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A WALKING ANALYSIS CASE STUDY ON A 4 YEARS OLD CHILD

Copilusi Cristian[1]
[1]University of Craiova, cristache03@yahoo.co.uk

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Abstract: In this paper we want to determine the angular amplitudes developed at the human locomotion system. This will be performed through an experimental analysis in case of a 4 years old child for walking activity. The experimental tests were performed by using CONTEMPLAS motion analysis equipment. This experimental research will lead us to create a database in order to design special orthotic devices for children locomotion rehabilitation.

1. INTRODUCTION

Today different motion analysis equipments are used in scientific research purpose for different domains, human health recovery, etc. As an example of these equipments which are used in the medicine domain especially kinetotherapy are: SIMI Motion, CONTEMPLAS, Vicon Motion System, BioSyn Systems, etc. [2, 12, and 13]. Many researchers have been developed analysis by using one of equipments mentioned above, and they have been obtained succesfull results [5, 6, 8, 9, 10.]

The aim of these motion analysis systems is to determine on experimental way some cinematic parameters in 2D or 3D environments, such as: trajectories, displacements, velocities, accelerations, etc. The research aim is to determine the angular amplitudes developed at the human locomotion system which will be useful in further researches to design new knee orthotics devices. The children are permanently in growth and that is the main fact that restricts the orthosis design research area. For this it will be propose a new orthosis type which consists in modules that can be modified by depending the children's age, sex, weight, height, etc. The modular orthosis for which we create this experimental research will be used only for children with ages between 4-7 years. The modular orthosis destination is for temporal recovery functions through therapeutic procedures only for walking activity.

Also many researchers, in biomechanics domain from different research centers have perform cinematic analysis of human segments for different activities. Mostly they tried on mature persons, and rarely for children, because are permanently in growth and they needs temporal recovery devices. These temporal recovery devices need to be modified periodically.

2. HUMAN LOWER LIMB ANATOMICAL CONSIDERATIONS

For human locomotion system study from a biomechanical viewpoint it is necessary to identify the motion possibilities developed through the specific joints. For this it is known that in a human lower limb structure exists: hip, knee and ankle joints as principal ones which mostly participate on walking activity. The hip joint permit to achieve 3 motion types such as: flexion-extension, abduction-adduction and internal/external rotation. As a remark the angular amplitude depends by the knee joint position. These motion possibilities are represented in figure 1 [1, 5, 7, and 14].

In the knee joint case, two different motion types are performed. These are: flexion, which is the most active one and internal/external rotation which has a passive character and it is achieved only for some shank position (figure 2) [1, 5, 7, and 14].

For ankle joint this is formed through a joint series which are complex ones and are interdependent from an anatomical viewpoint. For this joint two motions are performed: plantar/dorsal flexion and inversion/eversion motion (figure 3) [1, 5, 7, and 14].

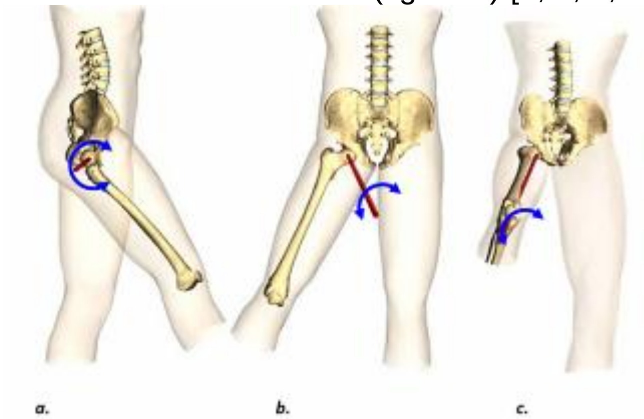

Figure 1. Hip joint motions : a-flexion/extension; b- eversion/inversion; c – internal/external rotation [10]

