Systems for verticalisation and restoring gait of the handicapped

J. Wierciak, B. Radziemski, D. Jasińska-Choromańska, K. Szykiedans
Warsaw University of Technology, Faculty of Mechatronics, Institute of Micromechanics and Photonics,
ul. Św. A. Boboli 8, 02-525 Warszawa

1. Introduction

Mechatronic systems and devices, in which microprocessor controller takes decisions in typical situations instead of man, are nowadays a group of technical objects that dominate in majority of fields related not only to manufacturing processes but also to our everyday life. Additionally they bring up a chance to improve life of people, who are affected with serious injuries. Besides important applications of mechatronic systems within medical equipment either supporting or providing treatment of various diseases a chance arises for effective restoring of human limbs’ movements lost due to some reason. People with paresis of lower limbs usually use a wheel-chair for moving in. This way of travelling has many advantages; particularly it provides users sense of safety resulting from mechanical stability of the chair. Using of a wheel-chair is also a source of some limits. Persons moving by wheel-chairs look at the surrounding world from different position than other people. Many elements of this world are located out of reach of their hands and eyes. One of possible solutions of this problem verticalisation is with the use of special orthopaedic instruments or devices.

2. Techniques of verticalisation

A man with paresis of lower limbs can be compared to mechanical structure consisting of a fit body connected to motion system of many DOFs having no working drives. Each lower limb can be considered to have 7 degrees of freedom. One of the simplest techniques of verticalisation is to eliminate all DOFs (lock all joints) by tightening parts of limbs to a stiff frame, which can then be positioned vertically. Static balance of the patient is guaranteed by proper distribution of supporting points of the frame. There are various technical solutions used in verticalisation depending upon health condition of a patient [2]. These are: special beds, verticaling devices, in particular for children (Fig.1a), mobile verticaling tables, wheel-chairs with electrical lift as well as the so called parapodia: static and dynamic. Majority of those instruments and devices is dedicated to treatment purposes. Verticalisation of non walking patients counteracts: decalcification of bones, degeneration of internal organs, reduction of warming function of blood as well as decrease of elasticity of muscular tissue and ligaments. Some of the mentioned devices can be used for moving the handicapped but it can take place only either with the aid of another people or due to additional drives (Fig.1b). Independent moving of a patient is possible in the case of dynamic parapodium (Fig.1c) though its use is limited to flat surfaces with no obstacles existence. The movement of parapodium is not a natural one because it is performed by balancing of the whole body of a patient.

3. Devices for supporting man’s gait

Further progress in the field of systems approaching everyday life of people with paresis to normal existence comes from rapid development of mechatronic systems supporting natural movements of man’s limbs [1, 3, 4, 5,
6]. Such systems are known under general name “wearable robots”, which explains their technical origin as well as their tight relation with the user, for whom they are a kind of cloth. These robots can be classified to the following categories depending upon the function they perform in cooperation with the human actor [3]:

- empowering robotic exoskeletons – that extend the strength of the human hand beyond its natural ability while maintaining human control of the robot,
- orthotic robots – which purpose is to restore lost or weak functions, e.g. following a disease or a neurological condition, to their natural levels,
- prosthetic robots – devices that substitute for lost limbs after amputation.

The examples of robots supporting man’s gait are presented in Fig. 2.

![Exoskeleton HAL](image1.jpg) ![Rewalk System](image2.jpg) ![Lower Limb Prosthetic Robot](image3.jpg)

**Fig. 2** Examples of wearable robots: a) exoskeleton HAL developed at Tsukuba University in Japan [5], b) ReWalk system for restoring the handicapped functions of lower limbs, designed and manufactured by Argo Medical Technologies [5], c) a lower limb prosthetic robot [3]

### 4. Final notes

In the Division of Design of Precision Devices at the Faculty of Mechatronics WUT a new project called VENI has been launched recently concerning a device for supporting man’s gait dedicated to people with paresis of lower limbs. The presented above review of the achievements within methods and systems aiding the handicapped to improve their life and health is a source of information about current trends in technology of orthopaedic equipment as well as wearable robots. It is an inspiration and a kind of a signpost for the team starting to design and make technical model of VENI device.

**Acknowledgements.** The presented works have been financed within a UE Research Project “ECO-Mobilność” No. UDA-POIG.01.03.01-14-154/09-00.

### References