ASPECTS REGARDING A NEW SHANK ORTHOSIS USED FOR HUMAN LOCOMOTION TEMPORAL RECOVERY

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Abstract: In this paper we follow to elaborate a new mechanical system used in a shank orthosis structure. This shank orthosis will be used by the persons with temporal locomotion disabilities.
Based on some human lower limb's anatomical and functional considerations and a study regarding the shank orthosis existent in present we conclude that at the ankle joint's level, the valgus/varus motion is suppressed.
The new orthotic mechanical system model will permit this controlled motion.

1. INTRODUCTION

The orthotic systems – orthosis contribute at some segments rehabilitation from human body structure. These are used by persons which were suffered traumas, resulted from accidents or by persons who posses locomotion deficiencies resulted from congenital malformations.
Many orthotic systems types are developed in present [3, 4, 5, 7,9], and the orthotics development totally depends by the human subject main functions.
In the last few years these orthotic systems have advanced a lot due to intelligent materials implementation (shape memory materials). These materials have simplified the orthosis structure.
So, on national or international plan exists many orthotic and prosthesis centers which fabricate and commercialize different orthosis types.
On national plan a remarkable contribution on manufacturing and commercialization has the Theranova Orthotic and Prosthetic Center from Oradea [8].
An orthotic system (figure 1) which was developed from intelligent materials is Dyna Ankle Dynamic Ankle Orthosis used to prevent ankle joint distortions, commercialized by Sportstek Center Australia [7].
The human ankle joint dorsal/plantar flexion is accomplished through the sustaining/ immobilization element deformation. This orthosis is made from an intelligent material with shape memory capacity.
Another orthotic system (figure 2), different from the one presented above, is the Sure Step Neuropathic CROW (Charcot Restraint Orthotic Walker), developed and commercialized by TruLife Braces Indiana USA [3]. This orthosis assures the plantar/ dorsal flexion by the specific form of the foot element.
By taking in account the orthotic systems summary presentation, it can be concluding that these assure a single motion – dorsal/plantar flexion developed at the ankle joint level. But this motion isn't the single one which contributes at the walking activity. This motion is compensated by the valgus/varus motion, and is realized in transversal plane by the human lower limb (figure 3).

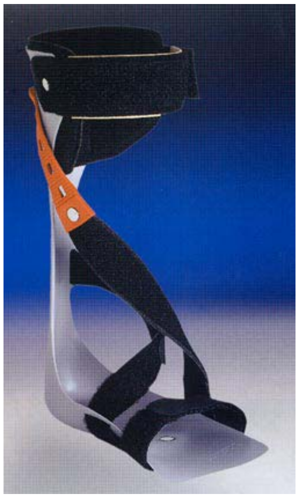

Figure 1. The Dyna Ankle dynamic ankle orthosis. **[7]**

Figure 2. Sure Step Neuropathic CROW orthosis. **[3]**

Figure 3. Valgus/varus motion.

2. HUMAN ANKLE JOINT MOTION LAW DETERMINATION

The experimental kinematics analysis was performed by using a acquisition and image analysis system, called SIMI Motion [6], which can be found in the endowment of the Kinetotherapy and Sport Faculty from University of Craiova. This experimental kinematics analysis is use in order to determine the human ankle joint motion laws, for implementing onto the new orthosis system virtual simulations.

The kinematics data's obtaining cycle presupposes the attachment of a markers series onto human lower limb subject (the one which is studied in this paper), by using for attachment of these markers, the anatomical points, which are characterizes the identification at a anatomical level of the interest articulations center positions.

The capture and take over phase of an image were performed through a PANASONIC high – rapid video camera which was found in the endowment of the SIMI Motion system, and the image recorder where performed with the ACER notebook aid.

The final phase of the experimental kinematics data's obtaining process is constituted from the images analysis by data's processing, and the markers position onto human subject where automated identified, with the software options help onto each frame, obtaining the kinematics curves (displacement, speed, accelerations) for each joint from the human lower limb structure.