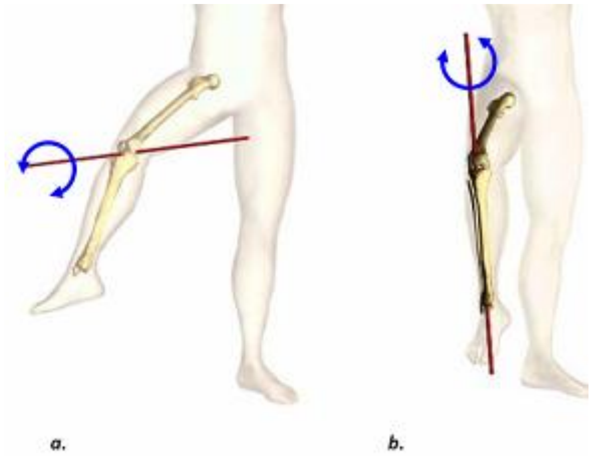

Figure 2. Knee joint motions : a-flexion; b – internal/external rotation [10]

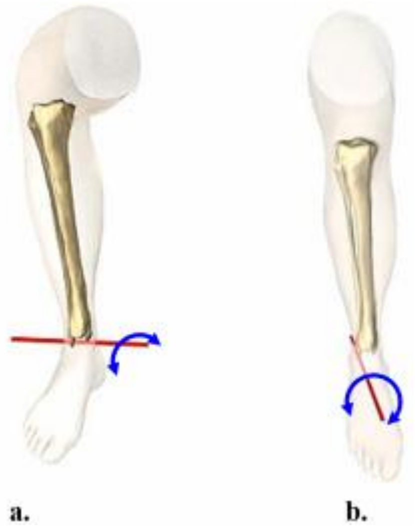

Figure 3. Ankle joint motions : a- dorsal/plantar flexion; b – inversion/eversion [10]

The limit values for joints specified in this research are presented in table 1.

Table 1. Human lower limb angular amplitudes

Joint	*Motion*	*Angular amplitude [degrees]*
Hip joint	Flexion→Extension (with straight leg)	90º ↔ 0 ↔ 30º
	Flexion→Extension (with bended leg)	120º ↔ 0 ↔ 30º
	Internal→external rotation	15º ↔ 0 ↔ 35º
Knee joint	Extension	0 ↔ 130º
	Internal→external rotation	10º ↔ 0 ↔ 140º
Ankle joint	Flexie plantar→dorsal flexion	35º ↔ 0 ↔ 20º
	Inversion→Eversion	30º ↔ 0 ↔ 60º

3. HUMAN LOCOMOTION SYSTEM EXPERIMENTAL MOTION ANALYSIS

The experimental analysis consists in 3D measurements with high-speed cameras of CONTEMPLAS equipment. The CONTEMPLAS equipment has two high speed cameras for capturing and recording sequences and a DELL notebook for sequences analysis in real time with Templo Standard module software [2]. University of Craiova-Faculty of Mechanics owns this special equipment, which is used for this experimental research presented in figure 4. The high-speed cameras are CCD-Chip 2.1.0 type. The acquisition process is achieved in real-time and the development of the experimental research was made in accordance with the procedure presented in figure 5.

Figure 4. CONTEMPLAS equipment

This equipment enables us to determine the desired points trajectories and spatial angular variations onto either mechanical or biomechanical mobile systems through successive identifications of the joint centers positions in their structures.

The kinematics data's obtaining cycle presupposes the attachment of 12 reflexive markers on a child locomotion system. For this, the anatomical points are identified, at an anatomical level of the interest articulations center positions. An aspect from the experimental analysis and also the Templo Standard Software is presented in figure 6.

