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NEW METHODS OF DATA AQUISITION AND WALKING ANALYSIS IN MULTIPLE SCLEROSIS AFTER FUNCTIONAL ELECTRICAL STIMULATION

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ABSTRACT

In multiple sclerosis the difficulty in walking represents one of the main patients concern. This difficulty is due to the instability of the muscles of the foot to lift it up during the swing phase of walking, known as dropped foot. Different alternatives in the rehabilitation treatment try to improve the walking, but at the present moment, in clinical medicine, scientific quantification and analysis of human walking mechanism is not highly accurate due to the lack of an objective analysis. Progress quantification in walking is essential in evaluation of the efficiency of reabilitation procedures, improvement of these procedures or elaboration of individual models for each patient..

Purpose

The purpose of the present research is represented by both the completion of a prospective study regarding efficiency of functional electrical stimulation in walking rehabilitation at patients with multiple sclerosis and the use of last generation non-invasive methods in analyzing and quantifying the results.

Methods

The present paper is a case report regarding the results obtained after application of functional electrical stimulation to a patient with multiple sclerosis. Functional electrical stimulation was applyed in order to stimulate muscular groups involved in walking by the use of a 2 channel neurostimulator (O2CHS II). The trigger points choosed for stimulation permitted to obtain dorsiflexion and eversion of the foot, associated with knee flexion. Acquisition and analysis of the data specific to walking (contact pressure, forces. moments) were made by using a pressure plate for static and dynamic measurements (RSSCAN) before and during stimulation.

Results

Registered by the pressure plate allowed identification and quantification of improvements of the patient`s walking problems by the use of electrical functional stimulation.

Conclusions

Functional electrical stimulation offers an alternative within the rehabilitation treatment in multiple sclerosis, by encouraging active movement of the food and by constantly taking the foot through the full range of movement with walking, and avoiding stiffening up of the ankle. Identification of certain analysis models in walking, will offer a viable instrument in evaluation and treatment of multiple sclerosis and sustainable results on national and international level.

Key words: multiple sclerosis, functional electrical stimulation, walking evaluation, plantar pressure

Introduction

Multiple sclerosis (MS) is a chronic neurological disease of unknown etiology which affects central nervous system, especially the brain, spine and optic nerves (A. Achiron and Y. Barak, 2000) and is characterised by demyelination of nerve fibers. Among clinical MS symptoms a common one is represented by motor and balance disorders: spasticity, muscular weakness and ataxia, decreased mobility (A.J..Lenman, F.M.Tulley, G. Vrbova et al, 1989). MS evolution is extremely variable and unforeseeable. In the absence of specific treatment, a percent of over 30% of MS patients will develop significant physical disability within 20-25 years since the onset of the disease. After 25 years only 1/3 of the patients are capable of working and 2/3 can walk (K.J. Aronson, 1996). But this prognosis is permanently changing due to the new therapies. Approaches nowadays focuse on the idea that MS treatment does not mean only drug administration, but also kinetotherapy, ergotherapy, consultance and psychological therapy.

MS rehabilitation treatment should focus on encouraging normal movements and functional activities, such as walking, which will facilitate and stimulate balance mechanisms. Unfortunately, as mentioned before, walking is affected in most of MS cases. Consequently, any procedure to improve motor activity and walking is of high benefit. Functional electrical stimulation (FES) involves applying low level electrical current to the neuromuscular system for either functional or therapeutical purposes. Therapeutical applications of FES aim to impede or reverse the progression of a disabling condition, and are typically used to strenghten weak muscles, but also the patient can benefit of muscular activity maintainace and spasticity reduction. In most countries FES is a common treatment for the patients who suffered a stroke, but FES as treatment in multiple sclerosis is rare due to the lack of clinical documentation. The benefits of using electrical stimulation through FES in therapeutic purpose can be summarized as follows: improvement in muscular tonicity, preventing of muscular atrophy, increasing in muscular force (T.A. Fredriksen, S. Bergman, J.P. Hesselberg et al., 1986; M. Javidan, J. Elek, A. Prochazak., 1992). By sequence activation of lower limb muscle groups a complex movement can be produced, similar to voluntary activities performed by the patient previous to demyielination in the nervous central system (J.H. Burridge. P. Taylor, S Hagan et al., 1997; J. H. Burridge, I.D. Swain, P.N. Taylor., 1998). At present, walking analysis is not highly accurate in clinical medicine due to the lack of an objective walking analysis (Bogey, 2004), including functional analysis of anatomic segments involved in walking activity. For the purpose of data collection and biomechanical modelling of human movement is highly necessary to measure the contact force (reaction) at the level of distal segment and the plantar pressures.

The research hypotheses

The efficiency of functional electrical stimulation within the rehabilitation treatment in MS will be shown by improvement of walking parameters, the most affected function in this disease. In order to obtain a correct scientific evaluation it is highly necessary to implement clinically methods in generation, standardization, data acquisition and analysis (walking analysis). Operational motivation in application of proposed non-invasive methods such as measurements of plantar pressures by pressure plates is given by the fact that the newest systems of measuring and scanning plantar pressures are capable not only of recording and analysing accurately plantar charge but also to predict the characteristics of rapid movements of the limb and shank.