The experimental analysis deployment in the sight of evidenciating the motion laws which were realized at the level of hip, knee and ankle joints, were performed on a human 26 years old subject with a 65 kg weight, 1,75 height, the elements length were: l_{femur}= 401mm; l_{tibia}=322 mm; l_{foot}= 210 mm; $l_{calcaneus-ankle}$= 66,5 mm; $l_{calcaneus-metatarsal}$= 130 mm.

The kinematics experimental analysis was deployed on walking activity, resulting the motion laws of the 3 joints.

For the walking activity, this was deployed in a 2D plane which the subject was moved in X axis direction on a 2,5 m distance, in a 4,2 seconds , deploying a number of 3 steps, such as is presented in figure 4.
Based on the kinematics analysis performed with the software equipment's help, this was generated in automatically mode the kinematics model having on base the markers emplacement mode (figure 5).
The software was permitted to generate the calculus of displacements, speeds and accelerations of interest depending on time. The obtained motion laws through this experimental kinematics analysis are presented summary in figure 6.
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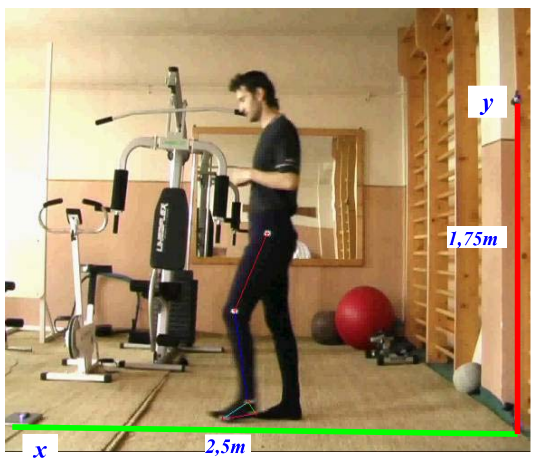

Figure 4. Aspect regarding the deploying activity of walking and equivalent kinematics model creation with the SIMI Motion software's aid.

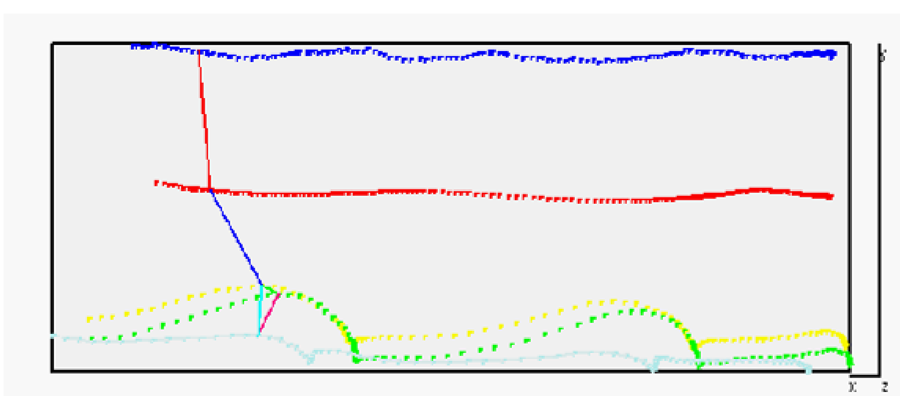

Figure 5. The kinematics model af the human lower limb studied in walking activity case.

