Evaluation of normal Gait using electro-goniometer

Neelesh Kumar¹, Dinesh Pankaj¹, Ankit Mahajan¹, Amod Kumar¹ and B S Sohi²

¹Central Scientific Instruments Organisation (CSIO), Chandigarh 160 030, India
²University Institute of Engineering & Technology (UIET), Chandigarh 160 014, India

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A potentiometer-based electro-goniometer has been developed to measure knee angle of normal healthy individuals (5), who were instructed to walk slow, normal and brisk for walking distance of 17 m. Data acquisition and analysis on acquired data were done using LabVIEW. For individuals with different physical parameters, it was found that frequency (steps/min) remains the same irrespective of varying velocities. Step length reduces as individuals walk without shoes.

Keywords: Gait cycle, Goniometer, Knee flexion angle, Step length, Stride length

Introduction

Quantitative estimation of human walking is normally done through gait analysis, which involves extraction and evaluation of Gait parameters¹². Clinical gait analysis allows measurement and assessment of walking biomechanics such as joint motion for identification of abnormal characteristics and recommendation of treatment alternatives³. Joint mobility can be determined by visual estimation, gyroscope, accelerometers, and goniometers⁴. Knee angle measurement using electro-goniometer is used increasingly⁵. Studies are available on evaluation of gait parameters during normal walking⁶⁷. Present study evaluates various spatio temporal parameters of normal walk with developed electro-goniometer. Walking comparison has been made on the basis of subject’s age, height, weight, sex etc.

Materials and Methods

Normal healthy individuals (5, both male/female; age, 21-30 y; weight, 49-72 kg; height, 157-175 cm) were evaluated of gait parameters for prosthetic development. All individuals were free from cardiovascular, orthopedic, clinical pathology affecting their ambulatory capacity, and were comfortably able to walk long distances without any external assistance.

Distance covered by uninterrupted walking was 17 m. All individuals were instructed to walk at their normal, slow and fast speed.

Five walking trials of each individual, for three self selected walking speeds were conducted. An electro-goniometer sensor using principle of potentiometry was developed to measure angles between two linear elements meeting at a joint. A linear potentiometer (5K) uses a principle of linear change in electrical resistance with linear change in angle of rotation of axis. Electro-goniometer device was connected to human knee joint. Electro-goniometer converts joint angle in to voltage, which is sensed by DAQ card. Maximum sampling rate of DAQ card was 500kS/s and it can digitize analog signals with 12 bit ADC. A suitable calibration factor is derived to calibrate measured knee angle values in terms of acquired voltages. Accuracy and precision of electro-goniometer depends on mechanical design and electrical properties of sensor. Precision achieved was ±0.5°. Acquired data was stored (rate 1 Hz) and analysed using LabVIEW (version 7.0) for calculation of spatial parameters (flexion angle, step length, forward velocity, cadence etc.). Step length is total distance along path of walk from foot strike of one foot to foot strike of opposite foot. Cadence is defined as the number of steps taken per unit time.

Results

Variation, reported in walking parameters for the subjects (n=5), is mainly due to physical characteristic
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The study reveals that cadence of individuals remained almost same in self-selected walking speed irrespective of walking patterns. Self-selected speed variation was 3.12-5.46 (slow), 4.12-6.07 (normal) and 5.54-7.59 (fast). Average cadence parameter were evaluated as 99.75 (slow), 120 (normal) and fast (132.45) walk. Knee flexion angle variation is 65° for slow walk (Fig. 1), 67° for normal walk (Fig. 2), and 69° for fast walk (Fig. 3). Experiments were also done to analyze walking patterns of individuals wearing footwear and without footwear. Knee flexion angle varies up to 4° with increase in walking speed with footwear. Significant increase in step, stride length up to 4 cms was analysed when walking with footwear.
Similarly, decrease in stride length up to 4 cms was observed in case of walking without footwear.

Conclusions
Studies on normal gait patterns of healthy individual for different walking speed give ability to diagnose any abnormalities. Experiments prove that changes in gait parameters like linear velocity are dependent on step length and stride length. Range of knee flexion angle for normal walking speed is 65°. Knee flexion angle varies with variation in velocity of walking. Knee flexion angle variation from slow and fast speed is 4°. These findings can be used for developing prosthetic control algorithm to provide swing stance stability based on different walking speeds. Significant increase in step, stride length and decrease in cadence is reported when walking with footwear. Additional weight of footwear adds inertial force during swing phase thus increasing step and stride lengths.

References