Methods

As mentioned before, the purpose of the present research is the completion of a prospective study regarding efficiency of functional electrical stimulation in walking rehabilitation at patients with MS. The initial extended study includes 20 patients with MS, but the is not yet finished, so we choose to present some intermediary results regarding only one of the patients. So the present article represents a case report regarding the results obtained after application of FES to a patient with multiple sclerosis within the framework of previous mentioned study.

We mention that the study had obtained the written consent of the patients or of their families in the individual evaluation files. The Ethics Commissions of the University of Medicine and Pharmacy and of the other clinical units involved approved the studies in the project conform to the Order of the Ministry of Education and Research no. 400/22.02.2007. The patients were introduced in the study after the request and written consent of them or their families. They were informed of the study motivation, data used and respect of their confidentiality.

***Subject*.** The patient data are summarised.:

General data: Pacient B.V. male; residence: urban; educational level: university; social status: married; family support: adequate; diagnosed in 2001 with MS, age at the disease onset: 35 years old; onset symptomatology: neuro-muscular fatigue; hereditary history: insignificant; physiological history: insignificant; pathological history: insignificant; disability level: incapacity to adapt 90%; remaining work capacity 10%.

Clinical neurological examination indicates motor disabilities represented by inexplicable fatigue, misunderstood by his family and friends, decrease of muscular force, especially at the level of lower limbs, pyramidal signs (spasticity, abnormal reflexes), walking disorders. Among sensitive findings there were recorded paresthesia and sensitive ataxia (a spastic ataxic walking).

Walking examination indicated disorders in walking, respectively crural motor bilateral deficiency, orthostatism and spastic/ paraparetic walking, crural pyramidal bilateral hypertonia, lower limbs clonoidia, RCA abolished, RCP-bilateral extension.

Paraclinical examinations indicated: glycemia 105 mg.dl; urea 29 mg/dl, cholesterol 208 mg/dl, triglycerides 45 mg/dl, HDLC 45 mg/dl, LDLC 154 mg/dl, GPT 18 U/L, VSH (1 h) 8 mm, VSH (2 h) 16 mm, WBC 13400, NeSe%= 67%, LY %=25%, MO%=5%, EO%=3%, Hb 13,8 g/100ml.

In 2003 and 2004 the patient was evaluated by magnetic resonance imaging (MRI). In 2003: MRI of head showed a hyperintensity centimetre lesion visible only in sagittal FLAIR sequence, (im.9.sc.5) deep in the white matter which may correspond to a focal degenerative lesion. There were no abnormalities of focal type in favour of MS diagnosis; ventricular system on medial line, cranial nerves, normally visible vascular structures. Investigations at the spine level were recommended.

In 2004: MRI of thoracic spine was performed, showing: vertebral bodies with homogenous signal without focal abnormalities or degenerating corporeal or disk processes. Thoracic spinal duct with normal dimensions (35 mm) without any symptom of extrinsic compression. Homogenous medullary thoracic parenchyma with AP diameter of 7 mm, without any abnormalities of focal signal or pathologic point of contrast substance.

Electrical functional stimulation

A 2 channel neurostimulator (O2CHS II) produced by the department of Medical Physics and Medical Engineering Salisbury was used for bilateral correction in walking. This is a neural prohtesis designed to improve walking, with 2 channels associated with a switch off device placed at the heel level to obtain dorsiflexion and foot eversion by stimulating extern sciatic popliteal nerve (SPE). The shank flexion could be performed depending on the electrodes placement. Electrical stimulation was realized by impulses of rectangular shape, using surface electrodes. In the case of muscles with intact motor neuron, stimulated by surface electrodes, the electric signal is a train of rectangular impulses of a frequency between 20 Hz and 40 Hz and a pulse duration between 5µs and 350 µs. Intensity of stimulation varied between 20 mA and 40 mA. Despite the fact that there was the possibility of using a current of a frequency up to 100 MA, it was taken into account the rapid fatigue of the stimulated muscle caused by the regulation of the parameters of current intensity and rectangular impulse duration.

Data aquisiton and analysis using pressure plates in static and dynamic regime

In our study we used a footscan plate scientific version, RSSCAN International, Olen, Belgium to record plantar pressure distribution and pressure values. In our experiment we used a plate of surface of 0,5m x 0,4m, with a total of 4096 sensitive pressure sensors (4 sensors per cm^2) which allows the measurement of vertical pressure. Data were recorded at a frequency of 50 Hz. The patient was asked to walk along the platform as natural as possible. The platform recorded forces and pressures along z axe in the above-mentioned areas in a file type Working Sheet Microsoft Excel. The measurements were made in the Centre of Research in Human Movement at the Faculty of Physical Education and Sport, University of Craiova.

