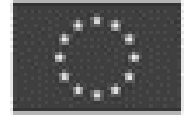




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DESCRIPTION OF KINEMATIC CHARACTERISTICS IN CHILDREN WITH LUMBAR AND LUMBOSACRAL MYELOMENINGOCELE AND CALCULATION OF NEW INDEXES FOR A COMPREHENSIVE EVALUATION

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Final Meeting - TRAMA Project
March 10th-12th 2010 – Bogotá, Colombia





INTRODUCTION

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INTRODUCTION



Myelomeningocele (MMC) is a very complex pathological condition due to a defect on the closure of neural tube. This involves many systems, and require a comprehensive approach to achieve rehabilitation.



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INTRODUCTION



Although it is true that the incidence of MMC in Chile, has decreased since the addition of folic acid to flour (January 2000), which was 0.6 per 1000 live births in 2005, such condition still remains a highly relevant pathology in view of the multi-system involvement and the costly treatments it entails.

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INTRODUCTION



The assessment of the motor involvement in such patients is also complex, since they never present with a symmetrical distribution of the lesion.

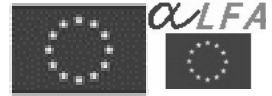
Numerous clinical classifications aiming at establishing the functional motor level of such patients have been described, in order to anticipate a gait prognosis and future musculoskeletal complications and thus facilitate their efficient therapeutic approach.

However, in clinical practice, such classifications do not seem sufficient in view of the above mentioned asymmetrical sensitive and motor involvements.

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INTRODUCTION



In 2007, the IRI Teletón of Santiago created the clinical guidelines for orthotic prescription in patients with Myelomeningocele.

In such clinical guidelines a functional motor classification was defined according to experts criteria and the published literature, but this classification has the same problem: it not seem sufficient in view of the asymmetrical sensitive and motor involvements.

Such classification is the one used currently and requires validation.



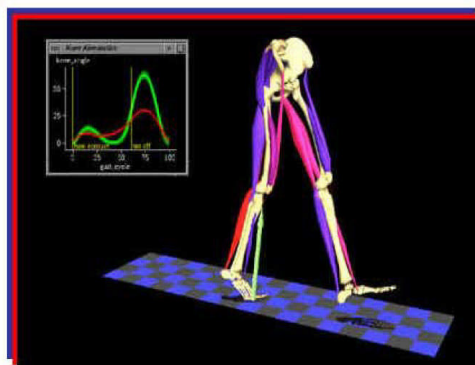
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INTRODUCTION



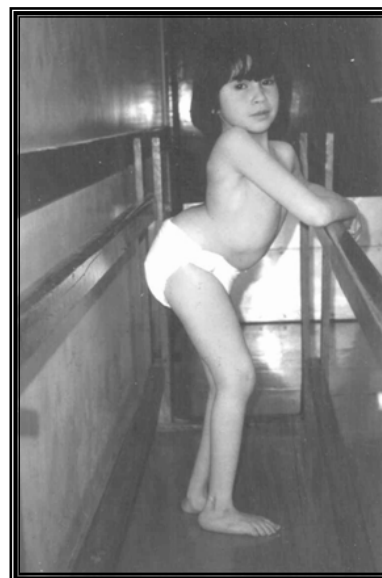
Thus, the three- dimensional gait analysis emerged as an important tool to quantify gait disorders in such individuals, particularly their time and distance parameters and their kinematic and kinetic aspects. Consequently, by helping in evaluating the basal conditions of gait, as well as the response to various therapies together with collaborating in the validation of our functional classification.



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According to the experience of the IRI Teletón Santiago and the literature currently available, the kinematic of children and youngsters with MMC, evidences disorders relatively similar in morphology, with differences in the magnitude of their functional motor level, particularly in the pelvic and hip kinematics in the three planes of movement



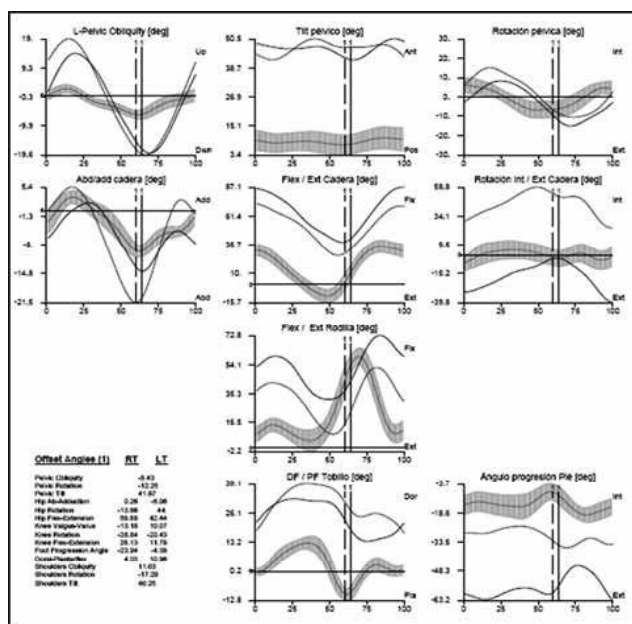
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Preliminary Experience: Kinematic behavior in children with MMC



