DEVELOPMENT OF A GAIT ANALYSIS PROTOCOL FOR THE EVALUATION OF STROKE PATIENTS

[1]Enrica Papi, [1]Ukadike C. Ugbolue, [1]Stephanos Solomonidis and [1]Philip J. Rowe.
[1]Bioengineering Unit, University of Strathclyde, Glasgow, UK
email: enrica.papi@strath.ac.uk

SUMMARY

A new protocol for motion analysis specifically designed for stroke patients is described and results of a preliminary study applying the novel method on healthy subjects are reported.

INTRODUCTION

The usefulness of human movement analysis, employing stereophotogrammetry, is now widely recognized in clinical and research practice. Despite this fact however, a standardized protocol is yet to be introduced, although data are shared and compared across laboratories [1]. Whilst being anatomically accurate and repeatable in the definition of bone segments, a protocol should allow for a fast and easy implementation to reduce patients' distress during test sessions. This is of primary importance when dealing with stroke patients who do get tired easily. Taking into account those requirements, a new protocol for the description of pelvis and lower leg motion has been developed and is presented. This investigation reports the reliability of a new protocol designed to determine the kinematics and kinetics of gait within a clinical setting.

METHODS

The protocol was applied using a twelve camera motion capture system (Vicon Mx Giganet, Oxford Metrics, UK) and four force plates (Kistler Instrumente AG, Switzerland). Data sampling was set at 100 Hz. A marker set (Figure 1) consisting of 5 rigid clusters, each comprised of four 14mm diameter markers and 12 skin markers placed on anatomical landmarks, the latter for calibration purpose only, was employed. All markers were of the passive reflective type. Clusters were positioned on the distal part of the thigh and shank segments and on the back of test subjects using hypoallergenic double sided tape. Clusters design followed specified design criteria [2]. Three additional markers on each foot were positioned on the first and fifth metatarsal head and on the calcaneus to describe the 3D motion of the foot. This marker set allowed the definition of anatomical frames of reference in accordance with standard recommendations [3, 4] and hence the reconstruction of the segment model. Hip joint centre location was estimated as in [5], whereas knee and ankle joint centre were assumed to be the midpoint between epicondyles and malleoli respectively. An optimisation procedure for orientating the knee flexion-extension axis prone to errors arising in femoral epicondyles identification during palpation was employed [6]. Joint kinematics were obtained using the method presented in [7] based on the joint coordinate system [8]. For pelvic angles calculation the sequence Rotation-Obliquity-Tilt was adopted [9]. Kinetics parameters were obtained by inverse dynamics.

Ethical approval from the University of Strathclyde was obtained prior to the commencement of the study. Barefoot level walking data were collected from 6 healthy subjects (aged: 29.8±6.7 years). They were asked to walk at self selected speed and 5 trials from each participant were analysed. The time required for a test session was approximately 20 to 30 minutes. Descriptive statistics were incorporated into the experimental design to assess repeatability and variability of the measurements. Intra-subject and inter-subject variability were analysed.

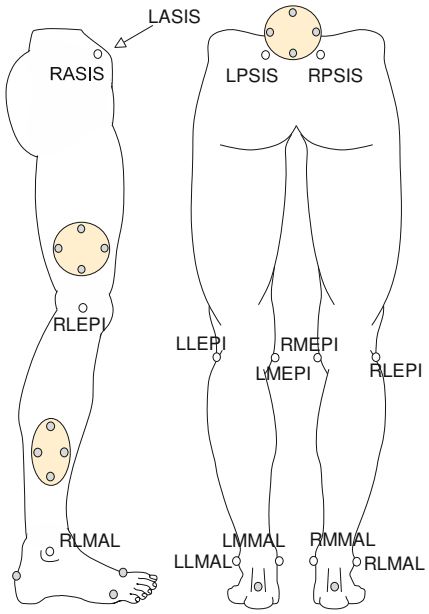

Figure 1: Marker set used for data capture. Anatomical landmarks location calibrated during the static trial are shown (white circles).

RESULTS AND DISCUSSION

Outcomes data showed a good agreement with previously conducted studies. Comparable results for left and right side were obtained. A small intra-subject variability for kinematic outcomes was observed in each subject. Minimum and maximum values of standard deviation averaged throughout a gait cycle for all measures were respectively 0.43° (Knee ab/adduction) and 2.47° (knee flexion/extension). Among subjects, the most repeatable measures were pelvic obliquity and knee ab/adduction (SD: 2.3°) whereas the least repeatable was hip rotation (SD: 6.6°).

The aim of motion analysis is to obtain reliable measurements in a repeatable fashion through an easy and rapid procedure. Results from this preliminary study showed an encouraging achievement towards this aim. Reliable and repeatable measurements have been obtained using the new proposed protocol.

With the elimination of the static calibration pointer technique, as originally introduced by Cappozzo et al.[10], the proposed protocol significantly reduces the subject preparation time as only one calibration trial for all anatomical landmarks is required. Patients' discomfort is thus minimized as they do not need to stand for a prolonged period during the static calibration session.

CONCLUSIONS

The method described allows for a 3D reconstruction of lower limb segments and a repeatable description of joint motion. A reliable method has been developed that is not time-consuming and useful for stroke patients.

REFERENCES

1. Ferrari A, et al., *Gait & Posture*. **28**:207-216, 2008
2. Cappozzo A, et al., *IEEE Trans Biomed Eng*. **44**:1165–74, 1997.
3. Wu G, et al., *J Biomech*. **35**: 543-548, 2002.
4. Baker R., *J Biomech*. **36**: 300-302, 2003.
5. Harrington ME, et al. *J Biomech*. **40**:595-602, 2007.
6. Schache AG, et al., *Gait & Posture*. **24**:100-109, 2006.
7. Cole GK, et al., *J Biomech Eng*. **115**:344–9, 1993.
8. Grood et al., *J Biomech Eng*. **105**:136-144, 1983.
9. Baker R., *Gait & Posture*. **13**: 1-6, 2001.
10. Cappozzo et al.,*Clinic Biomech*. **10**: 171-178, 1995.