As the sensor size is known (0,27cm) pressure is determined automatically. It is very important to perform the current measurement in a natural way. Therefore, the plate was placed in a normal route long enough to allow a normal walking, covered by a thin layer of EVA material. This material does not influence or alter the measurement, the route is comfortable for the patient and they do no not “target” the plate as it is invisible. The system permits automatic detection of left and right limb, static (at rest) or dynamic measurements (walking, running).

The studied parameters included:

- image of pressure distribution on both soles for each movement moment (each frame). These images were stocked in **bmp** format for each walking moment of the patient (each frame); dynamic pressures and center of pressure line; pressure/time for each foot zone.

- force values for each time unit for the 10 specific zones: halluxes (1), phalange (1), metacarpals (5), mediane zone (1), the two medial and lateral zone of calcaneus (2);

- mean pressure values for the 10 zones depending on time; surface of the 10 contact zones for each frame;

- specific angles (hallux valgus, open-close foot, etc) for each frame (depending on time).

- movement analysis: heel rotation, foot balance, medial forefoot balance, forefoot rotation, forefoot balance, meta loading, center of pressure line, center of pressure line of rearfoot, inversion – eversion, flexion – extension, hallux activity, hallux stiffness

The system allows visualization in different colours depending on the value of applied pressures; the graph force/time for each limb whenever necessary or desired; calculations such as: determination of foot dimension, comparison of two measurements sets, graph pressure/time for each limb zone, comparison of contact percentages or rear- mid- fore foot with the impulse of the respective foot parts, calculation of average in several measurements.

Data stocking: data obtained directly from the measurements and those processed by specific RSSCAN software for walking and balance are in Excel, depending on time and stocked in the computer in an integrated data basis.

Results

We could appreciate plantar pressure distribution in static and dynamic measurements for walking in a patient with MS, before and during FES (patient: V.B., age: 43 years old, 70 kg, foot size 42).

Recorded data were obtained directly from measurements or by processing of initial data by a specific RSSCAN software for the analysed movement.The data were automatically converted in Excel format, and mean values of recorded parameters were performed. The evolution of contact pressure depending on timing parameters and its distribution on characteristic anatomic plantar zones when the patient supported himself unilaterally and bilaterally during walking were also analysed.

Static measurements. Each foot was split into ten anatomical zones: medial and lateral zone under the rear foot, the midfoot, the five metatarsals, the hallux and the other toes. With this feature, the pressure under the foot can be linked to the relevant anatomical zones. In fig 1 is represented the distribution of contact pressures in stance phase for both lower limbs at ground contact, center of pressure and walking axis (red) towards walking direction (pink). in fig 2 is represented the normal distribution of plantar pressures in ratio with the 10 anatomic zones above-mentioned.. The magnitude of pressure distribution is shown based on a colour scale, blue representing the lowest pressure, red representing the highest pressure. Black represents absence of pressure. In comparation

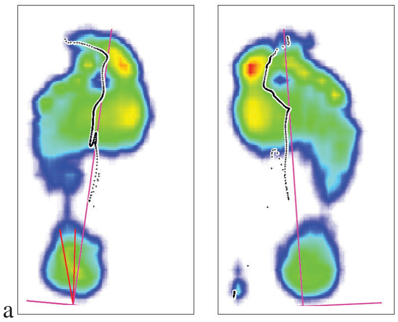

a b

Fig. 1. Static picture of the pressure distribution under the patient's feet, while the patient is standing on the plate. Maximum pressure measured under the foot during stance phase can be observed (a) without FES; (b) with FES

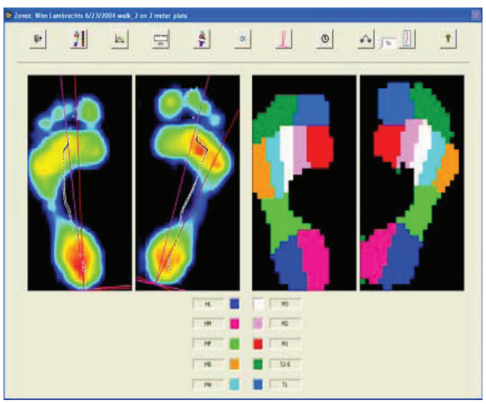
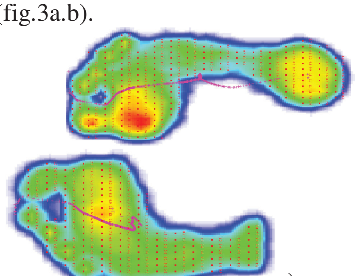


Fig.2. Normal distribution of plantar pressure for the 10 anatomical regions (static measurement)

HL: Heel Lateral
HM: Heel Medial
MF: Midfoot
M5: Metatarsal 5
M4: Metatarsal 4
M3: Metatarsal 3
M2: Metatarsal 2
M1: Metatarsal 1
T2-T5: Toe 2 to toe 5
T1: Hallux

