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O1 - Efficacy of multilevel functional surgery in the reduction of stiff knee gait in stroke patients. A retrospective study

E. Giannotti 1,2, A. Merlo 1, M. Galletti 1, P. Zerbinati 3, P. Prati 1, M. Longhi 1, S. Masiero 2, F. Mascioli 1, D. Mazzoli 1

1 Gait & Motion Analysis Laboratory, Sol et Salus Hospital, Rimini, Italy
2 Department of Orthopaedic Rehabilitation, University of Padova, Padova, Italy
3 Neuroorthopedic Service, Hand Surgery Unit, MultiMedica, Castellanza, Italy

INTRODUCTION
Equinus foot (EF) and stiff knee are the most frequent lower limb deformity in stroke survivors [1] and can be treated by functional surgery (FS). The efficacy of FS on EF reduction is well known in literature [2]. In this study, we assessed the efficacy of multilevel FS on SKG reduction, at one month from surgery.

METHODS
We retrospectively analyzed data from 25 patients (age 51±12 years, 11/14 right/left, 1-18 years from lesion, walking speed 20±10%height/s) with SKG following stroke that underwent multilevel FS performed by the same surgeon. For each subject, the intervention at both foot and knee level had been designed based on a clinical (force, shortening, spasticity) and instrumental (gait analysis) evaluation.

SKG is defined as a knee flexion peak during swing (KFP) lower than 45° [3]. In this study we arbitrarily defined three classes of KFP limitation as follows: severe SKG (KFP≤15°), moderate SKG (KFP between 15° and 30°), and mild SKG (KFP between 30° and 45°). KFP values before surgery and at one month after the intervention were compared by means of the paired Wilcoxon test in the whole sample and in the three preoperative subgroups. Next, a contingency table was created. This intersects the SKG classes before and after FS, thus outlining the clinically more relevant effects produced by surgery.

RESULTS
No adverse events arose in the sample during the first month following FS. EF was corrected in all patients. This allowed removing all preoperative walking aids and orthoses. In the sample, PKF significantly improved from 17±10° to 23±12° (p=0.003). In 6 cases (age range 34-80 years, 3/3 right/left, 1-18 years from lesion) PKF improvement was >15°.

When considering the three preoperative classes, PKF increased from 5±6° to 13±11° (p=0.025) in patients with severe preoperative SKG, varied from 23±4° to 27±10° (p=0.065) in patients with moderate preoperative SKG, and varied from 33° to 41° for the one subject with mild preoperative SKG.

Out of 25 subjects, SKG classification after multilevel FS resulted improved in 9 cases (36%), unchanged in 16 cases (64%), and never worsened (Table 1).

DISCUSSION
Functional surgery was effective, in correction EF and reducing, on average, SKG at one month from surgery. An improvement in the classification of SKG severity level was achieved by nearly 40% of the sample, with no relationship with subjects’ age and time from lesion. The analysis of relationships, if any, between preoperative clinical variables and postoperative instrumental data is ongoing.

REFERENCES
INTRODUCTION

Stability and balance keeping are extremely important aspects of gait for functional, safety and psychological reasons. In the field of rehabilitation medicine, the assessment of stability and the evaluation of the risk of fall could be of extreme importance. The present study aims at finding an eligible method for gait functional evaluation in lower limb amputees, able to provide an overall reliable information on stability and risk of fall also in short duration evaluation sessions, more adequate for amputees.

METHODS

Data were collected in a Movement Analysis Laboratory at the Rome branch of INAIL Prosthesis Centre. The experimental setup consisted in 6 infrared cameras (BTS Bioengineering, Smart DX6000) and passive markers placed according to Davis’s [1] protocol. Each participant performed 8-12 walking trials along a 9m straight path. Data were recorded from 19 trans-femoral amputees (TF, 29-74 years), 9 trans-tibial amputees (TT, 34-80 years) and 12 healthy controls (H, 29-77 years). Kinematics have been used to compute the centre of mass (CoM) as the centroid of the pelvis triangle. Obtained CoM’s trajectories were used to compute the Margin of Stability (MoS) [2], together with gait symmetry and regularity, computed from CoM acceleration signals along the Antero-Posterior (AP), Medial-Lateral (ML) and Cranial-Caudal (CC) directions as suggested in [3].