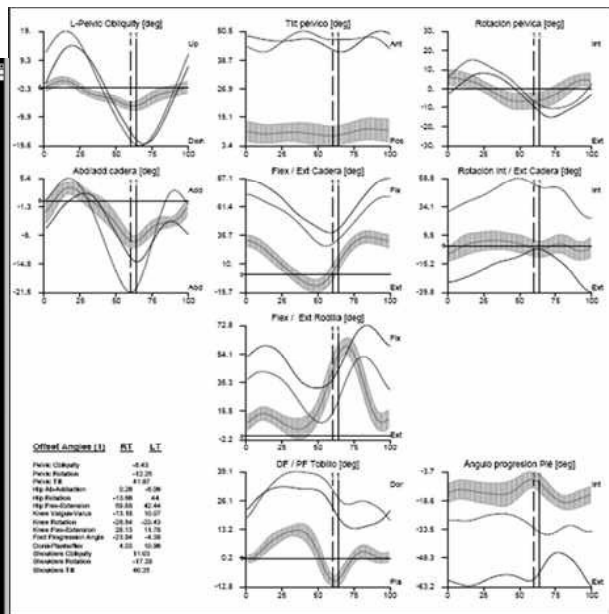
- ✍ Pelvis:
 - ✍ Increase of the oscillation in the coronal plane
 - ✍ Increase of the pelvic forward tilt in the sagittal plane
 - ✍ Increase of the pelvic rotation in the horizontal plane
- ✍ Hips
 - ✍ Flexion increased
- ✍ Knees:
 - ✍ Flexion increased in the Initial Contact
 - ✍ Less range of motion
- ✍ Ankles:
 - ✍ Dorsal Flexion increased



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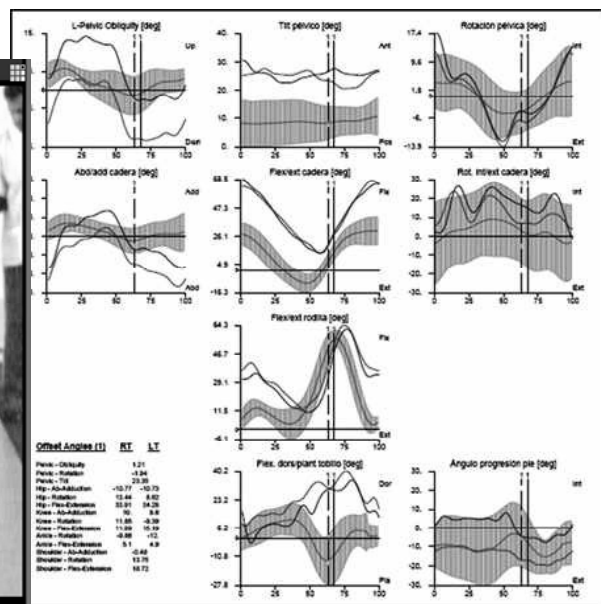
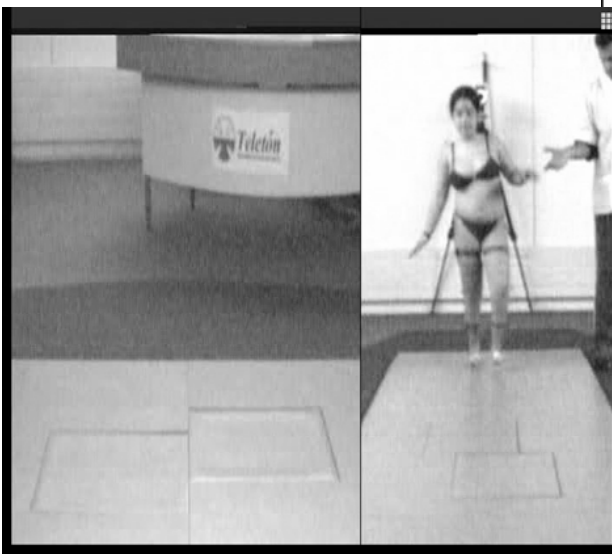
Myelomeningocele L3



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Myelomeningocele L4 – L5



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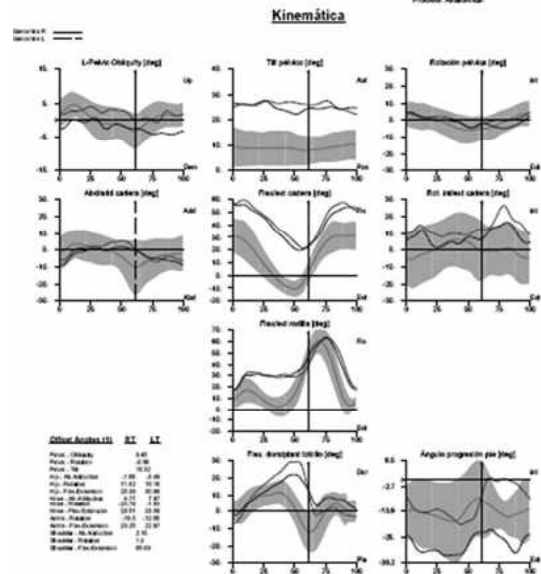


Myelomeningocele S1



TELETON

P. A. 1127xa03MMC S1



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Preliminary Experience: Kinematic behavior in children with MMC



- ✍ The results that we see in our experience agree with findings published in literature
- ✍ As the injury level is lower, these alterations decrease at:
 - ✍ Pelvis
 - ✍ Hips
 - ✍ Knees
 - ✍ Ankles
- ✍ The surgeries performed in our patients did not change their kinematic profile

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Preliminary Experience Indexes in MMC



With these results, we considered the idea of establishing indexes that allow us

- ✍ Compare this kinematic characteristics with the normal subjects and, establish a correlation index, between the level lesions and the normal gait.
- ✍ Establish the magnitude of the difference, between normal gait and the gait of our patients.
- ✍ Try to identify, if there are some kinematic points that are more representative than others, this will allow to accomplish evaluation with a reduced number of points.

CORRELATION COEFFICIENT
Z SCORE

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Preliminary Experience Indexes in MMC



CORRELATION COEFFICIENT

Compare in a quantitative way two groups of parameters, that are represented in a curve with identical physical magnitude.

Z SCORE

Measures the dispersion of each point of the patient curve in SD.