Dynamic measur c measurement captures the r the patient's feet, in time over the full length of the step from the initial contact of the footscan plate until the end of the foot roll-off. The measurement was taken individually for each foot, recorded and the software proceeded the information. It detected the left and right limbs and placed them in corresponding graphs. (fig.3a.b).


a)

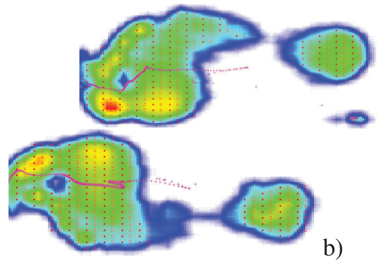
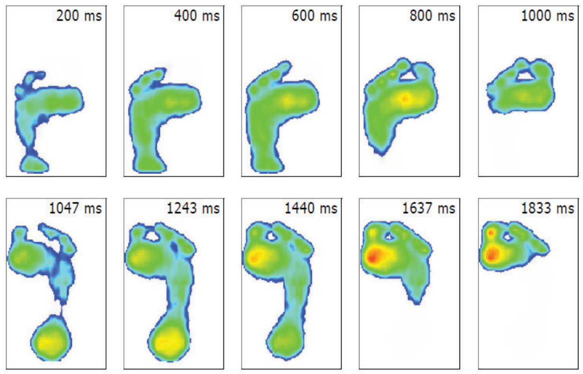

b)

Fig.3.Record of a single step in dynamics (a) without FES; (b) with FES

The dynamic image of the pressure during roll-off of the foot can be observed. The view loops continuously through all frames. The software calculates the values of contact pressure N/cm2 during one step, on each characteristic zone of the foot (the load rate). The load rate represents the speed of loading under the anatomical zones, in N/cm2 and can also be graphically presented in different points on the sole for both lower limbs. In our study we noticed the maximal pressure values for metatarsal zone M2 at the left foot, in comparison with the right foot, where contact pressure values are the highest, reaching 24N/cm2. We can also notice the positive influence of stimulation which leads to the decrease of maximal pressures to the value of 19N/cm2, which means that a greater surface of the foot is on ground contact; that means also a decrease of the stress in the foot.

The evolution of contact surface for both feet at 5 successive time moments from a step duration, without stimulation (a) and with stimulation (b) is presented in fig. 4 (timing parameters of significant events - a sequence of images from the roll-off of the foot, the timing for each image is indicated in milliseconds). We can notice the zones of maximum contact pressure which is in hallux and metatarsal zone 1 for the right limb and in metatarsal zone 3 without stressed pressure in the hallux or calcaneus for the left limb. We can also notice a correction in the distribution in both limbs but especially in the left one after stimulation, with the formation of plantar arch (disappearance of the contact in this zone). We can notice (in the case without stimulation) the great tendency of avoiding complete support on the left limb, and so there is not any zone with high pressure contact values (red); we can also observe the fact that the patient has ground contact with his calcaneous and metatarsal zones, the contact extending to plantar arch. When the left foot leaves the ground, the contact remains on metatarsal and phalangeal zones. At the right foot, the contact begins on the hallux, metatarsal 1 and calcaneous, completing on metatarsal and phalange, at its maximum on hallux/metatarsal. In case of stimulation, we can notice the rehabilitation of plantar arch at the left foot, correct distribution of pressures on anterior side and calcaneous. The system memorized to print inadequate times and that is why the results for the left foot seems incomplete.

a)



b)

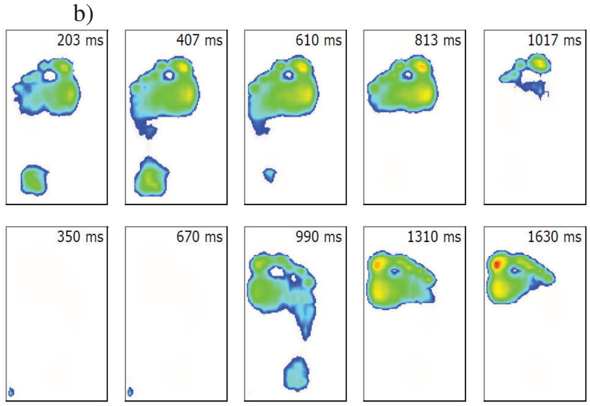


Fig.4. The graph of plantar contact surface in different walking moments (a) without FES; (b)with FES

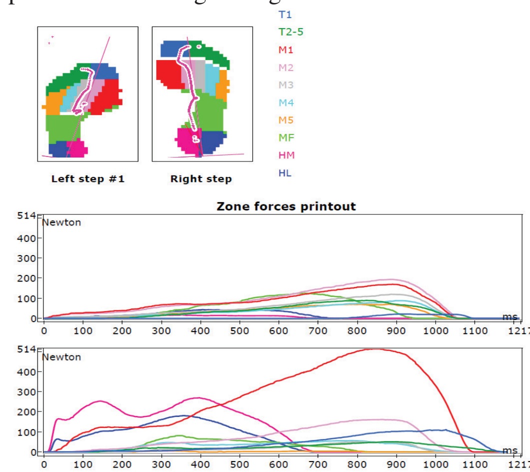
For each representation of the measured pressures there can be shown the measured forces as well (fig.5 a.b). The force curves show the vertical force in time during stance phase. The X-axis shows the time in ms (milliseconds), the Y-axis shows the force in N (Newton).