RESULTS

Amputees showed a significantly wider margin of stability than controls, both along AP and ML directions. Furthermore, amputees presented a significantly more asymmetric and irregular gait than controls along all the three analyzed directions. No significant differences were found between TT and TF in terms of stability parameters.

DISCUSSION

MoS analysis might indicate differences in motor control strategies between amputees and healthy subjects: specifically, a wider MoS (resulting from a wider base of support and a lower gait speed) could compensate the lower balance control abilities in such patients. The higher gait asymmetry and irregularity in amputees show, furthermore, how such patients have a reduced motor control, resulting in a less standardized and noisier gait pattern. Although the studied parameters don’t represent effective estimator of the risk of fall, they could give an overall functional characterization of gait, and could be used in clinical environment to improve therapies and design of prosthetic devices, starting from basic information such as stability and motor control.

REFERENCES

O3 - Assessment, through variability and stability indexes, of how environmental conditions influence gait
P. Tamburini¹, F. Storm², C. Buckley², MC. Bisi¹, R. Stagni¹ and C. Mazzà²
¹Dept. of Electrical, Electronic and Information Engineering, University of Bologna, Bologna, Italy, ²INSIGNEO Institute for in Silico Medicine, University of Sheffield, Sheffield, UK.

INTRODUCTION
Wearable sensors allow shifting gait analysis from the laboratory setting to daily life conditions [1]. Testing environment (indoor or outdoor) and walking protocols (free or controlled) might affect gait pattern, thus, an evaluation of how these aspects can influence the indexes used to assess gait performance and control is needed. It is hypothesised that, gait being a paradigmatic task, changes in walking protocols for young healthy adults can influence a subject’s performance (measured by gait variability indexes [2]) but not their underlying motor control (measured by the stability indexes [2]).

METHODS
19 healthy young adults (28±3y.o., 1.75±0.09m, 72.0±9.2kg) were recruited. Subjects wore two IMUs (Opal, APDM, USA): located on the lower trunk and on the ankle. Subjects completed four walking tasks in different operating conditions, as described in Table 1.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Acronym</th>
<th>Description</th>
<th>Duration/Repetitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoor controlled walking</td>
<td>ICW</td>
<td>Walking at preferred speed along an indoor straight path 20.0 m long walkway.</td>
<td>Eight repetitions.</td>
</tr>
<tr>
<td>Outdoor controlled walking</td>
<td>OCW</td>
<td>Walking at preferred speed along an outdoor straight path 50.0 m long walkway.</td>
<td>Six repetitions.</td>
</tr>
<tr>
<td>Indoor free walking</td>
<td>IFW</td>
<td>Walking along corridors within a university building, avoiding stairs.</td>
<td>Two minutes.</td>
</tr>
<tr>
<td>Outdoor free walking</td>
<td>OFW</td>
<td>Walking along footpaths open to the public in the city centre without any restrictions in route or walking speed, avoiding stairs.</td>
<td>Fifteen minutes.</td>
</tr>
</tbody>
</table>

For each participant and each condition 80 strides, excluding turns and resting periods, were analyzed, since this was the maximum number of strides available in all conditions. Gait variability (Standard Deviation (SD), Coefficient of Variation (CV) and Poincaré plots (PSD1)), and stability indexes (Harmonic ratio, Short term Lyapunov exponents, Recurrence quantification analysis and Sample entropy) were calculated on trunk acceleration data, choosing those that could be calculated with sufficient reliability based on the maximum number of strides in all walking conditions [2]. Kruskal-Wallis test (p_value=5%, Dunn-Sidak post-hoc correction) was performed to compare the indexes values obtained in the different walking conditions.

RESULTS
All variability indexes varied significantly among the analysed walking conditions, conversely from the stability indexes. In particular, Kruskal-Wallis test showed statistically significant differences for PSD1 between OCW and OFW and between ICW and OFW, with values being 35% higher in OFW than in OCW and ICW. SD and CV in ICW were significantly different from both OCW and OFW conditions, being approximately 20% lower.

DISCUSSION
The obtained results confirmed the study hypothesis: whereas the manifested gait performance (variability indexes) can be altered even in a well-achieved gait pattern as that of healthy young adults, the underlying motor control (stability indexes) is not influenced either by the environmental or by the type of walking. Future research will focus on testing different population to further and strengthen improve the validity of the obtained results.