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Preliminary Experience Indexes in MMC



We Found:

- ✍ There was a certain relation of the values of the Correlation Coefficients, with the level of injury of our patients
- ✍ The Z-Score show that as the injury level is higher, were more dispersion in SD of normal Z Score

The Correlation Coefficient and Z Score could be an useful index that will allow us to make an objective assesment of the gait in patients with MMC

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Indexes in MMC



While the current Thesis was being in work, the Gait Deviation Index (GDI), a new index for the global quantification of gait disorders , was published.

We decided to include such new index to assess the concordance between their results and the functional motor level of our patients and to compare it, with the other proposed indexes.

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INVESTIGATION PROBLEM

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INVESTIGATION PROBLEM



The purpose is to study the clinical characteristic and kinematic behavior in children with MMC, in order to reach some consensus in their alterations, in the evaluation methodology and in the therapeutic approach.

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HYPOTHESIS

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HYPOTHESIS



1. There are significant differences in the kinematic behavior of patients with MMC according to their motor functional level, to the values obtained at the initial contact for

- pelvic tilt
- hip flexion/extension
- knee flexion/extension

and ranges during gait cycle for

- pelvic rotation
- pelvic obliquity
- hip abduction/adduction

2. The correlation Index (CCK) and Z-Score allow weigh the motor damage and differentiate between different functional levels of patients with MMC.

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MATERIALS AND METHODS

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MATERIALS AND METHODS



Nineteen (19) children (38 limbs) with MMC aged between 4 and 13 years (mean age 9 ± 2.8 years).

Ten patients were female and 9 were male.

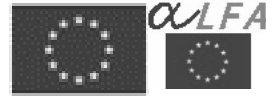
All the individuals were communitary ambulators according to the Hoffer Classification.

In addition, they were all able to walk barefoot and without the need of assistive devices.

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MATERIALS AND METHODS



Functional Ambulation Classification (Hoffer)
<p>Communitary Ambulators</p> <p>Patients walk indoors and outdoors for most activities; may need crutches, braces, or both. Wheelchair used only for long trips out of community.</p>
<p>Household ambulators</p> <p>Patients walk only indoors and with orthoses. Able to get in and out of chair and bed with little, if any, assistance. May use wheelchair for some indoor activities at home and school. Wheelchair is used for all activities in community</p>
<p>Non-functional ambulators</p> <p>Patients walk during therapy session at home, in school or in hospital. Wheelchair used for all other transportation</p>
<p>Non-ambulators</p> <p>Patients are mobile only via a wheelchair but usually can transfer from chair to bed.</p>

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MATERIALS AND METHODS



This patient group underwent a physical examination simultaneously carried out by two experienced Physiatrists.

The examination considered muscle strength as a critical parameter, following the MRC Classification in which M0 represents the absence of muscle contraction and M5 a normal muscle strength.

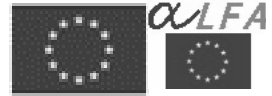
Each limb was graded depending on its respective motor function level, ranging between L3 and S2, according to the Classification created and used at the IRI, Teletón Chile 2007

MOTOR FUNCTIONAL CLASSIFICATIONS FOR MMC	
IRI TELETON	
NEUROLOGICAL LEVEL	
Toracic Level	Without Voluntary Movement on Lower Extremities
High Lumbar Level L1	Hip Flexors Lesser Than M3 Without Hip Abductors Weak Abdominal Muscles
High Lumbar Level L2	Hip Flexors Same or Higher Than M3 Hip Abductors Same or Lesser Than M3
Lumbar Level L3	Caudiceps M3 Hip Flexors Same or Higher Than M3 Abductors Same or Higher Than M3
Lumbar Level L4	Caudiceps Same or Higher Than M4 Tibialis Anterior Same or Higher Than M3
Lumbar Level L5	Tibialis Anterior Same or Higher Than M4 Gluteus Medius Same or Higher Than M3 Lateral Hamstrings Same or Higher Than M3 Tibialis Posterior Same or Higher Than M3 Peroneus Same or Higher Than M3
High Sacral or S1	Gluteus Mayor Same or Higher Than M3 Triceps Surae Same M3 Gluteus Medialis Same or Higher Than M4 Knee Flexors Same or Higher Than M4
Lower Sacral or S2-3	Gluteus Mayor Same or Higher Than M4 Triceps Surae Same M4 Essentially Intrinsic Muscles of the Foot
	BASED ON MEDICAL RESEARCH COUNCIL

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MATERIALS AND METHODS



Patient distribution age, sex and motor level.

Patients	AGE (YEARS)	SEX	R LEVEL	L LEVEL	TEST NUMBER	N° OF TRIALS
1	4	M	S1	S1	2422	4
2	5	F	L4	S1	2737	6
3	5	M	L5	L4	2687	7
4	5	M	L4	L4	2764	4
5	7	M	L4	L3	2466	7
6	7	F	L4	L4	2671	8
7	9	F	L4	L4	2502	6
8	9	M	L4	L4	2785	7
9	9	M	L4	L4	2472	7
10	9	F	S1	S1	2447	6
11	9	M	L4	L4	2412	4
12	9	F	L4	L4	2167	3
13	11	F	L3	L4	2467	7
14	11	M	L3	L4	2473	7
15	12	M	L4	L4	2214	6
16	12	F	S1	S1	2481	7
17	12	F	L3	L3	2460	8
18	13	F	L5	L5	2552	7
19	13	F	L5	S2	2118	3

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MATERIALS AND METHODS



The gait assessment was carried out too in identical conditions, on 7 healthy Chilean children aged between 6 and 10 years (mean age 7.4 ± 1.5 years). Four patients were female and 3 were male.

Such group of healthy children was compared to the Italian reference group.

In both cases (patients and healthy children), the parents were asked to sign an informed consent, in accordance with the Helsinki Declaration. Each participant received an explanation of the procedure.

All the patients and healthy children were asked to walk in their usual way and speed, through a wooden path measuring 5 meters in length and 1.40 meters in width.

