Studying Upper-Limb Kinematic Using Inertial Sensors Embedded in Smartphones.

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Abstract

Background: In recent years, there have been investigations concerning upper-limbs kinematics by various devices. The latest generation of smartphones often includes inertial sensors with subunits which can detect inertial kinematics. The use of smartphones is presented as a convenient and portable analysis method for studying kinematics in terms of angular mobility and linear acceleration
Objective: The aim of this study was to study humerus kinematics through six physical properties that correspond to angular mobility and acceleration in the three axes of space, obtained by a smartphone.
Methods: This cross-sectional study recruited healthy young adult subjects. Descriptive and anthropometric independent variables related to age, gender, weight, size, and BMI were included. Six physical properties were included corresponding to two dependent variables for each of three special axes: mobility angle (degrees) and lineal acceleration (meters/seconds2), which were obtained thought the inertial measurement sensor embedded in the iPhone4 smartphone equipped with three two elements for the detection of kinematic variables: a gyroscope and an accelerometer. Apple uses an LIS302DL accelerometer in the iPhone4. The application used to obtain kinematic data was xSensor Pro, Crossbow Technology, Inc., available at the Apple AppStore. The iPhone4 has storage capacity of 20MB. The data-sampling rate was set to 32 Hz, and the data for each analytical task was transmitted as email for analysis and postprocessing
The iPhone4 was placed in the right half of the body of each subject located in the middle third of the humerus slightly posterior snugly secured by a neoprene fixation belt.
Tasks were explained concisely and clearly. The beginning and the end were decided by a verbal order by the researcher. Participants were placed standing, starting from neutral position, performing the following analytical tasks: 180º right shoulder abduction (eight repetitions) and, after a break of about 3 minutes, 180º right shoulder flexion (eight repetitions). Both tasks were performed with the elbow extended, wrist in neutral position and the palmar area of the hand toward the midline at the beginning and end of the movement.

Results: A total of 11 subjects (8 men, 3 woman) were measured, whose mean of age was 24.7 years (SD = 4.22 years) and their average BMI was 22.64 Kg/m2 (SD = 2.29 Kg/m2). The mean of angular mobility collected by the smartphone was bigger in pitch axis for flexion (☐= 157.28°, SD= 12.35°) and abduction (☐= 151.71°, SD= 9.70°). With regard to acceleration, the highest peak mean value was shown in the Y motion axis during flexion (☐= 19.5°/s2, SD = 0.8°/s2) and abduction (☐= 19.4°/s2, SD = 0.8°/s2). Also, descriptive graphics of analytical tasks performed were obtained.

Conclusions: This study shows how humerus contributes to upper-limb motion and it identified movement patterns. Therefore, it supports smartphone as a useful device to analyze upper-limb kinematics. Thanks to this study it´s possible to develop a simple application that facilitates the evaluation of the patient.