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REFERENCES
INTRODUCTION

It has been highlighted that obesity influences gait reducing walking velocity, stride length, ankle dorsal flexion at initial contact and ankle power generation. Meanwhile, gait width, double support, hip flexion, knee extension during stance, hip moment and ankle power absorption was described increased [1, 2]. A tendency to the normalization of these parameters occur when subjects reduced their weight during growth [3]. In this paper we studied the effect of fast weight loss due to surgical intervention (Sleeve Gastrectomy) on gait pattern on adolescent with severe obesity. The aim is to assess the functional benefit of the surgery and to enhance the understanding on gait dynamic characteristics.

METHODS

11 patients (2 F; age 14.7±1.5, BMI pre 122.3±20 and post 81.5±13.9 assessment) before and after 1 year from surgery and 10 healthy people (7 F; age 18.7±4.9, BMI 57.3±11.5) participated to the study. We acquired the gait by an optoelectronic system (Vicon MX) and two force plates. Clinical evaluation excluded any syndrome associated with obesity. Fat mass on abdomen and thigh were restrained with a non-elastic dressing in order to avoid marker fluctuations. We applied the Davis’s protocol with a minor changes (the two asis markers were positioned laterally on the iliac crest in order to enhance visibility and reduce movement artefacts, meanwhile, we accurately measured inter-asis distance and asis-trocanter distance.) Patients walked barefoot at their preferred speed. We evaluated both kinetic and kinematic features of walking. Then we looked at the differences between the pre- vs post-surgery and with the control group.

RESULTS

As already reported in literature, we found gait deviations previously described and a normalization of gait parameters even after a fast weight loss (post vs control p=ns for al parameters shown below). In particular spatio-temporal parameters highlight a reduction in the stride width (pre vs post p<0.01) and an increase of the stride length (pre vs post p<0.01) after the surgery. We observed the significant increase of the hip flex/ext range (pre: 40±1.19; post: 43.76±1.21) and the decrease (pre: 13.66±0.74; post: 11.85±0.63) of the pelvic rotation range (pre vs post both p=0.02). Moreover we observed an increase of the ankle dorsiflexion moment with also an anticipation of it on the gait cycle and an increase of the positive work of the ankle (pre vs post p<0.01). Consequentially we observed the decrease of positive work of the knee always with a restoration to normal values (pre vs post p=0.01).

DISCUSSION

Our results led to consider that the weight reduction enhanced the exploitation of the dynamic characteristics of gait, previously denied by constrains due to fat mass. Therefore surgery benefits bring to changes of pelvic and hip movements. In particular there is an increase of the hip flex/ext range that brings to an increase of the stride length. Moreover the increase of the ankle positive work, of the ankle dorsal moment and the decrease of the knee positive work can be attributable to a faster opening of the ankle linked to the increased stride length.

REFERENCES

O5 - Mechanisms of trunk stabilization during gait termination in young and older women: a neuromechanical analysis.

L. Rum 1, L. Laudani 2, G. Vannozzi 1, A. Macaluso 1

1Università di Roma “Foro Italico”, Roma, Italy; 2Cardiff Metropolitan University, Cardiff, UK

INTRODUCTION
Ageing is associated with a decline in balance and an increased risk of falling, mainly during transitory locomotor tasks such as gait initiation and termination [1]. One of the main factors underpinning the balance impairment in older individuals is a decrease in head stability, which is partly due to an increased variability of trunk motion, as previously shown during gait initiation [2]. However, it is unclear whether an altered recruitment of the upper body muscles could also contribute to the increased variability of the upper body motion while terminating gait. Therefore, the purpose of this study was to evaluate activity patterns of the trunk muscles as well as movement variability of the upper body segments during gait termination in young and older women.

METHODS
Ten young (age: 23.1±1.1) and 10 older women (age: 73.8±2.4) performed three trials of gait termination at their self-selected fast speed. A stereophotogrammetric system (VICON, UK) was used to assess angular displacement of head, trunk and pelvis along the sagittal and frontal planes through the Plug-in Gait model. Movement variability was determined by calculating the average standard deviation (AvgSD) of angular displacement of head, trunk and pelvis [2]. An electromyography device (BTS, Italia) was used to record activity of the left erector spinae muscle at T9 (EST) and at L3 level (ESL). Principal component (PC) analysis was used to evaluate the most common patterns of muscle activation within the two groups [3].

