18th Congress of the Italian Society of Clinical Movement Analysis (SIAMOC)

Politecnico di Torino, Torino, Italy, 4th-7th October 2017

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O41 - Cortical representation of reaching and grasping movements in healthy subjects

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INTRODUCTION

The mechanisms that the central nervous system employs to control the movement performed with the upper limbs is still matter of research [1]. The present work proposes a neurophysiological approach allowing to decode the electrical activity during the reaching and grasping movement compared to a resting state condition through the assessment of the synchronization between high-density EEG and the data gathered by a stereofotogrammetric system. The results of this study could be particularly relevant for the evaluation of the mechanisms of functional recovery of finalist movements, such as reaching and grasping, in patients with acute stroke.

METHODS

Five healthy subjects were recruited (42.4±5.4 years). The motor performance during reaching and grasping (left/right arm) was simultaneously assessed by an optoelectronic system equipped with 8 infrared cameras and a high-density EEG (64ch). Eighteen markers were placed on anatomical landmarks in accordance with validated upper limb and trunk biomechanical model (RAB model – modified). The event-related synchronization/desynchronization method (ERS/ERD) was used for quantifying the task-related changes in brain activity in α and β frequency bands. ERD/ERS values were defined as the percentage decrease/increase of the power spectral density (PSD) during the task (Mov) with respect to the baseline value (pre-movement, Rest1 and post-movement, Rest2). Accordingly, event-related PSD decrements representing a decrease in synchronization of the underlying neuronal populations and indicating cortical activation resulted in negative values. Finally, the Wilcoxon test with Bonferroni correction *($p<0.05$)* was performed to detect significant differences between PSD in rest and movement.

RESULTS

The velocity of the mid point between the wrist markers was used to define the beginning and end of the Reach and Grasp Cycle. The ERD maps were derived for all trials and subjects and used for both individual and group analyses. The EEG analysis showed a significant ERD over the sensorimotor cortex in α and β, comparing Mov vs. Rest1 and Mov vs. Rest2 in both movements. The desynchronization was maximum over the contralateral central areas and, secondarily, over the ipsilateral motor areas. Moreover, the post-movement condition showed a PSD greater than the pre-movement condition in α and β.

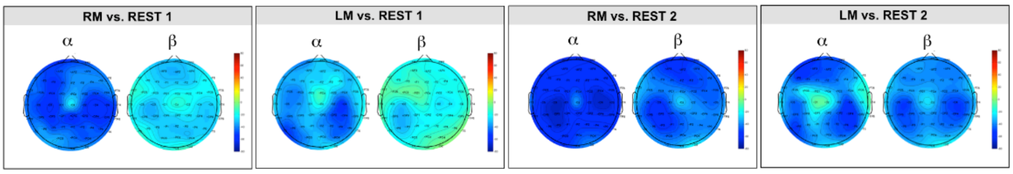

Figure 1. Event-related desynchronization in α and β, comparing Mov vs. Rest1 and Mov vs. Rest2.

DISCUSSION

The main result is that electrical changes are elicited in both the contralateral and ipsilateral somatosensory and motor areas, as well as in the frontal and occipital areas, bilaterally.

During Rest2, a significant synchronization of the activity in α and β frequency bands, greater than in Rest1, was detected. Though preliminary, these data shed light on the possibility of detecting and interpreting the activity changes induced by acute pathologies, such as stroke, and for monitoring the modulation of electrical brain activity by the motor performance over time, setting the basis for identifying the neurophysiological processes underlining recovery.

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O42 - Anatomical calibration of inertial and magnetic sensors for estimating upper limb kinematics

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INTRODUCTION

The use of inertial and magnetic sensors (MIMU) for the estimate of a consistent and clinically sound joint kinematics requires the knowledge of the orientation of the sensor with respect to the anatomical frame (AF) of each bony segment involved in the analysis. For upper limb kinematics, AF have been defined by using the direction of the angular velocity and gravity vectors as measured by the MIMU during selected segment's rotations and fixed postures [1]. However, hyperacute patients may present an impaired mobility and may not be able to assume specific posture and/or perform calibration exercises. Aim of this study was to develop an anatomical calibration procedure definition procedure based on palpable anatomical landmarks (ALs) for the estimate of upper limb kinematics.

