coefficients of variability (CV=SD/M) outcome (Fig. 1).

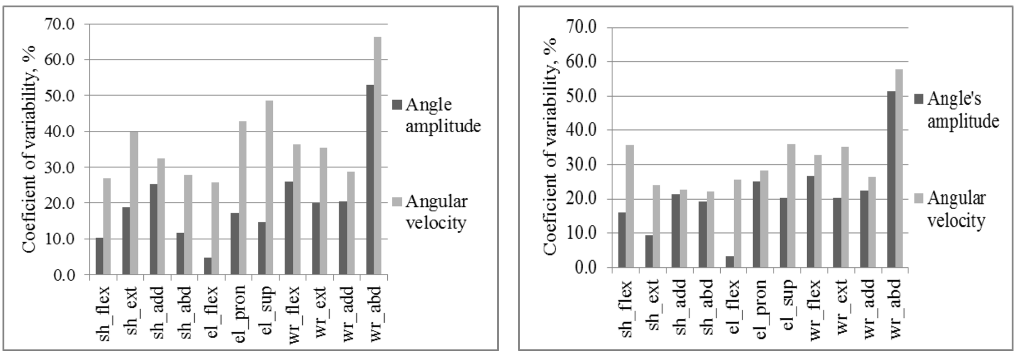

Fig. 1. Intraperson left-side (picture on the left) and right-side (picture on the right) coefficients of variability (CV) of angle's amplitudes and angular velocities of shoulder (sh), elbow (el) and wrist (wr) motions

Left-side motions showed that the lowest value of CV of angles amplitudes is at elbow flexion – 3.2% but highest is at wrist abduction 51.4% and the lowest/highest CV of angular velocities are 22.1% / 57.9% during elbow flexion/wrist abduction (Fig. 1). Right-side motions showed that the lowest value of CV of angles amplitudes is at elbow flexion – 4.7% but the highest at wrist abduction 52.9% and the lowest/highest CV of angular velocities are 25.7% / 66.3% during elbow flexion/wrist abduction (Fig. 1).

Comparing the right side motions of the left, intraperson CV of amplitudes of angles of both sides are very close but also differs from 1.5% during the elbow flexion to 10.3% during the wrist abduction and CV of angular velocity differs from 0% during the elbow flexion to 14.5% during the elbow pronation (Fig. 1).

Conclusions and discussion

There is a common way to examine human UE motions quality by evaluating of kinematic parameters such as angles amplitudes and angular velocities during specified motions methodology [13, 14]. Patient's upper extremity motions quality could be evaluated by comparing their kinematic motions parameters with healthy people parameters. However, from CV it is obvious that intrapersonal comparison could not be accurate during almost all UE motions. A different situation exists with interpersonal CV results because it is reliable for amplitude and angular velocity measurements and it means that the comparison of UE motions quality of the same person before and after the rehabilitation program should be available.

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