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MATERIALS AND METHODS



The gait assessment was carried out at the Gait and Movement Laboratory of the IRI Teletón Santiago

An optoelectronic ELITE E1 30 (BTS Bioengineering) device composed of 6 infrared cameras capturing at a rate of 100 Hz was used to capture the gait movement.



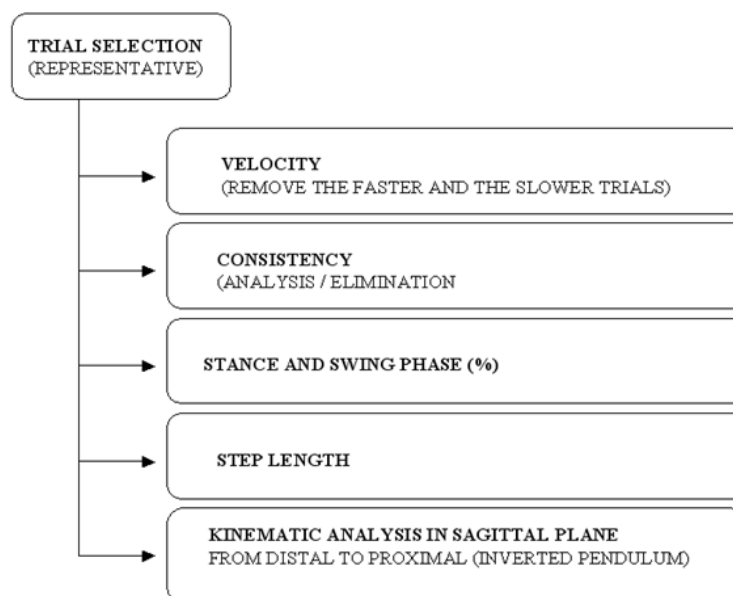
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MATERIALS AND METHODS



Trial selection process



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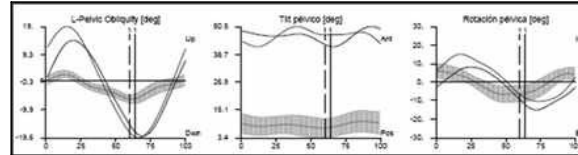


MATERIALS AND METHODS

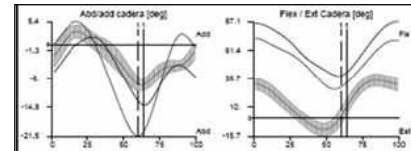


Parameters for the analysis of the kinematic behavior
(according to the literature)

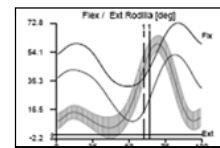
PELVIS Pelvic obliquity range during gait cycle
Pelvic tilt at initial contact
Pelvic rotation range during gait cycle



HIP Abduction/adduction range during gait cycle
Flexion/extension at initial contact



KNEE Flexion/extension at initial contact



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MATERIALS AND METHODS



Initially, for each functional motor level, the mentioned kinematic parameters and statistical analysis were calculated.

There were statistically significant differences between 2 or more motor levels, but not between consecutive levels.

Based on the latter, it was decided to re-group MMC cases in two groups:

Group 1: L3/L4

Group 2: L5/Sacral.

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MATERIALS AND METHODS

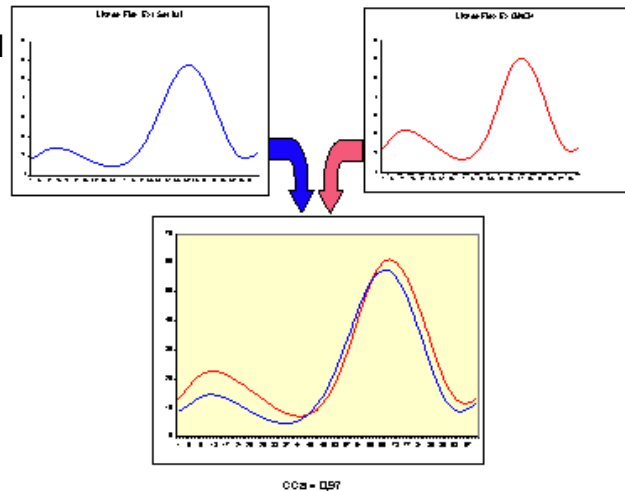


The normal Italian database was used as a reference set, for the CCK and Z – Score since there are no validated national figures available.

The inclusion of a group of healthy Chilean children was intended to support the use of such database, and thus, such group became **Group 3**.

There was a highly similar behavior among Italian database and healthy children, with a CCK close to 100% (0,97).

We used this group for statistical analysis of the kinematic behavior.



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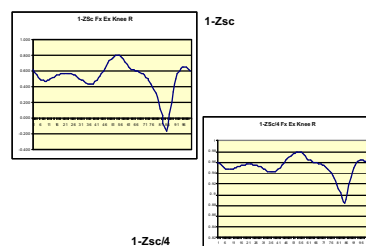
MATERIALS AND METHODS



Correlation Coefficient (CCK), Z Score and its supplement ($1-Zsc/4$) were calculated.

The calculation of Z score supplement was to plot the values with the same trend of other calculated indexes.

1-Z SCORE/4 function (Supplement): Is a function to change the Z SCORE value into a number positive and menor than 1.