When the forces are shown the graph represents total force of the calculated zone. If the pressures are shown, then the force shown is divided on the surface in which it is applied. When the forces are shown we can click to see the calculated force.

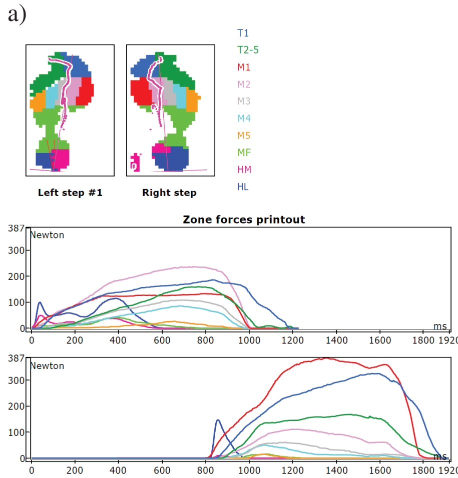
Fig. 5. Graph: Force/time for each foot zone (a) without FES; (b) with FES associated with the forces graph. The graphs of the force (N) for each zone during foot contact can be observed. The

The contact percentages & foot axis printout shows the contact percentages under the foot, direct information over the exo and endo rotation from the foot and an indication on the rearfoot pronation. In fig. 6 a we can notice a use of only 12% for calcaneous in comparison with 19% for the right foot; for both feet anterior metatarsal/phalangeal zone is predominant in the contact. The impulse offers information of the most important zones in propulsion, they representing frontal part of the foot in both cases. The great angle of foot axe towards walking direction at the left foot shows the tendency of interior rotation. We can clearly notice the

The percentages in which total contact is divided on the sole, among anterior, medial and posterior zones of the foot represents the usage degree during the step (impulse) and it can be used to identify plantar zones of high charge.



a)



b)

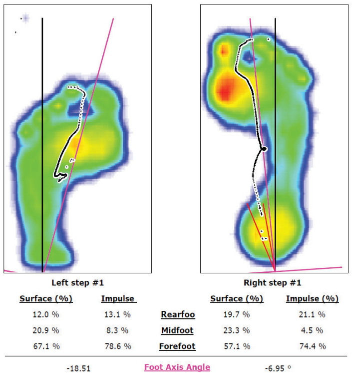
graph of forces distribution is similar to that of pressures with maximal values of 514 N for M1 zone of the right foot.

improvement of the angles the foot makes in walking direction in the case with stimulation on (b), decreasing for both feet to 9.6, respectively 4.8 degrees

a)

In fig. 7 are also represented the representative moments and zones such as anterior zone, calcaneous or first/last contact, as well as the foot axes. The inapropriate negative values of the left foot show that the patient`s first contact is insecure, he cannot make the contact at first, but finally he can touch the ground with anterior side of his sole.

In the last figure we can notice that the last patient`s contact with the left foot does not fit to pressure centers; thus, we can conclude that the patient is insecure and after lifting his foot he reaches back in ground contact for another second due to lifting of foot to an insufficient height. This problem is corrected by stimulation (b), pressure center line is improving and the patient does not hesitate to lift his left foot any longer.



b)