METHODS

8 healthy subjects were enrolled in the study. ALs for thorax, upper arm and forearm were identified and marked by an operator. AFs were defined according to the International Society of Biomechanics recommendations [2]. One MIMU was fixed with an arbitrarily orientation on each of the three segments. An accessory MIMU was mounted on a calipers-like pointing device to measure the length and the direction of selected axes defined by the marked ALs [3]. Retroreflective markers were then placed on the marked ALs and their trajectories recorded with a stereophotogrammetric system to obtain a reference joint kinematics. The humeral head was identified as suggested by [4]. Experimental data were collected while subjects performed three non-consecutive reach&grasp movements from an upright posture. Thoracohumeral and elbow kinematics were expressed in terms of: arm elevation plane (AEP), arm elevation angle (AEA), arm axial rotation (AR), elbow flex-extension (EFE), elbow prono-supination (EPS). Posture angles and range of motion (RoM) values were extracted for validating the proposed approach by means of statistical analysis. Bland and Altman plots, corrected for the effect of repeated measurement error, and Pearson's correlation coefficient were used for assessing the agreement and the association between methods, respectively. Differences between methods were ascertained by means of a paired Student's t-test.

RESULTS

Results of the statistical analysis are reported in Table 1.

Table 1. Reference value, bias, upper and lower limits of agreement (LOA) and correlation coefficient (*r*) relative to posture angle and RoM variables as obtained using the two methods (* p<.05).

	RoM				posture angles		
	reference (bias)	u-LOA	l-LOA	*r*	reference (bias)	u-LOA	l-LOA
AEP	71.8° (1.4°)	7.2°	-4.4°	0.974	n/a	n/a	n/a
AEA	71.7° (-3.6°)	4.3°	-11.5°	0.926	14.1° (3.4°)	11.8°	-5.1°
AR	153.3° (3.1°)	13.4°	-7.2°	0.967	26.7° (5.1°)	27.3°	-17.1°
EFE	113.4° (3.6°)	16.3°	-9.2°	0.991	7.4° (-5.7°)	18.3°	-29.6°
EPS	52.8° (2.3°)	11.6°	-7.1°	0.983	24.9° (0.6°)	10.6°	-9.3°

DISCUSSION

Results showed that anatomically calibrated MIMUs can be used as an ambulatory alternative to track the kinematics of upper limb. RoM was found not statistically different, highly associated and in good agreement with respect to the reference measures. Posture angles were found low-biased and not statistically different too, although large LOA were observed especially for AR and EFE angles.

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O43 - A graphical tool for the quantitative assessment of gait control performance: analysis of maturation and dual task effects.

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INTRODUCTION

In literature, there is a growing interest in understanding how the control of human walking matures and declines during lifespan [1, 2]. Gait is indeed emerging as a powerful diagnostic and prognostic tool for motor control analysis, particularly when the performance is assessed using user-friendly portable gait analysis systems [3]. In this context, dual tasks (DT) methodology is often used to assess the involvement of attentional resources in gait control [2, 3]. Traditionally gait performance is quantitatively analysed by assessing spatiotemporal parameters [2]. On the other hand, literature has recently proposed other parameters assumed to highlight features related to motor control behaviour [4]. This work aims to analyse the overall development of human gait during maturation in single task (ST) and DT condition, observing how the different quantitative measures of gait performance change with increasing age from childhood to adult age. To allow an interpretative synthetic overview of the results, an innovative graphical tool for gait performance assessment was designed and proposed.

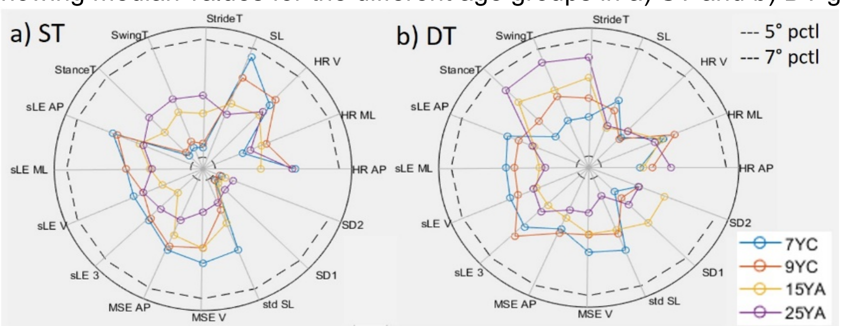
METHODS

Forty healthy subjects participated in the study: ten 7-year-old children (7YC), ten 9-year-old children (9YC), ten 15-year-old adolescents (15YC) and ten 25-year-old adults (25YA). Measures of acceleration and angular velocity of the trunk and of the shanks were collected using three tri-axial wireless inertial sensors. The participants were asked to walk at self-selected speed in ST and cognitive DT condition: DT consisted in counting backward aloud by *n* from a random starting number (*n* was fixed at 3 for children, 8 for adolescents and 7 for young adults). For each participant 20 strides were analysed. Normalized stride length (SL), stride- (StrideT), swing- (SwingT), stance- time (StanceT), standard deviation of SL and of StrideT (stdSL, stdStrideT), Poicarré plots of StrideT (SD1 and SD2), step symmetry were obtained on shank angular velocity data [4]. Harmonic Ratio (HR), short Lyapunov Exponents (sLE) and Multiscale Entropy (MSE) were calculated on trunk acceleration data along the 3 direction. A Friedman test was conducted to evaluate the effect of age and DT factors on the different parameters. A polar plot was defined for the most significant parameters and a graphical user interface (GUI) was designed to allow data analysis and interpretation.