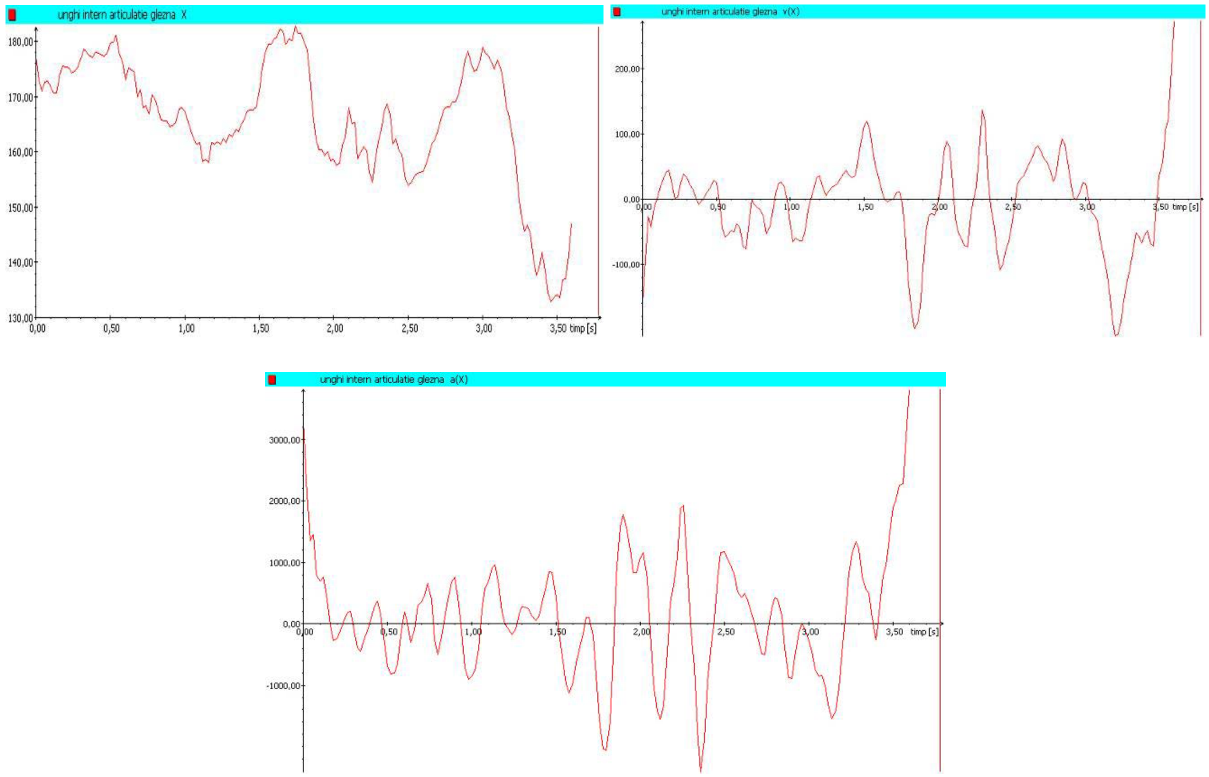

Figure 6. Angular variations of the ankle joint: displacements, speeds, accelerations.

3. NEW ORTHOTIC SYSTEM DESIGN

The new orthotic system design is based on a Hamilton ankle orthosis created by Hamilton Orthosis Center USA. This orthosis is represented in figure 7 and it has no mobility and we follow to give a controlled mobility and adjustable by using some shock absorbers bought from FESTO Pneumatic&Electric Automation.