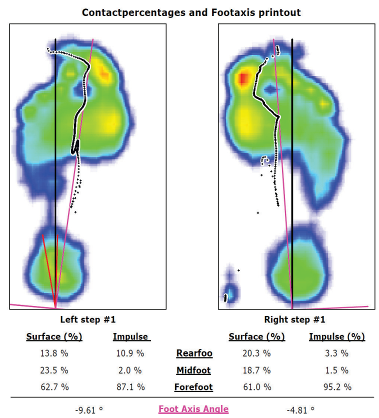
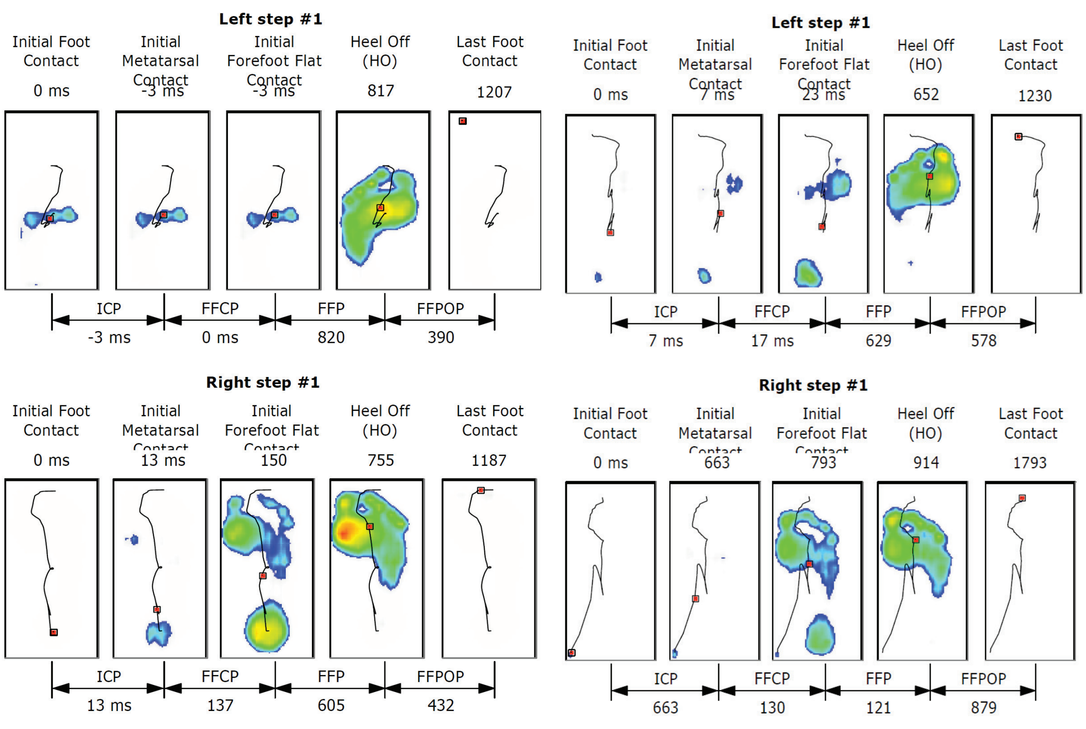


Fig.6. Graph showing the impulse and foot axis (a) without FES; (b) with FES



a) b)

Fig.7. Multisteps analyse mode (a) without FES; (b) with FES

This way of time measuring allows concentration on spatial and temporal parameters of and among different steps is called *multi-steps pattern*

The screen offers detailed information of different time parameters, both in milli-seconds and in percentages for the contact phase with calcaneous, initial contact with anterior part, complete contact or balance, propulsion. We can notice the exceed of normal values at the left foot in comparison with the right one, where the zones in which the values are higher are metatarsal 1-4. While stimulation, at the left foot the normal values are higher at the movement initiation as the patient has the tendency to keep ground contact with his left foot owing to muscular contraction following stimulation.

Subsequently, there was drawn a table with time standard values (table 1). The *timing table* lists the timing values according to the zones and the significant events during gait, compared to reference timing values.

Three colors are used to indicate the relation between the measured values and reference values

Blue: the timing parameter is early in time compared to the reference timing value.

Green: the timing parameter is within the range of the reference timing value. **Red**: the timing parameter is late in time compared to the reference value. This table evaluates (in comparison with normal values) the contact duration for the zones medial/lateral calcaneous, metatarsal 1/5 as well as the phases during walking and contact phase

Heelstrike (%): defined as the instant the heel region (HM-HL) first contacts the footscan® plate until one of the metatarsal heads contacts the footscan® plate.

Pre-Midstance (%): defined as the instant when one of the metatarsal heads contacts the footscan® plate until all the metatarsal heads made contact with the footscan® plate.

Midstance (%): defined as the first instant all the metatarsal heads made contact with the footscan® plate until the heel region lost contact with the footscan® plate.

Propulsion (%): defined as the instant the heel region lost contact with the footscan® plate until last contact of the foot on the footscan® plate.

Table 1. Timing values according to the zones and the significant events during gait, compared to reference timing values **(a) without FES; (b) with FES**