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RESULTS

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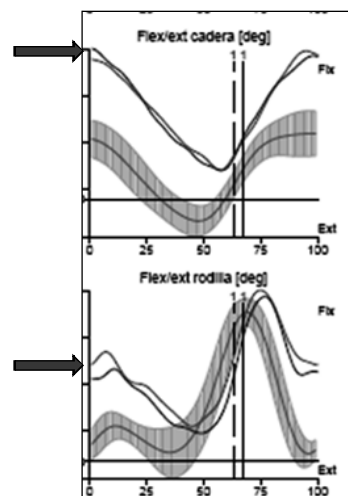
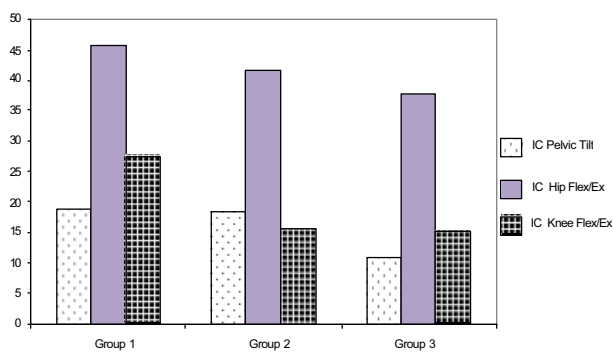


RESULTS – kinematic at Initial Contact



Means and medians of joint angles at initial contact for hip flexion and knee flexion are lower in group 2 (levels L4-S2) than in group 1 (levels L3-L4) and both are higher than those observed in the healthy group of Chilean children.

Mean values at initial contact



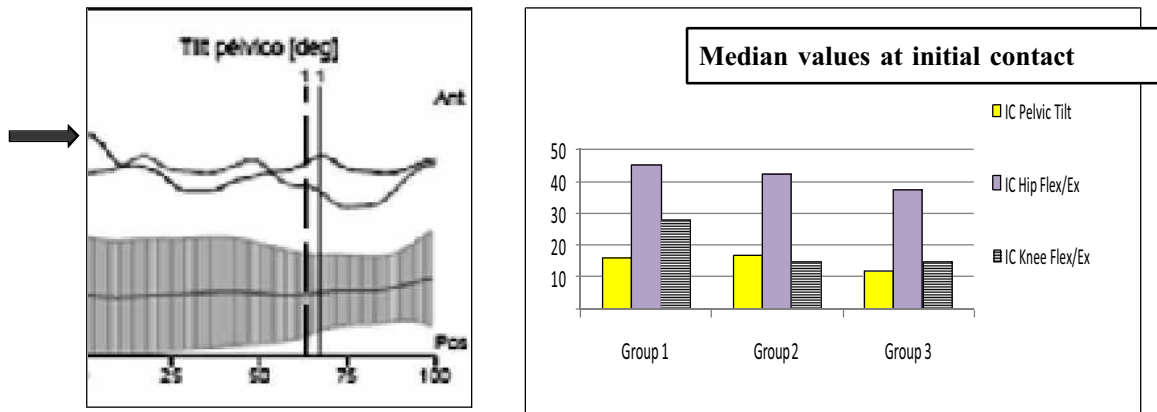
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RESULTS – kinematic at Initial Contact



No differences in pelvic tilt at IC between MMC patients (groups 1 and 2), but differ from healthy children group (group 3)



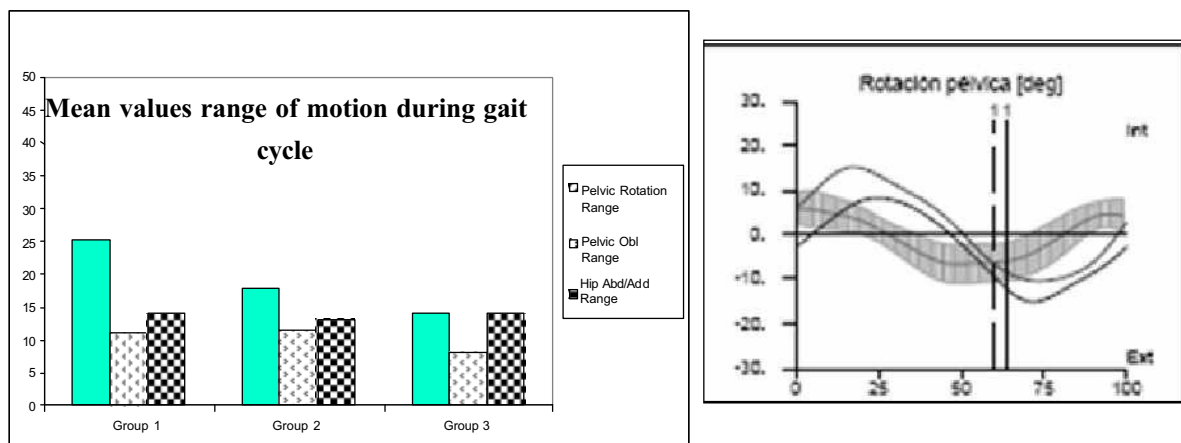
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RESULTS – Kinematic Range of Pelvic Rotation



For the range of pelvic rotation, mean and median values, are higher for group 1 than groups 2 and 3. The values observed in patients with MMC are clearly higher than those of healthy children.



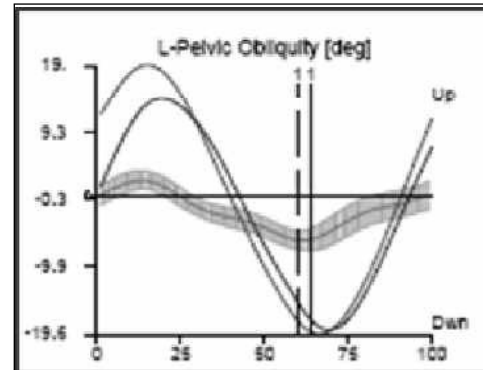
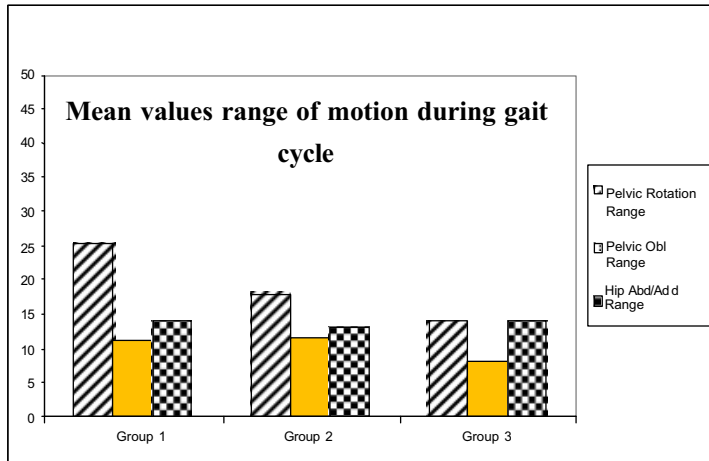
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RESULTS – Kinematic Pelvic Obliquity Range



Median and mean of pelvic obliquity range observed is very similar between patients. The same parameters for healthy children show a lower value than MMC patients.