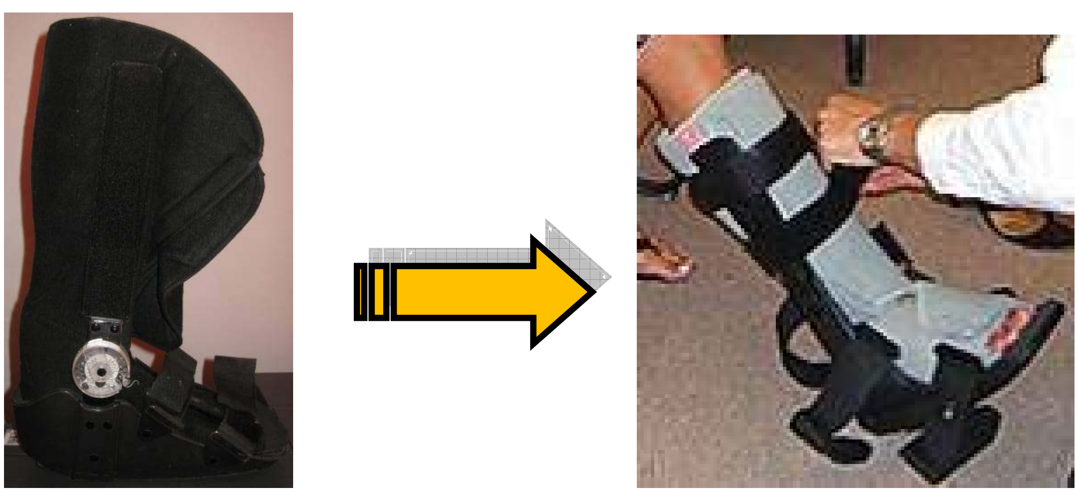

Figure 7. Hamilton ankle orthosis.

By measuring the shock absorbers geometrical forms we develop with the SolidWorks software aid the modified orthosis. This modified orthosis permit a controlled motion for dorsal plantar flexion and correct the valgus/varus motion.

The new orthosis mechanical system components are (according with figure 8): 1 – shank element; 2 – shock absorber superior sustaining device; 3 – dorsal/plantar flexion shock absorber; 4 - shock absorber inferior sustaining device; 4 – two shock absorbers mounted laterally for valgus/varus motion; 5 – foot.

The dorsal/plantar flexion motion is assisted by a YSR-C shock absorber mounted on the orthosis rear side. The dorsal/plantar flexion is assured through a rotation joint incorporated on the inferior sustaining device. The orthosis mount and access can be done from the front side. The valgus/varus motion can be assisted and controlled by a two DYSR shock absorbers mounted laterally in opposite side. When the one is compressed, the other is relaxed.

Through simulations in SolidWorks environment, by taking in account the ankle joint law presented above, this virtual model satisfies the desired motions (figure 9 and 10).

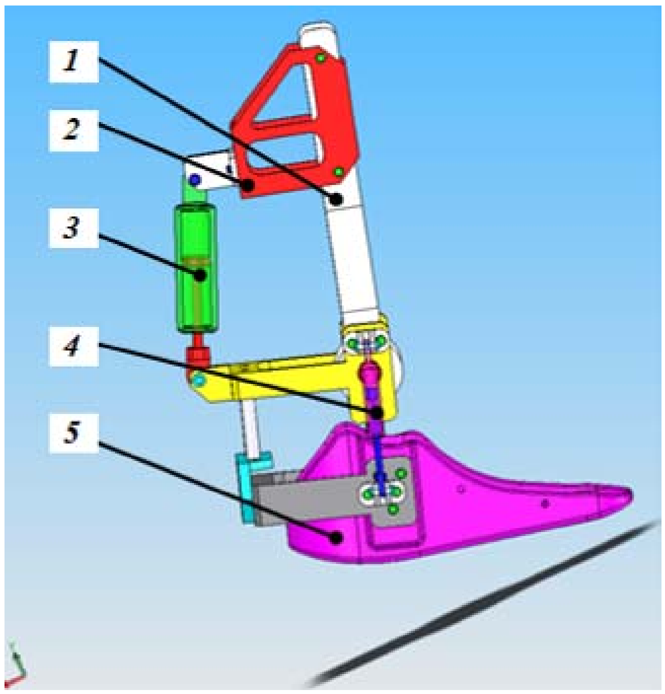

Figure 8. The new orthosis design.