RESULTS

Age showed a significant effect on all the parameters except for stdStrideT, HR and SD2. DT showed a significant effect on all the parameters except for MSE on the sagittal plane and sLE. Figure1 shows median results for the different age groups on the developed GUI for a) ST and b) DT condition.

Figure 1. GUI showing median values for the different age groups in a) ST and b) DT gait.



DISCUSSION

This study offers a comprehensive evaluation of gait performance changes from childhood to adulthood, both in ST and DT condition. In the future, with the inclusion of a higher number of data and the construction of reference bands for typical development, this tool has the potential to be used for the screening and monitoring of motor performance in developing population.

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O44 - Correlation between motor and cognitive parameters, in fully ambulatory relapsing-remitting patients with Multiple Sclerosis: a 3D gait analysis study

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INTRODUCTION
Multiple Sclerosis is a demyelinating disease of central nervous system, characterized by motor and sensitive impairments. Aims of our study were to detect changes in gait patterns in fully ambulatory patients with relapsing-remitting Multiple Sclerosis(RR-MS) and to evaluate correlations between motor and cognitive functions using a 3D gait analysis approach.

METHODS
29 RR-MS patients (mean age: 37.3±10 years; BMI: 23.7±3.6 kg/m2; EDSS: 2±0.9) and 22 age-BMI matched healthy controls (HC) were enrolled. The gait parameters were recorded with a stereophotogrammetric Qualysis system (240Hz), after placing forty-one passive markers on the body according to a modified Davis protocol. Cognitive functions were evaluated through Rao brief repeatable battery (Rao-BRB). The participants underwent 3D gait analysis in three conditions: 1) single-task (walk at self-selected speed); 2) motor dual-task (walking while carrying a tray with two glasses filled with water); 3) cognitive dual-task (walking while serially subtracting seven digits starting from 100). For all conditions, kinematic and spatio-temporal parameters (including the coefficients of variability, CV) were calculated. The latter were divided into velocity and stability parameters.

RESULTS
The RR-MS patients, compared to HC, showed during single-task an impairment of stability parameters including stance time (p≤0.05), stance time CV (p≤0.05) and swing time (p≤0.01). An increased degree of ankle dorsal-flexion was also observed (p≤0.05). The cognitive dual-task determined an increase of instability (swing time CV, p≤0.05; double limb support, p≤0.05; DLS/SLS, p≤0,01) and kinematic parameters (ankle dorsal-flexion, p≤0.05; thigh flexion, p≤0.05). The motor dual-task induced a significant increasing of instability parameters in RR-MS patients (stance time, p≤0.05; stance time CV, p≤0.01; swing time CV, p≤0.05; double limb support and its CV, p≤0.05). Furthermore, the motor dual-task induced reduction of the knee extension and increased thigh flexion (p≤0.05). Finally, an inverse correlation between cognitive performances and parameters of stability was observed.

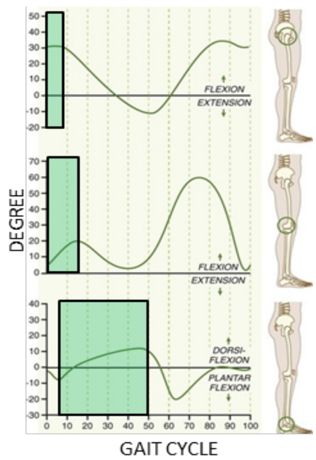

Figure 1. In normal Kinematic curves of ankle, knee and thigh joints, are highlighted the altered phases of gait cycle in RR-MS.

DISCUSSION
3D gait analysis may detect in fully ambulatory RR-MS patients a worsing stability parameters compared to HC. Worsening of motor pattern during cognitive or motor dual-tasks and the inverse correlation between cognitive performance and gait stability suggests a role of cognition in affecting gait in RR-MS patients. The study shows that 3D-gait analysis is a useful tool to document very slight motor impairment in patient with MS. This approach might be useful in clinical trials to refine the clinical evaluation.

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