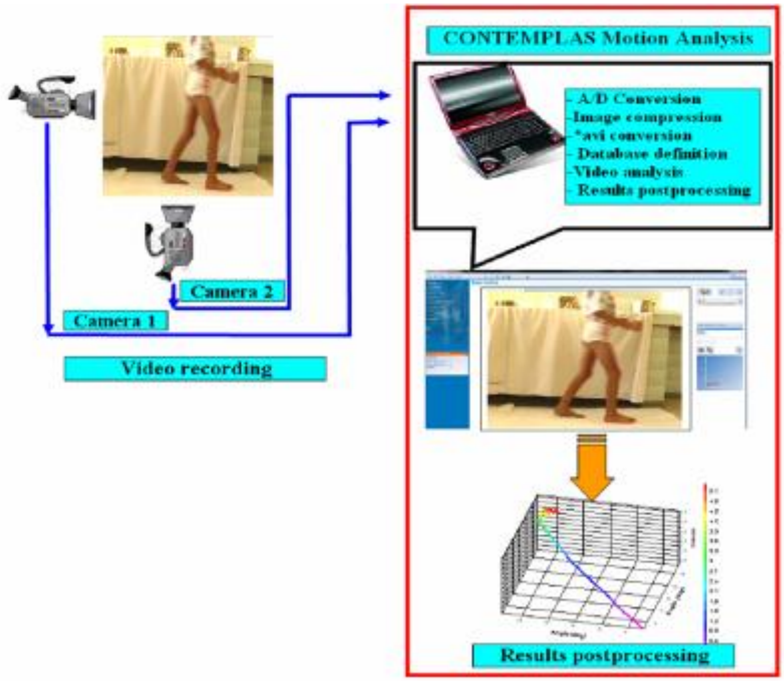

Figure 5. CONTEMPLAS equipment analysis scheme

Figure 6. CONTEMPLAS – Templo Standard interface analysis during a single gait

The obtained results are represented through angular amplitudes and trajectories of human locomotion system joint centers. These are represented in figure 7, figure 8 and figure 9.

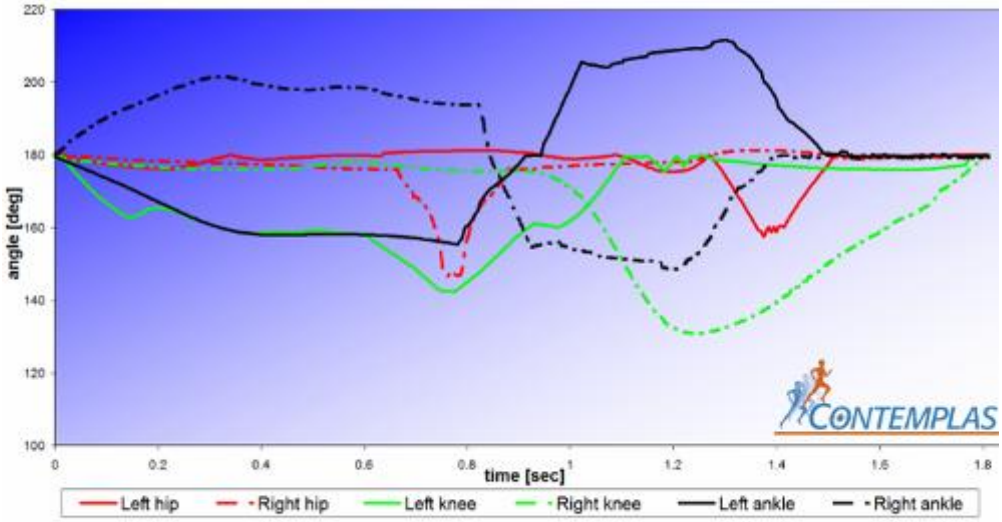

Figure 7. Locomotion system's angular amplitudes average for children at 4 years for walking activity