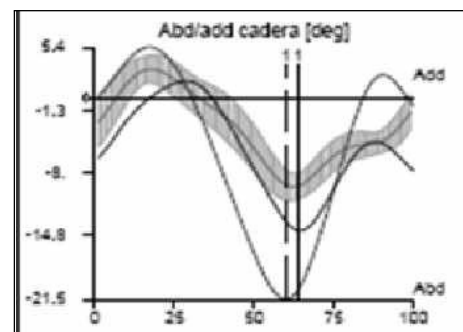
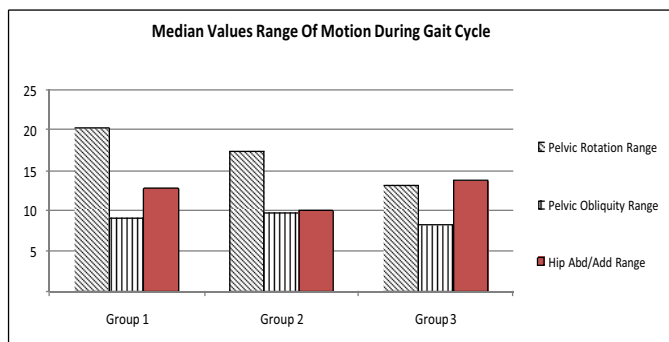
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RESULTS – Kinematic Range of Hip Abd/Add



For the range of hip abduction / adduction, the median value shows a less predictable behavior in relation to motor level. Lower values are observed in group 2, followed by group 1, and both lower than healthy children. In the case of the means there are no differences among the three groups.



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RESULTS



Statistical Analysis of kinematic data at I.C. (Mann Whitney tests)

Of the parameters evaluated at the initial contact, only for knee flexion there are significant differences between the two groups of patients with MMC.

Statistical differences between groups 1 and 2.						
	IC PELVIC TILT	IC HIP FLEX/EX	IC KNEE FLEX/EX	PELVIC	PELVI OBL RANGE	HIP ABD/ADD RANGE
U de Mann-Whitney	142	122	71	113	155	126
Sig. asintót.	0,66	0,286	0,008	0,177	0,975	0,346

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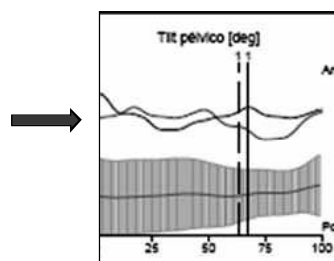
RESULTS



Statistical Analysis of kinematic data at I.C. (Mann Whitney tests).

Between groups 1 and 3 there are significant differences for initial contact pelvic tilt, hip and knee flexion, while between groups 2 and 3 there are only significant differences for the pelvic tilt at initial contact.

Statistical differences between groups 1 and 3.			
	IC PELVIC TILT	IC HIP FLEX/EX	IC KNEE FLEX/EX
U de Mann-Whitney	46	93	74
Sig. asintót.	0	0,012	0,002



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Statistical Analysis of kinematic data R. of. M. (Mann Whitney tests)

The ranges of motion evaluated don't show significant differences between groups of patients with MMC. Only there are statistically significant differences for the pelvic rotation range in the group of patients with MMC compared to healthy children.

Table 17. Statistical differences between groups 1 and 3.

	PELVIC ROT RANGE	PELVI OBL RANGE	HIP ABD/ADD RANGE
U de Mann-Whitney	71	140	178
Sig. asintót.	0,002	0,234	0,91

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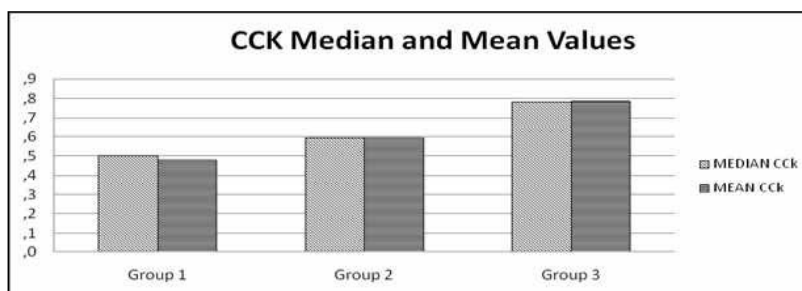
RESULTS – Indexes



Statistical Analysis

Median and mean values of kinematic correlation coefficients (CCK), 1-Zscore / 4 and GDI/100 of each patient group, confirm a trend closer to normal as the motor condition improves.

The lowest value is observed in group 1, followed by group 2 and finally the values closer to 1 are for the group of normal children.



