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	JIF = 1.500	SJIF (Morocco) = 7.184	OAJI (USA) = 0.350

SOI: 1.1/TAS DOI: 10.15863/TAS

International Scientific Journal

Theoretical & Applied Science

p-ISSN: 2308-4944 (print) **e-ISSN:** 2409-0085 (online)

Year: 2024 **Issue:** 05 **Volume:** 133

Published: 25.05.2024 **http://T-Science.org**

Issue Article

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CORRECTION OF LOWER LIMB DEFORMITIES OF CHILDREN WITH CEREBRAL PALSY THROUGH THE DEVELOPMENT OF MULTIFUNCTIONAL ORTHOPEDIC DEVICES

Abstract: *The review article describes the purpose and methods of the new study to develop multifunctional orthopedic orthoses, in which pre-designed individual orthopedic insole will be placed. The orthosis integrated with insole ensures the correction of congenital pathologies and prevention of orthopedic complications in children with cerebral palsy. At the same time, the combined effect of the orthosis and insole on patient's lower limb will qualitatively improve both the dynamics of movement and proprioception, i.e. the sense of body position and balance in space. The results of science-based studies and a practical solution to the problem are designed to provide CP patients with multifunctional orthopedic means. The outcomes of the research are related to the solution of the most important socio-economic problems - creation of normal living conditions for children with cerebral palsy and various severe and irreversible pathologies of the musculoskeletal system.*

Key words: *children, cerebral palsy, orthopedic products.*

Language: *English*

Citation: Shalamberidze, M. M., & Tatvidze, M. L. (2024). Correction of lower limb deformities of children with cerebral palsy through the development of multifunctional orthopedic devices. *ISJ Theoretical & Applied Science, 05 (133)*, 105-108.

Soi: http://s-o-i.org/1.1/TAS-05-133-22 ***Doi***: https://dx.doi.org/10.15863/TAS.2024.05.133.22

Scopus ASCC: *2742.*

Introduction

Cerebral palsy in children encompasses a group of clinical syndromes that affect movement and coordination for their entire life. Cerebral palsy (CP) is the result of permanent brain damage and may occur while the baby is in the womb, during birth, or in the first two years of life. The disease affects children's ability to control their muscle that is manifesting in motor disorders, namely: paralysis, a decrease or increase in muscle tone. Impairment in gross motor abilities that involve the movements of large muscles, can lead to problems like sitting, standing, crawling, maintaining balance, running, etc., while impairments in fine motor skills lead to disability in getting dressed, playing, eating, writing and other everyday activities.

According to the World Center for Disease Control and Prevention (CDC), CP is the most common cause of motor disability in children. Recent studies show that the frequency ranges from 1 to 4 per 1000 children. Globally, approximately 18 million people of all ages have CP.

According to the National Clinical Practice Guidelines of Georgia, the frequency and distribution area of CP is not specified.

Clinical manifestations of CP are heterogeneous and depend on the type of motor disorder. According to the modern classification, there are spastic, dyskinetic, ataxic and atonic forms of CP. The spastic form affects about 80% of the general population with CP, during which toe walking (equinus foot), crouch gait (hip and knee flexion, heel foot), push-up walking and cross-walking (hip adduction) are observed. The determination of the form of CP is extremely important in terms of prognosis and development of treatment guidelines.

In children with CP muscle growth relative to bone growth is restricted, which impairs the movement mechanism. With age secondary orthopedic complications are added to congenital pathologies, which progress in parallel with an increase in the load on the musculoskeletal system. The lower extremities lag behind in growth, the spine is curved, the hip is drooping, the coordinated work of the muscles is disturbed; the contractures of the joints and muscles are observed. These pathological processes are accompanied by pain, which further restricts motor activity and leads to an increasing disruption of the biomechanics of gait.

The National Clinical Practice Guidelines of Georgia states that the management of CP orthotics of patients is of critical importance in order to correct orthopedic problems, which has a high degree of recommendation. Timely orthosis and modification of orthotic size depending on the child age are extremely important. Orthosis becomes a major component of life for a significant part of children with CP and determines their degree of mental and social comfort [1-5].

Review part:

The aim of the research is to develop multifunctional orthopedic orthoses, in which a pre-designed individual orthopedic insole will be placed.