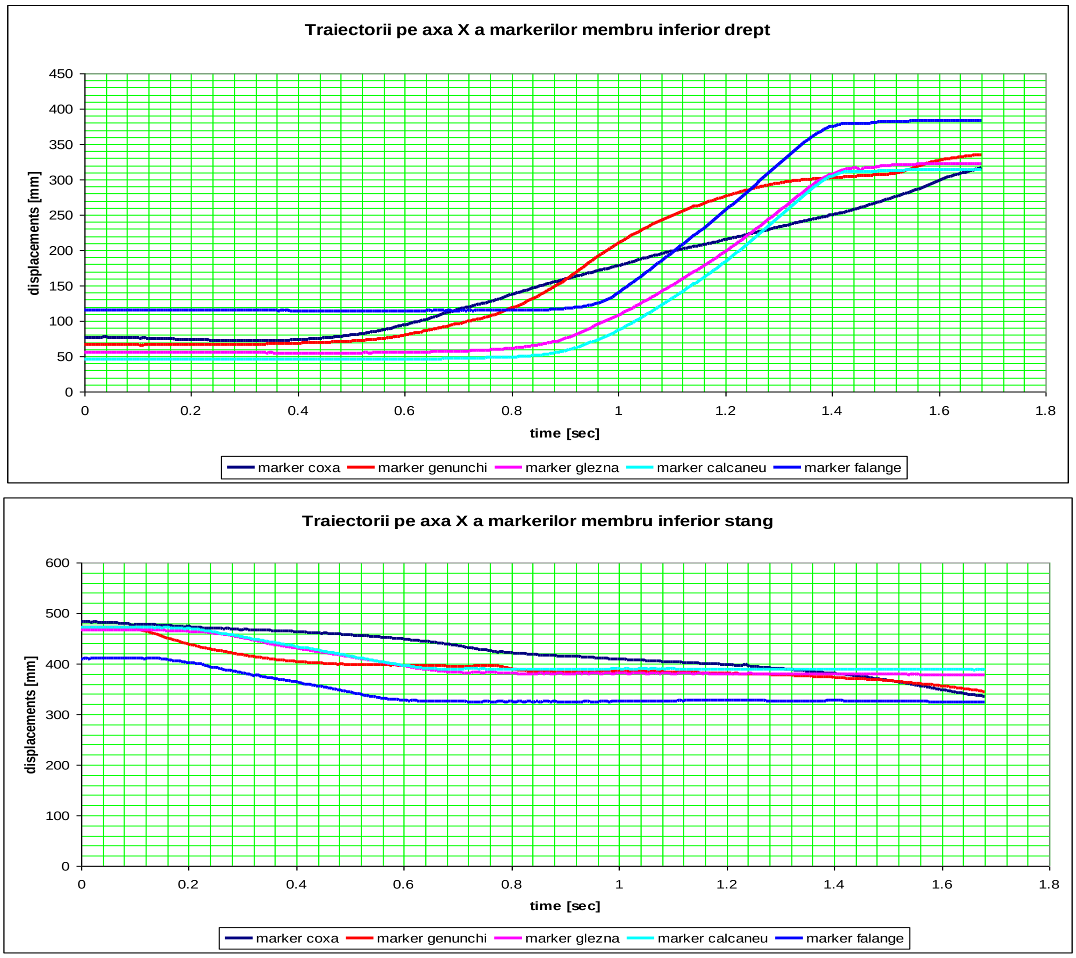

Figure 8. X axis trajectories of the attached markers generated by the CONTEMPLAS software for walking in case of a 4 years old child (a-right limb, b-left limb)