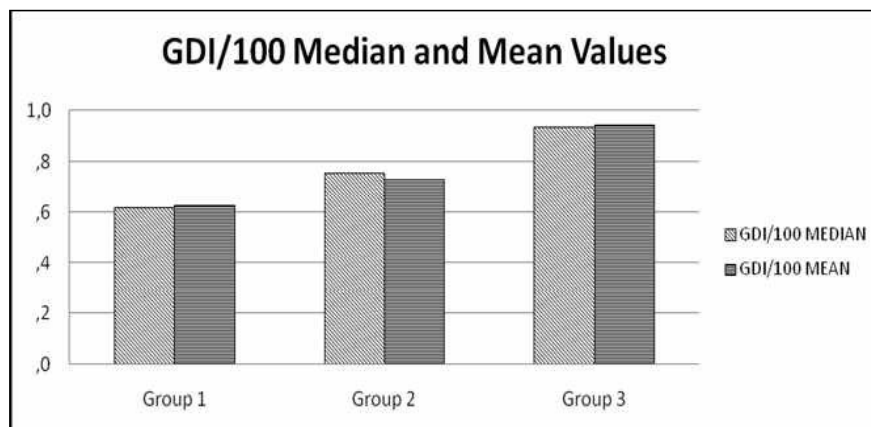
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RESULTS – Indexes



📊 Z-Score supplement ($1 - \text{Zscore} / 4$) and GDI/100 medians approach to 1, as the motor level improve. In both cases the values are lower in group 1, followed by group 2, finally being the group of healthy children the best.



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RESULTS – Indexes



Statistical Analysis

📊 The statistical analysis highlighted significant differences between groups 1 and 2 (Patients groups) for the Cck and GDI.

Group 1 vs 2

	Cck	1-ZSC/4	GDI
U de Mann-Whitney	73,5	95	51,5
Asint. significance	0,01	0,055	0,001

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RESULTS – Indexes



Statistical Analysis

Highlighted significant differences between groups 1 and 3 (L3/L4 vs Healthy subjects) for the CCK and GDI.

Group 1 vs 3

	CCK	GDI
U de Mann-Whitney	0,000	1,500
Asint. significance	0,000	0,000

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RESULTS – Indexes



Statistical Analysis

And highlighted significant differences between groups 2 and 3 (L5/S vs healthy subjects) for the CCK and GDI

	CCK	1-ZSC/4	GDI
U de Mann-Whitney	12	31	5,5
Asint. significance	0,01	0,006	0

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RESULTS – Indexes



Statistical Analysis

In the case of 1-Z score / 4, only significant differences were found between groups 1 and 3, 2 and 3 (patients v/s healthy). There are not significant differences between groups of patients with MMC.

Group 1 vs 3

	Cck	1-ZSC/4	GDI
U de Mann-Whitney	0,000	21	1,500
Asint. significance	0,000	0	0,000

Group 2 vs 3

	Cck	1-ZSC/4	GDI
U de Mann-Whitney	12	31	5,5
Asint. significance	0,01	0,006	0

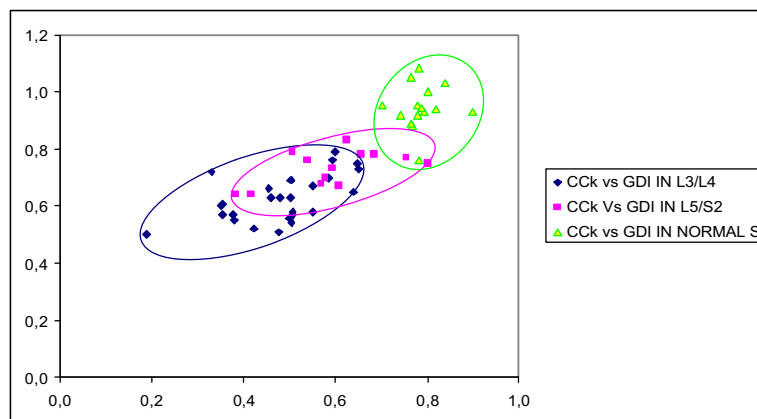
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RESULTS – Indexes Cck vs GDI



Plotting values Cck vs GDI on a scatter diagram can be observed a tendency to get close to normal values as the motor condition improves.....but with some overlap of values...



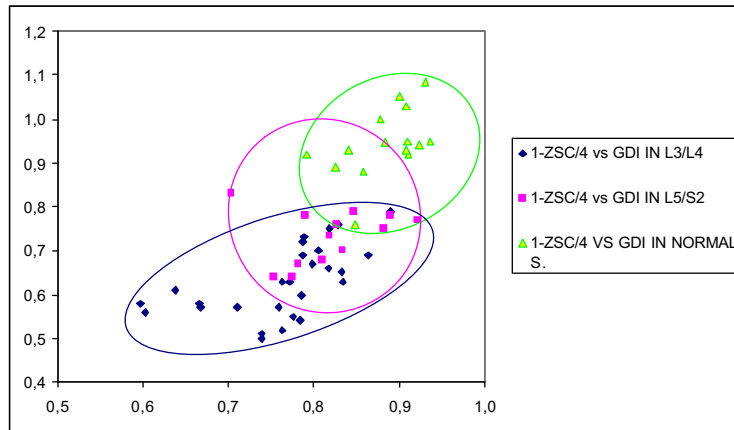
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RESULTS – Indexes 1- Z Score/4 vs GDI



Plotting values 1-Zscore/4 vs GDI on a scatter diagram can be observed a tendency to get close to normal values as the motor condition improves.... but with some overlap of values...



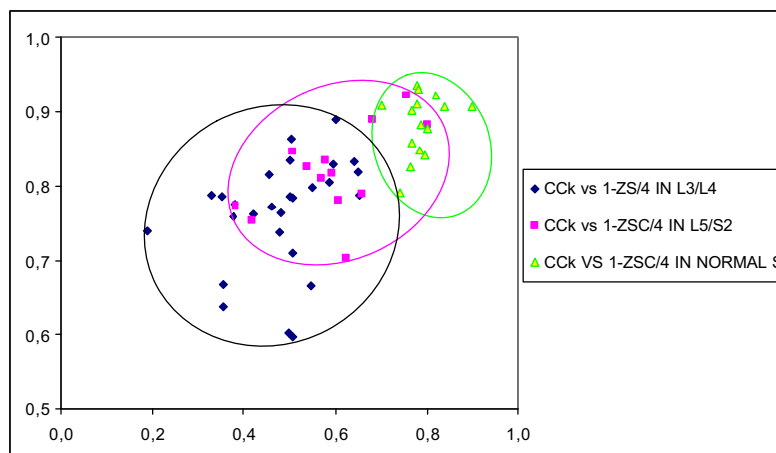
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RESULTS – Indexes CCK vs 1- Z Score/4



Plotting values CCK vs 1- Zscore/4 on a scatter diagram can be observed a tendency to get close to normal values as the motor condition improves....but with some overlap of values too...