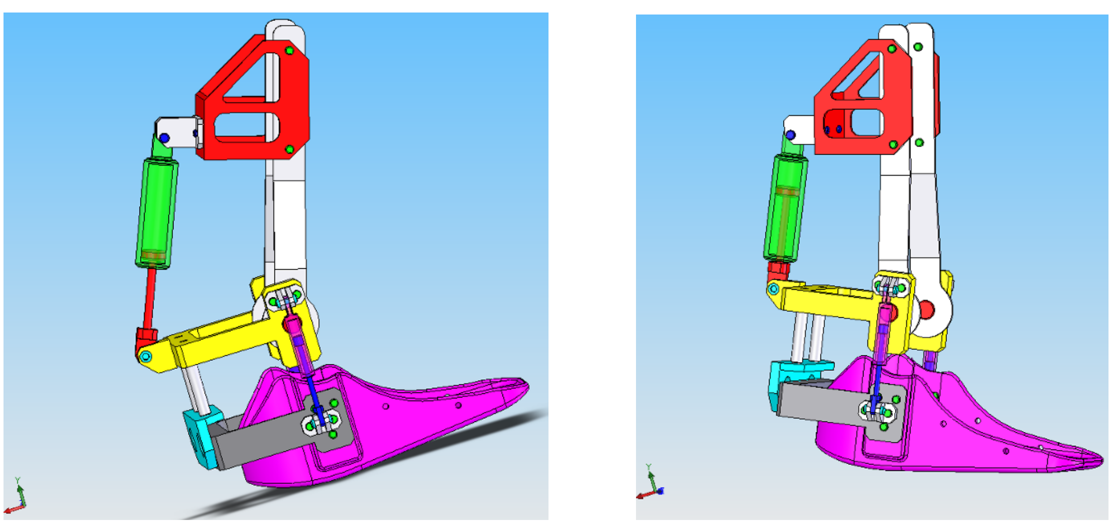

Figure 9. Aspects regarding the dorsal/plantar flexion of the new orthosis.

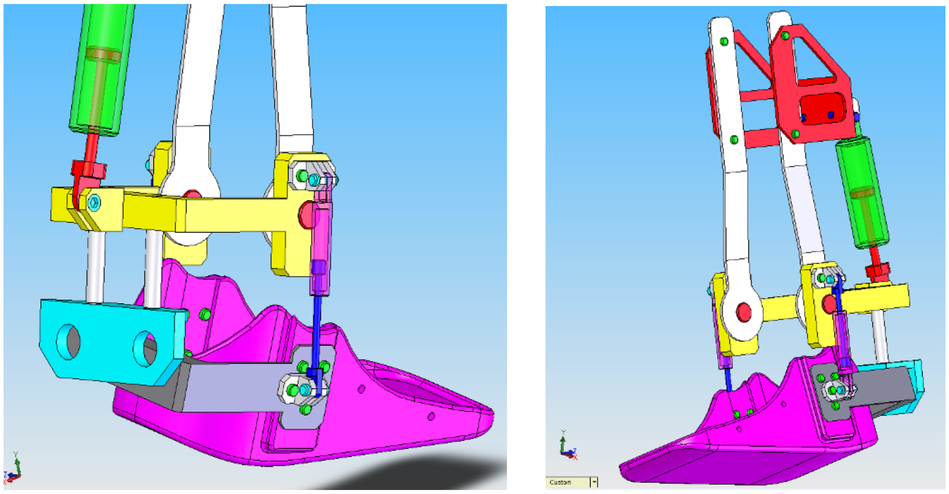

Figure 10. Aspects regarding the valgus/varus of the new orthosis.

4. CONCLUSIONS

1. Through this new orthosis it can be achieved independently two motions (plantar/dorsal flexion and valgus/varus motion).
2. These motions can be adjusted through mechanical adjusting devices mounting onto shock absorbers connection rods. This will correct the deficient foot.
3. This orthosis type can be fabricated from materials with low mass, and can have only 1450 grams;
4. Through virtual simulations, the mechanical solution adopted for this orthosis validates the real model.
5. The shock absorbers where adopted by taking in account the internal forces calculated in [1] and by connection rod displacement limit.

5. REFERENCES

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