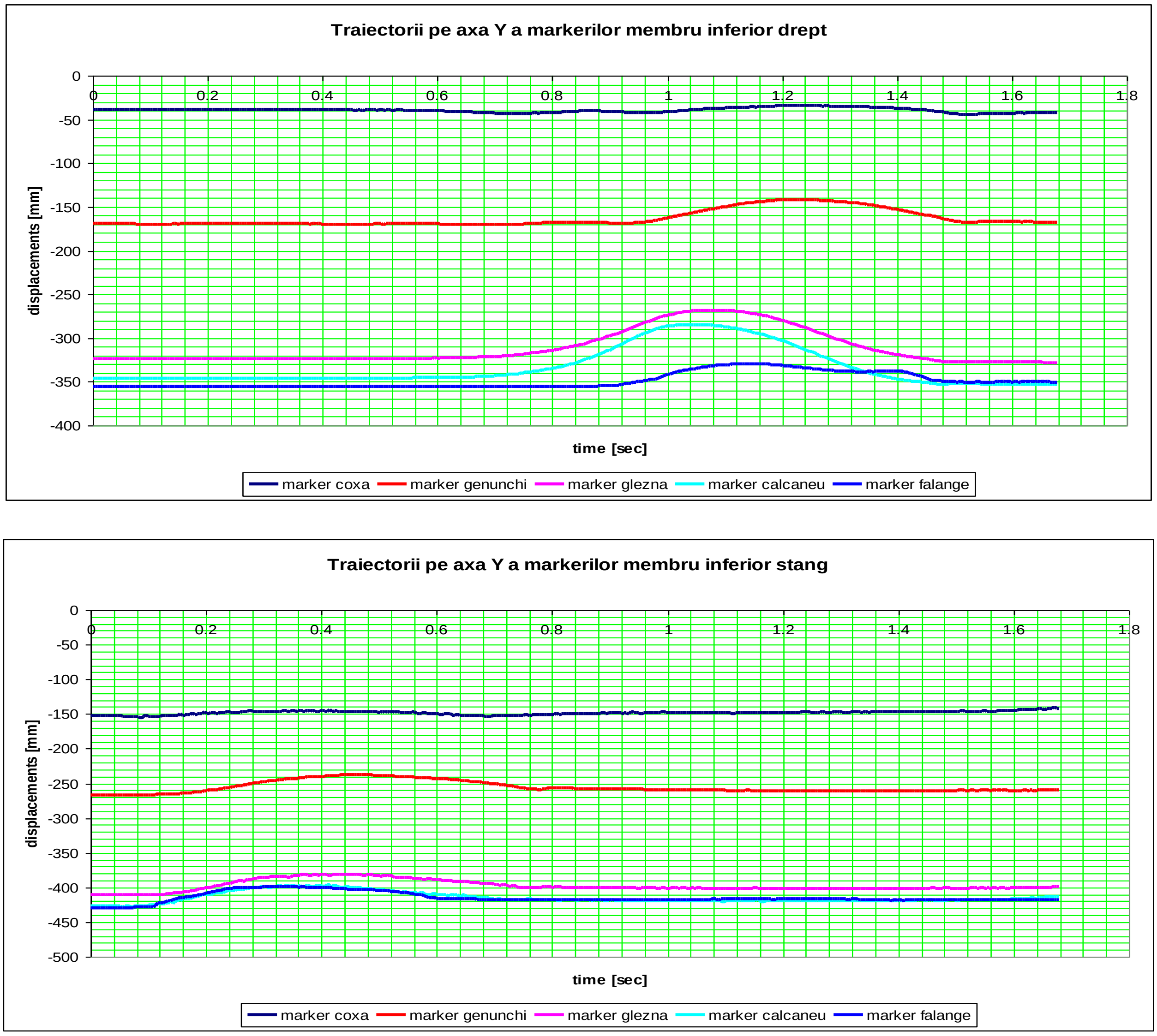

Figure 9. Y axis trajectories of the attached markers generated by the CONTEMPLAS software for walking in case of a 4 years old child (a-right limb, b-left limb)

4. CONCLUSIONS

As final conclusions it can be mentioned that this type of analysis has an original approach because the results help us to create a database used for children orthotics design. With these it can be presented here real models of a modular knee orthotic device for a 4 years old child (Figure 10) and another for 7 years old child (Figure 11).