An orthosis with integrated insole made by innovative technique ensures congenital anomalies correction and prevention of orthopedic complications in children with CP. The insoles will be manufactured with account of the locally over-pressure areas and made of relatively softer materials than the insole frame itself. Such combination of materials will increase the contact area between foot deformity and insole, which further reduce the balance deficit and allows the patient to feel much more comfortable.

Mutual action of orthosis and insole on the patient's lower limb will qualitatively improve both the dynamics of motion and proprioception, i.e. the sense of body position and balance in space.

To achieve the goals, the following tasks have been determined:

- Development of a new science-based methodology for the study of foot deformity and lower limbs;
- Study of foot deformity and lower limbs in children with CP using 3D scanning, using pedography and anthropometric techniques; grouping them according to the type and degree of disease and creation of patients' database;
- Analysis of the pedograms of foot deformities with account of the loads on the foot plantar part. Drawing of locally overloaded areas on pedograms by curved lines where loads exceed 150 kPa;
- Description of complex geometric shapes of curves of locally over-pressured areas on pedograms by methods of mathematical research, which will be taken into account during the 3D designing of individual orthopedic insoles;
- Development of new composite polymer materials of different hardness for the production of the frame of individual orthopedic insoles and over-pressured areas;
- Establishment of the regularities between the patient's weight, over-pressure area of the foot plantar part and the peak pressure on the foot plantar part, and selection of packages of perspective polymeric materials for manufacturing of insoles;
- 3D design of individual orthopedic insoles and manufacturing from combined polymer composite materials on a computer numerical control (CNC) milling machine;
- Study of lower limb shapes and sizes on a 3D scanner together with insole. Analysis of each patient's data individually and put in patients' database;
- Elaboration of a mathematical model of the lower limb geometric shape. Development of software programs based on mathematical algorithm and 3D design of orthoses together with insole;
- Preparation of a plaster cast of insoles for printing of the lower limb orthosis on a 3D printer, so that during the orthopedic printing process the insole itself is not damaged as a result of exposure to high temperature;
- Printing of the lower limb orthosis on a 3D printer together with insole plaster cast;
- Mechanical processing and cleaning of the lower limb orthosis printed on a 3D printer;
- Insertion of the insole into the lower limb orthosis, fixing the clamps and processing the inside with natural leather;
- Treatment of orthopedic products with special antibacterial substances for the prevention of fungal and bacterial diseases;
- Final correction of the orthosis fixed on the lower limb in the sagittal, frontal and horizontal planes;
- Trial wearing of lower limb orthoses, analysis of the results and correction with account of a patients' remarks;
- Development of medical and technical documentation of multifunctional orthosis.

Research methods:

During the implementation of the project, the following research methods were used [6-12]:

- method of pedography for computer diagnostics of the foot plantar part, loads on the foot plantar part, contact area and peak loads;
- anthropometric and 3D scanning method for the study of spatial and relief shapes of deformed feet, ankle joints, lower leg, knee joint and hip;
- boundary value problems for ordinary and partial differential equations, methods of differential geometry, linear and projection geometry, mathematical modeling to describe complex geometric shapes of deformed foot and lower limbs;
- 3D design methods for designing insoles and orthoses;
- methods of mathematical statistics for processing research results;
- methods of modeling and optimization of polymer compositions for selection of materials for orthopedic means;
- physical and mechanical research methods for determination of hardness, deformation, plasto-elasticity, shape stability and rigidity of materials.

Conclusions:

The practical implementation of the results of science-based research makes it possible to provide patients with CP with multifunctional orthopedic products [13].

Today orthoses in Georgia are intended only for limb fixation and do not meet international standards of orthopedic care. We believe that children with disabilities and their caregivers must be given a choice. The orthopedic means offered by us, along with fixation, will largely ensure the normalization of the motor function, and also dramatically reduce the discomfort caused by wearing an orthosis and the probability of side effects. All this is designed to improve the quality of life and, in spite of limited skills, give the patients motivation to live fully with other children. At the same time, the quality of life of persons associated with children with CP will improve. These include family members, patient caregivers, friends, and more.

The work was fulfilled with the financial support of Shota Rustaveli National Science Foundation of Georgia, Grant FR № 22 - 1515.

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