COMPARISON OF TWO ANKLE ELECTROGONIOMETERS AND MOTION ANALYSIS

Sujani N. Agraharasamakulam, Shaw Bronner and Sheyi Ojofeitimi
ADAM Center, Long Island University, Brooklyn, NY;
Email: an_sujani@yahoo.com, web: www.brooklyn.liu.edu/bbut04/adamcenter/index.html

INTRODUCTION

Flexible electrogoniometers (EG) have been used for gait and sports-specific lower extremity kinematic analysis. The commonly used EG sensor for the ankle is placed parallel to the Achilles tendon (Apara) (SG110, Biometrics, Ltd). Recently, a new ankle EG sensor was developed for placement at the lateral malleolus (Aperp) (SG110/A, Biometrics, Ltd).

In order to test the boundaries of the EG, we selected dancers for our study since they frequently work at extremes of joint motion. The purpose of this study was to examine the concurrent validity of the "new" ankle sensor (Aperp) to Apara EG as well as to a motion analysis (MA) system (the current gold standard), while measuring common dance movements in the sagittal plane.

METHODS

Seventeen dancers (10 female and 7 male), mean age 20.76 ±2.46 years (age range 18 – 27 years), with an average of 10 years of dance training were recruited for this study. The two flexible strain-gauge EGs were placed at the right ankle of each subject, connected to a portable data-logger, and sampled at 100 Hz. Concurrent recordings were made with a Vicon 5-camera motion capture system (MA), sampled at 120 Hz, in order to verify sagittal plane movements recorded by the EGs. Each dancer performed four repetitions of 10 selected dance movements. The EG data were filtered at 5.5 Hz using a 4^{th} order, low pass, zero lag Butterworth filter. The MA data were filtered using an FIR filter and resampled at 100 Hz. Multimodal peak angular displacement data were scored in a custom LabVIEW program.

Concurrent validity intraclass correlation coefficients (ICC) (3, k) comparing: a) the two EGs (Aperp v. Apara), and b) each EG to MA (EG v. MA) were calculated from 2-way ANOVAs ($p < 0.05$), for combined and individual movement conditions (SPSS 13.0).

RESULTS AND DISCUSSION

ICCs comparing the two EG devices were very high for both combined (r = 0.937) and individual conditions (range r = 0.842 – 0.971) (Table 1). ICCs comparing each EG device to MA were also high for combined (r = 0.954 and 0.958) and individual conditions (range r = 0.829 – 0.992).

Previous analyses of the EGs to a protractor have established a high level of accuracy in measurement, with the mean absolute residual error less than 1.0º [1]. Analysis of relative reliability during repeated measures on the same and following day are currently underway.

When used by the same observer, EGs have demonstrated good reliability for repeated measurement of ankle dorsi-plantarflexion [2]. However, these investigations focused on mid-range movements. Electrogoniometer measurement error increases with extreme positions [3]. Preliminary laboratory MA measurement of common dance movements reported non-weightbearing and weightbearing angular displacements at the ankle ranging from 41.4º(±2.3) dorsiflexion to 55.4º(±2.5) plantar flexion [4]. Because motion greatly exceeds those seen in gait analysis, the selection of EGs to measure dance movement required validation.

Subjects found the new ankle sensor (Aperp) to be more comfortable. Apara sensor breakage was frequent due to the stresses placed upon it by extreme plantar flexion. The Aperp sensor did not break during the course of this study.

CONCLUSIONS

Reliability and validity of EGs to measure basic dance movements in the laboratory is a crucial precursor to workplace exposure-risk analyses. Both ankle EGs were highly correlated to MA and to each other, making them acceptable for use in this population. The greater comfort and durability of the new Aperp sensor makes it appealing for worksite use.

REFERENCES

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Table 1: Comparison of ankle sensors and MA: ICC and degrees of freedom (DOF).

Selected Conditions	EGAperp v. EGApara	EGApara v. MA	EGAperp v. MA
Combined (1 – 10)	0.937 (297, 1)	0.954 (309, 1)	0.958 (296, 1)
Grand plié	0.918 (22, 1)	0.960 (25, 1)	0.933 (22, 1)
Passé	0.928 (25, 1)	0.939 (25, 1)	0.992 (25, 1)
Developpé side	0.911 (34, 1)	0.893 (35, 1)	0.878 (34, 1)
Battement arabesque	0.921 (23, 1)	0.937 (23, 1)	0.989 (24, 1)
Jump	0.971 (25, 1)	0.970 (25, 1)	0.978 (25, 1)