RESULTS
AvgSD of the trunk angular displacement along the sagittal plane was higher in older than young women (1.77±0.98° and 1.02±0.29°, respectively; p<0.05). Older women displayed higher AvgSD of head angular displacement along the frontal plane compared to young women (2.48±0.81° and 1.61±0.37°, respectively; p<0.05). PC analysis of the EST muscle waveforms showed that the first four PCs explained 64% and 61% of the total variance in older and young women, respectively. On the other hand, the PC analysis of the ESL waveforms highlighted that four PCs explained 65% of total variance in the older women, while three PCs explained 70% of total variance in young women (Fig.1). Moreover, visual inspection of the first PC highlighted a delayed activation of the ESL during the braking phase in older women compared to young women.

DISCUSSION
The increase in movement of the trunk and head along the sagittal and frontal planes, respectively, in older women is in line with previous reports on gait initiation [2]. At neuromuscular level, the higher number of PCs found in older women compared to young women indicated an age-related increase in the variability of muscle activation patterns of the lower trunk during gait termination. The results of the present study, therefore, suggested that an increase in neuromuscular variability of the lower trunk is a major factor underpinning the loss of stability in the upper body during such transitory locomotor task in older women.

REFERENCES
O6 - Ankle muscle co-contractions in Winters I hemiplegic children during gait
F. Di Nardo¹, A. Mengarelli¹, M. Malavolta¹, A. Strazza¹, V. Agostini², A. Nascimbeni³, M. Knafflitza, L. Burattini¹, S. Fioretti¹
¹Department of Information Engineering, Università Politecnica delle Marche, Ancona, Italy
²Department of Electronics and Telecommunications, Politecnico di Torino, Torino, Italy
³Rehabilitation Unit, S. Croce Hospital, A.S.L. TO5, Moncalieri (TO), Torino, Italy

INTRODUCTION
In children, hemiplegia is a common consequence of cerebral palsy and causes altered selective motor control, weakness and spasticity. It was shown that muscle activation and co-activation pattern is altered during hemiplegic gait [1]. Aim of the study is the quantification of altered co-activation patterns of gastrocnemius lateralis (GL) and tibialis anterior (TA) in Winters-type-I hemiplegic children during walking. In particular, we focused on those children that maintained, at least partially, a heel strike at initial contact. Both hemiplegic and non-hemiplegic sides were considered.

METHODS
Gait data of 16 children with Winters type I hemiplegia consequent to cerebral palsy (CP) were analyzed (10 males/6 females, age: mean (±SD) 8.9±2.8 years, height: 132±16 cm; mass: 29.3±9.9 kg). Children underwent a 2.5-minute walk test (more than 100 gait cycles for each child). Signals were acquired by multichannel recording system (Step32, Medical Technology, Italy). Lower limbs were instrumented with 3 foot-switches, below the heel and the first and fifth metatarsal heads, to characterize four different gait phases: Heel contact (H), Flat foot contact (F), Push-off (P), Swing (S). Single differential EMG probes, were attached over TA and GL according to Winter’s guidelines [2]. Large stride-to-stride variability of surface EMG signals was handled by Statistical Gait Analysis [3], processing separately distinct muscle “activation modalities”, averaging only across gait cycles with the same number of activations, and achieving mean activation intervals and occurrence frequency for each activation modality. Co-contractions were quantified by assessing overlapping period among TA and GL activations. Gait data from 100 control children were available and used as reference [3].

RESULTS
In the present study, only strides with H-F-P-S sequence were considered. Co-contractions between TA and GL activation intervals were detected in 100% of considered strides in hemiplegic side of CP patients, in 94.8±5.9% of strides in non-hemiplegic side of CP patients, and in 80.8±11.2% of strides in control subjects. No overlapping activity between TA and GL (i.e. no co-contractions) were observed only in strides where GL presented a single activation and simultaneously TA presented 2 activations. This occurred only in control subjects (19.2±10.4%, Fig. 1A) and in non-hemiplegic side of CP patients (5.2±5.1%, Fig. 1C). The percentage of strides with co-contraction was significantly higher (P<0.05) in CP patients (hemiplegic and non-hemiplegic side) compared to control subjects.

![Figure 1](image_url)

**Figure 1.** Mean co-contractions in three populations between GL (black) and TA (grey) in strides where GL presented a single activation and simultaneously TA presented 2 activations.