a

		Start Time (%		End Time (%		Total Time (%		Peak Time (%		Impulse (%)
Left Foot										
Med heel	0	0.8	50-65	63.8	50-65	63.0	15-22	27.9	45-55	30.7
Lat heel	0	0.8	50-65	67.9	50-65	67.1	15-22	43.6	45-55	69.3
M1	13-25	0.0	73-96	88.5	60-83	88.5	50-78	71.2	13-21	27.5
M2	10-20	0.0	80-95	89.6	70-85	89.6	60-75	73.2	14-24	25.0
M3	8-16	0.0	85-93	88.8	77-85	88.8	59-74	73.4	15-23	15.6
M4	7-15	0.0	84-92	88.5	77-85	88.5	55-73	74.5	10-18	14.3
M5	5-15	0.3	65-87	87.9	60-82	87.7	50-77	72.3	4-11	17.6
Heelstrike	0	0.8	5-15	0.3	5-15	-0.5				
Pre-Midstance	5-15	0.3	10-20	67.9	45-55	67.7				
Midstance	10-20	0.3	55-65	67.9	42-52	67.7				
Propulsion	55-65	67.9	100	100.0	35-45	32.1				
Right Foot										
Med heel	0	0.0	50-65	63.5	50-65	63.5	15-22	11.8	45-55	63.2
Lat heel	0	0.6	50-65	62.1	50-65	61.5	15-22	28.9	45-55	36.8
M1	13-25	0.8	73-96	94.1	60-83	93.3	50-78	68.0	13-21	51.9
M2	10-20	1.4	80-95	93.3	70-85	91.9	60-75	67.1	14-24	21.5
M3	8-16	1.4	85-93	92.1	77-85	90.7	59-74	67.7	15-23	11.2
M4	7-15	1.1	84-92	92.1	77-85	91.0	55-73	65.2	10-18	13.9
M5	5-15	12.4	65-87	79.2	60-82	66.9	50-77	26.1	4-11	1.4
Heelstrike	0	0.0	5-15	0.8	5-15	0.8				
Pre-Midstance	5-15	0.8	10-20	63.6	45-55	62.8				
Midstance	10-20	12.4	55-65	63.6	42-52	51.2				
Propulsion	55-65	63.6	100	100.0	35-45	36.4				

Low **Optimal** **High**

b

Timing values printout

		Start Time (%		End Time (%		Total Time (%		Peak Time (%		Impulse (%)
Left Foot										
Med heel	0	0.0	50-65	50.7	50-65	50.7	15-22	3.5	45-55	34.7
Lat heel	0	0.0	50-65	53.1	50-65	53.1	15-22	31.2	45-55	65.3
M1	13-25	0.0	73-96	83.2	60-83	83.2	50-78	27.6	13-21	20.0
M2	10-20	0.0	80-95	85.4	70-85	85.4	60-75	55.6	14-24	37.0
M3	8-16	0.3	85-93	84.6	77-85	84.3	59-74	54.5	15-23	18.7
M4	7-15	0.3	84-92	83.7	77-85	83.5	55-73	54.7	10-18	16.6
M5	5-15	1.6	65-87	79.4	60-82	77.8	50-77	53.7	4-11	7.8
Heelstrike	0	0.0	5-15	0.3	5-15	0.3				
Pre-Midstance	5-15	0.3	10-20	53.0	45-55	52.7				
Midstance	10-20	1.6	55-65	53.0	42-52	51.4				
Propulsion	55-65	53.0	100	100.0	35-45	47.0				
Right Foot										
Med heel	0	6.6	50-65	52.1	50-65	45.5	15-22	45.3	45-55	47.5
Lat heel	0	42.0	50-65	54.2	50-65	12.2	15-22	44.8	45-55	52.5
M1	13-25	41.1	73-96	95.7	60-83	54.5	50-78	64.8	13-21	55.4
M2	10-20	41.3	80-95	93.8	70-85	52.4	60-75	62.0	14-24	23.4
M3	8-16	41.0	85-93	94.3	77-85	53.3	59-74	59.7	15-23	12.9
M4	7-15	41.3	84-92	92.5	77-85	51.2	55-73	56.1	10-18	7.7
M5	5-15	47.7	65-87	68.4	60-82	20.7	50-77	55.7	4-11	0.6
Heelstrike	0	6.6	5-15	41.0	5-15	34.4				
Pre-Midstance	5-15	41.0	10-20	54.2	45-55	13.2				
Midstance	10-20	47.7	55-65	54.2	42-52	6.5				
Propulsion	55-65	54.2	100	100.0	35-45	45.8				

Low **Optimal** **High**

Discussions and conclusions

Most research studies analyse the clinical pathology retrospectively using clinic and para-clinic parameters in an advanced evolutional stage of the disease. The modalities of approaching and evaluation presented in literature are usually chosen individually, without a common tendency based on trans-disciplinary research which will surely lead to better and faster results. That is why a complete research, associated with experimental studies based on corroboration of clinical data, characteristic for each specialty involved in functional rehabilitation program of the patient with MS, using computerized programs of movement analysis, will permit the creation of a complex system of data acquisition and analysis with direct application on human motility. Such a system (which can be standardized) will facilitate health cost reduction and social integration of patients with MS (economic and social effects).

In our study the records made using a pressure plate RSSCAN allowed identification of walking deficiencies such as: crural bilateral motor deficiency, orthostatism and para-paretic spastic walking. Credibility and validity of this method results from previous studies: *R.Darmana, M. Schandella, S. Salmeron et al., 2001; F. Hagman, 2003.*

The obtained data based on pressure measurements in the absence or presence of functional electrical stimulation lead us to the following conclusions:

- Functional electrical stimulation offers an alternative within the rehabilitation treatment in multiple sclerosis, encouraging active movement of the food and by constantly taking the foot through the full range of movement with walking, avoids stiffening up of the ankle.