The angular amplitudes and lower limb segments dimensions are used as entry data for a dynamic analysis. Also the angular amplitudes represent the motion laws which dictate the orthotic devices motions specially designed for children.

The motion laws developed through the experimental research can be useful to joint actuators program and control from these modular orthotic devices specially designed for children with temporal locomotion disabilities according with biomechanical features of children.

The results presented here for healthy children, help us to design the assistive devices for children with neuromotor pathology, depending of age and anthropometric features that means an improvement and development of fast and well rehabilitation program.

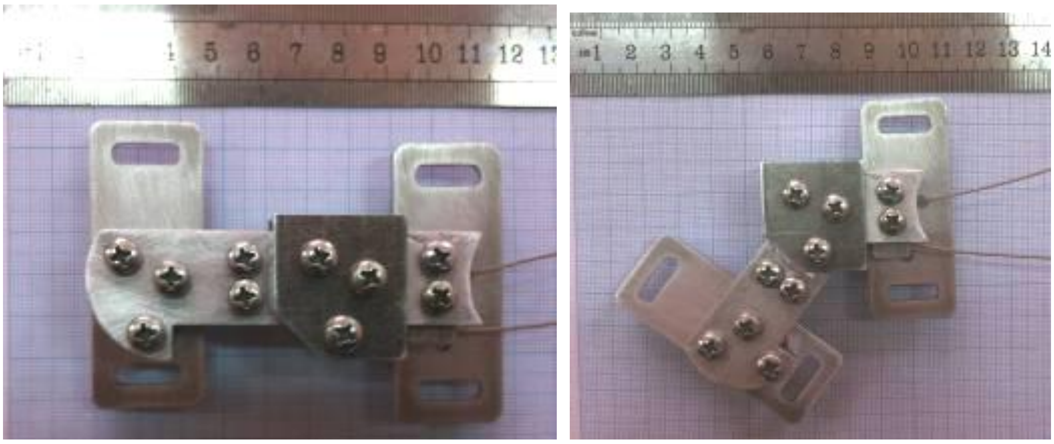

Figure 10. Modular orthosis real model used for 4 years children

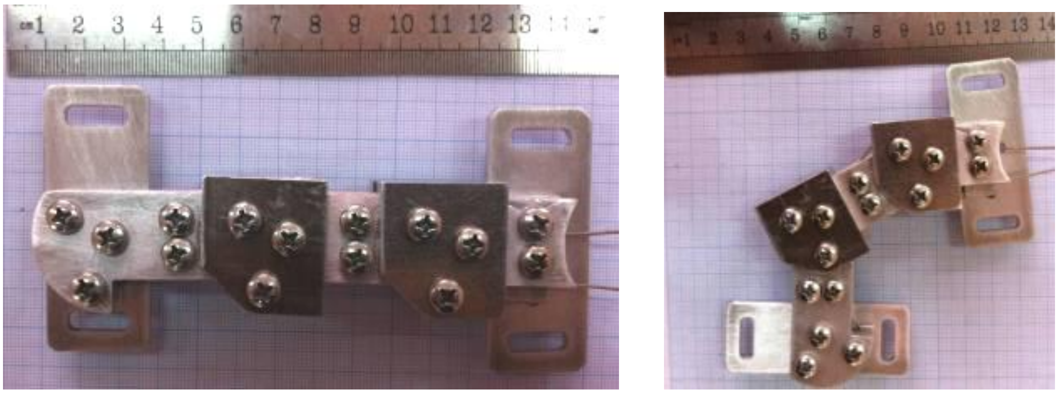

Figure 11. Modular orthosis real model used for 4 years children

Analyzed of joints kinematics for each phase of gait help us for modulate the construction of assistive devices and improvement the motor control for each joint in according with biomechanical rules. That means to improve the movement and stability of joint without decrease the role of dynamic stability involved by muscle system. Much more is possible to integrate the movement pattern of child in normal pattern of gait and to improve the balance during gait.

5. Acknowledgements

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