DISCUSSION
Despite the same sequence of gait phases (H-F-P-S), Winters type I hemiplegic children showed a significant increase in the recruitment of GL/TA co-contraction, with respect to controls. In general, this increase was detected in both non-hemiplegic and hemiplegic side. In hemiplegic side, co-contractions were observed also in those strides in which non-hemiplegic side showed no co-contractions (Fig. 1B vs. Fig. 1C). These co-contractions are likely due to attempts in improving balance, rather than to impairments in muscle recruitment.

REFERENCES
O7 - Carbon Ankle Seven spring orthoses in children affected by diplegic cerebral palsy: effect on gait efficiency and symmetry

C. Borghi1, R. Neviani1, C. Ferrara2, S. Costi3, D. Pandarese1, A. Ferrari3

1 Motion Analysis Laboratory LAMBDA, Santa Maria Nuova Hospital, Reggio Emilia, Italy, 2 Università di Parma, Parma, Italy, 3 Università di Modena e Reggio Emilia, Reggio Emilia, Italy

INTRODUCTION

Ankle foot orthoses (AFO) are frequently used to improve locomotor skills in cerebral palsied children (CP) although the level of scientific evidence to support their use is still moderate [1]. Moreover, rehabilitation commonly follows lower limb symmetry by physiotherapy, drug, orthoses and orthopaedic surgery because gait symmetry and energy efficiency are closely related [2]. To our knowledge no studies have been performed to compare gait efficiency and gait symmetry in CP. Carbon Ankle Seven spring orthosis (A7 – Otto Bock, Germany) is specifically designed to store energy when loaded and release it at toe-off in order to improve gait performance with respect to non-energy-storing AFOs. The aim of this study is to evaluate gait performance with A7 by comparing its effect on efficiency and symmetry versus a hinged AFO (HAFO).

METHODS

This prospective cross over study was conducted on 10 CP (5 male, 5 female, mean age 11 years) in a homogeneous group with specific walking deviations: the increased knee flexion throughout stance phase of gait. Subjects were provided with both custom made orthosis (HAFO and A7). CP wore orthosis bilaterally, in a randomly sequence, for 4-6 weeks respectively to achieve acclimatization to the orthosis. Kinematic and kinetic data were collected by means of 3D gait analysis with total3DGait protocol, while the subjects performed gait at self-selected speed. To evaluate overall performance and gait efficiency, normalized walking speed (SPEED), normalized stride length (STRIDE) and Biomechanical Efficiency Quotient (BEQ) [3] were calculated. To evaluate gait asymmetry the difference between right and left in step length (STEP) and knee flexion were computed. The mean difference in knee flexion between limbs was considered at initial contact (IC – 0-2% of gait cycle), loading response (LR – 0-10%) and mid-stance (MS – 10-30%). Outcome parameters were compared using a paired sample t-test. The level of significance was set at p<0.01.

RESULTS

Table 1. Comparison of SPEED, STRIDE, BEQ and asymmetry of knee flexion and STEP between HAFO and A7. Mean, standard deviation (SD) and p-value are shown.

<table>
<thead>
<tr>
<th></th>
<th>OVERALL PARAMETERS</th>
<th>ASYMMETRY (right vs left limb)</th>
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<tbody>
<tr>
<td></td>
<td>SPEED [%h/s]</td>
<td>STRIDE [%h]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HAFO</td>
<td>mean 68</td>
<td>64.3</td>
</tr>
<tr>
<td></td>
<td>SD 10</td>
<td>15.2</td>
</tr>
<tr>
<td>A7</td>
<td>mean 66</td>
<td>64.0</td>
</tr>
<tr>
<td></td>
<td>SD 12</td>
<td>14.5</td>
</tr>
<tr>
<td></td>
<td>p value 0.907</td>
<td>0.740</td>
</tr>
</tbody>
</table>

DISCUSSION

In this sample A7 is superior to HAFO in improving knee flexion symmetry of diplegic CP at IC and LR (p<0.01). No other statistically significant differences were found. However, with A7 there is an improvement in BEQ and in symmetry (MS and STEP) in 7 out of 10 subjects. Maximum worsening of these three indexes was always related to the same two children. A moderate correlation (0.49) was found between increase of gait efficiency (BEQ) and reduction of asymmetry (STEP). Considering BEQ and MS correlation is 0.38. These results suggest that future research should focus on detecting more specific outcome to evaluate the impact of A7 on gait efficiency (i.e. endurance test) and defining more specific indication to prescribe A7, taking into account functional effects of peripheral deformities and lever arm diseases.

REFERENCES