- The study shows that clinical implementation of the 2 channel neuromuscular stimulator (O2CHS II) can improve walking in MS patients. The benefits of ES through FES in therapeutic purpose can be defined as improvement in muscular tonicity and a decrease in spasticity. Stimulation of the muscles in a certain succession can realize walking movements. In MS case, voluntary command of movement and tune is affected by the lesions of central motor neuron, without being affected motor peripheral neuron, neural and muscular junction or other muscular cells. FES used with sequence activation of muscular groups in order of natural contraction can correct walking. Therefore, FES can be used to correct walking in the rehabilitation process of the patients with MS.

As this reserch is presenting intermediary results from a wider study, we must say that at this moment the patients with MS do not show a "carry over" effect without using the stimulator. Further studies will be carried on.

- Evaluation of walking by biomechanical parameters as pressure and forces in lower limbs offers a complex method.

So far, in all research studies which reffer to FES use in neurologic rehabilitation, performances regarding walking improvement were quantified through two parameters: the speed of walking a distance of 10 m and PCI – physiologic cost index. These evaluations are relatively subjective, without offering a quantifying data system. Moreover, there are other aspects of walking which can not be mirrored by these evaluations. Identification of certain analysis model for the patients with MS that can be used before and after FES will represent a viable instrument to evaluate and treat this disease, with results at international level.

Correct evaluation of walking during therapeutic operation and establishing the objectives of rehabilitation program starting from clear data and clinic and para-clinic parameters will assure a better feed-back of therapeutic efficiency.

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THE EFFECT OF INJECTING ACUTE L-CARNITINE ON ENDURANCE TIME İN RATS EXPOSED TO DİFFERENT WATER TEMPERATURE

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ABSTRACT

Purpose: Carnitine plays an important role in lipid metabolism by transporting long-chain fatty acids into the mitochondria for beta-oxidation. The effect of carnitine on exercise capacity is not clear. The aim of this study was to explain effect of injecting acute L-Carnitine on endurance time in rats exposed to different water temperature.

Material and Methods: Six groups (E18°C, E28°C and E38°C groups made exhaustive swimming CE18°C, CE28°C and CE38°C groups given L-Carnitine and made exhaustive swimming exercises) were formed and a total of 36 Spraque Dawley male rats, weighing 250-300 g were used in this study. In the study, the L-Carnitine was given to the groups 1-1.5 hours before the exercises in the doses of 100 mg/kg by intraperitoneal (I.P.) way. Exhaustive swimming tests were made in a rectangle shaped glass water tank that was 80x60x60 cm^3. The uncoordinated movements and staying under the water for 10 seconds without swimming at the surface were accepted as the exhaustion criteria of the rats.

Results: In the rats of CE18°C group the endurance time increased significantly comparing with the E18°C ($P <$ 0.01).There was not significantly different among other groups

Conclusion: This result suggests that carnitine may especially enhance the physical performance doing cold ambient. Carnitine might generate that effect by regulation lipid metabolism and mitocondrial functions.

Keywords: L-Carnitine; endurance time; Exercise; Rat;water temperature.

Introduction

Fat and carbohydrates are the primary metabolic fuels utilised by contracting skeletal muscles during exercise and resting (M.J. Watt, J.F. George, Dj. Heigenhauser, Dyck And L.S. Lawrence, 2002). Thus, it is not suprising that a variety of metabolic and biochemical markers is related to exercise performance and training. Manipulations of bioenergetics have frequently been proposed as strategies to enhance exercise endurance or capacity.The functions of carnitine in skeletal muscle are critical to sustaining normal bioenergetics during exercise (P.E. Brass, W.R. Hiatt, 1998).

L-carnitine (4-*N*-trimethyylammonium-3-hydroxybutyric acid), stored within skeletal muscle tissue as either free or acyl carnitine (F.B. Stephens, D.C. Teodosiu, D. Laithwaite, E.J. Simpson, And L. Paul, P.L. Greenhaff, 2006), is an endogeneus molecule well-established roles in metabolism (E.P. Brass, 2000), and plays important physiological roles shuttling the long-chain fatty acids across the inner mitochondrial membrane for ATP production and β-oxidation in peripheral tissues (İ. Gülçin, 2006). For health and performance the importance of mitochondrial function has been highlighted during the last few years (D. Hood, A. Joseph, 2005). It is well known that oxidation of fatty acids (FA) is augmented and lactate formation is reduced during exercise after endurance training. This is explained by an increased mitochondrial density in skeletal muscle and a concomitant increased activity of oxidative enzymes (J. Holloszy, E. Coyle, 1984).

Impairment of muscle contractility due to fatigue may play a role in determining human performance. Through unclear mechanisms, high carnitine concentrations were shown to delay muscle fatigue and permit improved maintenance of contractile force in studies using in vitro animal systems (M. Dubelaar, C. Lucas, W. Hulsmann, 1991; E. Brass, A. Scarrow, L. Ruff, K. Masterson, Van Lunteren, 1993). The relevance of these observations to human exercise is unknown.