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DISCUSSION

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DISCUSSION



☒ The functional motor involvement of patients with MMC is complex, because it does not present a defined level of paralysis or paresis, observing different levels of root involvement, which are in addition to other abnormalities such as damage in proprioceptive and sensory pathways.

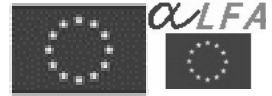
☒ Additionally, there are other difficulties such:

- Abnormal selective motor control
- Hydrocephalus
- Joint instabilities
- Bone torsional problems
- Joint contractures

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DISCUSSION



Statistical analysis of kinematic parameters studied, showed no significant differences between consecutive motor levels, being necessary to regroup patients in two groups: group 1 patients with high lumbar levels (L3 - L4) and group 2 patients with lumbosacral level (L5 and sacral). This would support the importance of further analysis of criteria used at the time of clinical classification.

Regarding the first hypothesis that proposes the existence of significant differences in the kinematic behavior of patients with MMC, according to their functional motor level, statistically significant differences were observed between patients versus healthy children for most of the kinematic parameters studied. But when compare patients between them, only significant differences were found for knee flexion at initial contact.

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DISCUSSION



In respect to the second hypothesis that both parameters, CCK and Z Score, can weigh motor involvement and establish differences between patients with different motor functional levels; It was found, that indexes proposed, show a tendency to approach normal as motor level improve.

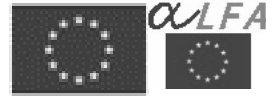
Although CCK showed significant differences between MMC patients groups, achieving differentiate them according to their functional motor level.

The Z score and its supplement only allow to distinguish the total patients group of the normal children, but does not differentiate patients with different motor levels.

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DISCUSSION



By using the GDI in our patients, we observed this gives a representative value about level of injury, making the difference between the groups according to their functional motor level, similar to that observed in case of correlation function (Cck).

Cck allows a similar analysis over time, with the difference as it's calculated for each joint kinematic curve, gives more specific information about different joint levels and its behavior over time on the natural illness course, or in response to different treatments. In other words this gives more information to understand joint behavior separately in different planes.

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DISCUSSION



Nevertheless it was not possible to establish precise ranges of values for both the Cck and GDI, to allow automatically classify the patient into a certain level motor functional, due to overlap in values between different groups of MMC patients.

These indexes may give a direction of the magnitude of patient's involvement and the evolution of the same individual over time, or after been subjected to different treatments. The comparison of patients groups with each other would provide information about which subjects have more severe compromise respect to others, but would not be possible to accurately categorize a functionally motor level.

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DISCUSSION



☒ If it's true the inclusion of a Chilean healthy children group was not the aim of our thesis, it was performed to analyze the validity of using the database of Italian children as normal reference group.

The similarities seen between both groups according correlation index (Cck) encouraged us to use the Italian normal group as reference, while maintaining the idea to get our own database of healthy Chilean children in the future.

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CONCLUSIONS



☒ The children with Myelomeningocele are difficult to assess because of the nature and complexity of the lesion that involve many systems and structures.

☒ The clinical classifications available only consider remaining muscle strength; they don't consider compensatory mechanisms of gait and they are also performed in different conditions to what happens in human gait.

☒ The kinematic parameters and indexes measured, shows that as the motor level is higher, the deviation from the median values of the healthy group and the database of Italian children is greater.

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CONCLUSIONS



☒ Kinematic parameters studied just showed significant differences in the degree of knee flexion at initial contact, allowing to distinguish the group of high lumbar patients to the lumbosacral group.

☒ However, this parameter showed no significant difference between patients with lumbosacral levels and healthy children.

☒ As observed in the case of the indexes evaluated, it is impossible to establish a range of knee flexion at initial contact of each motor level, for differentiating between them, persisting overlap in values between groups.

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CONCLUSIONS



☒ Unlike GDI that gives an overall value for each limb; CCK gives a global value for each joint in different planes, which could be important to know the real therapeutic impact at different levels.

☒ The analysis, showed similar kinematic behavior among Chilean healthy children and the Italian ones from the database with relatively high correlation index. Nevertheless our future goal is to complete the acquisition of our own database of healthy Chilean children.

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CONCLUSIONS



From our point of view the indexes proposed, specifically CCK and GDI are useful tools for clinical evaluation in patients with MMC, allowing to distinguish between them patients with varying injuries. Additionally are useful in treatment decision making and efficiency control over time in view of economical resources optimization and support the usefulness of gait lab.

The Z Score and its supplement have a lower value in differentiating groups of MMC patients with different injury levels.

Anyway, further investigations are necessary to establish more accurately the functional motor level and make differences according injury extent in children with Myelomeningocele.

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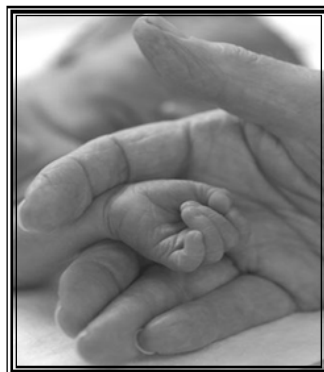


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Fuerza Chile!!

